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EVALUATION OF MANURE FROM GOATS FED PANICUM BASAL DIET AND SUPPLEMENTED WITH MADRAS THORN, LEUCAENA OR GLIRICIDIA

[EVALUACIÓN DE LA EXCRETA DE CABRAS ALIMENTADAS CON UNA DIETA BASAL DE PANICUM Y SUPPLEMENTADA CON PITHECELLOBIUM, LEUCAENA O GLIRICIDIA]

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SUMMARY

An experiment was carried out to assess the effect of supplementing a Panicum hay basal diet with leaves of Madras thorn (*Pithecellobium dulce*), Leucaena (*Leucaena leucocephala*) or Gliricidia (*Gliricidia sepium*) on the quality and quantity of goat manure. Twelve Small East African goats aged eight months on average and weighing 9.7kg (±1.52) were randomly assigned to four treatments. Panicum hay fed ad libitum plus 100g of maize bran constituted the control diet. The remaining three treatments consisted of the control diet supplemented with iso-nitrogenous levels of Leucaena, Gliricidia or Madras thorn, respectively. Crude protein concentrations in the forages were 3.5, 21, 23 and 25% for Panicum hay, Gliricidia, Madras thorn and Leucaena, respectively. The supplements were therefore offered at 19.5g DM/kgW$^{0.75}$ Madras thorn, 18.6g DM/kgW$^{0.75}$ Leucaena and 22.5g DM/kgW$^{0.75}$ Gliricidia. Daily total dry matter intake increased significantly ($P<0.05$) on supplementation from 229 for the control diet to 365, 387 and 398g for the diets supplemented with Madras thorn, Gliricidia and Leucaena, respectively. Animals supplemented with the legumes retained ($P<0.05$) more N (3.5, 3.6 and 3.7g N/day for Leucaena, Gliricidia and Madras thorn, respectively) than the control treatment (0.6 g N/day). Legume supplementation increased ($P<0.05$) daily weight gains from 2g per day for the control treatment to 19, 22 and 25g per day for diets supplemented with Gliricidia, Madras thorn and Leucaena, respectively. The effect of supplement on growth rate was not different between the legumes. Goats fed on legume supplements produced ($P<0.05$) more faeces (135g, 142g and 150g DM per day for goats fed Madras thorn, Gliricidia and Leucaena treatments, respectively) than those on the control diet (92g DM). The daily faecal DM outputs expressed as percentage of body weight were 1.13, 1.27 and 1.30% for the control diet supplemented with Madras thorn, Gliricidia and Leucaena, respectively, as compared with 0.98%, for the control diet alone. Legume supplementation in goats increased ($P<0.05$) faecal N content from 0.2 to 1.7% but had no effect on the C, P or K contents. Supplementation of a poor quality basal diet with legume forage is therefore recommended since, in addition to improving the performance of goats, it would increase the amount of manure produced and improve its quality.

Key words: Manure quality and quantity, Forage legumes.

RESUMEN

Se evaluó el efecto de suplementar una dieta basal a base de heno de Panicum con hojas de *Pithecellobium dulce*, *Leucaena leucocephala* o *Gliricidia sepium* sobre la calidad y cantidad de la excreta caprina. Se emplearon doce cabras de ocho meses de edad y peso promedio de (9.7±1.52 kg) asignadas a cuatro tratamientos. El tratamiento control fue heno de Panicum *ad libitum* más 100g salvado de maíz. Los tratamientos restantes fueron la dieta control más un nivel iso-nitrogenado de suplemento de Leucaena, gliricidia o Pithecellobium respectivamente. La concentración de proteína cruda en los forrajes fue de 3.5, 21, 23 y 25% para Panicum, Gliricidia, y Pithecellobium, respectivamente. El nivel de suplemento ofrecido fue entonces de 19.5g MS/kgPV$^{0.75}$ Pithecellobium, 18.6g MS/kgPV$^{0.75}$ Leucaena y 22.5g MS/kgPV$^{0.75}$ Gliricidia. El consumo total de materia seca se incrementó ($P<0.05$) con los supplementos siendo de 299g para la dieta control y 365, 387 y 398g para las dietas supplementadas con Pithecellobium, Gliricidia y Leucaena, respectivamente. Los animales supplementados con las leguminosas retuvieron más N ($P<0.05$) (3.5, 3.6 y 3.7g N/d para Leucaena, Gliricidia y Pithecellobium) que el tratamiento control (0.6 g N/d). La supplementación incrementó ($P<0.05$) la ganancia de peso de 2g/d para el control a 19, 22 y 25g/d para Gliricidia, Pithecellobium y Leucaena, respectivamente. Las cabras alimentadas con leguminosas produjeron más heces ($P<0.05$) (135g, 142g y 150g MS/d con Pitecellobium, Gliricidia y

