EFFECT OF INTERCROPPING HERBACEOUS LEGUMES WITH NAPIER GRASS ON DRY MATTER YIELD AND NUTRITIVE VALUE OF THE FEEDSTUFFS IN SEMI-ARID REGION OF EASTERN KENYA

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Abstract

Semi-arid region of Kenya is faced with inadequate quantity and low quality of livestock feeds. Research was conducted in the semi-arid region of eastern Kenya to investigate the contribution of two legumes, Seca (Stylosanthes scabra cv. Seca) and Siratro (Macroptilium atropurpureum cv. Siratro) to seasonal total fodder productivity and nutritive value when intercropped with Napier grass (Pennisetum purpureum cv. Bana). The treatments consisted of Napier grass planted as pure stand and intercropped with legumes. During the production phase, the grass and legumes were harvested for dry matter yield after every 8 weeks for a period of four wet seasons and two dry seasons between April 2002 and September 2004. Overall total herbage yield of the mixtures was higher than those of sole fodder grass with the grass constituting the major component of the yield. Seca was more productive and had a relatively stable yield than Siratro. It accounted for higher proportion of total DM yield of 15 - 34%. in Napier compared to Siratro which had less than 5% except in the drier season when yield failed. Total DM yield was highest during the short rains of year 2002 and declined thereafter in subsequent seasons and was lowest during the dry seasons. It was observed that crude protein of Napier grass was significantly (P< 0.05) enhanced by inclusion of the legume in the intercrop (CP 9.64 - 9.96% of DM) compared to sole Napier grass (CP 8.14% of DM). Napier grass intercropped with Seca was more degradable than sole Napier grass. It can be concluded that Seca formed a better association with fodder grass than Siratro and is recommended for intercropping in the semi-arid region of eastern Kenya.

Key words: Legumes, Napier, Semi-arid, Dry Matter, Nutritive Value and Livestock.

INTRODUCTION

The. Intensive fodder production systems based on Napier grass (*Pennisetum purpureum*) are increasingly becoming important to farmers who keep improved dairy cattle in the semi-arid region of eastern Kenya that receive between 500 - 800 mm of annual rainfall that receives higher amount of rainfall (Njarui and Wandera, 2000). Dry matter yield of the grass is generally low due to poor soil fertilization regimes and erratic rainfall. The fodder is productive during the wet season and the nutritive value is generally low and does not meet the animal production requirements throughout the year. It contains low to moderate crude protein (CP) content (6 - 12%) during the wet season, but declines to less than 5% during the dry period. Below a critical level of 6 - 8% CP in cattle diet, digestibility and voluntary intake of forage are likely to be reduced (Humphreys, 1991). The major challenge is to overcome the inadequate quantity and quality of these cultivated fodders. Use of fertilizers to improve yield and commercial concentrates as livestock supplements to enhance nutritive value is limited due to inability of farmers to purchase them.

The importance of herbaceous forage legumes in increasing herbage production of grasses and quality of feed produced has been recognised in Kenya (Mureithi *et al.*, 1995; Mwangi *et al.*, 2004). Including a legume in fodder grasses production would not only provide a nitrogen source to promote grass growth but enhance the quality of feed. Legumes benefit grasses by contributing nitrogen to the soil through atmospheric fixation, decay of dead root nodules or mineralization of shed leaves. The inclusion of a legume in Napier grass based diet has shown to improve animal performance in terms of milk production because of their high nutrient contents (Muinga *et al*., 1992).

Integration of tropical legumes in the fodder grass production system has shown to enhance livestock feed production elsewhere. Tothill (1986) reported that intercropping forage legumes with grasses improved feed quantity and quality. Mureithi *et al*. (1995) also reported improved quantity and quality of fodder in an alley farming system based on Napier grass intercropped with leucaena in coastal lowland of Kenya. In central highlands of Kenya, Mwangi (1999) showed higher total DM yield of Napier grass/legume intercrop than sole Napier grass. New forage legumes have become available through screening work (Gachene and Makau, 2000; Mureithi *et al.*, 2003; Njarui *et al.*, 2004), but they have not been integrated into the farming systems.

Therefore, it is imperative to develop a production system that increases availability of livestock feeds and improve fodder quality in semi-arid region of eastern Kenya. Forage legumes can be cheaper feed supplements than the commercial concentrates (Njarui and Wandera, 2000) and can easily be grown by the small-holder farmers. However, in order to exploit the potential of these legumes, a better knowledge is needed on how to fit these legumes into existing farming systems. The aim of the study was to evaluate the dry matter yield and quality of Napier grass when intercropped with two tropical herbaceous forage legumes, Seca (*Stylosanthes scabra* cv. Seca) and Siratro (*Macroptilum atropurpureum* cv. Siratro) in the semi-arid region of eastern Kenya.

