Nutritional improvement of maize silage for dairying: mixed-crop silages from sole and intercropped legumes and a long-season variety of maize.

1. Biomass yield and nutritive value

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Abstract

Fifteen legumes were evaluated for their potential to provide high yields of good quality material for inclusion with maize biomass to improve the nutritional value of maize silage. Optimum time of harvest and planting date relative to the maize crop were determined. In addition to growing the legumes as sole crops, their performance as in-row intercrops with a long-season maize cultivar was investigated, to determine whether the nutritive value of the maize biomass could be increased with little compromising of yield, and with a view to decreasing harvesting and mixing procedures and machinery requirements. High yields of biomass of high digestibility and crude protein content were produced by sole crops of soyabean, forage soyabean and lablab. Maximum digestible dry matter (DDM) yields of grain and forage soyabean were 4840 and 6140 kg/ha (at mid and late green pod), respectively, whilst the highest DDM yield measured for lablab of 5243 kg/ha at early green pod indicated that this legume had not reached its peak. Though sunnhemp was very productive as a sole crop, its stemminess and poor quality restricted its use to being harvested at very early flowering. To ensure synchronization of harvesting between these legumes and maize cut for silage at 16–17 weeks after planting, based on quality and yield of biomass, grain soya should be planted 1–2 weeks later than, and forage soya and lablab at approximately the same time as, the maize. The legumes showing potential for intercropping with maize were the soyabean, lablab and velvet bean and possibly sunnhemp and cowpea. In-row intercropping with

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long-season maize did not prove to be a viable system: the proportion of legume in the biomass was only 15% or less, except with velvet bean which comprised nearly 30% of the biomass but depressed maize yield unacceptably. © 1997 Elsevier Science B.V.

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1. Introduction

Spiralling production costs have seriously threatened viability of dairying in Zimbabwe, to the extent of forcing over 25% of large-scale producers out of dairying in recent years (Anderson, 1995). The most significant increase in variable costs come from those of feed, in particular protein concentrates such as cottonseed cake and soyabean meal. Small-holder dairy producers are similarly afflicted, and cannot afford high-cost protein concentrates to alleviate the general shortage of good quality feed; consequently average yields are only 6 l/day and milk production is seasonal (Dube, 1995). An alternative is to grow and conserve protein-rich forages on the farm.

Small-holder dairy farmers, as well as many large-scale producers, are unlikely to have access to irrigation. Therefore in order to provide protein-rich forages throughout the year they have to be grown during the summer rains, to both feed dairy cows during this period and to be conserved in sufficient quantities for the dry season (at least 6 months in Zimbabwe). Forages can be conserved either as hay or silage. In order to ensure optimum digestibility and nutrient content (particularly protein), the forage crop has to be harvested well before maturity (Beever, 1980; Leaver, 1988). This means that in Zimbabwe harvesting must take place during the rainy season which presents a major constraint to hay making, since it is difficult to ensure rapid and adequate drying to prevent putrefaction of the forage material. There are special problems with conserving lablab, the best adapted annual legume for Botswana, as the leaves shatter 3 days after cutting whilst the stems take 6 weeks to dry (Boitumelo and Mahabile, 1992). Silage making, on the other hand, can be carried out during the rains because the procedure is very rapid, and the forage is required to have no more than 30% dry matter (DM) (Hunt et al., 1992).

Although many dairy farmers in Zimbabwe currently make silage, it is predominantly pure maize silage, having a crude protein (CP) content of only approx. 75 g/kg DM (Topps and Oliver, 1993). It was hypothesized that a combination of an energy-rich crop, such as maize or sorghum, and a protein-rich crop, such as herbaceous legume, would ensile successfully and serve to produce protein-rich silage adequate for maintenance and production of dairy cows (Wilson and Wood, 1988). Although Nobbs and Oliver (1987) state that the protein content of maize silage can be improved by intercropping with velvet bean, silage yield is reported to decrease to approx. 25 t/ha as compared to approx. 40 t/ha for maize alone.
Intercropping of cereals with legumes has been shown to have considerable potential for increasing CP yields, for example introducing lablab into maize doubled yields up to 1300 kg/ha (Nnadi and Hague, 1986). However, this can be greatly influenced by spatial arrangement and density of the cereal and legume (Nnadi and Hague, 1986). In-row intercropping lends itself to harvesting using the commonly available single-row silage cutters.

