Supplementation with *Gliricidia sepium* and *Leucaena leucocephala* on voluntary food intake, digestibility, rumen fermentation and live weight of crossbred steers offered *Zea mays* stover

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Abstract

Twenty intact and five fistulated crossbred steers were used in two experiments to examine the effect of supplementing maize stover with *Gliricidia sepium* or *Leucaena leucocephala* forage on intake, rumen fermentation, microbial protein supply and live weight changes. The basal diet plus 1 kg maize bran was offered alone or supplemented with 7.5, 15, 22.5 or 30 g DM/kg of *Gliricidia* (experiment 1), and with either 15 or 30 g DM/kg of *Gliricidia* or *Leucaena* forage (experiment 2). Supplementation increased total dry matter intake (TDMI) (*P < 0.001*). DMI of stover was depressed (*P < 0.001*) in experiment 1 from 2.1 to 1.3 kg/day, but increased at the lower levels of supplementation in experiment 2. Diet digestibility was only significantly increased in experiment 2. Supplementation increased the rumen ammonia from 53 to 106 mg/l and from 31 to 111 mg/l in experiment 1 and 2 respectively, and tended to improve the degradation characteristics of the basal diet. The efficiency of microbial N supply ranged between 21.0 and 27.7 g N/kg DOMR. The live weight gains from supplementation were greater, and the responses to *Gliricidia* and *Leucaena* did not differ significantly. It is concluded that the supplementation improved dry matter intake and live weight gains, and that *Gliricidia sepium* could be an alternative supplement to *Leucaena leucocephala*. © 1997 Elsevier Science B.V.

Keywords: Cattle; Intake; Rumen; Live weight; Gliricidia; Leucaena; Legume forages; Rumen fermentation; Growth performance

1. Introduction

A major constraint to cattle performance in the tropics is the inadequacy of feeds, particularly during the dry season when the quality and quantity of natural pasture declines resulting in lower intakes and reduced cattle productivity. Crop by-products such as maize stover are an important source of dry season feed in Africa, yet because they are fibrous and generally low in nitrogen and digestible nutrients, supplementation is required to achieve reasonable levels of cattle production. Tree legumes, which
persist during the seasons of pasture scarcity can contribute protein-rich forage for cattle production (Devendra, 1993). In a previous work (Abdulrazak et al., 1995 and Muinya et al., 1995), it was shown that supplementing napier grass fodder with foliage from the tree legumes, *Leucaena leucocephala* and *Gliricidia sepium*, improved the dry matter intake and live-weight gain of young cattle and lactation performance of dairy cows. The recent infestation of *leucaena* in Africa by the pest *Heteropsylla cubana* (Reynolds and Bimbuzi, 1993) and its poor performance in acid soils, calls for alternative tree legumes to leucaena. *Gliricidia* may meet these requirements (Bennison and Paterson, 1993; Coates, 1995).

The objective of this study was to evaluate the effects of incremental supplementation with leucaena and *gliricidia* on the intake, rumen fermentation, microbial N supply and live weight of steers offered a diet of maize stover *ad libitum*. The estimates of rumen parameters and animal performance will contribute towards the development of feeding systems that utilise optimal levels of the legume forages for tropical cattle production.

2. Material and methods

2.1. Production environment

The experiments were conducted at the Kenya Agricultural Research Institute’s Regional Research Centre at Mtapa (3°56'S, 39°44'E) in the coastal lowlands of Kenya. The total rainfall and the mean temperature and relative humidity during each experiment were 87.6 mm, 26.6°C and 0.74 (experiment 1) and 2.6 mm, 27.6°C and 0.67 (experiment 2), respectively.