MATERIALS AND METHODS

Site

The experiment was conducted from April 2002 to September 2004 at Kenya Agricultural Research Institute (KARI), Katumani Research Station (1^{o}58'S; 37^{o}28'E), about 75 km SE of Nairobi city, Kenya. Elevation is 1600 m above sea level and the mean temperature is 19.6^{o}C. Mean annual total rainfall is 717 mm, with a bimodal pattern; the long rains (LR) occurs from March to May and the short rains (SR) from October to December with peaks in April and November respectively. Inter-seasonal rainfall variation is large with coefficient of variation ranging between 45 - 58 % (Keating *et al*., 1992). There is a distinct dry season (DS) between the LR and SR seasons which last for 4 months (June - September) where rainfall is unlikely and in January and February when amount of rainfall is negligible. Evaporation rates are high and exceed the amount of rainfall in all the months except in November in which rainfall exceeds evaporation. The land on which the experiment was established had been under natural fallow for one year preceding a crop of lablab. Analysis of the soil from the site indicated that it was sandy clay loam with pH of 5.6 (1:2.5 soil:water); organic matter 2.33% and soil nutrients (mg kg^{-1}) P 22.02; K 458.68; Ca 770.3; Mg 262.75; and (%) N 0.22.

Treatment and design

Treatments consisted of Napier grass (*Pennisetum purpureum* cv. Bana) planted as pure stand and intercropped with two herbaceous forage legumes; Seca stylo (*Stylosanthes scabra* cv. Seca) and Siratro (*Macroptilium atropurpureum* cv. Siratro). The design of the experiment was a randomised complete block design in a factorial arrangement with 3 replications. Plots sizes were 7 m x 7 m with 1 m between plots and 1.5 m between replications. Root splits of the grass were planted at a spacing of 1 m between and within rows in April 2002, giving 7 rows, each consisting of 7 stools and overall population equivalent to 10,000 stools ha^{-1}. A single row of the legumes was drilled by hand between the grass rows at the same time, giving 6 rows of 7 m long in each plot.

The seeds of Seca and Siratro are hard-seeded and were gently mechanically scarified by rubbing them between two sand papers to break the seed coat in order to facilitate water uptake before planting. The grass and shrub vegetation was cut back, land ploughed and harrowed twice to obtain a fine seedbed using a tractor. The seeds of Seca and Siratro were drilled in furrows of about 2 cm deep and covered lightly with a thin layer of soil at the half of the recommended seed rate of 3.5 and 4.5 kg ha^{-1}, respectively. The seeds were not inoculated with *rhizobium* at sowing, because they have shown to nodulate with native *rhizobia* in the soil (Mureithi *et al*., 2003). Triple super phosphate fertilizer (TSP) was applied to the legumes at a rate of 20 kg P ha^{-1} as it is a prerequisite for N fixation in the planting furrows and thereafter at the on-set of LR 03 and 04. Experiments were kept weed free throughout by hand weeding.

Measurements

The first rainy season (LR 02) from April to May and the first dry season (DS 02) from June to September were regarded as establishment phase and the subsequent seasons up to DS 04 as the production phase. Thus establishment phase was the 20 weeks following legume seedling emergence/formation of first leaf for the fodder grass. Prior to on set of the second wet season in October, 2002 (SR 02); the grass and legumes were harvested for DM yield determination (standardization cut). Thereafter, they were harvested after every 8 weeks for a period of 4 wet seasons (SR 02, LR 03, SR 03 and LR 04) and 2 dry seasons (DS 03 and DS 04). Two harvests were carried out each season except during DS 04 where one harvest was carried thus giving a total of 12 harvests. In DS 04, the second harvest was not carried out because both the grasses and legumes failed to achieve much growth due to prolonged drought and were below the cutting height

Sampling for DM yield was taken from a net area of 3 m x 3 m (three, 3 m rows of legume and 9 stools of the fodder grass in the middle rows) per plot. The grass was cut at 30 cm stable height while Seca was cut at 10 and Siratro at 15 cm height. After each sampling, the guard rows were cut to appropriate height according to the plant species and the forage removed from the plots. The fresh herbage was weighed using a spring balance of 25 kg with 0.10 kg sub-division and sub-samples taken where necessary. The sub-samples were cut into small pieces using hand sickles, put in paper bags, dried at 105°C for 48 hours in an oven and dry weight taken.

