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Effect of dried *Gliricidia sepium* leaf supplement on feed intake, digestibility and nitrogen retention in sheep fed dried KW4 elephant grass (*Pennisetum purpureum*) *ad libitum*

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Abstract. A feeding experiment was conducted to study the effects of supplementation with dried *Gliricidia sepium* leaves on dry matter (DM) intake, digestibility and nitrogen retention in sheep fed KW4 elephant grass. Four mature rams were fed elephant grass *ad libitum* supplemented with four levels of gliricidia leaves (0, 4, 8 and 12 g DM kg^{-1} lwt day^{-1}) in a 4 × 4 Latin square design. Supplementation with gliricidia leaves decreased elephant grass DM intake (g DM day^{-1} or g DM kg^{-1} $BW^{0.75}$ day^{-1}). However, the effect of supplementation on total DM intake of the rations was not significant ($P > 0.05$). Total crude protein intake significantly ($P < 0.001$) increased with increasing levels of gliricidia supplementation. Total DM digestibility and body weight changes were significantly ($P < 0.05$) improved by gliricidia supplementation; with the highest digestibility coefficient (60.5%) and body weight gain (89.3 g/day) obtained at 8 g DM kg^{-1} lwt day^{-1}. Gliricidia supplementation significantly ($P < 0.001$) improved nitrogen intake, absorbed nitrogen and retained nitrogen but with no significant difference at 8 and 12 g DM kg^{-1} lwt day^{-1} level of supplementation. The highest efficiency of N retention by sheep (44.9%) was obtained at 8 g DM kg^{-1} lwt day^{-1} level of gliricidia supplementation. The results indicated that supplemention of KW4 elephant grass with small quantities of gliricidia leaves up to 8 g DM kg^{-1} lwt day^{-1} enhance utilisation efficiency of the total ration. Further increases in the level of gliricidia supplementation, under the conditions of this experiment, reduced the intake of elephant grass leading to substitution effects of the basal.

Introduction

In sub-Saharan African (SSA) countries, Uganda in particular, the main feed resources for livestock are natural pastures consisting of grasses, legumes and browse tree species. Although grasses (e.g. *Panicum maximum*, *Pennisetum purpureum*) can yield as much as/or more than fodder trees/shrubs during the rainy season, their productivity and nutritive value decline sharply during the dry season. At that stage, pastures are deficient in energy, protein and minerals. This is aggravated by lack of alternative feed or supplementation during this critical period (Okello and Obwolo, 1984). However, excess forage produced during the rainy season can be conserved as hay for dry season feeding, when *in situ* pasture grazing is inadequate.

Elephant grass is a tropical forage that favours the hot and humid conditions and it is considered among the superior fodder producers in the world (Stephens, 1967). Average annual yield is about 300 tones green fodder per hectare equivalent to 49.5 tones dry matter (DM) containing 5.3 tones crude protein (Hassan et al., 1983). In the crop/livestock production system in the tall grass zone of Uganda, most farmers use a high yielding variety of elephant grass, Kawanda 4 (KW4), commonly referred to as *Uganda Hairless elephant grass*, as the sole fodder grass for smallholder dairy production under the cut-and-carry zero-grazing system. Elephant grass and its hybrids have been successfully used as the sole feed source for ruminants (Butterworth, 1965; Grant et al.,1974). However, unless a proper level of nitrogen fertilizer is applied (Capiel and Ashcroft, 1972; Ogwang and Mugerwa, 1976), protein supplement was suggested to improve growth and nitrogen balance in animals (Panda et al., 1967; Hassan et al., 1979). Methods of improving nutritive value of roughage feed by concentrate supplementation and chemical treatment of roughages are of limited use under Ugandan conditions owing to scarcity and high cost of importing the chemicals and purchasing the protein concentrates. It is suggested that a more practical approach will be the use of forage/fodder legumes as protein supplements to the low-protein grasses.

