Uganda Journal of Agricultural Sciences, 2012, 13 (1): 25-34 ISSN 1026-0919

Effect of legume foliage supplementary feeding to dairy cattle offered *Pennisetum purpureum* basal diet on feed intake and manure quality

S. Katuromunda[1], E.N. Sabiiti[1] and A. Mateete Bekunda[1]

[1]Department of Agricultural Production, College of Agricultural and Environmental Sciences, Makerere University, P. O. Box 7062, Kampala, Uganda

Author for correspondence: katuromunda@yahoo.co.uk

Abstract

In smallholder zero grazing dairy systems of Uganda, elephant grass (*Pennisetum purpureum*) is the main basal diet offered, and is supplemented with legume forages among others. Recent observations indicate reduction in fodder yields of *P. purpureum* although farmers are applying cattle manure to improve soil fertility and hence increase fodder production. This study evaluated the effect of legume supplementary feeding to dairy cattle offered *P. purpureum* basal diet on feed intake, and the output and manuring qualityof the resultant faeces. Four diets consisting of *P. purpureum* fodder fed *ad libitum* as a control, *P. purpureum* + *Calliandra*, *P. purpureum* + *Centrosema* and *P. purpureum* + *Desmodium* were offered to cows in a 4 x 4 switchover Latin square design. Legume supplementation increased (P<0.05) the total organic and dry matter, metabolisable energy (ME) and nutrient intake, and the apparent dry matter digestibilities (ADMD) as compared with the control. Faecal excretion was increased (P<0.05) by *Calliandra* and *Centrosema*. Cows which were supplemented with *Calliandra* excreted (P<0.05) larger amounts of N, P and K than cows fed either *Centrosema* or *Desmodium*. Supplementation with *Calliandra* proved to be better option since it enhanced feed intake and the output and quality of faeces that could be recycled within the crop-livestock production systems.

Key words: *Calliandra*, *Centrosema*, dairy cows, *Desmodium*, feed intake, faeces, *Pennisetum purpureum*, supplementation

Introduction

Ruminant livestock in the urban/peri-urban crop-livestock production systems of Uganda depend mainly on *P. purpureum* fodder for basal diet and limited crop wastes and agro-industrial by-products.These feeds have low levels of ME, CP, minerals and vitamins and high levels of fibre which render them incapable of providing sufficient nutrition to lactating dairy cows (Tolera and Sundstøl, 2000). Their quality can be improved through supplementation with energy and protein-rich feedstuffs such as legume forages,which have proved to be a better option for smallholder resource-poor farmers who cannot afford commercial concentrates (Kabirizi *et al*., 2000; Katuromunda *et al*., 2000; Kabirizi, 2006).

Mpairwe *et al*. (2003) established that in order to maximise milk production by Friesian x Zebu crossbred cows, the proportions of legume herbage in the total dry matter intake (DMI) should not exceed 0.48% of body weight. However, the output and fertiliser value of faeces from such feeding management were not explored. Research on the production and characteristics of cattle manure has been carried out in the semi-arid West Africa and temperate regions (Delve *et al*., 2001; Powers and Van Horn, 2001). It is desirable that comparative data on the quantity and fertiliser value of the manure produced by dairy cattle reared in the urban/peri-urban farming systems whose diets are supplemented with legume forages are generated. This data would be useful to farmers whenplanning for the utilisation of cattle manure as a fertiliser resource in the production of crops/ fodder.Therefore, this studyevaluated the effect of supplementing *P.purpureum* basal diet offered to dairy cowswith legume foliageon feed intake, faecal output and faecal nutrient concentration.

Materials and methods

Experimental site and design

The study was conducted at Makerere University Agricultural Research Institute Kabanyolo, which is located 19 km north of Kampala at 0^0 28" N and 32^0 37" E and at an altitude of 1204m.The climate of this area is sub-humid with moderately well distributed bimodal rainfall. The upland soils are deep, highly drained red soils that are classified as latosols.