2.2. Animals

Twenty *Bos taurus* (Ayrshire/Brown Swiss) × *Bos indicus* (Sahiwal) steers of known breed composition were used for both experiments measuring the intake, digestibility, microbial N supply and rumen kinetics. Weekly live-weight changes were recorded to estimate the average daily gains (g/day). Five fistulated steers of similar breed composition to the 20 steers were used for the studies in which the rumen pH, ammonia(NH$_3$-N) and fermentation characteristics of the feeds were determined at the start of the experiments. The mean live weight of the twenty steers and the fistulated steers were 90 kg (s.d. 9.0) and 428 kg (s.d. 53.3) (experiment 1), and 168 kg (s.d. 9.6) and 417 kg (s.d. 54.0) (experiment 2), respectively.

All steers were confined in individual ventilated stalls, and each week they were weighed and sprayed with an acaricide. Before the first experiment, the steers were drenched anthelmintic and blood was sampled from the vein for screening for trypanosomes.

2.3. Diets

Puani hybrid maize was planted at the research centre for the production of stover. During peak growth, triple superphosphate fertilizer was applied at the rate of 46 kg P$_2$O$_5$/ha. During weeding the maize was top dressed with calcium ammonium nitrate at the rate of 60 kg N/ha. After the maize was cut 5 cm above the ground; tied in bundles and stored in a shed used in the experiments.

*Gliricidia* and *leucaena* had been established pure stands with spacing of 1 m between and 3 m within the rows. During the experiments, the legume forages were harvested daily at approximate weeks of regrowth. Stems thicker than 5 mm were removed to ensure uniform forage composition.

2.4. Experimental design and procedures

In each experiment the twenty steers were divided into five groups on the basis of their live weight and allocated to five diets in a randomised design. Measurements were recorded for seven weeks.

Five fistulated steers were offered the same treatments in a 5 × 5 latin square design in which each period consisted of a 10-day adaptation and a data collection period.

The five experimental diets were as follows:
- Stover plus 1 kg of maize bran (control), or control plus 7.5, 15, 22.5 or 30 g DM/kg W$_{0.75}$ of *gliricidia* (experiment 1), or control plus 15 or 30 g DM/kg W$_{0.75}$ of *leucaena* forage (experiment 2).
- Whole dry maize stover was chopped with an electric chopper, crushed in a hammer mill and poured into feed bags. The bags were tied and hung in an oven at 40°C until dry. The dry stover was then ground and mixed with the appropriate amount of a rumen fermentation stimulator (10% dextrin, 2% yeast, 6% soyabean meal and 5% wheat bran).

The pH of the feed was determined, using a pH
to pieces of about 40–60 mm and offered ad libitum. The legume forage and 1 kg of
wheat bran were offered separately in two equal
portions at 06:00 and 15:00 h. The forage was harvested
in the morning for the afternoon feed and in the
evening for the following day feed. Refusals were
removed and recorded before offering new feed the
next day. Animals with refusals of the basal diet of
less than 1 kg fresh weight were offered 1 kg more
water than the amount offered the previous day. The
forage offered were sampled once per week for DM
determination. The live-weights recorded at the end
of each week of each experiment were used to
calculate the amount of legume forage to be offered
during the subsequent week. Water and a mineral
salt which contained 189 g Ca, 110 g P, 130 g Na, 4 g
K and 1.6 g Cu per kg, were on offer at all times.

2.1 Rumen pH, NH₃ and in sacco degradation

To determine the in sacco degradation characteristics
of the forages, five grams of dry (at 85°C)
samples milled through a 3.5 mm screen were placed
in nylon bags (140 X 75 mm, pore size 40 to 60
µm). During the last four days of each experiment
nylon bags in duplicate containing stover and
gliricidia (experiment 1), or stover, gliricidia and
wheat bran (experiment 2), were placed in the rumen.
The bags were removed after 6, 12, 24, 48, 72 and
120 h for legume forages and up to 120 h for stover
samples. All the bags were then stored in a freezer.

