Performance of Sahiwal and Friesian heifers fed on napier grass supplemented with graded levels of lucerne

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Two experiments designated A and B were conducted to evaluate the effect of supplementing napier grass with lucerne on dry matter intake (DMI) and weight gain (ADG) of Friesian and Sahiwal heifers. In experiment A which lasted 92 days, 24 heifers from each of Sahiwal and Friesian breeds were blocked by breed and randomly allocated to the following treatments: young napier + 0 kg lucerne (T1); young napier + 1.5 kg lucerne (T2); old napier + 0 kg lucerne (T3); old napier + 1.5 kg lucerne (T4); old napier + 2.5 kg lucerne (T5); old napier + 3.5 kg lucerne (T6) heifer^{-1}.day^{-1}. Supplementation significantly ($p < 0.05$) increased DMI from 4.3 to 6.7 kg.day^{-1} in Sahiwals and 5.2 to 7.8 kg.day^{-1} in Friesians ($p < 0.05$). Similarly, supplementation positively influenced ADG which significantly ($p < 0.05$) improved from 0.29 to 0.64 kg.day^{-1} for Sahiwals and 0.30 to 0.65 kg.day^{-1} for Friesians. In Experiment B, diets from experiment A were incubated in the rumen for 0, 3, 6, 12, 24, 48, 96 and 336 h using four steers to estimate degradation. The rumen degradation of lucerne-containing diets were significantly ($p < 0.05$) higher than those with napier grass alone. It was concluded from the study that lucerne has a great potential to improve animal performance in smallholder dairy farms.

Key words: Napier, lucerne, heifers, intake, weight gain, degradation

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Introduction

In the tropics, the majority of dairy cattle depend on low quality natural pastures and crop residues (Preston & Leng, 1987; Minson, 1990). In Kenya, dairy cattle under zero grazing system are mainly fed on napier grass (*Pennisetum purpureum*) which has been adopted owing to its high dry matter (DM) yields and palatability (Anindo & Potter, 1986; Boonman, 1993). Napier grass has a mean crude protein (CP) of 76 g.kg^{-1} DM at the farms (Wouters, 1987). However, this level is below the ARC (1980) recommended dietary CP levels for growing heifers of 10 to 12 g.kg^{-1} DM CP and as a result, the reported average weight gains for heifers fed on napier grass was less than 0.25 kg.day^{-1} (Gitau *et al.*, 1994). The subsequent result is lack of good replacement heifers.

The use of commercial protein sources on the farms is limited by high costs and unavailability (Valk, 1990). Therefore, to improve the performance of heifers, cheap and easily grown protein sources such as legumes need to be identified. It is established that legume inclusion in ruminants' diets could improve animal nutrition (Minson & Milford, 1967; Posler *et al.*, 1993) in addition to enhancing soil fertility through nitrogen fixation (Tothill, 1987; Mureithi, 1992). Zero grazing farmers in central Kenya region grow lucerne (*Medicago sativa*), as a protein source to supplement napier grass (MALDM, 1994). Of the legumes studied in Kenya, the highest DM yields have been recorded with lucerne both at the farms (Boonman, 1993) and under research conditions (Snijders, 1989). During the dry season when there is little growth on the farms, lucerne is purchased from commercial stores (Boonman, 1993). Thus, if napier grass and lucerne are both grown on the farm high nutrient yields and therefore high animal output are likely to be achieved. Unfortunately, farmers lack specific guidelines on how to combine napier grass with lucerne for dairy heifers and the effect of lucerne supplement on performance is not documented.

The objective of this study was therefore to investigate the effect of supplementing napier grass with graded levels of lucerne on rumen degradation, feed intake and weight gain of Sahiwal and Friesian heifers.

Materials and Methods

Location of the study area

The study was conducted between January and May 1995 at the National Animal Husbandry Research Centre, Naivasha, in the Kenyan Rift Valley (0°40'S, 36°26'E, 1900 m altitude). The mean annual rainfall for the study site is 620 mm and the mean annual temperature 18°C (Jaetzold & Schimdt, 1983).

Experiment A : Feed intake and growth experiment

Management of forage feeds

An existing napier grass (variety Bana) field measuring about 3.5 hectares (ha) was sub-divided into two equal plots, P1 and P2. Plot P1 was used for 6-week-old napier grass while P2 was used for 12-week-old grass. Plot P1 was further subdivided into 42 sub-plots and P2 into 84 sub-plots. In January, 1995 a clearing cut and weeding were done followed by fertilizer application at the recommended rates of 100, 100 and 150 $kg.ha^{-1}$ of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) respectively (MLD, 1991). During the period the total rainfall received was 352 mm. January and February were very dry (mean rainfall 29 mm per month, mean temperature 24.6°C) whereas the means for March to May were 101 mm per month with a mean temperature of 21.8°C. Thus during dry periods, when rainfall was not adequate, the plots were irrigated weekly to ensure continuous forage growth.

