

Utilisation of ley legumes as livestock feed in Zimbabwe

C. MAPIYE¹, M. MWALE¹, J.F. MUPANGWA¹,
P. H. MUGABE², X. POSHIWA³ AND
N. CHIKUMBA³

¹ Department of Agriculture, Bindura University
of Science Education, Bindura

² Department of Animal Science, University of
Zimbabwe, Mount Pleasant, Harare

³ Grasslands Research Station, Marondera,
Zimbabwe

Abstract

Rural communities in Zimbabwe rely heavily on integration between crop and livestock activities at farm level. This form of agriculture is under increasing pressure because of land degradation, recurrent droughts and increasing human population. Technologies aimed at achieving a balance, whereby crop and livestock can increase in productivity, while resource degradation is minimised, must be developed. Cultivation of ley legumes has the potential to improve the sustainability and productivity of the smallholder mixed-farming systems by providing high-quality feed that can boost crop and livestock production. This paper reviews selection, utilisation and adoption of major ley legumes, and highlights research gaps, constraints and opportunities for ley legume research in Zimbabwe.

Introduction

Rural communities in Zimbabwe and Africa, in general, rely heavily for their survival on integrated crop and livestock activities at farm level. This form of agriculture is under increasing pressure because of land degradation and expanding human population (Francis *et al.* 1997). Crop production is most commonly on a

subsistence basis and is severely limited by, inter alia, a shortage of inputs, recurrent droughts, lack of draught power and inherent poor soil fertility. Ruminant livestock are grazed largely on native pasture, that is usually in short supply and of poor nutritive value during the prolonged dry season (Muchadeyi 1998). Crop stovers make up the bulk of livestock feed during this time. Increasing rural resettlement has led to a rapid and general decline in the areas of grazing lands available to smallholder farmers (Nyoka *et al.* 2004). Therefore, the need to intensify and optimise both livestock and crop production is the major challenge being faced by smallholder farmers.

Technologies aiming at increasing productivity of crops and livestock, while enhancing well-being of farmers and minimising resource degradation, must be developed. One such technology is cultivation of ley legumes, which has the potential to improve sustainability and productivity of the smallholder mixed-farming systems by providing high-quality feed that can boost crop and livestock production in Zimbabwe. By providing soil cover, ley legumes reduce soil erosion and runoff, improve soil organic matter content and compete with weeds (Foppes 1993). Successful utilisation of ley legumes depends on the selection of locally adapted (climate and edaphic) species that produce reasonable quantities of quality forage. This paper reviews research on screening, evaluation, agronomy, conservation, utilisation and adoption of major ley legumes for the past two decades and highlights research gaps, constraints to and opportunities for ley legume research in Zimbabwe.

Screening and evaluation of ley legumes

Screening and evaluation research in Zimbabwe during the past two decades aimed to identify new ley legume varieties that could improve productivity in crop-livestock farming systems. Researchers concentrated on identifying ley

legumes that would be ideal for cereal-legume intercropping systems. Substantial evidence has been accumulated to show that ley farming is both feasible and potentially very beneficial for Zimbabwe (Muchadeyi 1998; Jiri 2003; Maasdorp *et al.* 2004). However, there are few examples of legume-based ley farming systems that have been readily adopted by farmers in Zimbabwe. Three species, namely: *Lablab purpureus* (lablab), *Mucuna pruriens* (velvet bean) and *Vigna unguiculata* (cowpea), have been successfully established, mainly to feed dairy cattle under different climatic and management conditions (Majee and Chikumba 1995; Muchadeyi 1998; Nyoka *et al.* 2004) (Table 1). *Crotalaria juncea* (sunhemp), *Glycine max* (soybean) *Vicia sativa* (vetch), *Pisum sativum* (pea) and *Lupinus albus* (white lupin) have been used to a lesser extent, and research on these species in Zimbabwe is limited. Despite little attention being given to the afore-mentioned species, they have shown a lot of potential in other tropical countries (Muchadeyi 1998). Hence, there is need to broaden the research agenda to include selection of these species, especially in smallholder areas of low agricultural potential.