One important attribute of forage legumes is their positive effect on intake and digestibility (Topps, 1992). *Gliricidia sepium* is believed to be the most widely cultivated multipurpose shrub legume, after *Leucaena leucocephala* (leucaena) (Sukanten et al., 1996). Under certain conditions gliricidia produced as much as or more biomass than leucaena (Sterwart et al., 1992). Gliricidia is commonly used to supplement poor quality roughage. During the dry season it may become a major source of feed for goats and cattle in dryland farming areas (Wiersum and Nitis, 1992; Simons and Sterwart, 1994). While gliricidia has been recognized as a useful species for many years, its use is still in its infancy in Uganda although the population of gliricidia trees is on increase around homesteads, mainly due to the zero grazing drive going on nation wide. The present study was, therefore, undertaken to evaluate the effect of supplementation with dried *Gliricidia sepium* leaves on feed intake, apparent nutrient digestibility and nitrogen retention by sheep fed dried elephant grass (KW4).

Materials and methods

Location

The experiment was conducted at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK) located in the fertile Lake Victoria crescent area, about 19 km north of Kampala (0°28′ N, 32°37′ E, altitude 1, 204 m a.s.l). The rainfall pattern of the area is bimodal with an annual mean of 1200 mm and two peaks in April and November. The mean maximum temperatures vary from 28.5 °C in January to 26.0 °C in July and minimum temperatures from 17.4 °C in April to 15.9 °C in July and August. The upland soils of Kabanyolo are classified as latosols or as ferrallitic soils. The soils are deep, highly drained red soils which are characteristic of the Buganda Catena series. Some characteristics of these soils include total N of 0.2%, available P of 0.1 ppm, soil pH of 6.2, clay and organic matter contents of 21.9 and 7.4% respectively.

Animals, diets and experimental design

Four mature rams 4.5 ± 0.12 years old and 43.0 ± 1.81 kg live weight, housed in digestion crates, were used in the experiment. Prior to the commencement of the experiment, all animals were drenched against gastrointestinal parasites. The animals were confined in individual metabolic cages and fed dried KW4 elephant grass *ad libitum* as the basal feed. The elephant grass was harvested at 6 to 8 weeks regrowth, which was wilted in the field for four days, chopped (2 to 5 cm), and dried under a drying shade. The gliricidia leaves came from regrowth shoots at 12 and 16 weeks cutting interval in the wet and dry seasons respectively. The shoots were wilted in the field for one day and later, dried under shade. Since there were four harvests of gliricidia leaves and more than 6 harvests for the elephant grass, the two feeds were mixed independently to make each feed homogeneous before the onset of the trial. Gliricidia leaves were fed at four levels: 0, 4, 8 and 12 g DM Kg^{-1} Lwt day^{-1} in a 4 × 4 Latin square design.

The animals were offered a known quantity of elephant grass hay *ad libitum* twice a day at 0900 and 1600 hours. Gliricidia leaves were fed prior to feeding of the elephant grass, at the morning feeding only and water was provided at all times. Faeces and refusals were collected from each sheep once a day prior to the morning feeding. Urine was collected via a plastic tube from the digestion crates to covered plastic buckets each containing 50 ml of 0.5N HCl in order to stop evaporative loss of nitrogen. The animals were weighed before and after each experimental period which consisted of a 14-day preliminary period followed by a 7-day collection period.