In sacco Degradability

The *in sacco* trials for rumen degradability were conducted at Egerton University, Njoro in April and May 2005. Two rumen fistulated steers (*Bos indicus x Bos taurus*) of 3 years old and 425 ± 45 kg live-weight fitted with flexible rubber cannulae of 110 mm internal diameter (Bar Diamond, Idaho, USA) were used. Each steer was individually penned in stall with a concrete floor, a metal roof was provided with an independent trough for feeding and automatic watering point. The steers were fed with signal grass (*Brachiaria decubense* cv. Basilisk) hay *ad-libitum*. Water was always available. In addition, each steer was provided with mineral block, 2 kg of concentrate and 0.5 kg of molasses to supply energy daily. A preliminary period of 10 days was allowed before the study began. Degradability was conducted for Napier grass intercropped with Seca and harvested in May 2004. The study on the grass intercropped with Siratro was not carried out because the proportion of Siratro was too little and it was regarded as unsuccessful. After oven drying at 65°C to constant weight, the samples were milled to pass through a 3.5 mm screen and about 3 g was weighed into nylon bags measuring 140 x 75 mm with a pore size of 40 to 60 *um*. The bags containing the samples were then tied to plastic tubes using rubber bands and incubated in duplicate for 3, 6, 12, 24, 48, 72, 96 and 120 h in the rumen of fistulated steers while the steers were used as replications. The bags were progressively put in the rumen starting with the bags to be incubated for the longest period and ending with bags to be incubated for the shortest period. After each incubation time, the bags were removed from the rumen, immediately rinsed in cold water and detached from the plastic tubing by cutting the rubber bands and then frozen immediately. The 0 h (control) residues were obtained by soaking the bags with sample in duplicate in warm water (39°C) for five minutes. At the end of experiment the bags were allowed to thaw, and all hand washed together in a bucket of water (39°C) until the water coming out of the bags was clear. The washed bags and residues were then dried in an oven at 65°C for 48 h and weighed. The rumen dry matter degradability (DMD) of each incubation time was calculated as DMD% = (wt of DM incubated - wt of residue x 100)/wt of DM incubated. The DM degradability values at various times of incubation were fitted to the Ørskov and McDonald (1979) exponential model; $P = a + b(1 - e^{-ct})$ where P is the DM disappearance at time t; 'a' is washing loss; 'b' the degradation and 'c' the rate of degradation h^{-1}. The potential degradability (PD) was estimated as (a + b) while the effective degradability (ED) was calculated using Ørskov and McDonald (1979) formula: $ED = a + [bc/(c + k)]$ where a, b and c are described above and k is the rumen flow rate which was assumed to be 0.05 h^{-1} (Ørskov *et al*., 1988).

In-vitro Gas Production

The same samples used in rumen study were tested for gas production at the Animal Science Department laboratory in Egerton University, Njoro. Samples were incubated *in-vitro* with rumen fluid in calibrated syringes following the procedure of Menke and Steingass (1988) as described by Abdulrazak and Fujihara (1999). Rumen digesta were obtained from the two steers used in the *in sacco* degradability study and pooled together in order to achieve a homogeneous inocula. The rumen digesta was collected at 08.00h before morning feeding, placed in a pre-warmed 3 litres vacuum flask and transported to the laboratory. In the laboratory, the rumen digesta was squeezed through two layers of cheese cloth and the strained rumen gassed with carbon dioxide.

About 200 mg of 1 mm milled samples were weighed in duplicate into 100 ml calibrated glass syringes. The pistons were then lubricated with pure oil to ease movement and prevent gas escape. The syringes with samples were pre-warmed at 39°C for 1 hour before addition of 30 ± 1.0 mls of the buffer mixture into each syringe. The syringes were incubated in a water bath maintained at 39 ± 0.1°C and gently shaken hourly for the first 8 hours of incubation. Reading for gas production was recorded at 0, 3, 6, 12, 24, 48, 72, 96 and 120 h after incubation. The mean gas volume readings were fitted to the model $Y = a + b(1 - e^{-ct})$ (Ørskov and McDonald, 1979) where Y is the gas production at time t, 'a' is the intercept of the gas production curve, 'b' is the asymptote of the exponential $b(1-e^{-ct})$, a+b represent potential gas production and 'c' denoted the rate of gas production.

The metabolizable energy (ME) and organic matter digestibility (OMD) at 48 h of dry roughage were calculated from the equation of Menke and Steingass (1988) as; ME (MJ kg^{-1} DM) = 14.78 – 0.0147ADF; OMD (%) = 18.53 + 0.9239GP + 0.0540CP; where 'ADF' stand for acid detergent fibre 'GP' gas production and CP, crude protein (ml 200^{-1} mg DM).