Leucaena respectivamente) en comparación con la dieta control (92g MS). La excresión fecal MS expresada como porcentaje del PV fue de 1.12, 1.27 y 1.30% para Pithecellobium, Gliricidia y Leucaena en comparación con 0.98% para la dieta control. La suplementación de cabras con leguminosas incremento el contenido de N en la heces de 0.2 a 1.7% pero no tuvo efecto en el contenido de C, P o K. Se recomienda suplementar forrajes de baja calidad con leguminosas ya que además de mejorar el desempeño productivo de las cabras también incrementa la cantidad y calidad de las heces.

Palabras clave: Calidad y cantidad de excretas, leguminosas forrajeras.

INTRODUCTION

Coastal lowland Kenya has well drained sandy soils, which are prone to leaching and have low levels of organic matter and nitrogen (Jaetzold and Schmidt, 1983). The low organic matter and nitrogen levels have resulted in low productivity hence low food production by smallholder farmers in the region (Saha and Muli, 2000).

Inorganic fertilizers have been used effectively to replenish deficient nutrients and improve crop productivity. They have an advantage over legume residues because of their faster nitrogen recovery by a crop (Sanchez and Palm, 1996). However the high fertilizer cost coupled with low producer prices of most food crops has resulted in low adoption of inorganic fertilizers (Saha et al., 1993).

The incorporation of legumes into crop production systems is one option that has received significant attention in recent years (Kang et al., 1990). Legumes offer a cheaper alternative for improving soil fertility through biological fixation of atmospheric nitrogen and mineralization of residues. Herbaceous legumes screened and found to be most productive in coastal lowland Kenya were mucuna (*Mucuna pruriens*), siratro (*Macroptiliun atropurpureum*), clitoria (*Clitoria ternatea*), calopo (*Calopogonium muconoidse*) *and* dolichos (*Lablab purpureus*) (Saha et al., 1997). Use of dolichos and mucuna as green manure resulted in an increase in maize grain yield by 3 and 12% respectively, compared with yield from unfertilised maize crop (Saha and Muli, 2000). However the use of green manure legumes in rotation with maize is not easily adopted because the farmer would be hesitant to forgo one of the two maize crops in a year. Alley cropping or hedgerow intercropping is an agroforestry practice in which perennial leguminous trees or shrubs are grown simultaneously with arable crops. The trees, managed as hedgerows, are grown in wide rows and the food crop or fodder is planted in the inter-space or 'alley' between the hedgerows. In a study conducted in coastal lowland Kenya, Leucaena and Gliricidia hedgerows were spaced 5m apart, with 4 rows of Napier grass planted between the hedgerows at a spacing of 100 x 25 cm (Mureithi et al., 1995). This production system leads to an increase in total forage dry matter yield. These legumes may be more acceptable by the farmers if they had multiple uses such as food, feed, shade, fuel wood, and soil fertility improvement. Madras thorn (*Pithecellobium dulce*) is another tree legume that naturally grows in coastal lowland Kenya at altitudes below 150m above sea level. It is used for live fence, fuel wood, poles, construction wood, fruits, fodder (leaves, pods and seeds), bee-forage, shade, windbreaks, soil conservation and the seeds are used as source of tannin (ICRAF, 1992). Hardly any literature is available on it its use in livestock feeding. However, goats which are browsers are known to feed on its leaves.

The leaves of tree and herbacious legumes have medium to high nitrogen contents (15-30% of DM), making them a valuable source of protein for livestock (Kaitho 1997). Legume fodders maintain a higher protein and mineral content than grasses, whose quality decline rapidly with progression to maturity (Norton, 1994). Thus the legume can also be fed to livestock, which will in return provide manure. The beneficial role of animal manure in crop production has been associated with their capacity to provide nutrients especially N, P and K, increase the soil’s cation exchange capacity (CEC), soil pH and water holding capacity, and organic matter content of soil. This in turn, enhances biological activity in the soil (Lekasi, 2001).

