POTENTIAL OF FODDER TREE/SHRUB LEGUMES AS A FEED RESOURCE FOR DRY SEASON SUPPLEMENTATION OF SMALLHOLDER RUMINANT ANIMALS

J. SIMBAYA
National Institute for Scientific and Industrial Research,
Livestock and Pest Research Centre,
Chilanga, Zambia

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Abstract

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Fodder tree/shrub legumes have the potential for alleviating some of the feed shortages and nutritional deficiencies experienced in the dry season on smallholder farms. Zambia has a wide range of naturally occurring tree/shrub species that can be used as fodder for ruminants. Over the years a number of trees have been selected for their agronomic qualities and are currently being used in arable farming systems to promote soil fertility and erosion control. There is a need to evaluate them for use as fodder for ruminants in the dry season. Because of their high content of protein, minerals and vitamins and availability in the dry season, fodder tree/shrub legumes have the capacity to complement the feeding of crop-residues and natural pastures. Tree/shrub legumes also have other advantages in that they are available on-farm and can also be used as a source of food, timber and medicines at village level. Being deep rooted, fodder trees are rarely affected by seasonal climatic changes. The main limitation to their use as a feed resource for ruminants is the high tannin content which may have detrimental effects on the performance of animals. A number of techniques including, wilting, sun-drying, treatment with chemicals and ammoniation have been developed to minimize their adverse effects. Controlled intake through stall feeding or mixing of tree/shrub fodder with basal diets could also be used to mitigate their toxic effects. Research is currently under way to establish rumen microbes that have capacity to detoxify tannins. To promote increased use of fodder trees on smallholder farms, farmers must be provided with information on the good quality fodder trees and the approaches to effectively utilise them. They should also be encouraged to start planting fodder trees in their food crop farming systems or establishing fodder gardens on fallow lands.

1. INTRODUCTION

Nutrition has been documented to be one of the most important factors limiting ruminant production in the traditional smallholder sector of Zambia [1]. This is because ruminant animals in the smallholder sector depend on natural pastures and crop residues for the greater part of the year. During the dry season, the natural pastures and crop residues available for animals after crop harvest are usually fibrous and devoid of most essential nutrients including proteins, energy, minerals and vitamins which are required for increased rumen microbial fermentation and improved performance of the host animal [2]. Inadequate nutrition in ruminant animals has often been associated with heavy economic losses to the farmers because of animal weight and condition losses, reduced reproductive capacity and increased mortality rates. In order to improve the productive and reproductive capacity of smallholder ruminant animals, there is a need to look at ways of extending the availability and quality of feedstuffs produced on smallholder farms. One potential way for increasing the quality and availability of feeds for smallholder ruminant animals in the dry season may be through the use of fodder trees and shrub legumes. Towards the end of the dry season in Zambia, there is usually a substantial amount of green fodder from planted and naturally occurring trees which can be used as a source of feed for smallholder farm animals.

Unfortunately, whilst fodder trees have been used as a traditional supplement to fibrous crop residues in many countries, little has been done in Zambia to promote the use of tree and shrub foliage in overcoming nutritional deficiencies in the dry season. These forages have the potential in alleviating feed shortages experienced in the traditional smallholder sector. This needs to be exploited to re-enforce the achievements that have been made by crop and soil agronomists in establishing leguminous trees and shrubs in arable farming systems as a way of improving soil fertility and maintaining crop yields.

The objective of this presentation is to look at some of the advantages of using fodder trees and shrub legumes as a feed resource for smallholder ruminant animals in the dry season. Some of the factors that have restricted the use of fodder legumes in ruminant animal feeding are also presented. Lastly, an attempt has also been made to identify available technologies that have been developed to minimize the limiting factors and thus promote the use of fodder legumes as a feed supplement in the traditional smallholder sector of Zambia.

TABLE I. IMPORTANT FODDER TREES AND SHRUBS IN ZAMBIA

Local Name	Known Botanical Name
Leucaena	*Leucaena leucocephala*
Mutowa	*Diplorphynchus condylocarporn*
Mulombe	*Pterocarpus angolensis*
Caliandra	*Calliandra calothysursus*
Nyamundolo	*Cajanus cajan*
Kapululambuzi	--
Musamba	--
Mpondo	*Bauhinia petersiana*
Kankande	*Zyziphus Abyssinia*
Makechi	*Cassis siamea*
Chilalampili	*Clerodedrum uninatum*
Thuza	*Flacourtia indica*
Msekese	*Piliostigma thonnigii*
Msolo	*Pseudolachnostylis maproneifolia*
Kalumpangala	*Dichrostachys cinerea*
Kalama	*Combretumfrigrans*
Sesbania	*Sesbania sesban*
Mapoloyakalulu	*Canathium crassum*
Mpovya	*Annona senegalensis*
Mungonondo	*Terminelia sericea*
Mubanga	*Pericopsis angolensis*
Chipembela	*Xeromphis abovata*
Gliricidia	*Gliricidia sepium*

Source : Phiri, D.M. 1996 (personal communication).