Sampling and chemical analysis

During the collection period, daily feed intakes and refusals were measured and samples of feed on offer and refusals for each sheep taken. The samples were oven dried at 60 °C for 48 hrs and milled to pass a 1 mm screen before chemical analysis. Total daily faecal output was measured for each sheep, mixed and a 10% sample taken and stored as separate samples in a freezer (–4 °C) for each experimental period. Similarly, the 24 hour urine output from each sheep was recorded, mixed and a 10% sample taken and stored as separate samples in a refrigerator for each experimental period. The seven days samples for each sheep were bulked at the end of the experiment and composited for each experimental period. Sub-samples of the faeces were then taken, oven dried at 60 °C to constant weight and ground (1 mm mesh) for later chemical analysis. The DM in the feeds and faeces was obtained by oven drying at 100 °C for 24 hrs. Ash of the feeds was determined by igniting samples in a muffle furnace at 500 °C for 5 hrs (AOAC, 1980). Nitrogen (N) content of the feeds, faeces and urine was determined by the standard micro Kjeldahl method (AOAC, 1980). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined using the procedures described by Goering and van Soest (1970) and in vitro dry matter digestibility (IVDMD) by Tilley and Terry (1963) method.

Statistical analysis

Analysis of variance was carried out to test the effects of the levels of supplementation on feed intake, digestibility, body weight changes and nitrogen utilization using the General Linear Models Procedure (GLM) in SAS (1987) for a balanced 4 × 4 Latin square design. Differences among treatment means were compared using Duncan's Multiple Range test.

Results

Intake, apparent digestibility and live weight changes

The chemical composition of elephant grass and gliricidia leaves used in the study are presented in Table 1. NDF and ADF contents were higher and crude protein content was lower in elephant grass than in gliricidia leaves. The rest of the constituents did not differ much between the elephant grass and gliricidia leaves.

Results of dry matter intake (DMI), apparent digestibility and live weight changes are presented in Table 2. Supplementation with gliricidia leaves had a significant ($P < 0.05$) effect on daily elephant grass dry matter intake but

Table 1. Chemical composition[1] (%DM) and in vitro dry matter digestibility (IVDMD) of KW4 elephant grass and dried gliricidia leaves.

	Elephant grass	Gliricidia leaves
Dry matter	90.39	89.41
Organic matter	87.51	87.53
Crude protein (N × 6.25)	10.25	19.72
Neutral detergent fibre	70.81	41.50
Acid detergent fibre	41.20	28.70
Ash	12.49	12.47
IVDMD	69.20	67.00

[1] Values are means of four feeding periods.

Table 2. Daily feed intake, apparent digestibility and body weight changes of sheep fed KW4 elephant grass supplemented with dried gliricidia leaves.

Parameter	Supplement level (g DM/kg Lwt/day)				SEM	F-test probabilities
	0	4	8	12		
Daily intake						
Dry matter (g DM)						
Elephant grass	1107.0^{a}	925.0^{ab}	837.4^{bc}	664.1^{c}	61.03	*
Gliricidia	0.0	174.1	348.3	522.5	–	–
Total	1107.0	1099.2	1214.2	1196.6	49.42	NS
Dry matter (g DM/kg $BW^{0.75}$)						
Elephant grass	59.4^{a}	55.2^{a}	49.7^{ab}	39.5^{b}	3.41	*
Gliricidia leaves	0.0	10.4	20.8	31.3	0.26	–
Total	59.4	65.6	70.5	70.8	3.39	NS
Crude protein (g)						
Elephant grass	102.5	94.81	85.83	68.07	–	–
Gliricidia leaves	0.0	36.92	73.84	110.76	–	–
Total	102.5^{c}	132.00^{b}	159.85^{a}	179.07^{a}	6.23	***
Total (g DM/kg $BW^{0.75}$)	6.14^{c}	7.86^{b}	9.56^{a}	10.69^{a}	0.39	***
Digestibility (%)						
Total dry matter	58.15^{b}	58.33^{b}	60.50^{a}	59.45^{ab}	4.19	*
Nitrogen	58.50^{b}	66.38^{a}	74.39^{a}	72.64^{a}	2.22	*
Body weight gain (g/day)	17.86^{b}	80.36^{a}	89.29^{a}	71.43^{a}	12.36	*

SEM = Standard Error of Mean.
Within row means with different superscripts differ significantly.
NS = Non-Significant; * = Significant ($P < 0.05$); ** = Significant ($P < 0.01$); *** = Significant ($P < 0.001$).

