Chapter 5

An Insight into Current and Future Production of Forage Crops in Zimbabwe

Allan Sebata

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.71997

Abstract

In Zimbabwe, most livestock are reared by smallholder farmers who live in marginal areas with low rainfall and hence poor forage production. As a consequence, livestock productivity is low and intermittent droughts result in animal mortalities. Forage crops have been widely promoted to provide feed resources to livestock, particularly during the dry season and in years of low precipitation. However, production of forage crops among the smallholder farmers remains low, especially in areas that receive low rainfall (<600 mm per annum). This chapter reviewed work on the production and promotion of forage crops in Zimbabwe in the past 50 years. The production and adaptation of different forage crops *viz.* improved grasses, herbaceous, and tree legumes to low and high (>800 mm per annum) rainfall areas is highlighted. Planting of improved grasses and herbaceous legumes in fallows and tree legumes as hedges and on contours hold the best promise in terms of improving the availability of forage crops for livestock feeding. Shortage of moisture remains the greatest constraint to increasing the area planted to forage crops. Therefore, the development of irrigation facilities needs to be encouraged to allow for the growing of forage crops.

Keywords: bana grass, ensiling, fallows, intercropping, reinforcement, tree legumes

1. Introduction

In Zimbabwe, the majority of the people live in rural areas with smallholder cropping and livestock production as the major sources of livelihoods. However, with the ever increasing population, the natural resources are constrained leading to low crop yields and livestock productivity. Livestock are reared on natural rangeland, which in most areas have been degraded leading to a decline in grass production. Thus, to improve livestock production, there is a need to promote forage crop production by smallholder farmers. Forage crops are plants grown for feeding livestock either directly as grazing pastures or as conserved hay and silage. They provide important nutrients (energy, protein, vitamins and minerals) to the livestock, particularly during the dry season when the natural grazing areas will be having poor quality forage.

The introduction of commercial smallholder dairy in Zimbabwe has seen an increase in the establishment of pasture grasses and legumes [1]. Some of the forage grasses grown include giant rhodes (*Chloris gayana*), Napier (*Pennisetum purpureum*), bana grass (*Pennisetum purpureum* cv. bana) and star grass (*Cynodon nlemfuensis*). Herbaceous legumes such as lablab (*Lablab purpureum*), fine-stem stylo (*Stylosanthes guianensis*), silverleaf desmodium (*Desmodium uncinatum*), siratro (*Macroptilium atropurpureum*) and velvet beans (*Mucuna pruriens*) have been established together with the grasses to improve dietary protein. In addition, multipurpose trees such as leucaena (*Leucaena leucocephala*) and sesbania (*Sesbania sesban*) are grown. However, the total area under forage crops remains very small (~4.2% of total arable land), mostly among the smallholder dairy farmers [2]. Chigariro [3] estimated that each individual smallholder dairy farmer was allocated between 0.4 (8% of arable landholding) and 0.8 ha (16% of arable landholding) for forage crop production in higher rainfall (>800 mm per annum) areas. However, an increasing number of small scale livestock keepers with irrigation facilities are now growing forage crops to feed their livestock during the dry season, which extends from June to November. This is meant to supplement the inadequate grass biomass and quality in natural rangelands particularly during drought years.

The aim of this chapter was to provide a review of the work done to date in Zimbabwe to promote forage crop production particularly in the smallholder farming sector. The chapter focused on reinforcing natural grassland with legumes, rehabilitating fallows with legumes, promotion of tree legumes as protein supplements, cropped forage grasses and legumes and forage crop conservation. The future prospects of forage crop production in the smallholder farming sector in Zimbabwe is also highlighted.

2. Reinforcing natural grassland with legumes

To improve animal production under natural rangeland conditions, strategies to increase grass production are required. One such strategy is grassland reinforcement with legumes, which increases both the quality and quantity of grazing. This has been found to improve the performance of individual animals and results in increased carrying capacity of the rangeland [4]. MacLaurin and Grant [4] reported cattle weight gains of over 60 percent per hectare (10,000 m^2) in rangelands reinforced with legumes as compared to the unimproved natural rangelands in Zimbabwe.

Selection of legume species adapted to the conditions in the high rainfall (>800 mm per year) areas of Zimbabwe was undertaken in the early 1960s [4]. Legumes found to be adaptable to these conditions included *Desmodium intortum* (greenleaf desmodium), *D. uncinatum* (silverleaf desmodium), *Macroptilium atropurpureum* (siratro), *Stylosanthes guianensis* var. intermedia (Oxley fine-stem stylo) and *Trifolium semipilosum* (Kenya white clover) [5]. *Stylosanthes guianensis* was found to establish and persist under adverse conditions [6]. It persisted under heavy grazing and increased its density through the establishment from shed seed [7]. Herbaceous legumes such as *Desmodium intortum*, *D. uncinatum* and *Macroptilium atropurpureum* have been found to persist under controlled grazing or cutting and produce yields of up to 10 tonnes dry matter per hectare per year on ploughed lands [8].

For the legumes to successfully establish, it is necessary to disturb the soil surface and to set back grass growth [6]. This can be done by burning-off of top hamper followed by disking the strips where the legumes are to be sown to improve emergence. The hard seeds of pasture legumes are scarified using hot water, dry heat or with concentrated sulphuric acid before planting [9].

Reinforcing *Hyparrhenia filipendula* grassland with *Stylosanthes guianensis* var. intermedia (Oxley stylo) and *Macroptilium atropurpureum* (siratro) increased dry matter yield by 58 and 49%, respectively, whereas crude protein increased by 64 (stylo) and 20% (siratro) (see **Table 1**) [10].