The harvesting of the sub-plots commenced 6 (42 days) weeks before the start of the experiment to allow the napier grass to be 6 weeks old at the start of the feeding experiment. The sub-plots were harvested on successive days such that the sub-plot to be fed on day 1 of the experiment was cut 42 days before, that for day 2, 41 days before, and so on. The P1 plot was harvested twice during the period. The adopted harvesting schedule ensured that the napier grass fed during the entire experimental period was 6 weeks old.

The harvesting procedure for the P2 field was similar to that used for P1, except that the plot was sub-divided into 84 sub-plots and that the first sub-plot was harvested 84 days before the start of the experiment, the second sub-plot 83 days before, and so on to ensure that the napier was the same age (12 weeks) throughout the experimental period.

A clearing cut was also done for a 1 ha two-year-old lucerne field (variety Hunter River). Fertilizer was applied at the rate of 100 and 100 $kg.ha^{-1}$ of phosphorus (P_2O_5) and potassium (K_2O) (MLD, 1991) and the lucerne allowed to grow again for 6 weeks. Irrigation was regularly done as for napier grass. The lucerne was then harvested using a mower, sun-dried for 60 h, baled and stored in a well ventilated hay shed.

Napier grass was harvested in the afternoon, chopped into 25-mm pieces and spread in an open shed until the following morning. Lucerne hay was similarly chopped.

Experimental animals, diets and housing

Twenty-four heifers from each of two breeds, Sahiwal (*Bos indicus*; 124.1 kg LW, SD = 1.92; average age of 15.3 months) and Friesian (*Bos taurus*; 170.1 kg LW, SD = 1.69; average age of 15.5 months) were selected from two large herds in the research station. Friesians were previously grazing an irrigated predominantly Kikuyu grass (*Pennisetum clandestinum*) and Kenya white clover (*Trifolium semipilosum*) mixed sward while Sahiwals were grazing a non-irrigated Naivasha star grass (*Cynodon plectostachyus*) pasture.

Since heifers within breeds had similar weights, they were blocked by breed. The 24 heifers of each breed were then randomly allocated to the six dietary treatments as follows: young napier + 0 kg lucerne (T1); young napier + 1.5 kg lucerne (T2); old napier + 0 kg lucerne (T3); old napier + 1.5 kg lucerne (T4); old napier + 2.5 kg lucerne (T5); old napier + 3.5 kg lucerne (T6) heifer^{-1}day^{-1}. Therefore each diet was offered to four Sahiwal and four Friesian heifers. Napier grass was given *ad libitum*. The heifers were housed and fed individually. A month prior to the start of the experiment, the heifers were treated against helminths. Spraying with acaricide to control ticks was carried out weekly. Water and licks were provided at all times.

Feeding , feed sampling and weighing procedures

Each morning the chopped feed (napier grass and lucerne) to be offered to each heifer was weighed. This was divided into in two equal portions and offered twice daily. The supplement was always given first. Feed to be offered (napier grass) was adjusted daily such that the refusals were not more than 10% of the feed offered.

Feed samples were obtained by regularly taking samples as the chopping progressed (about 10 kg). Sub-sampling was done by spreading the bulked sample on a polythene sheet to form a ridge and taking four segments of the ridge for each of the samples taken for DM, chemical analysis and rumen incubation. Samples of offered feed and refusals were collected daily, oven-dried and stored. Samples for each week were then composited for analysis. The weighing of the heifers was done before feeding on three consecutive days at the beginning of the trial and the procedure repeated fortnightly. The mean weight for the three weights was taken as each heifer's body weight at that time.

Experiment B: Rumen degradation

Four rumen-fistulated steers (two of each breed) approximately 18 months old with mean body weights of 295 kg (Sahiwal) and 340 kg (Friesian) were used. These steers were also individually housed and fed on a mixed diet of napier grass (75%) and lucerne (25%) *ad libitum*. Tick and helminth control were carried out as reported earlier in Experiment A.

Feed samples for rumen incubation were ground to pass through a 5-mm sieve, 5 g weighed and placed in nylon bags (Nybold Switzerland; polymide, porosity 26%, pore size 40 μm). The bags were incubated for 0, 3, 6, 12 (duplicate), 24, 48, 96 (triplicate) and 336 (quadruplicate) hours in each animal. After incubation, the bags were washed in tap water for 5 min after which they were oven-dried at 70°C for 48 h. The dried samples were then weighed to determine dry matter residue.