The following attributes were used for screening and evaluation: ease of establishment (high seed-production potential); ease of re-establishment (high soil-seed-reserve potential, hardseededness); longevity; ease of control during the crop phase; high nitrogen-fixation potential (a function of plant productivity and soil adaptation); drought tolerance; tolerance of diseases and pests; chemical composition; and animal production (a function of plant production and nutritive value) (Clatworthy and Madakadze 1988; Mutisi *et al.* 1994). The selection criteria should be extended to include important parameters such as: nutrient uptake efficiency; species complementarity (associative ability); economics of ley legume production; and animal production factors such as *in vivo*

digestibility, *in vivo* degradability and effects on milk yield, reproduction and growth rates.

Grasslands Research Station in Marondera identified *Lablab purpureus* cvv. Rongai and Highworth and ILCA Acc. 11642 as appropriate legumes for intercropping in the high-potential agro-ecological communal areas of Zimbabwe (Manyawu *et al.* 1993; Manyawu 1998). Grown alone, Rongai and Jhansi gave the highest forage yields (5.9 and 5.85 t/ha DM) and were ideal for use as annual or bi-annual fodder banks (Manyawu *et al.* 1993; Jingura *et al.* 2001). However, Highworth produced the highest grain and forage yields in semi-arid agro-ecological zones of Zimbabwe (Mutisi *et al.* 1994). In order to realise full benefits from lablab, there is a need to control diseases and pests (aphids and cutworms) (Manyawu *et al.* 1993). Therefore, it is important to select lablab accessions for resistance to not only bacterial and fungal diseases but also pest attack.

Preliminary findings from on-farm research in Chihota communal lands and Makaholi Research Station indicated that *Mucuna pruriens* and *Vigna unguiculata* produced high yields in warmer and medium-high rainfall areas with poor soil fertility in Zimbabwe (Majee and Chikumba 1995; Jiri 2003) (Table 1). *Vigna unguiculata* accession 121688 gave the highest forage dry matter yield (2.38 t/ha) after one season's growth in studies conducted in Hwedza (Manyawu 1998; Muringweni *et al.* 2004).

Selection of tropical legumes for leys has concentrated largely on the three above-mentioned species rather than on systematic screening of large germplasm collections for suitability as leys. Thus, it is suggested that screening and evaluation programs should be expanded to include accessions/cultivars of legumes that are more efficient and require fewer establishment and management inputs than existing species and cultivars. Different germplasm options should

Table 1. Climatic and edaphic attributes of common ley legume species and cultivars used in crop-livestock systems in Zimbabwe.

Species	Common name	Common cultivars	Soil type	Rainfall (mm)	Temperature (°C)
<i>Lablab purpureus</i>	Lablab	Rongai, Highworth and Jhansi	Deep sands to heavy clays	<500	18–30
<i>Mucuna pruriens</i>	Velvet bean	Utilis	Well drained, medium to high fertility soils	<600	19–27
<i>Vigna unguiculata</i>	Cowpea	—	Sandy to heavy soils	<500	25–35

Source: Majee and Chikumba 1995; Muchadeyi 1998; Nyoka *et al.* 2004.

be considered, including those developed for different environments in terms of soil, climate and production systems. In addition to a wider species range, evaluation of legumes should be based on an intra-specific variability as broad as possible.

Longevity of the species is another important consideration. Although the concept of a short-term ley almost implies that the respective legume is short-lived, persistent legume banks or mixed pastures with high legume content should also be considered. In comparison with annuals, longer-lived legumes will have an important advantage during the dry season. In this context, a potential option that should be researched is that of mixtures of complementary legume species. Possible topics for future research are as follows: characterisation of the potential of soil seed reserves and seedling recruitment; breaking of pest and disease cycles through legume leys; and measurement of animal production on legume leys (very limited data currently available).