did not significantly effect total DMI (g DM or g DM kg^{-1} $BW^{0.75}$). Gliricidia supplementation significantly ($P < 0.05$) decreased daily elephant grass DMI. However, when daily elephant grass DMI was expressed on metabolic body weight, there was no significant difference between the unsupplemented diet and diets supplemented at 4 and 8 g. Supplementation substantially ($P < 0.001$) improved total crude protein intake (CPI) (g DM day^{-1} and g DM Kg^{-1} $BW^{0.75}$). Higher levels of gliricidia supplementation resulted in significantly ($P < 0.05$) higher CP intake than the lowest (4 g DM kg^{-1} lwt day^{-1}) level of supplementation but there was no significant difference between rations containing 8 and 12 g gliricidia DM kg^{-1} lwt day^{-1}.

Supplementation improved dry matter and crude protein digestibility of the total rations. Total dry matter digestibility significantly ($P < 0.05$) increased with increasing levels of gliricidia and the highest digestibility coefficient (60.5%) was recorded for sheep supplemented at 8 g gliricidia DM kg^{-1} lwt day^{-1}. However, there was no significant difference in DM digestibility between treatments receiving 0, 4 and 12 g DM kg^{-1} lwt day^{-1} gliricidia supplements. Crude protein digestibility of the supplemented rations was significantly ($P < 0.05$) higher than the unsupplemented ration but there was no significant difference in CP digestibility between the gliricidia supplemented diets. The highest CP digestibility (74.4%) was recorded with the 8 g level of supplementation. An average daily weight gain of 17.9, 80.4, 89.3 and 71.4 g day^{-1} for the 0, 4, 8, and 12 g levels of gliricidia supplementation respectively, were recorded.

Nitrogen utilisation

The results for nitrogen intake, excretion, absorption and retention are presented in Table 3. Nitrogen intake by sheep fed elephant grass alone was significantly ($P < 0.001$) lower than for the supplemented sheep. However, there were no significant differences between 8 and 12-g levels of supplementation. Gliricidia supplementation improved significantly ($P < 0.05$) the nitrogen digestibility of the total rations but with no significant difference between the gliricidia supplemented diets. Total excreted-N (g day^{-1}) was statistically similar for all treatments. When faecal-N and urinary-N were expressed as percentages of N-intake, nitrogen excretion significantly ($P < 0.01$) decreased with increasing levels of gliricidia supplementation.

Absorbed-N and retained-N were significantly ($P < 0.001$) higher in the gliricidia supplemented diets than in the control diet but with no significant differences between 8 and 12 g level of supplementation. When absorbed-N was expressed as a percentage of N-intake, the efficiency of N absorption was 58.5, 66.4, 74.4 and 72.6% respectively for the 0, 4, 8 and 12 g supplemented diets. However, treatment differences in N absorption efficiency of animals with gliricidia supplements were not apparent. When retained-N was expressed as a proportion of N-intake, there were significant ($P < 0.01$) differences between the efficiency of N-retention by sheep on the control diet and gliri-

Table 3. Nitrogen utilisation by sheep fed KW4 elephant grass supplemented with increasing levels of dried Gliricidia leaves.