However, *S. guianensis* has been found to be intolerant to shading by the tall *H. filipendula* with long periods of rest [6]. Although, *M. atropurpureum* is more tolerant to shading, due to its twinning ability, it has poor dry matter yield when frequently grazed and will not persist under heavy grazing [4]. Clatworthy [11] recommended that grasslands reinforced with legumes be managed through rotational grazing with a grazing period of less than 2 weeks and rest period of at least 5 weeks. MacLaurin and Grant [4] reported steers grazing in grasslands reinforced with legumes as gaining 40 kg more than those on grassland only. However, weight gains of steers in grasslands reinforced with legumes were found to decline with decreasing rainfall [12].

A major constraint to grassland reinforcement with legumes has been the poor establishment of most species largely because of the low germination [4]. This has presumably led to the abandonment of reinforcement trials by research stations and farmers. However, it would be plausible to initiate new trials and broaden the legume species to be screened in view of the continued declining rangeland productivity. An alternative to natural grassland reinforcement would be to plant the legumes in fallow abandoned cultivated croplands. Tavirimirwa et al. [13] estimated that fallows constitute about 50% of the land, which was previously under

	Dry matter	**Crude protein**
H. filipendula only	5040	10.6
H. filipendula + stylo	7940	17.4
H. filipendula + siratro	7510	13.2

Source: Mufandeadza [10].

Table 1. Dry matter ($kgha^{-1}$) and crude protein (% dry matter) of *Hyparrhenia filipendula* grassland reinforced with *Stylosanthes guianensis* Var. Intermedia (stylo) and *Macroptilium atropurpureum* (siratro) in the high rainfall (>800 mm per annum) area of Zimbabwe.

cultivation in central Zimbabwe. The unavailability of legume species suited to the drier areas (<600 mm rainfall per year) is also a major challenge in grassland reinforcement with legumes. In addition, the nutrient requirements of the legumes in different soil types need to be determined [4].

Although herbaceous legumes produce high biomass and improve grassland dry matter yield in reinforcement trials, they offer poor foraging opportunities during the dry season because they shed leaves after frost and loose herbage as a result of trampling [8]. Hove et al. [14] found that herbaceous legumes such as *M. atropurpureum* and *S. guianensis* had been grown with limited success in the smallholder sector because of their lower productivity and failure to persist under low levels of management. This prompted the need to explore alternative fodder sources to improve availability of nutrient rich forage during the dry season.

3. Rehabilitating fallows with improved legumes

In most parts of Zimbabwe, large tracts of land are left to recover naturally following years of continuous cropping. Sowing improved legumes such as lablab or velvet bean (mucuna) has been found to accelerate the restoration to produce these fallows. Velvet beans grown on fallows yielded between 4700 and 11,300 kg/ha [15]. Both lablab and velvet bean crop can be grown, harvested and dried to make hay for feeding livestock or ploughed in as green mature to improve soil fertility. Planting forage legumes to restore fallow land improved maize grain yield by between 8 and 57%, which could be attributed to nitrogen fixation [15]. Therefore, the use of forage legumes in fallow restoration is beneficial in that large amounts of good quality forage is produced in addition to improved soil fertility. Muchadeyi [16] reported lablab crude protein content of about 12% of dry matter. The restoration of soil fertility is achieved through the fixation of atmospheric nitrogen and/or through an improvement in soil-physical properties [17]. In addition, lablab has been found to be drought tolerant with its deep and extensive root system contributing to soil organic matter content when decomposed, improving aeration and soil structure [15].

4. Use of tree forage legumes as protein supplements

In Zimbabwe, farmers have traditionally been feeding their livestock using leaves from native trees. However, in the last four decades, exotic (mostly from Central America) leguminous trees have been introduced because of their fast growth rates, acceptability to livestock and tolerance to frequent pruning and drought [18, 19]. In addition, these trees are long lived, require less maintenance and are palatable [20]. For example, *Acacia angustissima* is moderately palatable and digestible, *Calliandra calothyrsus* is palatable with low digestibility and *Leucaena leucocephala* is very palatable with high digestibility [21]. However, Hove [22] found *A. angustissima* and *C. calothyrsus* forage to be acceptable to livestock only after being dried. *Acacia angustissima, C. calothyrsus*, *Gliricidia sepium, L. leucocephala* and *Sesbania sesban* have been successfully introduced to smallholder dairy farmers in Zimbabwe [23]. Tree legumes are also referred to as multipurpose trees because they provide other products such as firewood and services such as soil erosion control [18].

The International Centre for Research in Agroforestry (ICRAF) in Zimbabwe tested and screened a number of leguminous tree forages suitability to provide forage to livestock particularly dairy cattle in the smallholder sector [24]. The biomass yield of five tree legumes in areas receiving high (>800 mm per annum) and low rainfall (<600 mm per annum) when cut once at the end of the rainy season is given in **Table 2**.