Agronomy of ley legumes

Ley legume experiments were conducted to provide additional information on the management of new pasture species that would have succeeded in evaluation trials. At Grasslands, it was established that lablab, cowpea and velvet bean should be planted with the first rains in October–November in order to maximise herbage yield. Velvet bean, cowpea and lablab are best sown into a well prepared, fallowed seedbed that has a good depth of subsoil moisture (at least 60 cm). Seed should be sown at a depth of 5–10 cm into moist soil with good seed-soil contact. For pure stands, the inter-row and intra-row spacings should range from 60–100 cm and 20–75 cm, respectively. The average seeding rates for velvet bean, cowpea and lablab are 20–30, 10–20 and 15–25 kg/ha, respectively. Normally, one seed per station is allowed, because the germination rate is very good (75–95%) for seed, which has been less than 18 months in storage. These ley legumes are inoculated with cowpea rhizobium, and lime is applied at a rate of 500–1000 kg/ha before planting. Basal applications of single superphosphate at a rate of 150–300 kg/ha and potassium (K) as muriate of potash at a rate of 40–200 mg/kg before or at planting are recommended (Muchadeyi 1998). It was also shown

that it is best to harvest lablab once (May–June) for optimum herbage yield (Manyawu 1998).

Results of intercropping research over the past two decades favoured the simultaneous planting of ley legumes (velvet bean, cowpea and lablab) with maize, napier/bana grass, millet or sorghum, except where the legume can be too vigorous for the companion crop (Muchadeyi 1998; Nyoka *et al.* 2004). Intercropping with legumes increased herbage yield by 40–60%, although the cereal grain yields were depressed by up to 20%. When velvet bean is mixed with grasses or cereals, the yield of cereals is naturally depressed to below 10 t/ha. However, the total yields depend on plant populations, quality of the season and the management systems employed (Muza 1998). Lablab should be sown about 28 days after the maize crop has been planted to avoid severe depression in cereal crop yield from competition. Where lablab precedes maize in a rotation, nitrogen fertiliser application can be reduced to 75% of the recommended levels in the subsequent maize crop (Muchadeyi 1998). In on-farm trials in the Hwedza communal area of Zimbabwe, varieties of velvet bean and lablab were found to improve the maize crop in the following year by up to 3 t/ha, compared with a ‘weed fallow’ before sowing the maize (Jiri 2003). Future research on the economics (costs and benefits) of using ley legumes is essential to allow farmers to make informed decisions relating to input costs and production benefits.

Conservation and utilisation of ley legumes

Velvet bean

Feeding value. In Zimbabwe, velvet bean is used as green manure and for cattle feed, as mature pods, hay, ensilage with molasses, maize-*Mucuna silage* or grazing (Jiri 2003). Dry matter (DM) production is high, reaching 9–12 t/ha in a 900 mm rainfall region in Zimbabwe (Muchadeyi 1998). Fresh velvet bean is of good quality (Table 2) with an average of 23% crude protein (CP) and 82% total digestible nutrients (TDN) (Topps and Oliver 1993; Muchadeyi 1998). Maasdorp and Titterton (1997) reported CP concentration of 182 g/kg DM in *Mucuna* forage in Zimbabwe at peak biomass yield (also peak digestible dry matter yield) at the early green pod stage. These results were comparable with those for lablab (164 g/kg)

and cowpea (200 g/kg). However, velvet bean is unpalatable to most livestock, despite an average digestibility of about 65%. Since *Mucuna* has high nutritive value, it would seem desirable to embark on research to improve its palatability.

Table 2. Nutritive value of velvet bean.

Component	Nutrient	Concentration
Seed meal	Crude protein (%)	23.0
	Digestible protein (%)	19.0
Seed meal hay	Crude protein (%)	23.5
	ADF (%)	10.7
Hay	Crude protein (%)	14–21
	ADF (%)	36.3
Seed	Protein (%)	25.5
	Digestible protein (%)	21.1
	Total digestible nutrients (%)	91.1
	Fibre (%)	12–15
	ME (MJ/kg at 90% DM)	12.1
Whole pod	Protein (%)	20.0
	Digestible protein (%)	14.4
	Total digestible nutrients (%)	82.2
	Fibre (%)	13.0
	ME (MJ/kg at 90% DM)	11.0

Source: Muchadeyi 1998; Topps and Oliver 1993.

Both whole and ground pods are unpalatable (Topps and Oliver 1993), though grinding tends to improve palatability (D'Mello 1995). Since pods act as a potent laxative, the quantity fed should be limited (*e.g.* 2 kg/d). Where grinding proves inconvenient, seeds or pods should be soaked for 24 hours before feeding (Topps and Oliver 1993). Although cooking *Mucuna* can reduce its toxicity and increase its digestibility (D'Mello 1995), Topps and Oliver (1993) warn against feeding it to pigs and poultry. It can cause acute vomiting and diarrhoea on account of the L-Dopa content (3,4-dihydroxy-L-phenylalanine), and can inhibit growth and reduce egg production in chickens.