The objective of this research was to evaluate a number of locally adapted legumes for their potential to produce high yields of good nutritional quality biomass for mixing with maize at ensiling, and to assess their optimum time of harvest and planting date in relation to the maize crop. Additionally, their performance under in-row intercropping was investigated, to determine whether the nutritive value of the maize biomass could be increased with little compromising of yield, and with a view to decreasing harvesting and mixing procedures and machinery requirements. Fifteen legumes with a range of seasonality and growth habits were selected for screening. The maize cultivar used was a long-season, high-yielding variety popular with dairy farmers for silage making in Zimbabwe.

2. Materials and methods

The legumes and their growth habit are listed below.

Short and bushy (non-trailing, non-twining):

- *Glycine max*, grain soyabean (cv. Duiker);
- *Glycine max*, forage soya (cv. Gamma);
- *Lupinus albus*, white lupin (cv. Lucky);
- *L. angustifolius*, narrow-leafed lupin (cv. Gungurru);
- *L. cosentinii*, sandplain lupin (cv. Erregulla);
- *L. luteus*, yellow lupin (cv. Juno); and

Tall (non-trailing, non-twining):

- *Crotolaria juncea*, sunnhemp.

Trailing or twining:

- *Desmodium uncinatum*, silverleaf desmodium;
- *Lablab purpureus*, lablab;
- *Macroptilium atropurpureum*, siratro;
- *Macrotyloma axillare*, archer;
- *Mucuna pruriens*, velvet bean;
- *Phaseolus coccineus*, scarlet runner bean (cv. White Emergo); and

Of these, soyabeans, the lupins, runner bean and cowpea are primarily grain
legume types, though cv. Gamma is used for forage, sunnhemp, lablab and velvet bean are annuals used for forage and green manuring, and lucerne, silverleaf, siratro and archer are perennial herbaceous pasture species. The two soyabean cultivars, Duiker and Gamma, represent, respectively, the early- to medium-maturing types with high seed-yield potential and the late-maturing types with high fodder-yield potential (COPA, 1981). A trailing habit in cowpea was considered more suitable for intercropping than an erect cultivar (Wien and Smithson, 1981). The maize cultivar used was ZS206, a late-maturing hybrid.

The fifteen legumes were planted either as sole crops or intercropped with maize (in-row) in mid-December, soon after the late start of the summer rains. All legume seed was inoculated with appropriate rhizobia strains. The site was 15 km north of Harare, at an altitude of 1480 m on a fersiallitic reddish brown clay soil, and in the year of this trial total rainfall received was 693 mm. The sole maize was planted at 17×90 cm, but this spacing was increased to 25×90 cm in the intercrops, i.e. target populations of 65 000 and 44 000 plants/ha, respectively (Nobbs and Oliver, 1987). The spacing of sole legumes was 11×30 cm, i.e. a target population of 303 000 plants/ha. When intercropped the target was two legume plants between maize plants. Basal fertilization per hectare consisted of 300 kg Compound D (8% N, 6% P, 6% K, 6.5% S), 350 kg single superphosphate (8% P, 12% S), 200 kg potassium chloride and 2 t lime, and in the case of lucerne 30 kg borax (22% B). Maize was topdressed with ammonium nitrate at 5 weeks after planting (WAP), at the rate of 5 g/plant.

A randomized complete block design was used. Sole legume and maize plots were planted in six pairs of adjacent randomized blocks, with analysis of variance for each done separately and intercrop/sole crop comparisons made informally. Net plot size was 17.94 m² for sole legumes and 29.25 m² for all maize plots.

The legumes were sampled (row lengths of 2.5 m and 3 m for sole and intercropped plots, respectively) at 2-week intervals from 10 to 18 WAP to monitor development, productivity and quality. The plants were separated into stem, leaf and pod, followed by drying (60°C) and weighing. Maize row-lengths of 3 m were harvested from all intercropped and sole maize plots at the milk-dough stage at 16 WAP.