Leaf yields were higher in areas, which received high rainfall. *Acacia angustissima* had the highest leaf biomass and *S. sesban* the least (**Table 2**). Hove et al. [25] reported *C. calothyrsus* biomass yield of 2500–5600 kg/ha/year and *A. angustissima*, *L. leucocephala* and *G. sepium* yields of more than 3000 kg/ha/year. Dzowela et al. [24] recorded leaf dry matter yields of 5500, 3200 and 5800 kg/ha/year for 3-year old stands of *A. angustissima*, *C. calothyrsus* and *L. leucocephala* respectively. Matimati et al. [21] reported leaf yields of 400–3300, 800–5600 and 200–700 kg dry matter/ha/year for *A. angustissima*, *C. calothyrsus* and *L. leucocephala*, respectively, 1 year after establishment. They postulated that to get leaf dry matter yields of about 3500, 4000 and 1000 kg/ha/year for *A. angustissima*, *C. calothyrsus* and *L. leucocephala,* respectively required tree densities greater than 6000 trees/ha (equivalent to a tree spacing of 1.5 × 1.11 m). Tree legume leaf dry matter yield was found to increase with increasing frequency of moderate harvesting [26]. Muinga et al. [27] found supplementation of a basal diet of Napier grass with *L. leucocephala* to improve the digestibility of the Napier grass and to increase its intake by cross-bred dairy cows. Gusha et al. [20] reported crude protein content of 30.5, 26.5 and 22.7% of dry matter for *G. sepium*, *A. angustissima* and *C. calothyrsus*, respectively. Pigeon pea (*Cajanus cajan*) was successfully used to provide browse during the dry season at Grasslands Research Station, Zimbabwe, between 1951 and 1956 [8]. Steers fed pigeon pea forage gained an average of 0.22–0.34 kg per day over a 30- to 90-day period compared to those on fertilised grass pastures, which gained 0.09–0.18 kg per day for the same period [28].

Tree legumes can be grown as hedges along the field boundaries or on contours to limit soil erosion or on fallow land and as pure stands or intercropped with other crops [8]. In high

Species	High rainfall	Low rainfall
Acacia angustissima	3520–5530	3260–4850
Leucaena leucocephala	2850–5810	2060–5690
Gliricidia sepium	3040–5040	2430–6340
Calliandra calothyrsus	3210–3530	1240–3200
Sesbania sesban	1710–2980	920–1490

Source: Dzowela et al. [24].

Table 2. Leaf yields (kg/ha/year) of five leguminous fodder tree species in areas of high (>800 mm per annum) and low (<600 mm per annum) rainfall in Zimbabwe.

rainfall (>800 mm per annum) areas, most farmers intercropped the tree legumes with food (such as beans) and other fodder crops (*D. uncinatum*, *M. atropurpureum* and *S. guianensis*) [14]. Nyaata et al. [29] found that *C. calothyrsus* could be intercropped with Napier grass (*Pennisetum purpureum*) without reducing grass yields. To stimulate high biomass production, tree legumes can be grown for at least 1 year before being clipped at a height of 50 cm to initiate coppicing. The coppicing shoots can then be browsed by livestock, harvested and fed to the animals fresh or after drying [21].

Tree legumes are an important feed component in smallholder dairying. For instance, 1 kg of dried *C. calothyrsus* (24% crude protein and digestibility of 60% when fed fresh) was found to provide digestible protein equivalent to 1 kg of dairy meal (16% crude protein and 80% digestibility) [30]. *Calliandra calothyrsus* has also been found to be a good protein supplement to basal diets of Napier grass and crop residues [31]. Increases in milk production of 0.6–0.75 kg milk per kilogram of dried *C. calothyrsus* fed as supplement has been recorded [18].

Tree legumes could also play an important role in mitigating the effects of climate change because they are deep rooted, resistant to drought and are able to maintain high nutrient levels during the dry season [32]. In Zimbabwe, currently only a few farmers are exploiting the research findings of higher tree legume performances and the associated improvement in livestock production following their supplementation of basal diets of Napier grass or crop residues. Interestingly, high adoption rates have been reported in areas where tree legumes were introduced to smallholder farmers [14].

5. Cropped forage grasses

Livestock production can be improved by providing better nutrition through feeding good quality grasses [33]. The provision of good quality grasses maybe achieved through the use of improved grass species, such as Napier grass and its hybrids [34]. Napier or elephant grass (*Pennisetum purpureum*) and its hybrids are important forage crops particularly in areas that receive low rainfall because of their adaptations to drier conditions. They are robust perennial grasses that have been widely used as tropical forage producing higher dry matter yield than most tropical grasses [35]. Napier grass is a perennial grass that is indigenous to sub-Saharan Africa. It can withstand repeated defoliation as it regenerates quickly after cutting or grazing producing highly palatable foliage [36]. Napier grass and its hybrids have been widely adopted by smallholder farmers for feeding dairy cattle in most parts of Eastern, Central and Southern Africa [3, 37]. However, they have low protein concentration, requiring supplementation with legumes and protein concentrates [38]. The *Pennisetum* hybrids are produced by crossing Napier grass and pearl millet (*Pennisetum glaucum*) to improve the biomass yield and nutritive quality of the Napier grass. Gupta and Mhere [39] reported the interspecific hybrids as producing more tillers and leaves and having faster growth rates than their parents. The Napier × pearl millet hybrids (hereafter referred to as bana grass) are the most promising forage crops in the drier parts of Zimbabwe, offering high productivity, excellent quality and drought tolerance [39]. These hybrids are propagated vegetatively because they establish easily through developing shoots. Bana grass benefit from the desirable characteristics of pearl millet such as vigour, drought resistance and disease tolerance and those of Napier grass, which are good palatability and high dry matter yield.

The nutritive value of forage crops affects their utilisation by livestock, which in turn influences the production of the animals. Turano et al. [40] reported crude protein values of between 6.4 and 8.3% dry matter and *in vitro* dry matter digestibility of between 54.5 and 70% for Napier × pearl millet hybrids and Napier grass varieties. While silage crude protein content of 13.08% dry matter and *in vitro* dry matter digestibility of 66.93% were reported [41]. Bana grass can give dry matter yields of 10,000–12,000 kg per hectare and the best time to harvest is 6–7 weeks after onset of regrowth [42]. Nyambati et al. [43] reported mean annual dry matter yield of Napier grass varieties of 10,300 and 22,100 kg/ha/year over three and six harvests, respectively. In East Africa, values of 15,000–22,000 kg/ha/year were reported for Napier grass varieties [44]. Chigariro [3] reported increased livestock production with milk yields almost doubling following the use of bana/Napier forage crops in the high rainfall (>800 mm per annum) regions of Zimbabwe. Bana grass can be grown together with lablab and mucuna to improve crude protein content of animal diets.