In the Coast Province of Kenya, 1,022,007 goats are kept as a means of obtaining quick cash and for use during cultural functions. The breed mainly kept is the Small East African goat, and the main product is meat. Goats therefore contribute to income generation and food security for the coastal communities (Kahindi, 2005). Dairy cattle manure has been studied and its effect on crop production documented (Bocchi and Tano, 1994, Mureithi *et. al.*, 1996 and Saha and Muli, 2000). Since many goats are reared in the Coast Province of Kenya, with emphasis on night housing, there is potential for goat manure to be used for improving crop yields. However, there is limited work done on goat manure as compared to cattle manure. Therefore the objective of this study was to compare the effect of supplementing goats with Madras thorn, Gliricidia or Leucaena on the quantity and quality of goat manure.

MATERIALS AND METHODS

Site

The study was carried out at the Kilifi Institute of Agriculture (KIA) which is situated 3° 50'South and 39° 44'East, at an altitude of about 3m above sea level. The site receives an average annual rainfall of 1200 mm while the mean monthly minimum and maximum temperatures are 22 and 30°C, respectively (Jaetzold and Schmidt, 1983).

Animals

Twelve Small East African goats aged eight to nine months, with average weight of 9.7kg (± 1.52), were used to determine voluntary feed intake, digestibility, live weight changes, manure quality and quantity. Before the start of the experiment the goats were de-wormed and their mean live weights recorded. The goats were housed individually in metabolic cages measuring 100 x 75cm, where urine and faeces were collected separately.

Feeds and treatment diets

Panicum hay was used as the basal diet in the experiment. This fodder was obtained from a farmer's field close to the experimental site. Leaves of Madras thorn were harvested from a live fence within the compound of KIA. The fence was then cut back and allowed to re-grow for six weeks. Leucaena and Gliricidia were obtained from hedgerows established in 1989 at KARI Mwapa after they had been cut back and allowed to re-grow for two months. The harvested Madras thorn, Leucaena and Gliricidia leaves were sun dried before the start of experiment. The control diet consisted of Panicum hay fed ad libitum plus 100g of maize bran. The other three treatments consisted of the control diet supplemented with iso-nitrogenous amounts of Madras thorn (19.5g/kg$W^{0.75}$DM), Leucaena (18.6g/kg$W^{0.75}$DM) and Gliricidia (22.5g/kg$W^{0.75}$DM). Water and mineral lick blocks which contained 32g P, 168g Ca, 105g Na, 195g Cl, 2.5g S, 0.31g I, 2.3g Zn, 1.5g Mn, 2.0g Cu and 0.15g Co per kg were offered ad libitum.

Procedures and sample analyses

The treatments were arranged in a completely randomized design (CRD) (Steel et al., 1997), and each treatment was replicated three times. Data was collected for seven weeks after a seven-day adaptation period. The basal diet was chopped manually to 50mm pieces and then offered in the morning and afternoon to ensure availability at all times. The supplements were offered at 0800 hours before the basal diet. Feed refusals were removed and weighed every morning to determine intake before fresh feed was offered. Animals were weighed weekly and their weights recorded. The amount of legume supplement was adjusted weekly to conform to live weight changes. The legume hay and maize bran were sampled weekly for chemical analyses.

In the last seven days of the trial, faeces and urine from the 12 goats were collected separately, weighed and recorded. Faeces were collected over a 24-hour period for every goat, and a 10% sample by weight taken and dried at 65°C and stored for nutrient analysis. At the end of the collection period, the faecal samples were bulked per animal, mixed and a composite sample taken to determine dry matter (DM), nitrogen (N), carbon (C), phosphorus (P) and potassium (K). Dry matter digestibility (DMD) was calculated as the difference between total DM intake (TDMI) and total faecal DM output expressed as a percent of TDMI (Abdulrazak, 1995). Urine was collected over 25ml of 10% hydrochloric acid per 100ml urine to minimize ammonia loss through evaporation. The urine was frozen and at the end of the seven day collection period. It was then pooled and sub-sampled per animal for N analysis.

The samples were ground to pass through a 3.5mm screen. The DM and N (Kjeldhal-N) were determined using the procedures of the Association of Official Analytical Chemist (AOAC, 1990). The total P, K and C were determined according to the methods described by Okalebo et al., (2002). Tannins were determined according to procedures described by Abdulrazak and Fujihara, (1999).

Data analysis

Data from the experiments were subjected to the analysis of variance, using the General Linear Model (GLM) procedure of the Statistical Analysis Systems (SAS, 1987). Mean separation was done using the least significant difference (LSD) method at $P< 0.05$.