Chemical Analysis

Chemical analysis was carried out for Napier grass and panicum herbage harvested at both 9 months and 2 years after planting. The plant samples for chemical analysis were dried at 65°C in an oven to a constant weight. The dry samples were ground using a hammer mill fitted with a 1 mm sieve and about 200 g was stored in separate bottles for analysis. Ash was determined by heating at 550°C for 8 hours in a muffle furnace. Crude protein was determined according to the method of Association of Official Analytical Chemist (AOAC, 1984). Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and lignin were determined using Ankom method of van Soest *et al.* (1991). The polyphenols were analysed using gravimetric technique of the same authors. Phosphorus was measured by ascorbic acid method (Watanabe and Olsen, 1965). The total K and Ca were measured according to methods of Okalebo *et al.* (2002).

Statistical Treatment

Data collected was statistically evaluated by analysis of variance using Statistical Analysis Systems (SAS) general linear model (SAS, 1987) and mean separated by Least Significant Difference (LSD) (Steel and Torrie, 1981. For DM production, the total yield from 2 harvests per each season was used. Data on combined total DM yield (grass + legumes) and DM yield of grasses and legume component were analysed separately for each season.

RESULTS

The seasonal total DM production of the Napier grass/Seca and Napier grass/Siratro intercrops and sole Napier grass and the contribution of Napier grass, Seca and Siratro to total yield are presented in Table 1. Both legumes depressed the DM of Napier grass at standardisation cut and in SR 02 although the yield reduction was not significant. In subsequent seasons, during the production phase, Napier grass benefited from the legumes by producing high herbage although it was not significantly higher than the sole Napier grass except in LR 03 and LR 04. In these seasons, Napier grass intercropped with Siratro had higher (P<0.05) yield than sole Napier grass. However, combined total DM yield for Napier grass/legumes intercrops was significantly high in LR 03, DS 03, SR 03 and LR 04. The Napier grass/Seca intercrop had the highest total DM production but was not significantly higher than Napier grass/Siratro intercrop in LR 03 and LR 04 and sole Napier grass during DS 03. Dry matter yield for all treatments was highest in the SR 02 (4.14 - 4.35 t ha^{-1}) and declined with seasons and was lowest in DS 04 (0.2 - 0.31 t ha^{-1}). Dry matter production for Seca and Siratro varied in all seasons and Seca significantly produced more yield in all seasons except at standardisation cut where yields were not significantly different. Seca made its highest contribution to total yield during SR 02 (629 kg ha^{-1}) and LR 04 (625 kg ha^{-1}) which accounted for 15% and 31% of total DM yield, respectively. Dry matter for Siratro was low (<200 kg ha^{-1}) in all seasons and accounted for less than 5% of total DM production. However, it produced negligible yield in SR 03 and LR 04 seasons (< 50 kg ha^{-1}) and failed in DS 03 and DS 04 while Seca was unproductive only in DS 04.

Tables, 3 and 4 shows minerals content and chemical composition, respectively of Napier grass, 9 months and 2 years after planting. The legumes did not influence the level of mineral in Napier grass and thus the means are shown. Across treatments, level of P and Ca increased over time from 9 months to 2 years while K declined (Table 3). After 9 months, the only significant effect of legume occurred in fibres and ash content of Napier grass. The sole Napier grass had higher fibres contents but lower ash than the intercropped Napier grass (Table 4). After 2 years, the Napier grass intercropped with Siratro and Seca had more CP (9.64 - 9.96%) than sole Napier grass (8.14%). However the level of fibres remained high but only the ADF content was significantly more in sole Napier grass than Napier grass grown with the legumes. On the contrary the level of ash increased and was higher (P<0.05) in sole Napier grass than in the other treatments.

The legume had significant effect on degradability of Napier grass but from 48 hours of incubation and onwards. Napier grass intercropped with Seca was degraded quicker than when grown alone (Figure 1). At 48 h of incubation, the intercropped Napier grass was 61% degraded compared to 53% of sole Napier grass while at 120 h of incubation 71% was degraded as compared to 68% of sole Napier grass. The rumen degradability parameters derived from fitting the degradability values to the exponential equation of Ørskov and McDonald (1979) are presented in Table 7. Only effective degradability was significant and was higher in the intercropped Napier grass than sole Napier grass. Differences between treatments for potential degradability (a+b) and rate of degradation (c) were small.