Parameter	Supplement level (g DM/kg Lwt/day)				SEM	F-test prob-abilities
	0	4	8	12		
Nitrogen intake						
g/day	16.41[c]	21.12[b]	25.58[a]	28.66[a]	1.00	***
g/kg $BW^{0.75}$/day	0.98[c]	1.26[b]	1.52[a]	1.71[a]	0.06	***
Nitrogen excretion						
Faecal (g/day)	6.81	7.11	6.55	7.84	0.41	–
Urine (g/day)	7.14	8.50	7.75	9.25	0.71	–
Total (g/day)	13.95	15.61	14.30	17.08	1.05	NS
% of intake (faecal)	41.82[a]	33.55[b]	25.55[c]	27.37[c]	1.16	**
% of intake (urine)	43.40[a]	40.35[a]	29.55[b]	32.10[b]	1.95	**
Nitrogen absorbed						
g/day	9.60[c]	14.02[b]	19.03[a]	20.82[a]	0.69	***
g/kg BW0.75/day	0.59[c]	0.84[b]	1.10[a]	1.24[a]	0.05	***
% of intake	58.50[b]	66.38[a]	74.39[a]	72.64[a]	2.22	*
Nitrogen retained						
g/day	2.46[c]	5.51[b]	11.28[a]	11.58[a]	0.45	***
% of N intake	14.88[c]	26.10[b]	44.90[a]	40.55[a]	2.77	***
% of N absorbed	24.42[c]	39.33[b]	60.28[a]	55.72[a]	3.46	**

SEM = Standard error of mean.
Within row means with different superscripts differ significantly.
NS = Non-significant; * = Significant ($P < 0.05$); ** = Significant ($P < 0.01$); *** = Significant ($P < 0.001$).

cidia supplemented diets but there was no significant difference between diets with 8 and 12 g levels of gliricidia supplement. The highest efficiency of N retention by sheep (44.9%) was obtained at 8 g level of supplementation. All the gliricidia supplemented diets had significantly ($P < 0.001$) superior efficiency of N-retention than elephant grass alone.

Discussion

The level of crude protein (10.3%) of the elephant grass used in the present study was slightly lower than the level (11–12%CP) required for moderate levels of production (ARC, 1980) but higher than the limiting level (6–8%) below which appetite and forage intake are depressed (Minson, 1982; Forbes, 1986). The CP (19.7%) content of gliricidia leaves used in the study was within the range of 9.0–30.0% of DM reported for gliricidia by Smith and van Houtert (1987) and Topps (1992).

Dry matter intake is an important factor and is a critical determinant of energy intake and performance in ruminants (Devendra and Burns, 1983).

Furthermore, it is important that feed supplements should not adversely affect intake of basal roughage diet. In the present study, supplementation with increasing levels of gliricidia leaves did not have a significant effect on total DM intake (g day^{-1} or g DM Kg^{-1} $BW^{0.75}$). Similar results were reported by van Eys et al. (1986) and Veereswara et al. (1993) where supplementation with leucaena, sesbania and gliricidia slightly depressed the DM intake of hybrid elephant grass (NB-21). The present results are, however, in contrast with those of Ademosun et al. (1988) and Ash (1990) who reported that supplementation of hay diets with *Leucaena leucocephala*, *Gliricidia sepium* and *Sesbania sesban* increased total DM intake. The significant decrease in the intake of the basal diet and lack of a significant difference in the total DM intake in this study, indicated strong substitution of the basal diet by the supplement. The substitution for elephant grass with gliricidia supplement was 16.4, 24.4 and 40.0% at 4, 8, and 12 g levels of supplement, respectively. Kimambo et al. (1992) also reported substitution effects for leucaena supplementation of maize stover.

Dietary protein supplementation is known to improve intake by increasing N supply to the rumen microbes (van Soest, 1982) and this was attributed to the positive effects of increasing microbial population and efficiency thus enabling them to increase the rate of breakdown of the digesta. When the rate of breakdown and passage of digesta increase, there is a corresponding increase in feed intake. Furthermore, legume supplementation of grass diets with less than 7% crude protein has been shown to increase dry matter intake and animal performance (Minson and Milford, 1967; Wagner, 1989). The optimum dietary level of proteinaceous supplementary forages was reported to be 30–50% or 0.9–1.5% of live weight (Devendra, 1988). However, in this study, feeding of moderate protein elephant grass hay with high CP gliricidia leaves did not stimulate increased elephant grass intake, despite the increased CP intake (Table 1). Thus the results confirmed those obtained by Mero and Uden (1990) who reported that the intake of Napier grass or *Chloris gayana* did not respond to leucaena supplementation, a legume that is comparable with gliricidia in the level of CP content.