Star grass (*Cynodon nlemfuensis*) is another important forage grass, which is adapted to low rainfall areas as it quickly produces foliage soon after the onset of the rains after the dry season [42]. Its crude protein content (5.54% of dry matter) at the end of the growing season was higher than that of grasses species found in natural grasslands (e.g. *Cynodon dactylon*—3.75% of dry matter) [13]. The crude protein content of 5.54% at the beginning of the dry season was high enough to mitigate against livestock weight losses making *C. nlemfuensis,* a suitable grass species to establish in fallow lands. In addition to the crude protein content, *C. nlemfuensis* is less fibrous than *C. dactylon* and other native grasses [13].

Forage sorghum (*Sorghum vulgare*) was bred specifically for feeding livestock. For instance, some varieties have sweet thin stems, are leafy and have good tillering ability. In addition, forage sorghum has comparable water soluble carbohydrates to maize (180–250 *vs.* 280–510 g/kg dry matter) [45, 46]. Water soluble carbohydrates are essential for successful ensilaging [47]. Forage sorghum silage has metabolisable energy of 9.5 MJ/kg dry matter compared to 10.2 MJ/kg dry matter for maize silage [48]. The sorghum silage was found to be of good fermentable quality, with a crude protein content of 12.0% of dry matter, when intercropped with lablab [46]. In addition, forage sorghum has been found to be adaptable to low rainfall producing high biomass yields [46].

6. Cropped herbaceous forage legumes

In Zimbabwe, a number of tropical herbaceous legumes have been introduced, screened and the most adapted selected as forage crops. Tropical herbaceous legumes have fast growth rates and perform well in unfertile sandy soils due to their ability to fix nitrogen. They are mainly used as green manure, in intercropping, crop rotation and as fodder for livestock. In addition, forage legumes have higher crude protein content than grasses [49]. For example, Murungweni et al. [50] reported crude protein content of 17.3 and 20.3% of dry matter for dolichos bean (*Lablab purpureus*) (hereafter referred to as lablab) and velvet bean (*Mucuna pruriens*) (hereafter referred to as mucuna) hay, respectively, while most grasses have lower values (<13% of dry matter). Herbaceous forage legumes can be grown with food crops and then fed to livestock as supplements to crop residues and native pasture hay basal diets. Dry matter yields of 400–1058 and 345–1937 kg/ha/year for lablab and mucuna, respectively, can be attained in high rainfall areas (>800 mm per annum) [51]. In sub-Saharan Africa, mucuna and lablab are grown by smallholder farmers for feeding livestock [52]. In Zimbabwe, they have emerged as important forage or green-manure legumes for use in the smallholder crop–livestock systems [15, 51]. In addition, cowpea (*Vigna unguiculata*), which is traditionally grown as a food crop by smallholder farmers can be used to feed livestock to supplement native pasture hay diets.

Although research and promotion of forage legumes has been going on for more than half a century, smallholder farmers' adoption rates remain very low [52]. In view of the increasing demands for livestock products, strategies have to be put in place to improve adoption of forage legume production by smallholder farmers to increase animal production. One such strategy would be to identify farmers with irrigation facilities and willing to increase forage production. In addition, provision of information on the performance of different forage legumes under a wide range of environmental conditions can help farmers to make informed decisions. For instance, Murungweni et al. [50] reported a 15-fold increase in adoption rates of forage legume use by smallholder farmers in the high rainfall (>800 mm per annum) areas of Zimbabwe following on-farm trials. If this success can be replicated on a large scale, livestock production could increase substantially. Mucuna and lablab found to be the most adopted legumes for use in rotation with maize, restoration of fallow lands and for fodder production [34, 51]. The incentive for growing these forage legumes were enhanced soil fertility, which increased maize yield and provision of fodder for livestock. For example, maize yield doubled when the crop was grown a year after a legume [51]. The growing of legume forage crops also enabled smallholder farmers to replace commercial livestock feeds, reducing production costs. In addition to their good forage attributes, mucuna and lablab are also drought tolerant [51]. Furthermore, improved availability of seed could result in more farmers growing forage legumes.

Lablab is a high yielding forage crop with dry matter yields of about 10,900 kg/ha/year. It has a crude protein content of 14–19% of dry matter and low fibre content and high digestibility. Lablab can be fed as fresh foliage, hay or silage, although freshly harvested forage need to be wilted before feeding to avoid a bad flavour in the milk.

Mucuna is a tropical legume, which grows well in soils of low fertility because of its ability to fix nitrogen. It has a crude protein content of 11–23% of dry matter (dried beans contain 20–35% of dry matter crude protein) and has low fibre content.

Cowpeas are drought tolerant, grow well in sandy soils of low fertility and have high crude protein content (20–30% of dry matter). Three types of cowpeas have been developed *viz*. dual purpose, food type and forage type. Dual purpose cowpeas are semi-erect, produce average grain and forage yields, which can be used as food both for humans and for feeding livestock. The food type cowpeas varieties are erect with high pod yield and low vegetative biomass, while the forage type is spreading/prostrate with low pod yield but high biomass yield. Cowpeas are highly palatable to livestock with high intake and digestibility due to the high crude protein, vitamins and mineral content. They can be fed to livestock as fresh forage, hay or silage.