Four Friesian (*Bostaurus*) x Zebu (*Bosindicus*) crossbred dairy cows that were in early lactation were used. At the start of the experiment, their weights were taken using a heart girth tape measure and this was repeated fortnightly. Cows were housed individually in concrete-floored stalls. Four diets were offered to cows in a 4 x 4 switchover Latin square design.The diets comprised *P. purpureum* fodder fed *ad libitum* (as a control), *P. purpureum* fed *ad libitum* + *Calliandra* meal, *P. purpureum* fed *ad libitum* + *Centrosema* meal and *P. purpureum* fed *ad libitum* + *Desmodium* meal. Legume supplements were offered at 0.50% of the animal body live weight, and constituted 20% of the DM offered. Also, all the cows received 2.68 kg DM (0.53% body live weight) of dairy meal daily as additional supplement to ensure that the diets contained 11-13% CP required for moderate levels of milk production (ARC, 1980).

Feed management

Legume forages were harvested at once before commencement of the study, dried under shed, ground to pass through a 3 mm sieve and kept in jute bags. This was done to ensure that theirchemical composition was the same throughout the experimental period. *Pennisetum purpureum* fodder was harvested daily, chopped and fed to the cows. Feed troughs were filled with fodder at 07.30 hrs, 12.00 noon and at 17.00 hrs to ensure *ad libitum* supply. Dairy meal and legume meal were fed to cows in the morning and made sure that they were all consumed before providing fodder. Water troughs were kept full throughout the day. The diets were maintained for 14 days of adjustment and 14 days for data collection.

Sampling and preparation of feed for analysis

500 g samples of feed (*P. purpureum*) and leftovers for each cow were collected daily in the morning and evening. In the evening, the two feed samples for each cow were mixed thoroughly and sampled again to obtain two 250 g sub-samples, one for DM determination and the other for chemical analysis. The two leftover samples for each cow collected daily were also sampled following the same procedure. The feed and left over samples were oven dried and kept in the laboratory. After two weeks of collection, the oven dried sub-samples of feeds and leftovers for each cow needed for chemical analysis were ground to pass through a 1-mm sieve, bulked and sampled again to obtain a final sample. Samples of feeds and left overs for DM determination were weighed to obtain weights for calculating daily DMI.

Sampling and preparation of faeces for analysis

All the faeces excreted daily by each cow were kept in a plastic bucket till evening when they were weighed. After weighing, the faeces for each cow were thoroughly mixed and two 250 g sub-samples taken. Contamination of faeces by urine was minimized by the floor being slanted so that urine flowed away and scooping the faeces from the floor immediately they were defecated. Faecal samples were dried and then treated the same way as for the feed samples.

Chemical analysis of samples

Composite samples of feeds and feed left overs were analysed for OM content; total N, P, Ca and K (Okalebo, 1985); neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin (ADL) using the Van Soest and Robertson (1985) method; total soluble polyphenolic compounds (Constantinides and Fownes, 1994) and neutral-detergent-insoluble nitrogen (NDF-N) (Van Soest *et al*., 1987). Faecal samples were analysed for the same chemical components as for feeds and left overs following the same procedures.

Statistical analysis of data

Data were analysed using general linear models of the Statistical Analysis Systems (SAS, 2004). Significant differences are reported at the 5% level.

Results

Chemical composition of experimental feeds

Calliandra had the highest CP, fibre-bound nitrogen (NDF-N), polyphenol and potassium contents as well as the lowest fibre (NDF, ADF and ADL) content than *Centrosema* and *Desmodium* (Table 1). The concentrations of NDF, ADF and P were highest in *Desmodium*, while Ca was highest in *Centrosema*.

Feed intake and digestibility and metabolisable energy intake

Total DMI, total organic matter intake (OMI) and ADMD were significantly increased by the legume meal supplements as compared

Table 1. Mean chemical composition of feeds fed to the lactating dairy cows

Component	Feed supplements				
	P. purpureum	Dairy meal	*Calliandra*	*Centrosema*	*Desmodium*
	g kg^{-1} DM				
Organic matter	906.70	931.80	946.80	953.90	928.20
Crude protein (N x 6.25)	91.60	173.40	231.30	125.00	131.30
Polyphenols	nd	nd	73.53	11.07	10.98
NDF-N (g kg^{-1} NDF)	6.22	24.78	25.65	12.39	9.09
NDF	390.57	293.61	366.25	488.13	616.70
ADF	445.52	149.52	375.58	447.08	505.35
ADL	73.84	40.38	109.39	202.23	153.85
Minerals					
Phosphorus (P)	2.40	9.00	2.20	1.80	2.40
Potassium (K)	16.80	10.20	14.20	12.10	8.90
Calcium (Ca)	1.21	1.10	2.52	4.00	4.75