2. IMPORTANT FODDER TREE AND SHRUB LEGUMES IN ZAMBIA

Table I shows some of the important trees that have been identified to be potential feed resources for ruminant animals in Zambia. Among these, probably the most familiar ones are *Leucaena leucocephala, Gliricidia sepium* and *Sesbania sesban* which have been established in nearly all parts of the country.

It should be noted that these trees have different agronomic requirements and can be found only in areas where climatic conditions favour their agronomic requirements. Thus, established trees on farm lands will also have different surviving capacities and some tree

species may do very well in one part of the country and perhaps not so well in other areas depending on the prevailing climatic conditions and soil fertility. Most of the listed trees are still found in nature and can either be selected for establishment in arable farming systems or may be selectively maintained in natural grazing areas to be used as browse species. It should be noted that nearly all the fodder species currently grown in arable farming systems in Zambia were selected mostly to improve soil fertility or prevent environmental degradation through reduced soil erosion. Characteristics often considered for such purposes usually include factors such as establishment or growth rates, promotion of soil fertility, compatibility with food crops and promotion of soil stability. Feeding quality characteristics of generated fodder are given little attention. A very good example for this type of research is the one being conducted at Msekera Regional Research Station in Chipata. A number of farming system research programmes have addressed this problem through intercropping of legumes with cereal food crops to improve soil fertility and maintain crop yields without any use of chemical fertilizers. It is important that the trees that have been selected over years should be evaluated for feeding quality characteristics if they have to be used in feeding ruminant animals. The results from a number of studies have clearly demonstrated the potential of fodder trees and shrubs in meeting nutritional requirements of animals in the dry season. Some of the results are outlined below.

3. NUTRITIONAL CHARACTERISTICS OF FODDER LEGUMES

The composition of common fodder trees and shrubs is shown in Table II. The most important aspect of fodder trees as a source of feed for farm animals is the high protein content which ranges from 14–29%. Some studies have demonstrated a higher protein content of even up to 34% which, unlike in most grass species, does not seem to change with leaf maturity even when they dry and fall off to the ground [3]. The protein content in fodder legumes consist of both soluble and insoluble components and as such is used both as an important source of nitrogen for increased rumen microbial activity and by-pass protein for

TABLE II. CHEMICAL CONSTITUENTS (% IN DM) AND ENERGY (KCal/kg DM) OF SELECTED FODDER TREES AND SHRUB SPECIES

Source	Dry Matter (%)	Crude protein	Fibre	Ash	Calcium	Phosphorus	Energy
Acacia	29.0	15.1	22.6	8.2	1.21	0.06	8.4
Cassava	21.1	24.2	15.6	6.6	2.62	0.22	14.4
Calliandra	26.4	24.0	21.7	8.0	1.6	0.20	12.6
Erythrina	32.0	25.8	17.4	6.7	-	-	14.3
Ficus	17.0	14.0	22.4	5.8	1.31	0.17	12.0
Gliricidia	25.0	14.7	19.9	4.7	1.58	0.29	12.8
Jackfruit	36.6	14.0	22.1	11.5	1.46	0.15	14.2
Leucaena	30.0	22.2	19.6	4.4	0.27	0.12	12.1
Pigeon peas	25.2	22.8	20.1	5.8	0.37	0.17	13.4
Prosopis	23.4	14.0	17.8	6.8	2.73	0.15	11.2
Sebania	18.0	22.6	18.4	9.3	1.48	0.34	13.6
Tamarind	28.0	14.0	21.0	8.6	2.81	0.20	14.4

Source: [6].

supplying amino acids to the lower gut of the host animal [4]. In addition to being a good source of protein, fodder legumes are also an important source of minerals such as sulphur, calcium, copper and iron even though they have been shown to be a poor source of manganese, zinc and phosphorous. The other advantage of using fodder legumes as a source of feed for ruminant animals is that supplementation of forages up to about 35% does not seem to have any effect on the intake of fibrous feed materials. As such the intake of dry matter is often increased by the amount of green fodder given to the animal [2]. The increase in the intake of materials when animals are supplemented with fodder legumes may be due to increased microbial fermentation in the rumen and subsequent higher rate of passage of digesta through the gastro intestinal tract. The dry matter content of most fodder legumes is considerably low and tend to vary with leaf maturity. This has a detrimental effect on the use of fodder trees and shrubs as a source of metabolizable energy for animals especially when compared to grass species. The low metabolizable energy content of fodder legumes is also associated with the high fibre content of these materials which also tend to reduce protein digestibility in these materials [5].