Animal production. Velvet bean hay has been successfully substituted for dairy concentrates in Zimbabwe without decline in milk yield or quality and has been recommended for this purpose (Murungweni *et al.* 2004). In other tropical countries, it has been used mainly for protein supplementation in bovines, sheep and goats. As an example, providing velvet bean as a supplement for sheep resulted in a daily liveweight gain of 60 g/animal compared with 44 g/d when commercial concentrates were fed (Maasdorp *et al.* 2004). In Kenya, cows fed *Mucuna* yielded 15% more milk than those fed the control diet alone, which consisted of maize stover *ad libitum* plus

three kilograms of maize bran daily (Juma *et al.* 2006).

Grazing. For dairy cows grazing on pasture grass in the communal areas of Zimbabwe (1200 mm rainfall), *Mucuna* proved to be the best annual legume for late summer and autumn grazing (mid-February to mid-May) in order to reduce concentrate feed requirements (Murungweni *et al.* 2004). If not grazed too heavily, *Mucuna* grew back sufficiently well to provide a second grazing one month later. Smallholder farmers favour delaying the grazing of *Mucuna* until after seed collection, rather than using the biomass earlier, when it is more nutritious (Maasdorp and Titterton 1997).

Hay. Small-scale farmers in Zimbabwe are reluctant to cut *Mucuna* for hay, as that would mean foregoing seed harvest. *Mucuna* is seldom used for hay, as it is difficult to handle because of entangled vines, and needs to be cut early to avoid the prolonged periods required for drying of the thick fleshy pods, with resultant leaf loss (Jiri 2003). A few large-scale commercial farmers intercrop maize with *Mucuna*, cut and store it in small stacks at maturity, then mill and feed it to cattle as required during the dry season.

Silage. Although many dairy farmers in Zimbabwe currently make silage, it is predominantly maize silage, with a CP content of only about 6–8%. Intercropping silage maize with *Mucuna* improves its nutritive value (Jiri 2003). Titterton and Maasdorp (1997) compared mixed silages (50:50 v/v) made from maize and 15 legumes. Fermentation of the maize-*Mucuna* mixture in terms of NH₃:N ratio proved successful, as it did not exceed the 10–15% upper limit for legume silages (Mahanna 1994). While CP concentration of the maize-*Mucuna* silage (138 g/kg DM) was second only to forage soybean (153 g/kg), the maize-*Mucuna* silage was otherwise of only moderate nutritive value. Its digestibility and metabolisable energy content were 50% and 8.0 MJ/kg, respectively (Mahanna 1994). Harvesting *Mucuna* earlier, and wilting it before ensiling, could improve the quality of silage from the maize-*Mucuna* mixture (Jiri 2003). Maize-*Mucuna* silage is useful forage for dairy cattle and other productive animals. When given to cattle at the rate of 5 kg per 100 kg body mass (25–30% DM), silage from a maize-*Mucuna* intercrop provides enough nutrients for body maintenance (Maasdorp and Titterton 1997).

Lablab

Lablab is a dual-purpose legume used as a fodder for grazing and conservation in Zimbabwe, as well as green manure or cover crop and in cut-and-carry systems and as a concentrate feed (Mutisi *et al.* 1994). It can be incorporated into cereal cropping systems as a ley legume to address the decline in soil fertility and is intercropped with maize to provide better legume/stover feed quality (Muza 1998; Jiri 2003). When used for forage in large areas, lablab is often sown with annual grass/cereals such as napier/bana grass, maize, sorghums and millets. In smallholder systems, lablab can be intercropped with maize (Muchadeyi 1998).

Feeding value. Seasonal yields of 2 t/ha leaf or 4 t/ha stem and leaf are common in the subhumid subtropics (Jingura *et al.* 2001). Leaf has CP concentration of 21–38%, while levels are 20–28% for grain and 7–20% for stem (Table 3). Digestibility ranges from 55–76%, commonly exceeding 60% (leaves) (Muchadeyi 1998). Grain contains tannins, and phytate and trypsin inhibitors, but soaking or cooking reduces the activity of these compounds (Topps and Oliver 1993; D'Mello 1995).