Zero-hour measurement was obtained by soaking
bags in warm water (37°C) for about 15 minutes.
At the end of the degradability trial the bags were
washed under running water until the water
coming out of the bags was clear. The samples were
then dried in an oven at 85°C to determine DM
appearance. The DM disappearance values were
then fitted to the exponential equation of McDonald
(1971).

\[ y = A + b(1 - e^{-CT}) \]

The degradation curve is described as: within
the initial time T, \( y = A \), i.e. the initial washing loss;
and after the time T, \( y = a + b(1 - e^{-CT}) \) where a, b
are degradation constants. During the last two
weeks of the degradability study, about 100 ml rumen
fluid samples were collected at 0, 1, 2, 3, 4, 6, 8, 10 and
12 h after the morning portion of supplement was of-
fed. The pH of the sample was determined imme-
diately, using a pH stick. The sample was strained
using a clean cotton cloth and the liquid fraction
acidified with HCl acid and stored at -20°C for
later analysis of rumen ammonia.

2.6 Urine and faeces collection

The total daily faecal output and spot urine samples
of the 20 steers were collected by stationing an
attendant with a bucket by each animal to collect all
excreta voided during the last 7 days of the trial. The
spot urine samples were collected between 09:00 and
13:00 h. Urine samples were measured daily and 100
ml of urine were stored in small plastic bottles
containing 7 ml of 10% H₂SO₄ to give a pH below
3. The urine samples were stored at -20°C to be
analyzed for purine derivatives (allantoin and uric
acid) and creatinine. After recording the weight, a
proportion (0.10) of the 24 h faecal collections was
stored at 4°C. At the end of the collection period the
faecal samples were bulked, mixed and a sub-sample
obtained for DM and ash determinations.

2.7 Solid outflow rate

Chromium-mordanted stover was prepared accor-
ding to the method of Uden et al. (1980). All the
twenty steers were dosed orally with 130 g Cr-mor-
danted stover, and grab samples were taken at 6, 12,
20, 25, 30, 46, 54, 70, 94, 102 and 118 h post-dos-
ing, and stored at 4°C for analysis of chromium
oxide.

3. Analytical methods

DM of feeds and of faeces were determined by
drying the samples in an oven at 105°C for 24 h, ash
by ashing at 550°C for 8 h, and crude protein (CP)
by the official methods of the Association of Official
Analytical Chemists (Association of Official Analytical
Chemists, 1984). Neutral detergent fibre (NDF)
and lignin were determined by the method of Goer-
ing and Van Soest (1970). Rumen NH₃-N was
determined as described by Preston and Leng (1987),
and purine derivatives according to the method of
Chen et al. (1990a). Faecal sample for the determina-
tion of particulate passage were digested with a
combination of sulphuric, perchloric and nitric acid.
Chromium concentration was assayed with an atomic absorption spectrophotometer (Perkin-Elmer 2380). Microbial purine absorbed (MPA) by the animals was estimated from the daily excretion of purine derivatives (PD) based on the model described by Chen et al. (1990b). The ratio PD:C (mmol:mmol) concentration in the spot urine samples was corrected for metabolic body weight \( W^{0.75} \), since daily creatinine excretion in urine appears as a function of the metabolic weight of the animal. The calculation was made as

\[
\text{PD:C} = \frac{\text{PD concentration}}{\text{creatinine concentration} \times W^{0.75-1}}
\]

Calculation of PD excretion from spot samples of urine was based on the findings of Mejia (1992) that the ratio of PD to creatinine concentration was positively related to daily output of PD.

\[
\text{PD} = (C \times W^{0.75-1}) = 1.79X + 4.51 \quad (r^2 = 0.84) \quad (1)
\]

where \( X = \) daily excretion of PD (mmol/day).

The supply of microbial N (i.e., entering the small intestine) was calculated from MPA using the following factors (Chen, 1989) that, digestibility of microbial purine is 0.83 and the ratio of purine-N to total microbial-N ratio is 0.116:1.00. Thus microbial N supply (g/day) = MPA \times 0.83 \times 0.116 \times 1000 = 0.727 \times MPA, where 70 is the N content (mg/mmol) of purine.