RESULTS AND DISCUSSION

Chemical composition of feeds

Panicum hay contained 0.56% N, which is below the minimum level of 1.12% N required for optimal microbial function in the rumen (Minson and Milford, 1967). The legumes were therefore appropriate N supplements because they had 3.36, 3.68 and 4.00% for Gliricidia, Madras thorn and Leucaena, respectively (Table 1). These nitrogen contents were within the range of 2.4 - 4.9% reported for legumes by

Kaitho (1997). The carbon content (37.01-42.49%) seemed not to vary much across the different feeds. The P and K contents of the feeds were low, and that is why a mineral lick was supplied ad libitum to minimise the deficiency.

Effect of supplementation on manure quality and output

Goats supplemented with legumes had higher N intake and loss than those fed on the control diet only (Table 3). The low N intake and loss in goats fed on the control diet may be attributed to the extremely low N content of Panicum hay. Njarui et al. (2003) working on four legumes noted an increase in N loss from goats on supplementation as compared to goats fed the basal diet only. The low total N loss in goats fed on the control diet was probably because of lower N intake since animals are known to excrete 36 –58 % of total N intake (Lekasi et al. 1998).

Table 1. Chemical composition (%) of feeds used in the experiment on DM basis.

Feed	N	C	P	K	Tannins
Gliricidia			3.36		
Leucaena	4.00	39.94	0.03	0.73	3.24
Madras	3.68	38.02	0.03	0.98	4.39
Panicum hay	0.56	42.49	0.01	0.64	1.94
Maize bran	2.40	37.01	0.03	1.62	nd

nd = not determined

Effect of supplementation on feed intake and growth performance

Basal diet intake was not affected by legume supplementation (Table 2). However, the TDMI increased by 59, 62 or 74% when the goats were supplemented with Madras thorn, Gliricidia or Leucaena, respectively. The legume supplements did not differ in their effect on TDMI. Similar observations were reported by Abdulrazak et al. (1997) who found an increase in TDMI in crossbred steers when maize stover which had 0.54%N was supplemented with Leucaena or Gliricidia. The dry matter digestibility in goats supplemented with Madras thorn or Leucaena was not significantly different (P>0.05) from that in goats fed the control diet. The major limitation to digestibility in poor quality forages like the hay used in this experiment is low N content. However, supplementation of hay with legume forages did not improve digestibility except for Gliricidia. Digestibility in goats fed on Gliricidia was increased significantly ((P>0.05) by 6% compared to the un-supplemented goats. The legume supplements did not differ significantly in their effect on DMD.

Goats supplemented with legumes lost more nitrogen (3.1- 3.6g /day/goat) than those that were fed the control diet only. However, the legume supplements did not differ in their effect on N loss. Goats on legume supplementation lost more N through the faeces (2.0-2.7g/day/goat) than through the urine (0.4-1.2g/day/goat). The values of N loss in urine and faeces are within the range reported by (Lekasi et al. 1998), which were 47-76 % and 24 -53 % for total faecal and urine N loss, respectively. Goats supplemented with Leucaena produced significantly (P< 0.05) more faecal N (2.7 g/kg/day) as compared to those on Madras thorn (2.0 g/kg/day). This could be explained by the high tannin content (4.39 %) in the leaves of Leucaena compared to that in Madras thorn (1.94%**)** that could have bound protein rendering it unavailable for digestion. From the N loss figures it would appear like the goats fed on Panicum hay alone were more efficient and that increasing N in the feed only led to increased loss. However, the N balance increased significantly (P<0.05) with legume supplementation, from 0.6 for the control diet to 3.7, 3.6 and 3.5g per day for Gliricidia, Madras thorn and Leucaena, respectively.

Table 2. Mean daily dry matter intake (g/d), weight gain (g) and digestibility for goats fed Panicum hay supplemented with Madras thorn, Gliricidia or Leucaena hay.

Diet	Daily dry matter intake				Dry matter digestibility	Average daily weight gain
	Panicum hay	Legume	Maize bran	Total		
Control	138.9 ^{a}	-	90	228.9 ^{b}	59.9 ^{b}	1.59 ^{b}
Madras thorn	112.6 ^{a}	162.3 ^{a}	90	364.9 ^{a}	62.9 ^{ab}	21.6 ^{a}
Gliricidia	128.2 ^{a}	170.2 ^{a}	90	387.4 ^{a}	63.5 ^{a}	18.7 ^{a}
Leucaena	158.0 ^{a}	146.0 ^{a}	90	397.6 ^{a}	62.0 ^{ab}	25.4 ^{a}
$LSD_{0.05}$	51.52	44.03		81.00	3.20	6.90

Column means followed by the same superscript are not significantly different at P< 0.05

Table 3. Effect of legume supplementation on nitrogen intake by goats, N output in faeces and urine, and N loss.