7. Forage crop conservation

Forage crops can be conserved as hay or silage for feeding livestock during the dry season when the grass in the natural rangeland would have declined in nutritive quality. In dairy farming, silage is the more preferred method of conserving forage crops. The aim of making silage is to preserve the energy and protein content of the forage for feeding during the dry season. The forage crops are harvested at an early growth stage when their nutrient quality is still high. Silage making is divided into three stages *viz*. forage harvesting and transporting, chopping and compaction and air sealing. Silage is made by putting freshly cut forage into a sealed place such as a pit covered with plastic or a plastic bag called a silo. The forage material is chopped into small pieces and compressed in the silo to remove air to create anaerobic conditions. The silo is then completely sealed to prevent air entry. Under these anaerobic conditions, lactic acid bacteria convert some of the sugars in the forage crop into lactic acid. The nutrient value of good silage should be comparable to that of the forage used to make it. A good silage has a pH of less than 5.0, the percent of total nitrogen which is ammonia ($NH_3N:N$) of less than 15%, lactic acid which is 50% or more of the total organic acids and butyric acid content of not greater than 0.5% of the total dry matter.

When selecting material for making silage, the following need to be considered; plant material nutritive value (energy, protein, vitamins and minerals), easy of ensiling and most suited crop for the area (rainfall, soil type, temperature, day length). The amount of silage to be made will depend on the number of animals to be fed, length of feeding period, proportion of silage in total ration and equipment available on the farm.

Since maize is a staple food for most households in Zimbabwe, other grass plants such as bana grass can be used to make silage. To get the best quality silage from bana grass, harvesting should be before it develops internodes (6–8 weeks after onset of resprouting or shoot development). Dry matter content should be between 30 and 40% to get good compaction. Only forage that will be ensiled should be cut on each occasion to minimise wilting loses. Ensiling should be done in as short a time as possible preferably within a day to preserve forage quality. The plant material should be fine and evenly chopped to maintain forage quality. For instance, it can be chopped into 2 cm pieces using a motorised chopper or into 4–5 cm pieces manually using axes. The material should be compacted tightly to remove all the air out of the silo. After compaction, the silo should be sealed tightly to prevent air entrance. All the sides of the silo should be covered with polyethylene and soil put on top of the cover to keep it air tight and avoid soil and water entrance.

Cereal crops such as maize, forage sorghum and bana grass can be ensiled with legumes to improve silage quality. Ensiling tree legumes mixed with maize or Napier grass improves the energy and protein content of the silage [52]. Cereal silages are rich in energy but low in crude protein while the converse is true for legume silages [53]. Ensiling maize with legumes increases the crude protein content of the silage. For instance, crude protein content increased from 7.7% of dry matter for maize silage only to 9.3–15.3% of dry matter with a legume incorporated [54]. Maasdorp and Titterton [55] ensiled the leaf material of four forage tree legumes with maize, on a fresh mass ratio of 50:50 (w/w) and the crude protein content increased to 14.0, 15.5, 17.2 and 18.7% of dry matter for maize-*Calliandra calothyrsus*, maize-*Gliricidia sepium*, maize-*Leucaena leucocephala* and maize-*Acacia boliviana* silages, respectively. The fermentation characteristics of *A. boliviana*-maize and *L. leucocephala*-maize silages are shown in **Table 3**.

The crude protein content of ABM and LLM silage were above the minimum requirement for growth (11.3% of dry matter) in ruminant animals [57]. Titterton et al. [52] reported higher crude protein content values of 20.87 and 17.60% of dry matter for ABM and LLM respectively. The metabolisable energy content of the silages was above the minimum acceptable level of 8 MJ/kg dry matter required for maintenance [58]. Ensiling increased the modified acid detergent fibre but reduced the neutral detergent fibre content of the silages.

Although ensiling cereal crops with tree legumes improves the quality of the silage, it has not been widely promoted among the smallholder farmers. For example, Hove et al. [14] reported a few farmers (7%) as ensiling tree legume leaves mixed with maize in high rainfall (>800 mm per annum) areas of Zimbabwe.

Forage crops can also be harvested during the wet season and preserved as hay for feeding animals during the dry season. To make hay, the forage crops are harvested at 50% flowering stage and air dried for a day or two to reduce moisture content. Legumes such as cowpea, lablab and mucuna can be air dried and rolled into bundles and stored in shades with good ventilation.

Constituent	**Before ensiling**			**After ensiling**		
	MS	**ABM**	**LLM**	**MS**	**ABM**	**LLM**
Crude protein	7.6	15.6	14.1	6.9	14.8	13.2
Modified acid detergent fibre	28.0	28.5	28.8	31.1	33.7	34.8
Neutral detergent fibre	51.6	52.1	52.3	49.9	49.1	47.7
Acid detergent fibre	36.3	36.1	36.9	35.0	34.6	35.3
Ash content	6.0	6.2	6.2	5.8	5.6	5.7
Metabolisable Energy/MJ/kg dry matter	11	10	10	10	10	9

Source: Phiri et al. [56].