NDF = Neutral detergent fibre; NDF-N = Neutral-detergent-insoluble nitrogen; ADF = Acid detergent fibre; ADL = Acid detergent lignin; nd = Not determined with the control diet (Table 2). Total OMI for the *Calliandra* supplemented diet was similar to that of *Centrosema* diet, but was higher than that of *Desmodium* diet. The metabolisable energy of feed (MEF) and the metabolisable energy intake (MEI) were higher ($P \leq 0.05$) in the legume supplemented diets than in the control, but there were no differences ($P > 0.05$) among the supplemented diets.

Nutrient intake

Supplementation with legume meal significantly increased the daily intake of nutrients as compared to the control diet (Table 3). Cows whose diet was supplemented with *Calliandra* consumed larger amounts of N than cows supplemented with either *Centrosema* or *Desmodium*. Among the supplemented diets, daily K intake was higher for the *Calliandra* and *Centrosema* diets, while Ca intake varied in the order *Calliandra*<*Centrosema*<*Desmodium*.

Chemical composition of faeces

The faeces excreted by cows offered *Calliandra* contained higher ($P < 0.05$) N and lower NDF contents than those of cows whose diets were supplemented with *Centrosema* and *Desmodium* (Table 4). Faeces excreted by cows offered *Desmodium* contained higher ($P < 0.05$) amounts of P and

Table 2. Mean daily DM and OM intake and digestibility by lactating cows fed *P. purpureum* and different legume meal supplements (n= 4)

Component	Control diet	Feed supplements			$LSD_{(0.05)}$
		Calliandra	*Centrosema*	*Desmodium*	
Dry matter intake (DMI)					
Basal feed (*P. purpureum*)	8.96^b	9.73^a	9.55^{ab}	9.40^{ab}	0.62
Dairy meal	2.68	2.68	2.68	2.68	-
Legume meal supplement	-	2.68	2.65	2.66	-
Total DMI (kg cow^{-1} day^{-1})	11.64^b	15.09^a	14.88^a	14.74^a	0.62
Total DMI (g kg^{-1} LW day^{-1})	24.26^b	30.78^a	30.41^a	29.57^a	1.28
Total OMI (g kg^{-1} LW day^{-1})	22.09^c	28.22^a	27.92^{ab}	27.02^b	1.16
Digestibility (g kg^{-1})					
ADMD	624.38^b	673.74^a	677.90^a	695.79^a	31.28
DOMD	642.54^b	691.30^a	694.97^a	712.26^a	30.01
Metabolisable energy					
MEF (MJ kg^{-1} DM)	8.82^b	9.53^a	9.59^a	9.75^a	0.14
MEI (MJ head^{-1} day^{-1})	103.57^b	144.56^a	144.02^a	144.71^a	2.73

^{ab} Means within the same row having different superscripts are significantly ($P < 0.05$) different; ADMD = apparent dry matter digestibility; DOMD = digestibility of organic matter in dry matter; MEF = metabolisable energy of feed; MEI = metabolisable energy intake; LW = live weight

Table 3. Daily N, P, K and Ca intake by lactating dairy cows fed *Pennisetum purpureum* and different legume meal supplements (n = 4)

Nutrient intake	Control diet	Feed supplements			$LSD_{(0.05)}$
		Calliandra	*Centrosema*	*Desmodium*	
	g kg^{-1} LW day^{-1}				
Total N	0.322[c]	0.536[a]	0.433[b]	0.433[b]	0.012
Total P	0.093[b]	0.106[a]	0.102[a]	0.105[a]	0.004
Total K	0.371[c]	0.469[a]	0.455[a]	0.415[b]	0.023
Total Ca	0.021[d]	0.035[c]	0.043[b]	0.046[a]	0.001

[abc] Means within same row having different superscripts are significantly (P<0.05) different

Table 4. Mean chemical composition of faeces excreted by lactating dairy cows fed on *Pennisetum purpureum* and different legume meal supplements (n = 4)