For chemical analysis, due to the large number of samples involved, the biomass harvested from replications for each sole crop legume, and similarly for the intercrop legumes, from any one time of harvest were combined, the results thus being indicative of nutrient value and trends, though not statistically comparable. These were then milled on a whole plant basis and two subsamples of each analysed for CP (Miller, 1982) and modified acid detergent fibre (MADF) (Goering and Van Soest, 1970). Unfortunately some samples were lost, leading to missing data points. Digestible crude protein (DCP) was derived from CP, using DCP% = 0.9 CP% - 3 (Leroux and Sithole, 1974), being an acceptable system for low-producing cows (Reynolds, 1987). DM digestibility was derived from MADF, using DM digestibility % = 99.43 - 1.17 MADF% (Linn and Martin, 1991).
3. Results

3.1. Sole cropping

3.1.1. Biomass yield and partitioning

There were marked differences between the productivity of the fifteen legumes. By far the most productive was sunnhemp, with a maximum dry matter (DM) yield of over 12 t/ha at 18 WAP. The next most productive legumes were forage soyabean and lablab, with yields of over 9 t DM/ha at 18 WAP, significantly more ($P < 0.05$) than soyabean and white lupin which yielded approx. 7 t DM/ha at approx. 15 and 18 WAP, respectively.

The performance of the other sole cropped legumes was relatively poor. Sandplain lupin gave a maximum yield of nearly 5 t DM/ha at 16 WAP, which was not significantly more than that of velvet bean of nearly 4 t DM/ha, also at 16 WAP, whilst the maximum biomass produced by cowpea was just over 4 t DM/ha at 14 WAP. The maximum biomass produced by runner bean, the narrow-leafed and yellow lupins, and by the four perennial herbaceous pasture species up to 18 WAP, was approx. 3 t DM/ha or less. Runner bean foliage was heavily infested with rust (Uromyces vicia-fabae) and cercospora blight (Cercospora canescens) which reduced biomass rapidly 12 WAP. Growth curves (Fig. 1) and results concerning quality parameters are presented only for the eight most productive of these legumes.

With the highest yielding grain legume species, i.e. the soyabean and white lupin, the proportion of biomass comprising leaf and pod (Fig. 2) increased with pod development and was at or near maximum as biomass peaked. However, with the other five high yielding legumes, including the two grain legumes sandplain lupin and cowpea, the proportion of stem increased as growth proceeded.

3.1.2. Yield of digestible nutrients

Yields of digestible nutrients and DCP are shown in Figs. 3 and 4. Maximum yield of digestible dry matter (DDM) largely coincided with peak biomass, though sandplain lupin and sunnhemp yielded most DDM approximately 1 week earlier. Peak DDM yields occurred at approx. 14 WAP for cowpea, 15 WAP for soyabean and sandplain lupin, 16 WAP for velvet bean, 17 WAP for sunnhemp and 18 WAP for forage soya and white lupin. With lablab both DM and DDM increased up to the last time of sampling at 18 WAP. The stage of development at which peak DDM yield occurred differed between species: early green pod for sandplain lupin and velvet bean (and lablab at 18 WAP), green pod for soyabean, cowpea and sunnhemp, and late green pod/early maturity for forage soya and white lupin. Maximum DCP yield coincided with that of DDM, with the exception of sunnhemp for which DCP yield was greatest considerably earlier at 14 WAP.

It is to be noted that the grain of maize cultivar ZS206 reached the milk dough
Fig. 1. Yields of eight legumes grown as sole crops, from 10 to 18 weeks after planting.