Table 3. Chemical composition (% of dry matter) of maize silage (MS), *Acacia boliviana*-maize (ABM) and *Leucaena leucocephala*-maize (LLM) mixed silages before and after ensiling.

http://dx.doi.org/10.5772/intechopen.71997

8. Future prospects of forage crop production

In Zimbabwe, currently less than 3% of smallholder farmers are growing forage crops [2]. This inevitably means low livestock productivity due to feed shortages, particularly during the dry season. However, farmers with smallholder dairy projects in areas receiving medium rainfall (600–800 mm) grew between 0.1 and 1 ha of fodder crops [1]. Forage and browse legumes grown were *M. pruriens*, *L. purpureus*, *V. unguiculata*, *M. atropurpureum, S. guianensis, L. leucocephala, A. angustissima, C. calothyrsus, C. cajan* and *S. sesban* while the most common cultivated grasses were *Pennisetum* spps and *C. nlemfuensis*. This suggests that large scale promotion could see more farmers growing forage crops, which could improve feed availability to livestock. However, most parts of Zimbabwe receive low and erratic rainfall and farmers have no irrigation facilities, which constrain production of forage crops. Thus, to increase forage crop production in areas receiving low rainfall farmers need to invest in irrigation facilities. For instance, dry matter yields of Napier grass varieties and pearl millet × Napier grass hybrids ranged from 10,300 to 32,100 kg/ha/year without irrigation and 19,600–55,800 kg/ha/year with irrigation, evidence that moisture stress can reduce biomass yield of rain fed forage crops [40]. Furthermore, increases in forage crop production can be achieved through farmer training, improved supply of seed and other inputs such as rhizobial inoculants [42].

Author details

Allan Sebata

Address all correspondence to: allan.sebata@nust.ac.zw

Department of Forest Resources and Wildlife Management, Faculty of Applied Sciences, National University of Science and Technology, Zimbabwe

References

[1] Mapiye C, Foti R, Chikumba N, Poshiwa X, Mwale M, Chivuraise C, Mupangwa JF. Constraints to adoption of forage and browse legumes by smallholder dairy farmers in Zimbabwe. Livestock Research for Rural Development. 2006;**18**:1-6

[2] Hanyani-Mlambo BT, Sibanda S, Rukuni M. Farming Systems in Zimbabwe's Smallholder Agricultural Sector: The Case of Gokwe South District. Department of Agricultural Economics and Extension, University of Zimbabwe, Zimbabwe; 2000

[3] Chigariro B. The farming Systems of the Zimbabwean District of Wedza and the role and adoption of forage legumes in small-scale crop–livestock enterprises. In: Whitbread AM, Pengelly BC, editors. Tropical Legumes for Sustainable Farming Systems in Southern Africa and Australia. Canberra, Australia: Australian Centre for International Agricultural Research (ACIAR) Proceedings No. 115; 2004 180 pp

[4] MacLaurin AR, Grant PJ. Research experience of reinforcing veld with legumes in Zimbabwe. In: Kategile JA, Said AN, Dzowela BH, editors. Animal Feed Resources for Small-Scale Livestock Producers - Proceedings of the Second Pastures Network for Eastern and Southern Africa (PANESA) Workshop, Held at the International Laboratory for Research on Animal Diseases, Kabete, Nairobi, Kenya, 11-15 November 1985. Kenya: International Development Research Centre; 1985

[5] Barnes DL. The preliminary evaluation of grasses and legumes for use in the high rainfall sandveld of Rhodesia. Proceedings of the Grassland Society of Southern Africa. 1966;**1**:69-74

[6] Clatworthy JN, Thomas PI. Establishment of *Stylosanthes guianensis* in Marandellas sandveld. Proceedings of the Grassland Society of Southern Africa. 1972;**7**:76-83

[7] Clatworthy JN. Screening of legumes for veld reinforcement. Proceedings of the Grassland Society of Southern Africa. 1980;**15**:111-116

[8] Clatworthy JN, Maclaurin AR, Avila M. The possible role of forage legumes in communal area farming systems in Zimbabwe. In: Kategile JA, Said AN, Dzowela BH, editors. Animal Feed Resources for Small-Scale Livestock Producers - Proceedings of the Second Pastures Network for Eastern and Southern Africa (PANESA) Workshop, Held at the International Laboratory for Research on Animal Diseases, Kabete, Nairobi, Kenya, 11-15 November 1985. Kenya: International Development Research Centre; 1985

[9] Grant PJ, Clatworthy JN. How to establish pasture legumes. Rhodesian Farmer. 1978; **48**:13-19

[10] Mufandeadza OT. Effect of Frequency and Height of Cutting on the Yield, Composition and Quality of the Herbage of Grass Grown Alone or in Mixture with Legumes. Annual Report 1976/77. Zimbabwe: Division of Livestock and Pastures, Department of Research and Specialist Services; 1978. pp. 173-176

[11] Clatworthy JN. Pasture research in Zimbabwe: 1964-1984. In: Kategile JA, editor. Pasture Improvement Research in Eastern and Southern Africa. Ottawa, Canada: IDRC; 1985. pp. 25-58

[12] Kelly RD. Tiffin, JdeW. Effect on Animal Production of Veld Reinforced with Siratro or Fine-Stem Stylo in a Medium-Rainfall Area. Annual Report 1981/82. Zimbabwe: Division of Livestock and Pastures, Research and Specialist Services; 1984. pp. 163-164

[13] Tavirimirwa B, Manzungu E, Ncube S. The evaluation of dry season nutritive value of dominant and improved grasses in fallows in Chivi district, Zimbabwe. Online Journal of Animal and Feed Research. 2012;**2**:470-474

[14] Hove L, Franzel S, Moyo PS. Farmer experiences in the production and utilisation of fodder trees in Zimbabwe: Constraints and opportunities for increased adoption. Tropical Grasslands. 2003;**37**:279-283

[15] Jiri O, Maasdorp BV, Temba E, Whitbread AM. The role of dual purpose and forage legumes to improve soil fertility and provide high quality forage: Options in a maize-based

system in Zimbabwe. In: Whitbread AM, Pengelly BC, editors. Tropical Legumes for Sustainable Farming Systems in Southern Africa and Australia. Canberra, Australia: Australian Centre for International Agricultural Research (ACIAR) Proceedings No. 115; 2004. 180 pp