Component	Control diet	Feed supplements			$LSD_{(0.05)}$
		Calliandra	*Centrosema*	*Desmodium*	
	g kg^{-1} DM				
Dry matter content	175.68[a]	170.79[bc]	168.99[c]	173.00[ab]	3.01
Faecal-N content	15.97[b]	17.66[a]	15.64[bc]	15.37[c]	0.43
Faecal-P content	9.11[a]	8.21[b]	7.45[c]	9.12[a]	0.58
Faecal-K content	15.92	16.56	16.04	17.60	1.97
Faecal-Ca content	2.64	2.56	2.58	2.62	0.08
NDF	698.91[a]	676.80[c]	684.66[bc]	691.32[ab]	11.77
NDF-N (g kg^{-1} NDF)	12.15[a]	12.61[a]	10.62[b]	10.11[b]	0.95
ADF	403.70[c]	437.99[b]	416.59[c]	471.52[a]	19.01
ADL	126.54	125.45	123.43	125.09	7.95

[abc] Means within same row having different superscripts are significantly (P<0.05) different

fibre (NDF and ADF) contents than those of cows whose diets were supplemented with *Calliandra* and *Centrosema*.

Faecal output and nutrient content in faeces

Faecal-DM and OM excretions were significantly increased by *Calliandra* and *Centrosema*, and not by *Desmodium* as compared with the control (Table 5). Given the mean live weight of cows used in this experiment as 504±61 kg and the mean faecal-DM excreted as 4.60, the percentage daily faecal-DM excretion in relation to body live weight was 0.91%. Cows whose diet was supplemented with *Calliandra* excreted larger amounts of N, P and K than cows supplemented with either *Centrosema* or *Desmodium* (Table 5). Higher (P<0.05) amounts of Ca were excreted in faeces by cows fed *Calliandra* and *Centrosema*.

Table 5. Mean daily faecal output and nutrient excretion in faeces by lactating cows fed *P. purpureum* and different legume meal supplements (n = 4)

Component	Control	Feed supplements			$LSD_{(0.05)}$
		Calliandra	*Centrosema*	*Desmodium*	
Faecal excretion (kg cow^{-1} day^{-1})					
DM	4.32^{c}	4.87^{a}	4.75^{ab}	4.46^{bc}	0.32
OM	3.74^{c}	4.22^{a}	4.12^{ab}	3.85^{bc}	0.28
Nutrient content (g kg^{-1} LW day^{-1})					
Faecal-N	0.141^{bc}	0.176^{a}	0.150^{b}	0.139^{c}	0.011
Faecal-P	0.057^{b}	0.063^{a}	0.055^{b}	0.054^{b}	0.006
Faecal-K	0.141^{b}	0.185^{a}	0.150^{b}	0.127^{c}	0.010
Faecal-Ca	0.022^{b}	0.025^{a}	0.0256^{a}	0.023^{b}	0.002

^{abc} Means within same row having different superscripts are significantly (P<0.05) different

Discussion

Chemical composition of experimental feeds

The experimental feeds provided varying concentrations of N, polyphenols, fibre fractions (NDF and ADF) and minerals to the cows. *Pennisetum purpureum* had low levels of CP compared to other feeds and thus was a low quality feed,and if not supplemented would result in depressed feed intake and digestibility(Tolera and Sundstøl, 2000). Legume forages used in this study provided the critical nutrients, especially CP which were low in *P. purpureum*.

Feed intake and digestibility and metabolisable energy intake

Significant increases in total DMI and OMI and digestibility following supplementation were attributed to higher CP (N) content that was availed to the rumen microbes by the legume meal. When supplied with sufficient amounts of N, the rumen microbial population increased. This increase enabled them to speed up the rates of DM and OM degradation and clearance from the rumen, which in turn created room for more feed to be consumed (Abule *et al*., 1995). The increase in MEI with supplementation was due to higher OM intake and higher ME contents in the legume meal as compared to the *P. purpureum* (Mpairwe *et al*., 2003). Higher nutrient (N, P, K and Ca)intake in the supplemented diets resulted from additional amounts of nutrients that were supplied by the legume meal.