Chemical analysis

Feed samples were collected daily before morning feeding and composited weekly. The DM was determined by oven-drying at 105°C for 24 h. Feed samples for chemical analysis were, however, oven-dried at 70°C for 24 h. The latter were then ground using a Wiley mill to pass through a 1-mm screen before analysing for organic matter (OM, ashing at 500°C) and Kjeldahl nitrogen (AOAC, 1990). Neutral detergent fibre (NDF) and acid detergent lignin (ADL) were analysed using the method of Van Soest & Robertson (1985). Calcium and magnesium were determined by flame atomic absorption and phosphorus by spectrophotometry (AOAC, 1990). Silica was determined as the ash after the ADF ash was leached for 1 h with 48% hydrobromic acid.

Calculations and statistical analysis

The average daily gains (ADG) over the experimental period were calculated by regressing body weight (kg) of individual heifers (measured fortnightly), on time (in days). The average daily gains (ADG), DM degradation and feed intake were subjected to analysis of variance using the general linear model procedure (GLM) available in SAS (1988). The treatment effects were further partitioned into single degree of freedom orthogonal contrasts. Residual DM at the various incubation times was expressed as fractions of original amounts incubated and the results analysed by non-linear regression (SAS, 1988) according to the model of Robinson *et al.*, (1986):

$$R_t = U + (100 - S - U) * e^{-kd*t}$$

where R_t is residue at time t (%), U is rumen undegradable fraction (336 h incubation, %), S is water soluble fraction (0 h incubation, %) and k_d is fractional rate of degradation (% h^{-1}). The rumen degradation results of the individual diet ingredients were used to calculate the degradation of treatment diets by the method of de Visser (1993) as follows:

Diet degradation = (napier DMI/Total DMI) × napier degradation + (lucerne DMI/Total DMI) × lucerne degradation

The substitution rate was estimated using the following formula: $r = [(a-b)-c]/b \times 100$, where r is substitution rate (%), a is total DM intake (kg), b is DM in supplement (kg) and c is DM intake of basal feed without supplement (kg). Feed efficiency was calculated as gain per feed intake (OM).

Results

Chemical composition

The composition of napier grass and lucerne is shown in Table 1. As expected, napier grass had lower DM content (173 and 185 $g.kg^{-1}$ DM, respectively for 6 and 12 weeks) than the lucerne hay (845 $g.kg^{-1}$ DM). The CP content of lucerne hay (190 $g.kg^{-1}$ DM) was more than twice that of napier grass (85 and 63 $g.kg^{-1}$ DM for 6 and 12-week-old napier grass). However, neutral detergent fibre (NDF) was higher for napier grass than it was for lucerne. Lucerne showed higher OM content since its ash content was lower compared to napier grass. The mean silica levels for napier grass were higher than lucerne whilst the latter showed a higher ADL level. Lucerne was richer in calcium than napier grass although its phosphorus levels were lower. However, the magnesium levels in napier grass and lucerne showed little variation.

Nutrient intake and weight gain (ADG)

The results indicated that lucerne supplementation positively influenced ($p < 0.05$) DM, OM, CP, and NDF intake (Table 2). Friesian heifers showed higher DM and OM intake than the Sahiwal heifers ($p < 0.05$) but the reverse was true when the intake was expressed per metabolic weight.

Table 1 Chemical composition of napier grass (6 and 12-week-old) and lucerne used as ingredients in the heifer diets (treatments)

Composition	Component		
($g.kg^{-1}$ DM basis)	Napier (6 weeks)	Napier (12 weeks)	Lucerne
DM %	173	185	847
OM	788	797	847
CP	85	63	190
NDF	593	611	455
ADF	336	384	447
EE	15	13	16
ADL	3.7	4.5	6.6
Total ash	212	203	153
Residue ash	74	94	34
Silica	72	86	23
Calcium	2.9	2.5	7.5
Phosphorus	5.4	4.4	3.8
Magnesium	1.9	2.1	1.9

DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral detergent fibre, ADF = acid detergent fibre, EE = ether extract, ADL = acid detergent lignin.

Heifers under supplementation (T2, T4, T5 and T6) gained significantly ($p < 0.05$) more weight than those on napier grass alone (Table 2). However, the means for T1 and T3 showed no significant ($p < 0.05$) difference. Treatments T5 and T6 had the highest gains of over 0.60 kg per day for both breeds. Except for T2 and T4, the substitution rates for the supplement were generally low.