3.1. Statistical analysis

Data from the experiments were subjected to analysis of covariance using the General Linear Model (GLM) of the SAS computer package (Statistical Analysis Systems, 1987). In experiment 1, polynomial contrasts were used to estimate effects of the level of supplement (Snedecor and Cochran, 1980). The model also evaluated the effect of age (0.25–0.42 or 0.50–0.67 Satwal genotypes) on experiment 2 the type and levels of legume, live-weight was a covariate in the analysis of dry matter intake and live-weight change. In the analysis of Latin square experiments, the effects of diet, period, and animal were fitted. The fractional rates of microbial passage were derived by fitting the model of Grovum and Williams (1973).

4. Results

The animals remained healthy throughout the experiments. The chemical composition of feeds as presented in Table 1, the legume results are presented as means of seven observations. The legumes forages had a higher CP and lower DM NDF and than maize stover. In experiment 2, gliricidia contained relatively more NDF (427 vs 394 g/kg DM) than leucaena. Crude protein content of gliricidia was similar in the two experiments, and slightly lower than that of leucaena.

DM intake, diet digestibility, live-weight gain and microbial nitrogen supply in experiments 1 and 2 are presented in Tables 2 and 3, respectively. During the first week of the experiment the steers refused some of the gliricidia offered, but all were

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Chemical composition of feeds used in experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DM (g/kg)</td>
</tr>
<tr>
<td><strong>Experiment 1</strong></td>
<td></td>
</tr>
<tr>
<td>maize stover</td>
<td>863</td>
</tr>
<tr>
<td>gliricidia</td>
<td>254</td>
</tr>
<tr>
<td>maize bran</td>
<td>870</td>
</tr>
<tr>
<td><strong>Experiment 2</strong></td>
<td></td>
</tr>
<tr>
<td>maize stover</td>
<td>867</td>
</tr>
<tr>
<td>gliricidia</td>
<td>258</td>
</tr>
<tr>
<td>leucaena</td>
<td>310</td>
</tr>
<tr>
<td>maize bran</td>
<td>875</td>
</tr>
</tbody>
</table>

nd = not determined.
Table 2

<table>
<thead>
<tr>
<th>Level of gliricidia (g DM/kg W^{0.75})</th>
<th>s.e.d</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>7.5</td>
</tr>
<tr>
<td>DM (kg/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>forage</td>
<td>2.1</td>
<td>1.8</td>
</tr>
<tr>
<td>gliricidia</td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td>total</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Digestibility:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM (g/kg)</td>
<td>516</td>
<td>471</td>
</tr>
<tr>
<td>OM (g/kg)</td>
<td>570</td>
<td>509</td>
</tr>
<tr>
<td>ADG (g/day)</td>
<td>203</td>
<td>179</td>
</tr>
<tr>
<td>N supply (g N/kg DOMR)</td>
<td>30.8</td>
<td>27.2</td>
</tr>
<tr>
<td>OM supply (g N/kg DOMR)</td>
<td>23.4</td>
<td>27.7</td>
</tr>
</tbody>
</table>

DOMR = digestible organic matter fermented in the rumen, taken as 0.65 of the digestible OM intake (ARC, 1984).

Consumed subsequently. The incremental levels of gliricidia depressed linearly (P < 0.01) the intake of the maize stover diet, but increased linearly (P < 0.001) the total DMI by approximately 0.21 kg DM/day for every 10 g DM/kg W^{0.75} /day offered. In experiment 2, steers consumed significantly (P < 0.05) more stover when 15 g DM/kg W^{0.75} but not 30 g DM/kg W^{0.75} of either gliricidia or leucaena was offered. Supplementation with either of the legume forages increased the total DMI (P < 0.001). In experiment 2, but not in experiment 1, supplementation increased diet digestibility (P < 0.01).