[16] Muchadeyi R. Herbage yields, chemical composition and *in vitro* digestibility of dual purpose legumes intercropped with maize for dry season fodder supplementation. MSc thesis, University of Zimbabwe. 1998

[17] Wilson JR. Advances in nitrogen cycling in agricultural ecosystems. In: Proceedings of the Symposium on Advances in Nitrogen Cycling in Agricultural Ecosystems, Brisbane, Australia, 11-15 May 1987. Wallingford, UK: CAB International; 1988. p. 333

[18] Franzel S, Carsan S, Lukuyu B, Sinja J, Wambugu C. Fodder trees for improving livestock productivity and smallholder livelihoods in Africa. Current Opinion in Environment Sustainability. 2014;**6**:98-103

[19] Hess HD, Tiemann TT, Noto F, Franzel S, Lascano C, Kreuzer M. The effects of cultivation site on forage quality of *Calliandra calothyrsus* var. Patulul. Agroforestry Systems. 2006;**68**:209-220

[20] Gusha J, Ngongoni NT, Halimani TE. Nutritional composition and effective degradability of four forage trees grown for protein supplementation. Online Journal of Animal and Feed Research. 2013;**3**:170-175

[21] Matimati I, Maasdorp BV, Hove L. On-farm productivity of *Acacia angustissima*, *Calliandra calothyrsus* and *Leucaena leucocephala* in a subhumid area in Zimbabwe. African Journal of Range and Forage Science. 2009;**26**:75-80

[22] Hove L. Growing Trees for Profitable Milk Production. World Agroforestry Centre: Nairobi; 2004

[23] Chakeredza S, Hove L, Akinnifesi FK, Franzel S, Ajayi O, Sileshi G. Managing fodder trees as a solution to human–livestock food conflicts and their contribution to income generation for smallholder farmers in southern Africa. National Resource Forum. 2007;**34**:286-296

[24] Dzowela BH, Hove L, Mafongoya PL, Maasdorp BV. Recent work on the establishment, production and utilization of multipurpose trees as a feed resource in Zimbabwe. Animal Feed Science and Technology. 1997;**69**:1-15

[25] Hove L, Ndlovu L, Sibanda S. The effects of drying temperature on chemical composition and nutritive value of some tropical fodder shrubs. Agroforestry Systems. 2003;**59**: 231-241

[26] Matimati I. Determining Stage of Cutting for *A. boliviana* (Syn. *A. angustissima*), *C. calothyrsus* and *L. leucocephala* for Optimising Leaf Production. BSc Agric (Hons) Thesis. Zimbabwe: University of Zimbabwe; 1999

[27] Muinga RW, Topps JH, Rooke JA, Thorpe W. The effect of supplementation with *Leucaena leucocephala* and maize bran on voluntary food intake, digestibility, live weight

and milk yield of *Bos indicus* × *Bos taurus* dairy cows and rumen fermentation in steers offered *Pennisetum purpureum ad libitum* in the semi-humid tropics. Animal Science. 1995;**60**:13-23

[28] Mills PFL. Pigeon pea as a pasture legume in the high rainfall sandveld regions of southern Rhodesia. Rhodesia Agricultural Journal. 1961;**58**:171-172

[29] Nyaata OZ, O'Neil MK, Roothaert RL. Comparison of *Leucaena leucocephala* with *Calliandra calothyrsus* in Napier (*Pennisetum purpureum*) fodder banks. In: Shelton HM, Gutteridge RC, Mullen BF, Bray RA, editors. Leucaena-Adaptation Quality and Farming Systems. Vol. 86. ACIAR Proceedings. Proceedings of a Workshop Held in Hanoi, Vietnam, 9-14 February; 1998. pp. 257-260

[30] Roothaert R, Franzel S, Muriuki K. On-farm evaluation of fodder trees and shrubs preferred by farmers in central Kenya. Experimental Agriculture. 2003;**39**:423-440

[31] Paterson RT, Karanja GM, Roothaert R, Nyaata Z, Kariuki IW. A review of tree fodder production and utilization within smallholder agroforestry systems in Kenya. Agroforestry Systems. 1998;**41**:181-199

[32] Wambugu C, Place F, Franzel S. Research, development and scaling up the adoption of fodder shrub innovations in East Africa. International Journal of Agricultural Sustainability. 2011;**9**:100-109

[33] Humphreys LR. Tropical Pasture Utilisation. Cambridge, UK: Cambridge University Press; 1991. p. 206

[34] Pengelly BC, Whitbread A, Mazaiwana PR, Mukombe N. Better use of research resources to deliver adoption and benefits to farmers. In: Whitbread AM, Pengelly BC, editors. Tropical Legumes for Sustainable Farming Systems in Southern Africa and Australia. Canberra, Australia: Australian Centre for International Agricultural Research (ACIAR) Proceedings No. 115; 2004. 80 pp

[35] Hanna WW, Chaparro CJ, Mathews BW, Burns JC, Sollenberger LE, Carpenter JR. Perennial Pennisetums. In: Moser LE, Burson BL, Sollenberger LE, editors. Warm-Season (C4) Grasses. Madison, WI, USA: American Society of Agronomy Monograph Series No. 45; 2004. pp. 503-535

[36] Lowe AJ, Thorpe W, Teale A, Hanson J. Characterisation of germplasm accessions of Napier grass (*Pennisetum purpureum* and *P. purpureum* x *P. glaucum* hybrids) and comparison with farm clones using RAPD. Genetic Resources and Crop Evolution. 2003;**50**:121-132

[37] Valk YS. Review Report of the DEAF Surveys during 1989 NDDP/M41/ 200. Nairobi, Kenya: Ministry of Livestock Development; 1990