One possible explanation for improved digestibility in the present study could be that gliricidia supplementation was able to supply the required nitrogen for microbial action in the rumen for the break down of the digesta, as a result of increased CP intake. Legume supplements have been shown to be more effective when fed with roughage containing less than 20 g N kg^{-1} digestible organic matter, as evidenced by higher rumen ammonia concentration from increased availability of ruminally fermentable nitrogen (Egan, 1986). Ademosun et al. (1988) and Adejumo and Ademosun (1991) also observed improved digestibility of the diet and the total intake of digestible dry matter of hay diets supplemented with graded levels of leucaena and gliricidia. Similarly, Ash (1990) observed improved CP digestibility in goats fed guinea grass hay (6.75%CP) supplemented with gliricidia or sesbania tree leaves. However, the results of this study contrast those of Dharia et al.

(1987) who used crossbred heifers and did not observe any improvement in CP digestibility of Napier (NB-21) grass based diet supplemented with gliricidia leaves. The improved DM digestibility and highest CP digestibility coefficient (72.8%) of the total ration, indicate that the optimal level of gliricidia supplementation for efficient utilization of elephant grass could be achieved at 8 g DM kg^{-1} lwt day^{-1}.

The significant difference in liveweight gain between the control and supplemented treatments may be attributed to increased crude protein intake, DM and CP digestibility. Kay and MacDearmid (1973) indicated that a dietary crude-protein content of 11% was ideal for normal weight gain by sheep and goats. Similar results were reported by Mafwere and Mtenga (1992) who observed that as dietary crude-protein level was increased from 11.4 to 13.2, 15 and 16.7%, corresponding growth rates of 34.1, 65.6, 68 and 70.5 g day^{-1}, respectively, were obtained for weaned lambs fattened on *C. gayana* hay and lablab seed meal as protein supplement.

The results of this study indicated no significant differences in the efficiency of N absorption between the control diet and the gliricidia supplemented diets. However, gliricidia supplementation improved nitrogen retention in the animals. Moreover, the crude protein digestibility and nitrogen retention of the gliricidia supplemented diets were significantly higher than that of elephant grass alone and increased with increasing level of supplementation. This indicated that the productivity of animals given elephant grass hay containing moderate levels of crude protein may be limited by inefficient utilisation of N and that could be enhanced by gliricidia supplementation which improves nitrogen utilisation in the body. Many unimproved grasses that constitute the main component of ruminant diets in the humid and subhumid tropics, appear to fall in this category. The digestibilty of nitrogen in sesbania, gliricidia and leucaena leaves reported by Veereswara et al. (1993) was 85.45, 77.30 and 80.00%, respectively, indicating the potential value of tree legume leaves as N supplements to low quality roughages. Thus, tree legumes, like gliricidia, which are being introduced and/or grown in SSA countries like Uganda, can play an important role in maximizing utilization of grass forages and improving animal production. The results further indicated that supplementing elephant grass with gliricidia, at higher levels of supplementation than 8 g DM kg^{-1} lwt day^{-1} reduced the intake of grass thus leading to substitution effects of the basal.

Conclusion

Supplementing dried elephant grass with *Gliricidia sepium* did not improve total DM intake but improved total DM digestibility, total nutrient intake and N retention and thus the performance of sheep improved with supplementation. The results showed that supplementation of elephant grass ration with small quantities up to 8 g DM kg^{-1} lwt per day of gliricidia leaves are required to increase efficiency of elephant grass utilization by sheep. It was concluded that gliricidia leaves could play a major role as economic protein supplement to improve the nutritive value of grass based rations on which the majority of livestock in sub-Saharan Africa subsist. Therefore, gliricidia leaves could be of particular benefit to resource poor farmers who cannot afford to buy costly protein feed supplements.

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