Diet	Intake of N in feed	Urine N	Faecal N	Total N loss	N balance
	------ g/day/goat ------				
Control	1.0 [b]	0.2 [a]	0.2 [c]	0.4 [b]	0.6 [b]
Madras thorn	6.8 [a]	1.0 [a]	2.0 [b]	3.1 [a]	3.7 [a]
Gliricidia	7.2 [a]	1.2 [a]	2.4 [ab]	3.6 [a]	3.6 [a]
Leucaena	6.6 [a]	0.4 [a]	2.7 [a]	3.1 [a]	3.5 [a]
$LSD_{0.05}$	1.8	1.3	0.6	1.3	1.7

Column means followed by the same superscript are not significantly different at P< 0.05

Table 4. Effect of diet on daily faecal output per goat and composition.

Diet	Faecal DM output			Faeces composition (%)			
	Actual (g)	As % live weight	As % intake	Carbon	N	P	K
Control	91.67 [b]	0.98 [b]	40.15 [a]	37.80 [a]	0.2 [b]	0.17 [a]	0.97 [a]
Madras thorn	135.00 [a]	1.13 [ab]	37.07 [b]	31.20 [a]	1.5 [a]	0.22 [a]	0.40 [a]
Gliricidia	141.67 [a]	1.27 [a]	36.45 [b]	32.60 [a]	1.7 [a]	0.35 [a]	0.41 [a]
Leucaena	150.00 [a]	1.30 [a]	37.98 [ab]	36.80 [a]	1.8 [a]	0.30 [a]	0.50 [a]
$LSD_{0.05}$	25.07	0.18	2.67	18.97	0.31	0.25	0.67

Column means followed by the same superscript are not significantly different at P< 0.05

Legume supplementation increased the faecal N content from 0.2% to an average of 1.7% but had no effect on the carbon, P and K contents (Table 4). Manure from goats fed on the control diet had a higher C:N ratio of 189:1 than the supplemented treatments. Use of manure with such high C:N ratio as soil amendment is likely to cause net N-immobilization by soil microbes and, hence, N deficiency in crops. Manure from goats on legume supplementation had comparable C:N ratios (19:1, 21:1 and 20:1 for Gliricidia, Madras thorn and Leucaena, respectively) that were similar to the critical C:N ratio (20:1) below which net mineralization would readily occur. The moderate C:N ratio of manure from goats fed legume supplement is an indication that mineralization may occur in goat manure, even though at low rates (PPI, 1983). Mineralization rates may be improved if goat manure is used in combination with suboptimal rates of inorganic nitrogen as suggested by Saha et al. (2007). The faecal DM output in goats given legume supplement was increased by 47 to 64% over that in goats fed the control diet only. This was probably due to the higher TDMI in goats fed the legume supplements compared to those fed on the basal diet only. Expressed as a percentage of live weight, faecal output increased significantly ($P<0.05$) under supplementation with Gliricidia or Leucaena by 30 and 33 %, respectively. Madras thorn had no significant effect on faecal output expressed as a percentage of live weight. The observed values of faecal output in goats fed legume supplement (1.13, 1.27 and 1.30 % live weight for Madras thorn, Gliricidia and Leucaena, respectively) are in agreement with 1.0-1.8 % of live weight reported by Lekasi et al. (2001).

CONCLUSION

Legume supplementation increased average daily faecal output and resulted in manure with higher N content than that from goats fed the control diet. High quality diets on smallholder farms, which include legume supplementation, would ensure the production of large quantities of high quality (N-rich) goat manure. Such manure would have great potential for improving soil fertility in coastal lowland Kenya. This potential can be estimated by considering the faecal output of the Small East African goat which weighs about 25kg. Assuming the total faecal production is 1.17% of the body weight, one goat is expected to produce 107kg manure DM per year. Goats supplemented with legumes produced faeces containing an average of 1.67% of N, hence one goat would provide 1.79kg N per year. The recommended nitrogen rate for maize production in coastal lowland Kenya is 60kg N ha^{-1}. To achieve this rate of N application, a farmer will need 3.6 tonnes of manure, obtainable from 34 goats. To achieve the same with the control diet, one would need to keep 255 goats. Legume supplementation is therefore recommended to improve animal performance and improve the quality of manure for crop and forage production. This will, in turn, contribute to increased food production.

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