[38] Nyambati EM, Sollenberger LE, Kunkle WE. Feed intake and lactation performance of dairy cows offered Napier grass supplemented with legume hay. Livestock Production Science. 2003;**83**:179-189

[39] Gupta SC, Mhere O. Identification of superior pearl millet by Napier hybrids and napiers in Zimbabwe. African Crop Science Journal. 1997;**5**:229-237

[40] Turano B, Tiwari UP, Jha R. Growth and nutritional evaluation of napier grass hybrids as forage for ruminants. Tropical Grasslands. 2016;**4**:168-178

[41] Manyawu GJ, Sibanda S, Mutisi C, Chakoma IC, Ndiweni PNB. The effect of pre-wilting and incorporation of maize meal on the fermentation of bana grass silage. Asian-Australian Journal of Animal Science. 2003;**16**:843-851

[42] Mapiye C, Mupangwa JF, Mugabe PH, Chikumba N, Poshiwa X, Foti R. A review of improved forage grasses in Zimbabwe. Tropical and Subtropical Agroecosystems. 2006; **6**:125-131

[43] Nyambati EM, Muyekho FN, Onginjo E, Lusweti M. Production, characterization and nutritional quality of Napier grass [*Pennisetum purpureum* (Schum.)]. African Journal of Plant Science. 2010;**4**:496-502

[44] Muia JMK, Taminga S, Mbugua PN, Kariuki JN. Effect of supplementing Napier grass (*Pennisetum purpureum*) with poultry litter and sunflower meal based concentrates on feed intake and rumen fermentation in Friesian steers. Animal Feed Science and Technology. 2001;**92**:113-126

[45] McDonald P, Henderson AR, Hermon SJE. The Biochemistry of Silage. New York: A Wiley-Interscience Publication; 1991

[46] Mhere O, Maasdorp BV, Titterton M. In: Smith T, editor. Proceeding of Workshop on Livestock Production Research in the Semi-Arid Tropics. Matopos, Zimbabwe, United Kingdom: Department for International Development (DFID); 1999

[47] Titterton M, Bareeba FB. Grass and legume silages in the tropics. In: Silage Making in the Tropics with Particular Emphasis on Smallholders. Proceedings of the FAO Electronic Conference on Tropical Silage ('T Mannetje, L. Eds). September–December 1999. 2000

[48] Titterton M. The feasibility of using forage sorghum in drought years for silage in Zimbabwe. In: Kirk R, editor. Proceedings of Annual General Meeting on Forage Production for Dairying in Zimbabwe. Grasslands Society of Zimbabwe. p. 1997

[49] Nyoka R, Chikumba N, Chakoma I, Mazaiwana P, Mukombe N, Magwenzi N. Evaluation and screening of forage legumes for sustainable integration into crop–livestock farming systems of Wedza district. In: Whitbread AM, Pengelly BC, editors. Tropical Legumes for Sustainable Farming Systems in Southern Africa and Australia. Canberra, Australia: Australian Centre for International Agricultural Research (ACIAR) Proceedings No. 115; 2004. 180 pp

[50] Murungweni C, Mabuku O, Manyawu GJ. Mucuna, lablab and paprika calyx as substitutes for commercial protein sources used in dairy and pen-fattening diets by smallholder farmers of Zimbabwe. In: Whitbread AM, Pengelly BC, editors. Tropical Legumes

for Sustainable Farming Systems in Southern Africa and Australia. Canberra, Australia: Australian Centre for International Agricultural Research (ACIAR) Proceedings No. 115; 2004. 180 pp

[51] Manyawu GJ, Jiri O, Chigariro B, Mazaiwana PR, Nyoka R, Chikazunga D. A socioeconomic evaluation of an ACIAR-funded project on the use of forage legumes in integrated crop–livestock systems on smallholder farms in Zimbabwe. In: Whitbread AM, Pengelly BC, editors. Tropical Legumes for Sustainable Farming Systems in Southern Africa and Australia. Canberra, Australia: Australian Centre for International Agricultural Research (ACIAR) Proceedings No. 115; 2004. 180 pp

[52] Titterton M, Maasdorp BV, Mhere O, Nyoni L. Forage production and conservation for dry season feeding of dairy cows in semi-arid region of Zimbabwe. In: Smith T, Mhunduru J, Richards JI, editors. Proceedings of the Second Workshop on Livestock Production Programme Projects in Zimbabwe, (February, 1999). Chatham, UK: NRIL; 2000. pp. 23-34

[53] Catchpole VR, Henzell EF. Silage and silage making from tropical herbage species. Herbage Abstracts. 1971;**41**:213-221

[54] Titterton M, Maasdorp BV. Nutritional improvement of maize silage for dairying: Mixed crops silages from sole and intercropped legumes and a long season variety of maize. 2. Ensilage. Animal Feed Science and Technology. 1997;**69**:263-270

[55] Maasdorp BV, Titterton M. The use of planted trees for fodder. In: Smith T, editor. Proceeding of Workshop on Livestock Production Research in the Semi-Arid Tropics. Matopos Zimbabwe: Department for International Development (DFID); 1999

[56] Phiri MS, Ngongoni NT, Maasdorp BV, Titterton M, Mupangwa JF, Sebata A. Ensiling characteristics and feeding value of silage made from browse tree legume-maize mixtures. Tropical and Subtropical Agroecosystems. 2007;**7**:149-156

[57] ARC (Agricultural Research Council). The Nutrient Requirements of Livestock. Commonwealth Agricultural Bureaux. England: Slough; 1984

[58] Ekern A, Vik-Mo I. Conserved forage as feeds for dairy cows. In: Broster WH, Swan H, editors. Feeding Strategy for the High Yielding Cow. London: Grenada Publications; 1979