Legume produced significant effect on gas production of Napier grass and is shown in Figure 2. Napier grass intercropped with Seca produced higher amount of gas than sole Napier grass and was significant (P<0.05) at 48, 72, 96 and 120 hours. The cumulative gas production after 120 h of incubation of Napier grass intercropped with Seca and sole Napier grass was 50 and 45 ml 200^{-1} g DM, respectively. The parameters of gas production characteristics derived from fitting the gas production values to the exponential curves of Ørskov and McDonald (1979) are presented in Table. Organic matter digestibility at 48 h of incubation was significantly higher for intercropped Napier grass than sole Napier grass.

DISCUSSION

The effect of legumes on DM yield of grass was not consistent throughout the production phase. Growing legumes with grasses depressed yield of grass in SR 02 while in other seasons, from LR 03, there was a benefit although not significant. The absence of a consistent beneficial effect of legumes on DM yield of associated grasses has been reported by Ezenwa and Aken'ova (1998) in tropical Nigeria. In SR 02, yield of Napier grass was depressed by 16 and 9% by Seca and Siratro, respectively (Tables 1). This type of yield reduction at initial year of production is consistent with work of Njunie *et al.* (2000) when they intercropped cowpea with Napier grass in coastal lowland of Kenya. Legumes benefited the grasses more when the rainfall was relatively high. For example, in LR 03, (rainfall, 402 mm) yield of Napier grass increased by 16 and 25% when grown with Seca and Siratro, respectively compared to sole grass. In contrast, during the DS 03 (rainfall, 10 mm) mean yield of Napier grass increased by 11% respectively when intercropped with Seca and Siratro. Mureithi *et al.* (1995) showed a beneficial effect to Napier grass when grown together with leucaena in coastal lowland of Kenya. They recorded increased yield of Napier grass when planted adjacent to leucaena hedgerows than sole Napier grass or Napier grass growing away from leucaena. This contradicts results of Mwangi (1999) who found out that intercropping Desmodium depressed DM yield of Napier grass but overall total yield (grass+legumes) was higher. Increased yield of fodder grasses in intercrops compared to sole grass during the production phase could have been due to improved soil fertility through nitrogen fixation by the legumes. Legumes benefit the grass by contributing nitrogen to the soil through atmospheric N_2 fixation, decay of dead root nodules and mineralization of shed leaves. Seresinhe *et al*. (1994) has indicated that inclusion of legume in a pasture mixture stimulates the growth and increases the N uptake of grass.

Results show intercropping legumes with Napier grass produced higher total yield advantage than sole grass. These results are in agreement with those of Akinyemi and Onayinka (1982) while working on Panicum and *Centrosema pubescence* sward mixture in Nigeria. Mwangi and Thorpe (2002) also reported increased DM production from 20 to 25 and 27 t ha^{-1} yr^{-1} by integrating axillaris (*Macrotyloma axillare*) and Greenleaf desmodium, (*Desmodium intortum* cv Greenleaf) respectively in Napier grass system in central Kenya. In Sri Lanka, Seresinhe and Pathirana (2000) showed enhanced yield of grass and total output of gliricidia (*Gliricidia sepium*) and *P. maximum* cv. Guinea mixed forage systems. Other workers who have reported higher forage DM yield from grass/legume mixtures than pure stand grass includes; Ezenwa and Aken'ova (1998) in West Africa, Niang *et al.* (1998) in Rwanda; Tudsri and Kaewkunga (2002) in Thailand and Berdahl *et al*. (2001). In some instances large difference were reported than in this experiment, e.g. Berdahl *et al.* (2001) showed average DM yield of 8.7 and 2.71t ha^{-1} from grass/lucerne mixture and sole grass, respectively. Yield of intercrop were low at standardisation cut despite a longer period of growth (20 weeks) compared to that reported by Njarui and Wandera (2000) of Napier grass or Panicum 6.6 and 7.5 t ha^{-1}, respectively primarily due to poor distribution of rainfall. There was strong influence of rainfall on DM production and the highest DM was recorded in SR 02 and LR 03 which were the wettest seasons. The total rainfall was 346 and 402 mm for SR 02 and LR 03, respectively which was well distributed. In the SR 03 yield were considerably reduced due to low rainfall total (176 mm) while in both the dry seasons (DS 03 and DS 04) the plants depended on residual moisture for growth. Except during the dry seasons (DS 03 and 04) there were great difference in DM production between grass and legumes with mean DM of legumes only accounting for 17 - 28% in Napier grass. Seca accounted for a higher ($P<0.05$) proportion than Siratro except during LR02. . The proportion of Seca to total DM yield varied from 15 - 31% in Napier grass while the contribution of Siratro to overall forage yield was relatively low (<6%), in both grasses except during SR 02 where it approached 10%. This may be an indicator of its unsuitability to the mixture. These percent were lower than those reported by Njarui and Wandera (2000) when they intercropped glycine (*Neonotonia wightii* cv. Cooper) and axillaris with Napier grass in similar semi-arid environment. They found out that the legumes accounted for a mean of 28 - 42% of total DM production in Napier grass. Dzowela (1986) reported a mean of 20% of forage legume (Desmodium) in Rhodes grass. In a study on Napier grass/legume intercrop in Central Kenya, Desmodium and axillaris contributed 11 and 7.7% of total yield respectively (Mwangi and Thorpe, 2002). Ezenwa and Aken'ova (1998) found a wide variation of legume proportion to the mixture in a study of Napier grass and guinea grass with Verano, tropical kudzu (*Pueraria phaseloides*) and glycine mixture. The legume in the mixture ranged from 32 - 38, 36 - 39 and 21 - 24% for Verano, tropical kudzu and glycine, respectively.