Faecal output

Higher faecal output in the *Calliandra* and *Centrosema* supplemented diets was as a result of increased feed consumption coupled with faster rate of passage through the digestive tract. Faecal-DM output is an inverse function of the ADMD (Kyvsgaard *et al*., 2000). Since ADMD is the difference between the quantity of feed consumed and the quantity of faeces collected, highly digestible diets would result in reduced faecal output. Thus, because of higher ADMD, significant reduction in faecal output would have occurred in the supplemented diets. But the results indicated the reverse implying that the reduction in faecal output which would have occurred as a result of increased feed digestibility was counteracted by an increase in feed intake and faster passage through the digestive tract.

Nutrient excretion in faeces

High concentrations of N in *Calliandra* were responsible for excretion of larger amounts of N in the *Calliandra* supplemented diet. The N content in *Calliandra* was almost twice that in *Centrosema* and *Desmodium*. Lekasi and Kimani (2003) observed that the amount of N excreted in faeces was highly influenced by N contents of feeds; and the higher the amount of N in the diet, the more that was excreted in faeces. *Calliandra* also contains high levels of polyphenols and tannins (Bareeba and Aluma, 2000). These compounds form complexes with CP in feeds and as a result reduce protein digestibility, which in turn leads to increased excretion of N in faeces (Maasdorp *et al.*, 1999).

A large proportion of P consumed by cows on all the diets was excreted in faeces because P is excreted almost exclusively in faeces (Powell *et al*., 1994). Also, some of the P excreted comes from endogenous sources (NRC, 2001). Dairy cows that were offered the control diet excreted more Ca than they consumed. Animal responses are influenced by the Ca:P ratio, such that exclusive feeding of one of them causes problems. The recommended ratio for lactating cows is 1-2:1 (MAFF, 1987). The Ca:P ratios of all the diets used in this study were very low, ranging between 0.22:1 and 0.44:1. Therefore, low concentrations of Ca in the diets compared to P probably caused an imbalance in the absorption of Ca from the digestive tract.

Implications of increased faecaland nutrient excretion

Faecal excretion is an unavoidable component of dairy production and a potential threat to the environment if not properly managed (Harvey, 1989).In the recent past, feeding strategies for dairy cattle have targeted maximising milk output without minding about subsequent increase in the output of animal excreta (Mpairwe *et al*., 2003; Juma *et al*., 2006). However, as the faecaloutput increasesdue to increasing animal numbers as well as supplementation with legume meal, its management becomes critical for environmental sustainability (Alocilja, 1998). The population of stall-fed exotic and crossbred dairy cattle in Kampala district is estimated to be 3550 head of cattle (Kibombo, 2007).Assuming that each of these cows weighs 504 kg LW on average,consumes 9.4, 2.7 and 2.7 kg DM of *P. purpureum*, dairy meal and legume meal, respectively, and that all faeces excreted are collected and conserved, the computed quantities of faeces and faecal components of these cows are presented in Table 6.

If all these faecal components are transported by rain water annually to the water bodies, eutrophication is likely to increase

Table 6. Mean faecal output and composition fora 504 kg crossbred dairy cow offered *Pennisetum purpureum* fodder supplemented with dairy meal and legume meal[β]

	Faecal -DM	Faecal -OM	Faecal -N	Faecal -P	Faecal -K
Daily output(kg cow^{-1} day^{-1})	4.60	3.98	0.076	0.029	0.076
Annual output (kg cow^{-1} yr^{-1})	1,679	1,453	28	11	28
Annual output for 3550 cows of 500 kg mean LW (tonnes yr^{-1})	5,960	5,157	98	38	98
Quantities recovered under efficient conservation	3,576	3,094	59	30	78

[β] Amounts consumed were 9.4, 2.7 and 2.7 kg DM of *P. purpureum*, dairy meal and legume meal (*Calliandra*, *Centrosema* or *Desmodium*), respectively

(Woomer *et al.*, 1998). However, this can be avoided by efficiently collecting, conserving and utilizing the excreta as a bio-fertiliser resource which can contribute to the sustenance of crop/fodder production. Dairy farmers who lack land where to apply the manure can process it sell it to farmers in need of it. Eghball *et al*. (1997) reported that depending upon how the manure is handled, as much as 50% of the N excreted by stall-fed cattle is lost through runoff and volatilisation by the time it is ready for field application. Powers and Van Horn (2001) noted that whereas losses of P and K from manure are quite small, losses of N are unavoidable, at least 35% of excreted N in best case scenarios and 60% or more, in most situations. Thus, assuming that efficient collection and conservation of cattle excreta permitted 60% recovery of N and 80% of P excreted in faeces, the annual recovery of N and P would be 59 and 30 tonnes, respectively (Table 6). Although these quantities appear small, they canstill be of great importance given the farm sizes owned by the urban/peri-urban smallholder farmers.