LSD (p=0.05) at 10, 12, 14, 16 and 18 WAP
= 0.86, 1.45, 1.33, 1.94 and 1.86
Fig. 2. Proportion of leaf and pod in the dry matter of eight legumes grown as sole crops, from 10 to 18 weeks after planting.
Fig. 3. Yields of digestible dry matter (DDM) of eight legumes grown as sole crops, from 10 to 18 weeks after planting.
Fig. 4. Yields of digestible crude protein (DCP) of eight legumes grown as sole crops, from 10 to 18 weeks after planting.
Fig. 5. Crude protein content of eight legumes grown as sole crops, from 10 to 18 weeks after planting.
Fig. 6. Digestibility of eight legumes grown as sole crops, from 10 to 18 weeks after planting.
and soft dough stages, the recommended stages for silage cutting, at 16 and 17 WAP, respectively.

3.1.3. Nutritive value

Legume CP content (Fig. 5) and digestibility (Fig. 6) declined with age. CP content when DDM yield was at a maximum (and peak biomass in most cases) was high at 200 g/kg DM or more in soyabean, sandplain lupin and cowpea, moderate in forage soya (173 g/kg DM), lablab (164 g/kg DM) and velvet bean (182 g/kg DM), but relatively low at only 134 g/kg DM in white lupin and approx. 110 g/kg DM in sunnhemp. Digestibility at the time of peak DDM, however, was approx. 60% or more only for soyabeans and cowpea, and had dropped to just above 40% in white lupin and sunnhemp.

3.2. Intercropping

3.2.1. Biomass and partitioning

The only legumes to produce a biomass yield approaching or just exceeding 1 t DM/ha at about the maize milk/soft dough stage of 16/17 WAP were the soyabeans, sunnhemp, lablab and velvet bean, when runner bean and cowpea biomass yields were approx. 0.5 t DM/ha. However, maximum cowpea yield was 1 t DM/ha, at 10 WAP. The lupins produced a maximum of approx. 100–250 kg DM/ha and the perennial forage legumes accumulated no more than 100 kg DM/ha by 16 WAP. Yields of the seven highest yielding legumes are presented in Fig. 7. The coefficients of variation and S.E.D. for these fortnightly data sets were high, a reflection of the inherent variability in microclimate under intercrop conditions (Wien and Smithson, 1981).

A comparison of legume productivity under intercrop and sole conditions is made in Table 1. Also presented in Table 1 are maize biomass yields at 16 WAP and the proportion of legume in the intercrop dry matter. Only velvet bean significantly (P < 0.05) decreased yield of the maize. The percentage of legume in these intercrops was greatest with velvet bean, at 29.4%. The soyabeans, sunnhemp, lablab and cowpea had a dry matter proportion close to 10%, and for the other species it was even less.

Trends with growth of the proportion of leaf and pod in the biomass for the seven higher yielding legumes were similar to those of the sole crops, except for cowpea in which the proportion remained fairly constant with intercropping as compared to steadily declining in the sole crop. However, for the trailing/twining legumes, i.e. cowpea, lablab, velvet bean and runner bean, the proportion of leaf and pod was higher under these shaded conditions, their percent values for the sole vs. intercrop situation at 16 WAP being 31.4 vs. 37.6, 23.7 vs. 33.6, 29.6 vs. 35.4 and 27.7 vs. 45.2, respectively.
Fig. 7. Yields of seven legumes intercropped with maize, from 10 to 18 weeks after planting.

LSD (p=0.05) at 10, 12, 14, 16 and 18 WAP = 0.22, 0.22, 0.26, 0.36 and 0.41
Table 1
Comparison of sole and intercrop legume and maize yields, and proportion of legume in the intercrop biomass at 16 WAP