Overall total DM yield declined with season after the SR 02 with much higher reduction in the dry seasons, due to low moisture available for growth. In DS 04, both legumes failed to produce any yield while in DS 03 only Seca was productive and accounted for 21 and 20% of the total DM yield in the fodder grass. Wandera *et al.* (2000) also recorded a decline in yield of Napier grass intercrops in the relatively wetter central and western highlands of Kenya.

Both *in sacco* and *in-vitro* experiments indicated that Napier grass intercropped with Seca was more degradable than sole Napier grass. The higher degradability may be linked to its higher CP content (Table 4) which provides more N for microbial utilisation (Abdulrazak *et al*., 1997). Generally the feeding value of the forages and extent of forage degradation is constrained by amount of fibre content (NDF). Wood and Manyuchi (1997) showed that *in-vitro* gas production technique was sensitive to the nitrogen levels of the medium and roughages with more N are more degradable than those with low N content. The degradable fraction of potential degradability and effective degradability of 77.62 and 38.7% for intercropped Napier grass respectively reported here were comparable to those of Kariuki (1998) and Zewdu *et al*. (2002). Both the rate of degradation and gas production were lower than values reported by Sileshi *et al*. (1996) for Napier grass grown in Ethiopia; the effective degradability were also low but in their case they assumed a passage rate of 0.02 h^{-1}. It is difficulty to explain the slight increase of DMD (%) for Napier grass at 120 hours (Figure 2). This could have been due to the bags being broken down by microbes thus allowing the finer particles of feed to pass through during washing. Nevertheless, most of the feed in the rumen is usually digested by 72 h and therefore the increased fermentation at 120 h of incubation may not be relevant to the physiological situation of an animal. The value for degradability appeared to be higher in the rumen than in the gas production. Wood and Manyuchi (1997) has pointed out that this is because unlike in glass tubes the ruminants are able to supply nitrogen to the rumen. The extent of digestion of Napier grass when intercropped with Seca was greater than for sole Napier grass and this according to Ibrahim *et al*. (1995) is largely associated to influence of legume to the in cell wall level of the grass probably due to increased N level from legume.

Legumes fix atmospheric N_2 and therefore have a higher protein and feed value than associated grasses where soil N is low (Schwenke and Kerridge, 1990). Legumes benefited Napier grass by improving the CP content and reducing the fibre content (ADF). The Napier grass intercropped with legumes had more CP than sole Napier grass but for Panicum, the effect of legume relative to control was not significant. In Rwanda, Niang *et al.* (1998) showed that CP content of Napier grass associated with leguminous shrubs (*Calliandra* and *Sesbania*) increased from 11.3 to 17.8% in Napier grass. Unlike the work of Seresinhe and Pathirana (2000) that showed reduced NDF of guinea grass when intercropped with gliricidia, this work did not show significant effect by intercropping legumes with grasses. The polyphenols declined with application of fertilizer and were much lower when N fertilizer was used than FYM. Generally, the level of P, Ca, CP, fibres and polyphenol in both fodder grasses increased across all treatments and were highest after 2 years than after 9 months of growth. The K and lignin declined while ash content remained relatively the same at both sampling. The increase was higher where the Napier grass was intercropped with legumes and in plot where it was fertilized and this clearly indicates that both legumes and fertilizer improve the quality of the fodder grasses.