Rumen degradation

The lucerne supplement significantly ($p < 0.05$) improved degradation. Generally, the higher the proportion of supplement in the diet, the higher the degradation (Table 3). The fractions *S, D, U* and the rate of degradation, k_d of the diets are shown in Table 3. Napier maturity was also observed to have a negative influence on degradation. At same levels of supplementation, diets containing 12-week-old napier showed a lower degradation as the respective *S, D* and *U* fractions showed.

Discussion

Tropical forages support lower levels of animal production than temperate grasses owing to low CP and digestibility (Minson, 1990). Napier grass in this study had a CP content of 85 g. kg^{-1} DM (6 weeks) and 63 $g.kg^{-1}$ DM (12 weeks) and may be considered to represent what is available in smallholder dairy farms. However, according to the definition of Leng (1990) that low quality forages as those with less than 80 $g.kg^{-1}$ DM CP, the 6 weeks napier grass had marginal CP content while the 12 weeks one would clearly be low quality feed. Nevertheless, lucerne (190 g. kg^{-1} DM CP) would be an excellent supplement since it is easily grown by the smallholders. Legume supplements to low quality tropical grasses improve rumen microbial activity (Minson & Milford, 1967; Reed *et*

Table 2 Mean daily total intake of organic matter (OM), neutral detergent fibre (NDF), crude protein (CP), dry matter (DM), average daily weight gains (ADG), substitution rate (SR) and feed efficiency (FE) for Friesian and Sahiwal heifers consuming 6 or 12 week Napier grass (*ad libitum*) supplemented with graded levels of lucerne

	Intake							
Treatment	DMI (kg)	g DM $kg^{0.75}$	OM (kg)	NDF (kg)	CP (kg)	ADG (kg)	SR (%)	FE (%)
T1 Napier (6 weeks) + 0 kg lucerne								
Friesian	5.4^a	97^a	4.3^a	3.2^a	0.46^a	0.34^a	0.00	0.06
Sahiwal	4.7^b	118^b	3.7^b	2.8^b	0.40^b	0.29^b	0.00	0.06
mean	5.1	114	4.0	3.0	0.43	0.31	0.00	0.06
T2 Napier (6 weeks) + 1.5 kg lucerne								
Friesian	6.4^a	118^a	5.2^a	3.6^a	0.68^a	0.52^a	0.23	0.08
Sahiwal	5.3^b	131^b	4.3^b	3.0^b	0.59^b	0.40^b	0.53	0.08
mean	5.9	125	4.8	3.3	0.64	0.46	0.38	0.08
T3 Napier (12 weeks) + 0 kg lucerne								
Friesian	5.2^a	97^a	4.2^a	3.2^a	0.33^a	0.35^a	0.00	0.08
Sahiwal	4.3^b	111^b	3.5^b	2.1^b	0.27^b	0.30^b	0.00	0.07
mean	4.8	104	3.9	2.7	0.30	0.32	0.00	0.07
T4 Napier (12 weeks) + 1.5 kg lucerne								
Friesian	6.1a	119a	5.8a	4.3a	0.61a	0.52a	0.34	0.09
Sahiwal	5.3b	134b	4.6b	3.4b	0.52b	0.42b	0.22	0.08
mean	5.7	126	5.2	3.9	0.57	0.47	0.26	0.09
T5 Napier (12 weeks) + 2.5 kg lucerne								
Friesian	7.5a	141a	6.1a	5.2a	0.75a	0.65a	0.07	0.09
Sahiwal	6.3b	147b	5.2b	3.6b	0.67b	0.61a	0.08	0.10
mean	6.9	144	5.7	4.1	0.71	0.63	0.08	0.10
T6 Napier (12 weeks) + 3.5 kg lucerne								
Friesian	7.8a	147a	6.4a	4.4a	0.87a	0.66a	0.10	0.09
Sahiwal	6.7b	157b	5.5b	4.7b	0.80b	0.64a	0.21	0.10
mean	7.3	152	6.0	5.0	0.84	0.65	0.16	0.10
S.E.D ($n = 8$)	0.116	1.420	0.103	0.102	0.008	0.037	0.06	0.01
Significance								
T1 vs T2	***	**	***	***	***	***	***	***
T1 vs T3	***	***	ns	**	***	ns	ns	***
T1 and T2 vs T3, T4, T5 and T6	***	***	***	***	***	***	ns	***
T3 vs T4, T5 and T6	***	***	***	**	***	***	***	ns

ns (not significant), $p > 0.05$; **$p < 0.01$ and ***$p < 0.001$.