In both experiments the unsupplemented steers gained weight. In experiment 1, the live-weight gains increased linearly (P < 0.01) with gliricidia supplementation: for every 10 g DM/kg W^{0.75} increment, approximately 69 g/day live-weight was gained. In experiment 2, live-weight gains were approximately 700 g/day at the higher level of supplementation.

Table 3

<table>
<thead>
<tr>
<th>Level of supplements (g DM/kg W^{0.75})</th>
<th>s.e.d</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>G15</td>
</tr>
<tr>
<td>DM (kg/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>forage</td>
<td>2.3</td>
<td>2.6</td>
</tr>
<tr>
<td>OM</td>
<td>502</td>
<td>569</td>
</tr>
<tr>
<td>N supply (g N/kg DOMR)</td>
<td>30.8</td>
<td>27.2</td>
</tr>
</tbody>
</table>

DOMR = digestible organic matter fermented in the rumen, taken as 0.65 of the digestible OM intake (ARC, 1984).

Calculated microbial N supply = 0.715 × estimated purine.

L = linear, Q = quadratic effect.
Table 4
Rumen pH, ammonia, and in sacco degradation of feeds measured in steers offered maize stover plus maize bran alone or with forage

<table>
<thead>
<tr>
<th>Level of gliciridia (g DM/kg W&lt;sup&gt;0.81&lt;/sup&gt;)</th>
<th>0</th>
<th>7.5</th>
<th>15</th>
<th>22.5</th>
<th>30</th>
<th>r.e.d</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rumen pH</td>
<td>6.99</td>
<td>6.79</td>
<td>6.88</td>
<td>6.73</td>
<td>6.72</td>
<td>0.17</td>
<td>NS</td>
</tr>
<tr>
<td>NH&lt;sub&gt;3&lt;/sub&gt;-N (mg/l)</td>
<td>53</td>
<td>81</td>
<td>87</td>
<td>91</td>
<td>106</td>
<td>28.2</td>
<td>NS</td>
</tr>
</tbody>
</table>

Degradation constants

<table>
<thead>
<tr>
<th></th>
<th>maize stover</th>
<th>gliciridia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>8.3</td>
<td>7.7</td>
</tr>
<tr>
<td></td>
<td>71.5</td>
<td>70.7</td>
</tr>
<tr>
<td></td>
<td>0.018</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>0.084</td>
<td>0.136</td>
</tr>
</tbody>
</table>

A is the water soluble component and B the insoluble component; B = (a + b) - A.

Type of legume did not affect the response (Table 3). In experiment 1 gliciridia supplementation increased quadratically (P < 0.05) the calculated microbial N supply. When expressed proportionally to the digestible organic matter fermented in the rumen (DOMR), the efficiency of MN supply ranged between 21.0-27.7 g N/kg DOMR. In experiment 2 the efficiency ranged between 20.5-24.6 g N/kg DOMR.

Table 5
Rumen pH, ammonia, and in sacco degradation characteristics of feeds measured in steers offered maize stover plus maize bran alone or with gliciridia forage

<table>
<thead>
<tr>
<th>Level of supplements (g DM/kg W&lt;sup&gt;0.81&lt;/sup&gt;)</th>
<th>0</th>
<th>G15</th>
<th>G30</th>
<th>G50</th>
<th>L15</th>
<th>L30</th>
<th>r.e.d</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rumen pH</td>
<td>6.97</td>
<td>6.99</td>
<td>6.86</td>
<td>6.96</td>
<td>6.93</td>
<td>6.93</td>
<td>0.081</td>
<td>NS</td>
</tr>
<tr>
<td>NH&lt;sub&gt;3&lt;/sub&gt;-N (mg/l)</td>
<td>31</td>
<td>85</td>
<td>101</td>
<td>95</td>
<td>91</td>
<td>111</td>
<td>20.4</td>
<td>NS</td>
</tr>
</tbody>
</table>