Conclusions and recommendations

Supplementing *P. purpureum* diet offered to lactating dairy cows with legume foliage meal significantly increased DMI and OMI as well as nutrient (N, P, K and Ca) intake. Faecal-DM and OM excretions were significantly increased by *Calliandra* and *Centrosema*, and not by *Desmodium*. Faecal–N, P and K were higher in *Calliandra* supplemented diets, while Ca was higher in *Calliandra* and *Centrosema* supplemented diets. Because of having significantly higher N and lower NDF contents, the faeces excreted by cows offered *Calliandra* were considered to be of better manuring quality than those excreted by cows whose diets were supplemented with *Centrosema* and *Desmodium*. Therefore, supplementing *P. purpureum* basal diet offered to dairy cows with legume foliage particularly *Calliandra* enhances feed intake, and consequently the amounts of faeces and faecal nutrients (N and P) available for recycling within the crop-livestock production systems. Since legume forages are grown on-farm, farmers should be encouraged and supported to grow more since this would further increase milk yield as well as faecal output and faecal nutrients available for recycling.

Acknowledgements

We thank the Rockefeller Foundation and Sida/SAREC for funding this research. We also thank the management and technical staff of Makerere University Agricultural Research Institute Kabanyolo, for their invaluable assistance during the experimental stage and data collection. We thank the staff in the Department of Animal Science for assisting us with the laboratory analyses of samples and statistical analyses of the data.

References

Abule, E., Umunna, N.N., Nsahlai, I.V., Osuji, P.O. and Alemu, Y. 1995. The effect of supplementing teff (*Eragrostis tef*) straw with graded levels of cowpea (*Vigna unguiculata*) and Lablab (*Lablab purpureus*) hays on degradation, rumen particulate passage and intake by crossbred (Friesian x Boran (Zebu)) calves. *Livestock Production Science* 44: 221-228.

Alocilja, E.C. 1998. Zero-excess manure management in dairy through optimum rations. *American Society of Agricultural Engineers* 41(2): 497-501.

ARC (Agricultural Research Council), 1980. The Nutrient Requirements of Ruminant Livestock.Commonwealth Agricultural Bureau, Slough, UK.

Bareeba, F.B. and Aluma, J. 2000. Chemical composition, phenolics and *in vitro* organic matter digestibility of some multipurpose tree species used for agroforestry in Uganda. *Uganda Veterinary Journal* 6(1): 89-92.

Constantinides, M. and Fownes, J.H. 1994. Tissue-to-solvent ratio and other factors affecting determination of soluble phenolics in tropical leaves. *Communications in Soil Science and Plant Analysis* 25: 3221-3227.

Delve, R.J., Cadisch, G., Tanner, J.C., Thorpe, W., Thorne, P.J. and Giller, K.E. 2001. Implications of livestock feeding management on soil fertility in the smallholder farming systems of sub-Saharan Africa. *Agriculture, Ecosystems and Environment* 84:227-243.

Eghball, B., Powers, J.F., Gilley, J.E. and Doran, J.W. 1997. Nutrient, carbon, and mass loss of beef cattle feedlot manure during composting. *Journal of Environmental Quality* 26:189-193.

Harvey, R.M. 1989. Environmental regulations and dairy farms. In: Proceedings of Florida Dairy Production Conference, 113-118. Gainsville Dairy Science Department, University of Florida.

Juma, H.K., Abdulrazak, S.A., Muinga, R.W. and Ambula, M.K., 2006. Evaluation of Clitoria, Gliricidia and Mucuna as nitrogen supplements to Napier grass basal diet in relation to the performance of lactating Jersey cows. *Livestock Science* 103(1-2): 23-29.

Kabirizi, J. 2006. Effect of incorporating forage legumes in smallholder dairy farming systems on feed availability and animal performance. PhD Thesis. Makerere University, Kampala, Uganda. Unpublished.