Animal production. Supplementing the diet of sheep and goats with lablab in Zimbabwe can improve condition of does and ewes, and increase birth weights and growth rates of kids as well as milk yields (Mutisi *et al.* 1994; Ndlovu and Sibanda 1996; Titterton and Maasdorp 1997). In Brazil, zebu cattle grazing maize stalks, dry grass and green lablab gained 350 g/hd/d over a 3-month period, while cattle without lablab lost weight. In south Africa, on rotation pastures with lablab and grasses, 50 bulls gained an average of 40 kg/hd in 63 days and 9–13 L milk/head/day were obtained from cows grazing pure lablab. In subtropical Australia, cattle gains have ranged from 0.09–1.04 kg/hd/d, depending on the feeding conditions (Muchadeyi 1998). In summer and autumn, when grass forage crops and lablab were the predominant feeds for dairy cows, milk production from these forages on 12 farms ranged from 6.5 to 10.5 kg/cow/d (Chataway *et al.* 1992).

Hay. Trials in Zimbabwe have demonstrated that the use of a lablab hay supplement resulted in milk yield increases slightly less than those obtained

through the use of velvet bean (Maasdorp and Titterton 1997; Murungweni *et al.* 2004).

Table 3. Chemical composition of lablab.

Nutrient	Whole plant	Leaf	Stem
Ash (%)	10.1		
Digestible organic matter (%)	60.2		
Crude protein (%)	15.9	22	10
Neutral detergent fibre (%)	46.6		
Acid detergent fibre (%)	33.1	22	38
Acid detergent insoluble nitrogen (%)	0.23		
ME (MJ/kg DM)	–	11.2	8.5
Calcium (mg/kg)	9.6		
Phosphorus (mg/kg)	2.1		

Sources: Jingura *et al.* 2001; Mutisi *et al.* 1994; Topps and Oliver 1993.

Silage. Research at Matopos and Henderson demonstrated that lablab and cowpea herbage, mixed with maize or sorghum forage, could be successfully ensiled to provide high quality fodder during the dry season (Maasdorp and Titterton 1997). Well preserved silages of up to 3.8 pH and 12% CP were obtained without the use of additives (Titterton and Maasdorp 1997).

Cowpea

Cowpea is one of the most important tropical dual-purpose legumes in Zimbabwe, being used for vegetables (leaves and flowers), grain, fresh cut-and-carry forage and hay and silage. The species has high potential as a green manure for soil enhancement (Jiri 2003).

Feeding value. Cowpea can produce 3–10 t/ha DM in 8–12 weeks, with grain production of 250–4000 kg/ha (Manyawu *et al.* 1993). It has high nutritive value: CP in green foliage 14–21%, in crop residues 6–8%, and in grain 18–26%; plus *in vitro* dry matter digestibility (IVDMD) of foliage >80%. *In vitro* dry matter digestibility of residues after grain harvest is 55–65% (Topps and Oliver 1993; Muchadeyi 1998). Few studies are available where it was fed as a supplement. It is non-toxic for ruminants; however, for monogastrics, trypsin inhibitors and the presence of tannins need to be taken into account, although heat treatment reduces trypsin inhibitors (Topps and Oliver 1993; D'Mello 1995).

Animal production. Very few studies are available in Zimbabwe, but in other countries, feeding cowpea as a supplement produced a 10–20% increase in milk yield (Colombia) and 50% higher animal liveweight gain (67 g/d with sheep) (West Africa). In some trials on cowpeas in Australia, lambs gained 197 g/hd/d over a 30-day grazing period. First-cross lambs grazing cowpeas gained 198 g/hd/d during the first month with a decline to 159 g/hd/d over the last 30 days (Muchadeyi 1998). In a pen feeding study in north Queensland, steers fed green chop cowpea gained 0.64 kg/d (Thurbon and Winks 1970). Rate of gain increased to 0.91 kg/d when molasses was added to the ration at 24% of the DM on offer.

Hay. Excellent hay can be made from cowpea, especially in mixtures with maize, forage sorghum or millet (Jiri 2003). Information on the utilisation of cowpea hay in Zimbabwe is inadequate and this aspect warrants investigation.