Degradation constants

<table>
<thead>
<tr>
<th></th>
<th>maize stover</th>
<th>gliciridia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>7.8</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>73.2</td>
<td>69.6</td>
</tr>
<tr>
<td></td>
<td>0.020</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>30.7</td>
<td>31.4</td>
</tr>
<tr>
<td></td>
<td>48.9</td>
<td>46.8</td>
</tr>
<tr>
<td></td>
<td>0.092</td>
<td>0.096</td>
</tr>
<tr>
<td></td>
<td>30.2</td>
<td>31.9</td>
</tr>
<tr>
<td></td>
<td>44.7</td>
<td>42.7</td>
</tr>
<tr>
<td></td>
<td>0.072</td>
<td>0.084</td>
</tr>
</tbody>
</table>

A is the water soluble component and B the insoluble component; B = (a + b) - A.

2G, 2L = levels of gliciridia and leucaera respectively.
offered maize stover plus maize bran alone or with gliricidia or leucaena.

<table>
<thead>
<tr>
<th>Level of supplements (g DM/kg W(^{0.75}))</th>
<th>s.e.d</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>G30</td>
<td>L15</td>
</tr>
<tr>
<td>0.0212</td>
<td>0.0352</td>
<td>0.0220</td>
</tr>
<tr>
<td>0.0851</td>
<td>0.1068</td>
<td>0.1592</td>
</tr>
<tr>
<td>47.5</td>
<td>29.3</td>
<td>48.0</td>
</tr>
<tr>
<td>13.8</td>
<td>10.2</td>
<td>7.8</td>
</tr>
<tr>
<td>61.4</td>
<td>39.5</td>
<td>55.9</td>
</tr>
</tbody>
</table>

Table 1: Levels of gliricidia and leucaena respectively.

Effect of supplements on forage digestion and feed intake

The stover in these trials had a similar chemical composition to that reported by Getachew et al. (1994) and Shem et al. (1995). The high lignocellulose and low N contents of stover result in low intakes by cattle, and when stover is offered alone, nutrient intakes are generally insufficient for maintenance requirements. Consequently maize bran was offered to all the animals in these experiments to minimise any possible live-weight loss.

Tree legume forages have several effects when offered as supplements to such poor quality feeds; they supply nutrients such as N and S (Egan, 1986), which improve the rumen environment and the degradation characteristics of the feeds, and generally they result in increased dry matter intake. In this study, supplementation with gliricidia and with leucaena significantly improved total DMI, and in both experiments the improvement could be attributed to a reduction in the particulate retention time in the gut. The MRT was higher in the unsupplemented than supplemented animals (61.4 vs 54.1/h), in agreement with the results of Bamualim et al. (1984). The increase in total DMI is consistent with the results of Bonsi et al. (1994) who studied legume supplementation of a teff straw diet.

Supplementation with gliricidia forage in experiment 1 depressed the intake of maize stover even at the lower levels of inclusion. By contrast, in experiment 2 when gliricidia and leucaena were offered at 15 g DM/kg W\(^{0.75}\), more stover was consumed than when unsupplemented. Supplementation of low quality diets have been reported both to improve the intake of the basal diet (Minson and Milford, 1967; Pathirana et al., 1992), and to depress intake (Mosi and Butterworth, 1985; Getachew et al., 1994).

Smith and van Houtert (1987) indicated that when gliricidia is readily consumed it distends the rumen, restricting the intake of the basal diet, while Tjandraatmadja et al. (1993) associated the lower intake
of gliricidia forage to its distinctive odour. In these studies, gliricidia was offered after wilting for about 7 h post-harvest; it was readily consumed; and, it was extensively degraded in the rumen. As the degradation of stover was not depressed, it is unlikely that the substitution of stover in experiment 1 was due to decreased cellulolysis.