<table>
<thead>
<tr>
<th>Legume</th>
<th>% Inter-crop/sole</th>
<th>Maize biomass % (kg/DM/ha)</th>
<th>% Legume in intercrop total DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>—</td>
<td>8014</td>
<td>—</td>
</tr>
<tr>
<td>Soyabean — grain</td>
<td>18</td>
<td>7696</td>
<td>14.4</td>
</tr>
<tr>
<td>Soyabean — forage</td>
<td>18</td>
<td>9421</td>
<td>11.8</td>
</tr>
<tr>
<td>Lupin — white</td>
<td>4</td>
<td>8750</td>
<td>2.5</td>
</tr>
<tr>
<td>Lupin — sandplain</td>
<td>3</td>
<td>8054</td>
<td>1.5</td>
</tr>
<tr>
<td>Lupin — narrow-leaved</td>
<td>3</td>
<td>9973</td>
<td>0.6</td>
</tr>
<tr>
<td>Lupin — yellow</td>
<td>4</td>
<td>8696</td>
<td>0.9</td>
</tr>
<tr>
<td>Lucerne</td>
<td>2</td>
<td>8062</td>
<td>0.4</td>
</tr>
<tr>
<td>Sunnhemp</td>
<td>8</td>
<td>8031</td>
<td>9.9</td>
</tr>
<tr>
<td>Lablab</td>
<td>18</td>
<td>7972</td>
<td>15.5</td>
</tr>
<tr>
<td>Velvet bean</td>
<td>44</td>
<td>4029</td>
<td>29.4</td>
</tr>
<tr>
<td>Runner bean</td>
<td>39</td>
<td>6873</td>
<td>6.7</td>
</tr>
<tr>
<td>Cowpea</td>
<td>15</td>
<td>6848</td>
<td>7.2</td>
</tr>
<tr>
<td>Silverleaf</td>
<td>5</td>
<td>8589</td>
<td>1.2</td>
</tr>
<tr>
<td>Siratro</td>
<td>6</td>
<td>8036</td>
<td>1.0</td>
</tr>
<tr>
<td>Archer</td>
<td>3</td>
<td>8762</td>
<td>0.8</td>
</tr>
<tr>
<td>L.S.D. (P = 0.05)</td>
<td></td>
<td>1695</td>
<td>4.7</td>
</tr>
</tbody>
</table>

3.2.2. Nutritive value

Trends in crude protein content and digestibility values were very similar to those for monocropping. The enhancement of leaf and pod relative to stem for the trailing/twining legumes under the shaded intercrop conditions was not reflected in nutritive value. DDM yields are shown in Fig. 8. As with the sole crops, peak legume DDM occurred at approximately the same time as peak biomass.

4. Discussion

4.1. Sole cropping

Although sunnhemp was by far the most productive legume, its potential for mixed-crop silage was low as up to 70% of its biomass was stem and had a poor digestibility. The maximum DDM yield for sunnhemp was 4877 kg DM/ha, a yield of 12 t DM/ha having a digestibility of only 40.4%.

The legumes which showed good potential, yielding well as sole crops (Fig. 1) and having reasonable CP content (Fig. 5) and digestibility (Fig. 6), were soyabean, forage soya and lablab. With the soyabean (and cowpea), unlike all the other
Fig. 8. Yields of digestible dry matter (DDM) of seven legumes intercropped with maize, from 10 to 18 weeks after planting.
species, high digestibility was maintained as the crop grew. In lablab, despite an increase in stem to over 70% of the biomass, moderate digestibility was maintained. (The proportion of leaf and pod did not always prove to be a reliable indicator of nutritive value with the trailing/twining legumes.) The maximum DDM yields of these species were 4840, 6140 and 5243 kg/ha for soyabean, forage soya and lablab, respectively, the lower yield of the grain soyabean cv. Duiker reflecting its shorter season of growth. Lablab has the additional advantage of regrowing well, even in the early dry season, following an earlier cut (Manyawu et al., 1994). Although the soyabeans gave good yields at this heavy soil site, they would yield less on sandier soils and in marginal rainfall areas (COPA, 1981). Lablab is likely to be more widely adapted, having proved fairly drought resistant [APRU (1979) as cited by Boitumelo and Mahabile (1992); Manyawu et al. (1994)] and it grows well on many soil types (NAS, 1979). Sunnhemp is reported to have some drought resistance and to thrive on almost any type of soil (NAS, 1979).

Only moderate DDM yields were produced by white and sandplain lupins, cowpea and velvet bean, i.e. maximum DDM of 2946, 2631, 3298 and 2094 kg/ha, respectively. Lupins are apparently better adapted to the cooler winter months. The shorter season L. albus cv. Wat yielded up to 14 t DM/ha under winter irrigation on the same soil type at a nearby site (Mapfumo, 1995), as compared to only 7 t DM/ha from the longer season cv. Lucky in this trial. The vigorously twining velvet bean grew relatively better when it had maize stems for support in the intercrop.