CONCLUSION

The results showed potential to produce high quantity of livestock feed of higher nutritional quality by incorporating a legume in a fodder grass production system. The legumes improved the yield fodder grasses and overall total herbage yield of the mixture was higher than sole fodder grasses. Seca was more productive and had a relatively stable yield in both grasses than Siratro and hence more suitable in the mixture. The results further indicate that there was significant gain in CP and reduced ADF and lignin by inclusion of legumes in Napier thus improving herbage nutritive value and digestibility but for Panicum the gains were not significant. These mixtures are recommended for use in the semi-arid region of eastern Kenya.

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Received for publication on October 16 , 2006
Accepted for publication on November 22 , 2006

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Tab. 1. : Dry matter production of Napier grass/Seca, Napier grass/Siratro intercrops and sole Napier grass at Katumani.

Seasons	Treatments	Dry matter yield (kg ha^{-1}) Grass	Legume	Total
LR 02/DS 02	Napier grass/Seca	1255	155	1410
	Napier grass/Siratro	1608	174	1782
	Sole Napier grass	1715	-	1715
	LSD	NS*	NS	NS
	CV	43.8	33.4	38.6
SR 02	Napier grass/Seca	3635	629	4264
	Napier grass/Siratro	3949	197	4146
	Sole Napier grass	4352	-	4352
	LSD	NS	130	NS
	CV	18.9	30.0	17.2
LR 03	Napier grass/Seca	2598	454	3052
	Napier grass/Siratro	2812	93	2905
	Sole Napier grass	2239	-	2239
	LSD	544	84	538
	CV	20.5	29.2	18.8
DS 03	Napier grass/Seca	634	173	807
	Napier grass/Siratro	574	0.0	574
	Sole Napier grass	682	-	682
	LSD	NS	50	142
	CV	20.0	55.6	20.0
SR 03	Napier grass/Seca	1276	284	1560
	Napier grass/Siratro	1239	11	1250
	Sole Napier grass	1238	-	1238
	LSD	NS	62	272
	CV	21.1	40.2	19.1
LR 04	Napier grass/Seca	1366	625	2616
	Napier grass/Siratro	1950	51	2001
	Sole Napier grass	1352	-	1352
	LSD	454	76	448
	CV	27.6	21.3	23.7
DS 04	Napier grass/Seca	271	0.0	271
	Napier grass/Siratro	217	0.0	217
	Sole Napier grass	254	-	254
	LSD	NS	-	NS
	CV	41.5	-	41.5

NS* Not Significant

Tab. 3. : Effects of legumes on minerals content (% of DM) in Napier grass sampled after 9 months (December 2002) and 2 years (May 2004) of cropping.

	P		K		Ca	
Treatment	9 months	2 years	9 months	2 years	9 months	2 years
Napier grass/Seca	0.21	0.29	4.42	3.95	0.21	0.40
Napier grass /Siratro	0.24	0.31	4.46	3.69	0.21	0.41
Sole Napier grass	0.20	0.29	4.08	3.39	0.23	0.45
Mean	0.22	0.30	4.32	3.68	0.22	0.42

Tab. 4. : Effects of legumes on chemical composition (% of DM) in Napier grass after 9 months (December 2002) and 2 years (May 2004) of cropping.

	CP		ADF		NDF		Lignin		Polyphenol		Ash	
Treatments	9 months	2 years	9 months	2 years	9 months	2 years	9 months	2 years	9 months	2 years	9 months	2 years
Napier /Seca	6.11	9.96	40.07	43.57	63.23	68.75	10.18	3.60	0.96	1.91	15.80	14.97
Napier /Siratro	6.60	9.64	39.77	43.91	62.81	69.08	10.56	3.77	0.92	1.92	15.82	14.84
Sole Napier	6.20	8.14	41.51	45.19	64.78	65.92	10.34	4.46	0.98	2.09	14.35	15.97
LSD (P<0.05)	NS	1.26	1.53	1.16	1.54	NS	NS	0.74	NS	NS	0.93	0.89
CV (%)	25.93	13.27	3.74	2.60	2.40	5.67	5.74	18.46	18.24	12.81	5.93	5.81