5.2. Rumen ammonia concentrations

Tree legume contains considerable amounts of antinutritional factors like tannin which have depressed intake and digestion in ruminants (Makkar, 1991). Polyninyloxyrolidone (PVP) has been used to reverse tannin inhibition of digestive enzymes (Blytt et al., 1988) and to assess the phenolic-related antinutritive factors in these browse species (Khazaal and Ørskov, 1994). Incubating leucaena and gliricidia in vitro with or without PVP, resulted in no difference in gas production between the samples with or without PVP (Abdulrazak, 1995). This would indicate that tannin-like compounds were unlikely to have had any inhibitory effect, at least on the digestion in the rumen. The total extractable phenolics measured in gliricidia and leucaena were approximately 15.6 mg/g DM (Abdulrazak, 1995). Mean ammonia levels in the rumen liquor of the unsupplemented animals were relatively lower (31 vs 53 mg/l) in experiment 2 than in 1. The provision of ruminally degradable nitrogen from the legume forages in experiment 2 may have improved the N status in the rumen, resulting in an increase in the intake of the basal diet. The level of NH₃-N in the rumen depends on several factors, one of which will be the type of diet being fermented. While Satter and Slyter (1974) indicated that 50 mg/l was the minimum level required for the maximum microbial growth in the rumen, Mehrez et al. (1977) showed that with high energy diets, NH₃-N levels as high as 238 mg/l were required to maximize the digestion of fibre. In experiments 1 and 2, supplementation with legume forages increased rumen NH₃-N from 53 to 106 mg/l and 31 to 111 mg/l, respectively. Levels of 50-80 mg/l seemed to have been sufficient for fibre digestion because higher levels did not significantly increase the degradation characteristics of the feeds in the rumen.

Studies to estimate the changes in the microbial population in the rumen were not carried out; however, it could be speculated that the legume alleviated nutrient deficiencies, in the probably increased cellulolytic microbes and the degradation rate of improving the intake of the basal diet. This type of intake of basal diet was observed at the lower level of leucaena supplementation in experiment 2; consistent with those reported by Mirson and Battersford (1967). Ash (1990) and Kukumbo et al. (1984). At the higher levels of supplementation, the intake of the basal diet tended to decline, probably due to the bulk of the forage supplement.

Supplementation with legume forages improved the digestibility of the diets in experiment 2; this is in which the digestibility of the control diet was lower than in experiment 1. Mosi and Battersford (1985) and McMeniman et al. (1988) reported improvement in digestibility in sheep when the crop residue diet supplemented with legume and increasing levels of the legume Trifolium bense (Clover), respectively. The improved digestibility could have resulted from reduced levels of ADF and lignin (Van Soest, 1982).

Microbial N supply tended to improve with supplementation. Differences in purine derivatives resulting from supplementation may not have been expected as the treatment differences were relatively small (Chen, personal communication). The estimated values were within the range 14 to 60 g N/kg DOMR suggested by Agricultural Research Council (1980), and were consistent with those reported in the previous experiments (Abdulrazak, 1995).

5.3. The effects of supplements on animal performance

Supplementation with the legume forages increased total N supply: it increased the supply in the rumen and the microbial N supply and it provided some rumen undegradable protein in the form of amino acids to the small intestine. These N sources would have contributed to the increased live-weight gains (Ørskov, 1992). The responses in experiment 2 were such that every 10 g DM/kg W₀.75 resulted in 69 g/day live-weight gain. In experiments 2
supplementation were greater, and of gliricidia and leucaena indicated that for low quality basal diets, protein is most effectively used at about 30% level.

In conclusion, the results indicate that moderate (20–30%) of tree legume forage supplements can significantly improve the intake and performance of ruminants in the tropics, particularly during the dry season. Since Leucaena leucocephala has been heavily attacked by the insect pest Heteropteryx dubia in many regions, it is also concluded that Gliricidia sepium could be an alternative supplement to Leucaena leucocephala. Research is needed to evaluate other potential tree legumes as ruminant foods.

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References


Groven, W.L., Williams, V.J., 1973. Rate of passage of dry matter through the alimentary tract and