The poor growth of the other species was related to disease incidence, seasonality, seed size and perenniality. Incidence of leaf disease in runner bean was markedly enhanced in this non-trellised crop. The L. angustifolius and L. luteus cultivars grown were shorter season crops than the other lupins, as well as being better adapted to winter production as shown by comparison with yields obtained by Mapfumo (1995). It would be reasonable to assume that the low yield of the four perennial herbaceous pasture species, i.e. lucerne, silverleaf, siratro and archer, was related to slow establishment associated with very small seeds and a perennial growth habit. The potential of these species is likely to be improved by using permanent stands (DR and SS, 1976, 1977; GRS, 1994), though yields per cut would still be less than the biomass produced by the higher yielding annual legumes tested in this trial.

The potential of the higher yielding legumes for improving the protein content of maize silage is indicated by their DCP yields. The DCP yield of maize when ready for ensiling [based on silage DCP% (Nobbs and Oliver, 1987)], was 312 kg/ha, whereas the maximum DCP yields of soyabean, forage soya, lablab and sunnhemp were 3.5–4 times greater, and were approximately twice as much with white lupin, sandplain lupin, cowpea and velvet bean.

Legume material to be included in maize silage to improve its nutritive value would need to be of good nutritional quality. To achieve this some crops would have to be ensiled before attainment of peak DDM yield, as already indicated for sunnhemp in which DCP yield peaked 3 weeks earlier than DDM yield. This would
apply also to white lupin. White lupin and sunnhemp would need to be cut at approx. 13 WAP (early green pod) and 11 WAP (early flowering/very early green pod), respectively, instead of 18 and 17 WAP, to ensure a reasonable CP content (150 g/kg DM or more) and digestibility (55% or more). However, this would decrease DDM yield by approx. 15% for white lupin and 31% for sunnhemp.

Maximum DDM yield (and usually peak biomass yield) coincided with the maize cutting time of 16–17 WAP for sunnhemp and velvet bean only. However, sunnhemp should be planted approx. 4–5 weeks later than maize which confirms the recommendation of Mullins (1968) to cut as the crop begins to flower at 65–70 days of growth. Similarly, with white lupin, although peak DDM yield occurred at 18 WAP, to ensure good quality material it would have to be planted 3–4 weeks after this late-season maize. For good synchrony, soyabean and sandplain lupin would need to be planted approx. 1–2 weeks later and forage soya approx. 1–2 weeks earlier than this maize cultivar. Results indicated that planting the relatively late-flowering lablab at the same time or 1–2 weeks earlier than this late-season maize should ensure high yields of good quality biomass. This is confirmed by trials at a slightly cooler site approx. 75 km away (Manyawu et al., 1994) in which maximum lablab yields were achieved by cutting at 4.5 months in early May, with considerable leaf loss thereafter.

4.2. Intercropping

As might be expected with a tall, leafy crop such as maize, in-row intercropping generally had a marked depressing effect on legume growth. The lupins and herbaceous pasture species were particularly intolerant of the heavily shaded, highly competitive conditions in the maize crop (Table 1), whilst sunnhemp was slightly less affected. The soyabean, lablab and cowpea exhibited a greater competitive ability. However, two of the twining legumes, velvet bean and runner bean, proved exceptional. Considering that the sole crop population densities were more than three times their intercrop density, these two species grew about as well when intercropped. The support offered by the maize plants which improved leaf display seemed to offset competitive effects of the maize and to decrease disease incidence. Runner bean yields were low, however, and velvet bean smothered the maize and significantly depressed maize yield, to approximately half that of the sole maize (Table 1).

Amongst the higher yielding legumes there was good synchrony between the late-season maize and soyabean, forage soya and lablab (Fig. 7), these legumes having peak biomass and maximum DDM yield at approx. 16 WAP. Harvesting time of the grain soyabean, however, would be fairly critical as there was a sharp decline in biomass after 16 WAP.