[a,b] Within treatments, figures bearing different superscripts differ significantly ($p < 0.05$).

al., 1990). Indeed such supplementation increases both energy and protein supply leading to enhanced animal performance (Norton & Poppi, 1995a). This has been demonstrated using other

Table 3 Rumen degradation of the napier grass diets supplemented with varying levels of lucerne

Treatment	Fraction			
	S	*D*	*U*	k_d
T1 Napier (6 weeks) + 0 kg lucerne	27.2	51.2	22.6	3.3
T2 Napier (6 weeks) + 1.5 kg lucerne	27.7	55.9	21.9	3.4
T3 Napier (12 weeks) + 0 kg lucerne	21.7	45.7	25.3	2.7
T4 Napier (12 weeks) + 1.5 kg lucerne	27.1	48.2	23.9	3.0
T5 Napier (12 weeks) + 2.5 kg lucerne	27.7	50.9	23.1	3.1
T6 Napier (12 weeks) + 3.5 kg lucerne	28.4	53.1	22.6	3.3
S.E.	2.3	3.1	2.9	0.6

S = soluble; D = slowly degradable; U = undegradable fraction (U); k_d = rate of degradation (% per hour); S.E. = of diets offered to Friesian and Sahiwal heifers.

legumes in cattle (Muinga *et al.*, 1995; Abdulrazak, *et al.*, 1996) and goats (Richards *et al.*, 1994; Van Eys *et al.*, 1986).

In this study, supplementing napier grass with lucerne increased the crude protein content of the diet leading to enhanced nutrient intake. Across the four levels of supplementation, the difference in intake was about 1.0 kg DM per day. The heifers receiving lucerne supplements consumed slightly less napier grass but total DM intake was higher. This could partly be attributed to the substitution effect. The DMI of Friesian was higher than the Sahiwal heifers, an observation that may be explained by the fact that, within the same treatments, Friesians had heavier body weights. However, intake per metabolic weight was higher for the Sahiwals. This observation tends to support the proposition that *Bos indicus* breeds are better adapted to tropical feeds than *Bos taurus* (Cunningham & Syrstad, 1987). It is also probable that there was some compensatory growth in the Sahiwals because they were previously on a relatively low plane of nutrition (Ehoche *et al.*, 1992).

The increase in weight gain on lucerne supplementation could be explained by improvement in nutrient intake and degradation. It was unexpected that weight gains from 6 and 12 weeks napier would be similar and this could not be easily explained. However, the low gains observed on these diets have been recorded previously on sole napier grass diets (Moran, 1983; Pachauri & Pathak, 1989).

The rates of substitution observed in the study were generally low, a fact that could be attributed to the relatively low levels of lucerne supplement though Sahiwal heifers in T2 showed significantly higher substitution rate for unexplained reasons. The small substitution effect of lucerne contrasts with the effect of concentrate supplements on the intake of basal grass diets. Nevertheless, these results correspond with Van Eys *et al.*, (1986) who found little or no substitution when goats fed on napier grass as a basal diet were supplemented with *Leucaena*. Certain protein-rich supplements demonstrate substitution effect (Mosi & Butterworth, 1985; Norton & Poppi, 1995b) while others show no such characteristic (McMeniman *et al.*, 1988; Ash, 1990) and hence the results from this study were not surprising. It has also been observed that the extent of substitution depends on the rate of degradation (Khalili, 1993).

Most legumes are more lignified than grass (Smith *et al.*, 1972), a phenomenon that was observed in this study. Despite this, lucerne-containing diets were degraded more than the napier grass-only diets. This could be explained by high protein content in the supplemented diets and the high silica content associated with napier grass. Silica binds cellulose and hemicellulose in a manner similar to lignin, thus reducing digestion (Van Soest, 1982). Studies with other legumes have also attributed high degradation to the fragility of cell walls, good buffering capacity and readily degraded mesophyll and phloem tissues (Ndlovu, 1992; Broderick, 1995).

The efficiency with which napier grass was utilized tended to increase with the level of supplement. The supplemented 6 weeks napier grass was more efficiently used than the unsupplemented one. For the 12 weeks napier grass, the highest efficiency occurred at 2.5 kg lucerne supplementation level. It may be possible that at the higher supplementation level, energy became a limiting factor and hence no further improvement in the efficiency of utilization could be gained.

Conclusion

The improved protein status of the diet increased the supply of protein to the rumen, making the rumen microbes proliferate, thus enhancing microbial activity. This consequently led to higher nutrient intake and weight gains. Therefore, the results from this study suggest that lucerne supplementation would greatly improve animal production in smallholder dairy farms.

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