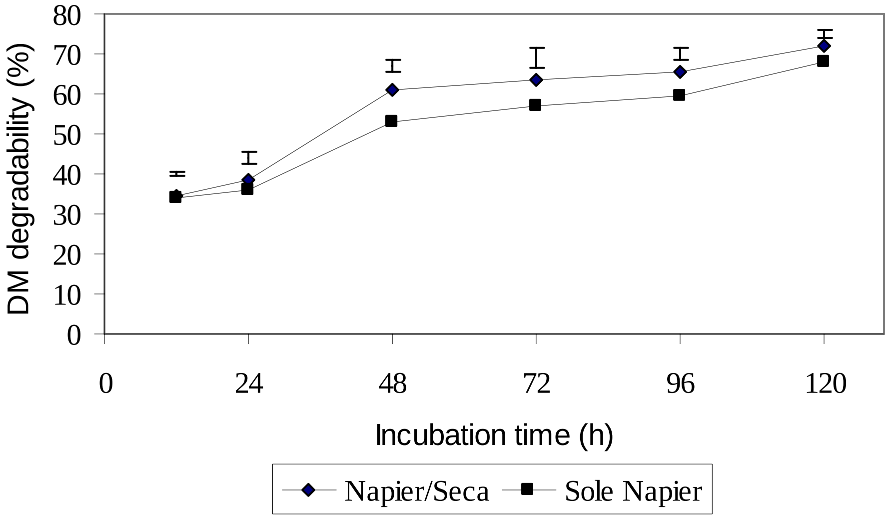

Fig. 1. : *In sacco* rumen dry matter (DM) degradability of Napier grass intercropped with Seca and sole Napier grass.

Tab. 7. : Derived parameters of the *in sacco*, rumen dry matter degradability (RMD) characteristics of Napier grass when intercropped with Seca and sole Napier grass

Rumen DMD characteristics	Treatments		CV	LSD
	Intercropped Napier	Sole Napier		(P<0.05)
Washing loss (A)	24.6	24.8	6.7	NS
Insoluble but fermentable fractions (B) %	53.0	55.4	12.1	NS
Rate of degradation of B (h^{-1})	0.018	0.013	34.8	NS
Potential degradability (A+B) %	77.62	80.25	9.9	NS
Effective degradability (ED) %	38.69	35.96	1.2	1.2

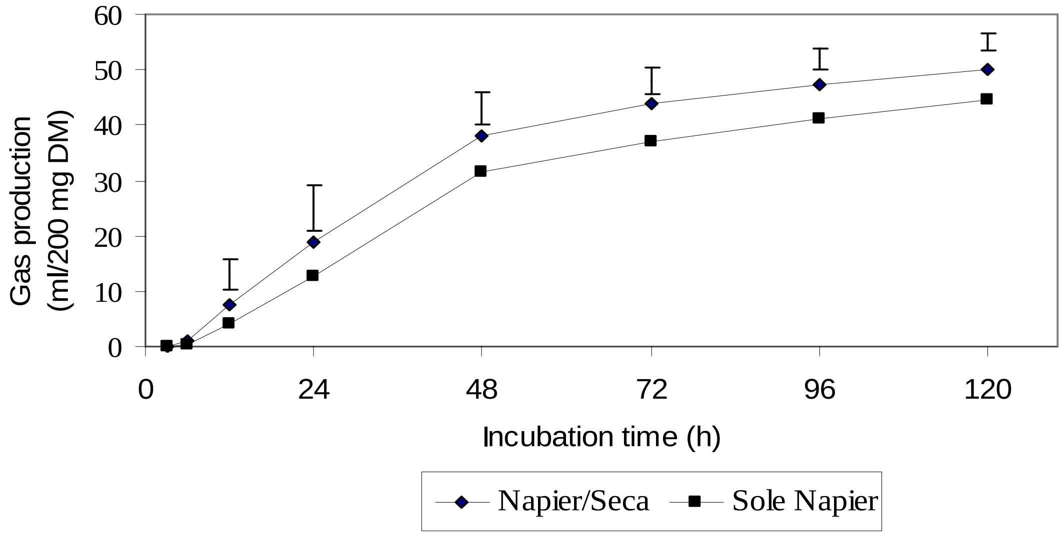

Fig. 2. : Cumulative gas production with time (3, 6, 12, 24, 48, 72, 96 and 120 hours) for Napier grass intercropped with Seca and sole Napier grass. Bars represent the LSD, P<0.05 from 12 h where statistical analysis was performed.

Tab. 8. : Parameters of the gas production characteristics of Napier grass intercropped with Seca and sole Napier grass

Gas production characteristics	Treatments		CV	LSD
	Intercropped Napier	Sole Napier		(P<0.05)
Intercept of gas production curve (a)	-4.0	-2.8	2.8	0.17
Asymptote of the exponential (b) %	57.4	53.4	3.6	3.2
Rate of gas production of b (h^{-1})	0.026	0.021	24.9	NS
Potential gas production (A+B) %	53.4	49.9	3.9	NS
Metabolizable energy (ME) MJ kg^{-1} DM	8.41	8.21	1.6	NS
Organic matter digestibility (OMD) MJ kg^{-1} DM	592	522	4.9	45