The intermediate yielding legumes runner bean and cowpea attained peak biomass and DDM earlier than 16 WAP (Figs. 7 and 8), as they did when sole cropped. However, delayed planting of these species when intercropped is not an option, since legume yield would be further depressed. This applies also to
sunnhemp, which needs to be harvested very early to ensure reasonable quality biomass. A better option with intercropping of these species may be to use a shorter season maize cultivar, but although this may improve the legume:maize biomass ratio it is likely to decrease the maize yield. This could be marked when attempting to synchronize with peak runner bean and cowpea biomass and DDM or with sunnhemp at very early flowering. Furthermore, sunnhemp yields at this optimum time of quality will be low.

Although intercropping caused a significant depression in maize yield only with velvet bean, any intercropping benefits in terms of biomass yields and ease of harvesting are not worthwhile for mixed legume—maize silage with this system of in-row intercropping with long-season maize. The maximum legume yields achieved in these intercrops were approx. 1 t DM/ha and the proportion of legume biomass was approx. 15% or less except for velvet bean (Table 1). Although velvet bean approached a reasonable proportion, of nearly 30%, this was achieved through an unacceptable decrease in maize yield.

Intercropping for mixed legume—maize silage may be more successful with delayed planting with velvet bean, adjusting the planting pattern to allow more space and light for the legume component, such as planting the legumes between the maize rows instead of in-row or planting the maize (and legume) in paired rows [as found to be optimum for sorghum and cowpea (IGFRI, 1991) with 25 cm between rows (IGFRI, 1990)], increasing the legume population to counteract diminished plant size (Baker, 1981), or delaying maize planting relative to that of the legume (Arias et al., 1990). Although Kusekwa et al. (1992) rejected the lablab cv. Rongai for intercropping between rows of maize, sorghum and bullrush millet as it depressed grain yields, their results indicated that for the purposes of biomass production this planting pattern could be successful: cereal biomass was decreased by approximately one fifth, but total biomass was increased considerably and consisted of more than 50% legume. Kaiser and Lesch (1977) found that when maize density in 0.9-m rows was decreased to approx. 18 000 plants/ha and combined with an in-row lablab population of approx. 107 000 plants/ha the legume contributed 40.8% to the DM, which had a CP content of 137 compared to 77 g/kg DM for sole maize, resulting in a 23% increase in CP yield. However, total biomass yield was reduced by 31%. When maize population was maintained at approx. 54 000 plants/ha and lablab increased from approx. 36 000 to 107 000 plants/ha, legume contribution increased from 11.5 to 16.0%, CP content from 90 to 94 g/kg DM, and CP yield from 109 to 116% of that of sole maize, but total biomass decreased by 5–7%.

5. Conclusion

Of the fifteen legumes tested, those which proved to have potential for producing a high yield of good quality material when grown as sole crops were grain soyabean when harvested at 15 WAP, forage soyabean at 18 WAP and lablab at
16–18 WAP (all at early–late green pod). Sunnhemp was by far the most productive legume, but its digestibility was poor. For synchronization of harvesting of cereal and legume, a sole crop of grain soya should be planted 1–2 weeks later than a long-season maize cultivar harvested at 16–17 WAP, sunnhemp should be harvested at 11 WAP by planting 5–6 weeks after the maize, and forage soya and lablab should be planted at approximately the same time as maize or possibly slightly earlier with lablab.

The legumes showing potential for intercropping with maize were the soyabeans, lablab and velvet bean. However, in-row intercropping of these legumes with long-season maize is not a viable system. The proportion of legume was too low except for velvet bean, which smothered the maize. With velvet bean a slight delay in planting may reduce this problem. With the other species, planting the legume between maize rows and increasing the population, and with sunnhemp and cowpea using shorter season maize, might prove more successful.

Legume yield performance in this trial relates to a sub-humid site with a heavy soil (though in a year of below normal rainfall). The potential of these legumes needs to be ascertained elsewhere, particularly on sandy soils and in more marginal (semi-arid) rainfall areas.

References


Dube, D., 1995. The role of high quality dry season forage from mixed crop silages in the small-holder