Adoption of ley legume technology

Ley legumes play an important role in sustaining the livelihoods of small- and medium-scale farmers throughout the tropics, mainly as a result of their positive effects on crop and livestock production, and contribution to economic and environmental sustainability (Francis *et al.* 1997). However, in Zimbabwe and many other regions of the tropics, the potential of forage legumes for sustainable development is largely untapped and adoption of ley legumes, in particular, has so far been limited. Prior to independence in 1980, ley legume research in Zimbabwe had targeted only large-scale commercial dairy and intensive (pen-fattening) beef producers, with limited work on small-scale and smallholder producers (Mupangwa 1994). Consequently, this led to the widespread adoption of ley legume technologies by commercial farmers in high-potential areas, rather than marginal areas, where the majority of small-scale and smallholder farmers are found. Recent research has shown that velvet bean, lablab and cowpea are promising protein sources for small-scale and smallholder dairy farmers, especially those in low-potential agro-ecological zones of Zimbabwe (Murungweni *et al.* 2004; Nongoni *et al.* 2006).

The major factors limiting adoption of ley legumes include the scarcity and high cost of seed, difficulties associated with establishment

and maintenance, inaccessibility of research results by end users and lack of appreciation of the value of ley legumes by farmers (Mupangwa 1994; Chigairo 2004; Maasdorp *et al.* 2004)). In this context, the importance of developing functional seed and inoculant delivery systems cannot be over-emphasised. The rate of adoption of available ley legume technologies, however, besides being affected by traditional thinking and farming practices, seems to be determined mainly by economics. Benefits from the system must be substantially higher than the ley establishment and maintenance costs. In this context, important factors to be considered are: the extent of soil degradation due to continuous cropping (usually farmers fail to see any urgent need to restore soil fertility); prices of alternative fertilisers required for the arable crop; labour and fertiliser requirements to establish ley legumes; and prices of crop and livestock products (Pengelly *et al.* 2004). Use of these ley legumes has been shown to increase profits by over 300% in smallholder dairy systems (Murungweni *et al.* 2004). In a participatory action research program on the use of forage legumes in cropping systems in some parts of Zimbabwe, the keys to successful forage legume adoption in rural communities were seen as: the emerging market for livestock products; a motivated and educated extension service working with a range of research specialists; and the opportunities for beneficial synergies to be exploited from a mixed crop-livestock production system (Chigairo 2004).

A participatory approach that has been developed for tree/shrub legumes in Zimbabwe enhanced both the development of forage legume technology and its scaling out to new areas (Pengelly *et al.* 2004) and this approach should be adopted and adapted for ley legume forages. The future challenge is to strengthen this participatory approach in the development of forage technologies, especially in the process of scaling out such technologies. This approach should recognise the diversity of farmers' needs and be accompanied by awareness campaigns in order to get long-term and widespread adoption of forage technologies in Zimbabwe. It is important to develop effective linkages among researchers, extension workers, decision-makers, farmers and other stakeholders, who have a complex knowledge base and widely dispersed expertise for both the development and diffusion of improved multi-purpose legume species. Therefore, continuous

selection of ley legumes should proceed in collaboration with stakeholders in numerous locations within a range of utilisation systems, using farmer participatory methods to ensure long-term and widespread adoption of ley legume technologies.

Conclusions

It is generally accepted that increasing population pressure on arable land leads to declining land productivity. Consequently, low-input-based changes in agricultural production systems in the tropics are required in order to restore and maintain the productivity of land. Short-term ley legumes may be one possible option for addressing this important challenge. Therefore, continuous evaluation and selection of ley legume germplasm to respond to existing and evolving constraints and changing demands and opportunities is mandatory to ensure widespread and long-term adoption by smallholder farmers. Adoption of ley legumes with high grain production, increased quantity and quality of crop residue, drought resistance and high leaf:stem ratio would provide the most benefit for poor smallholder dairy farmers in Zimbabwe. In spite of the adoption difficulties, ley legumes are an option that merits further attention and continuing efforts by researchers, extension agents, farmers and other stakeholders. There is a need for Government and non-governmental organisations to play their part by providing funding and other incentives to promote adoption of forage legume technologies by farmers in Zimbabwe.

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