Kabirizi, J.M., Bareeba, F.B., Sabiiti, E.N., Ebong, C., Namagembe, A. and Kigongo, J. 2000. Effect of supplementing crossbred lactating dairy cows fed elephant grass based diets with Lablab hay and a concentrate. *Uganda Journal of Agricultural Sciences* 5:9-15.

Katuromunda, S., Sabiiti, E. N. and Bareeba, F. B. 2000. Effects of Siratro and maize bran supplementation on feed intake and milk yield and composition of crossbred lactating cows fed *Pennisetum purpureum* basal diets. *Makerere University Agricultural Research Institute Kabanyolo (MUARIK) Bulletin* 3:49-56.

Kibombo, F. 2007. Report of The Veterinary Officer of Kampala District for the month of December 2007. Unpublished.

Kyvsgaard, P., Sorensen, P., Moller, E. and Magid, J. 2000. Nitrogen mineralization from sheep faeces can be predicted from the apparent digestibility of the feed. *Nutrient Cycling in Agroecosystems* 57: 207-214.

Lekasi, J.K. and Kimani, S.K. 2003. Livestock management and manure quality. In: Canon, E.N. Savala, M.N. Omare and Woomer, P.L. (Eds.). Organic Resource Management in Kenya - Perspectives and Guidelines. Forum for Organic Resource Management and Agricultural Technologies (FORMAT), Nairobi, Kenya. 184pp.

Maasdorp, B.V., Muchenje, V. and Tetterton, M. 1999. Palatability and effect on dairy cow milk yield of dried fodder from the forage trees *Acacia boliviana*, *Calliandra calothyrsus* and *Leucaena leucocephala*. *Animal Feed Science and Technology* 77:49-59.

MAFF (Ministry of Agriculture, Fisheries and Food), 1987. Energy allowances and feeding systems for ruminants.Reference Book 433. London: Her Majesty's Stationery Office. pp. 68-73.

Mpairwe, D.R., Sabiiti, E.N., Ummuna, N.N., Tegegne, A. and Osuji, P. 2003. Integration of forage legumes with cereal crops. I. Effects of supplementation with graded levels of lablab hay on voluntary food intake, digestibility, milk yield and milk composition of crossbred cows fed maize–lablab stover or oats–vetch hay *adlibitum*. *Livestock Production Science* 79: 193-212.

NRC (National Research Council), 2001. Nutrient Requirements of Dairy Cattle. 7th Revised Edition, National Academy of Sciences, Washington, DC.

Okalebo, J.R. 1985. A simple wet ashing technique of P, K, Ca and Mg analysis of plant tissue in a single digest. *Kenya Journal of Science and Technology* B6:129-133.

Powell, J.M., Fernández-Rivera, S. and Höfs, S. 1994. Effects of sheep diet on nutrient cycling in mixed farming systems of semi-arid West Africa. *Agriculture, Ecosystems and Environment* 48: 262-271.

Powers, W.J. and Van Horn, H.H. 2001. Nutritional implications for manure nutrient management planning. Applied Engineering in Agriculture. *American Society of Agricultural Engineers* 17(1): 27-39.

SAS (Statistical Analysis Systems Institute), 2004. Statistical Analysis Systems Institute Inc., SAS OnlineDoc® 9.1.3, SAS Institute Inc., Cary, NC, USA.

Tolera, A. and Sundstøl, F. 2000. Supplementation of graded levels of *Desmodium intortum* hay to sheep feeding on maize stover harvested at three stages of maturity 1. Feed intake, digestibility and body weight change. *Animal Feed Science and Technology* 85: 239-257.

Van Soest, P.J. and Robertson, J.B. 1985. *Analysis of Forage and Fibrous Foods*. A laboratory manual for Animal Science 613. Cornell University, Ithaca, New York, USA.

Van Soest, P.J., Conklin, N.L. and Horvalt, P. J. 1987.Tannins in foods and feeds. In: Cornell Nutrition Conference for Feed Manufacturers. Departments of Animal Science and Avian Science, Cornell University, New York. pp. 115-122.

Woomer, P.L., Bekunda, M.A., Karanja, N.K., Moorehouse, T. and Okalebo, J.R. 1998. Agricultural resource management by smallhold farmers in East Africa. *Natural Resources* 34(4):22-33.