A number of studies have been conducted to evaluate the potential of fodder legumes in promoting different aspects of productivity in animals. Table III shows the effect of fodder legumes *Gliricidia sepium* and *Leucaena leucocephala* in promoting dry matter digestibility of fibrous crop residues in beef animals. As mentioned earlier, both these fodder legumes produced a slight increase in dry mater intake of fibrous crop residues; increase being higher with *L. leucocephala.* The real gain in supplementing animals with fodder trees or shrubs was in the average daily weight gain, which increased with increased levels of green fodder in the diet. Thus, fodder legumes have the potential to increase intake of feed resources and to promote animal weight gain. This is further demonstrated in Table IV which presents comparison of diets supplemented with *G. sepium* foliage or urea-molasses blocks in promoting rumen ammonia production and live weight gains in animals. Again the results show that fodder legumes are comparable to urea-molasses blocks in promoting animal live weight gains in the dry season. Other studies have shown the importance of using fodder legumes in promoting milk production [4, 6]. Thus, it may suffice to say that fodder trees and shrubs have the capacity to promote all aspects of animal production when used as supplements.

TABLE III. DRY MATTER INTAKE (DMI IN kg), DRY MATTER DIGESTIBILITY (DMD IN g/kg) AND AVERAGE DAILY GAIN (ADG IN g/d) OF BEEF ANIMALS WHEN CROP RESIDUES ARE FED AT DIFFERENT LEVELS (g/kg FEED)

Source/levels	0.0	7.5	15	22.5	30
Gliricidia					
DMI	5.2	5.1	5.2	5.4	5.7
DMD	608	610	592	578	606
ADG	306	358	429	371	478
Leucaena					
DMI	5.2	5.8	6.2	6.6	6.7
DMD	598	611	616	616	590
ADG	538	711	719	789	850

Source: [7].

TABLE IV. RUMEN AMMONIA AND LIVE WEIGHT GAIN IN BEEF ANIMALS FED DIETS SUPPLEMENTED WITH GLIRICIDIA GREEN FODDER OR LIQUID UREA-MOLASSES

Supplement	Rumen NH_3 (mg N/L)	Initial weight (kg)	Final weight (kg)	Live weight gain (g/d)
No Supplement	50	194	244	580
Gliricidia	170	204	266	717
Urea-molasses	250	203	269	751

Each supplement was given at 10% of basal diet; source: [3].

4. ADVANTAGES OF PLANTING FODDER TREES/SHRUBS

Unlike other feed resources that may be used on smallholder farms, fodder legumes have a number of advantages in that they are readily available on the farm and can be used for other purposes. Being perennial plants, fodder trees are not susceptible to sudden climatic changes and continue to produce high quality fodder even during drought years when grasses and other annual forages are dry and long gone [8]. Their capacity to grow fast enables them to produce large quantities of biomass, which can be used not only for animal feeding but also as mulch in cropping systems. They are also used to control soil erosion [9]. When intercropped with food crops, fodder legumes do not compete with food crops for nutrients as their deep root system enables them to tap nutrients from the deeper soil layers, which are generally not available for shallow rooted food crops. They also improve soil fertility by fixing atmospheric nitrogen and have other symbiotic relationships, which enhances uptake of minerals such as phosphorus by plants [10]. In the dry season, fodder trees also provide shade to animals and protect them from the hot and dry weather conditions which are common at this time of the year. They are also used as a source of firewood, provide timber for construction and fencing, and function as a hedge around the fields. A number of these trees bare fruits, which are used as a source of food for humans. Others have pharmacological properties and have been used to treat a number of ailments at village level.

5. LIMITATIONS TO THE USE OF FODDER TREES AS A FEED RESOURCE FOR ANIMALS

The main limitation to effective utilisation of fodder legumes as feed for ruminants is the high content of tannins and other anti-nutrients such as saponins, cyanogens, mimosine, coumarins, etc which limit nutrient utilisation [4, 11]. These compounds are also known to have other detrimental effects, which may range from reduced animal performance to neurological effects and increased animal mortality rates [5]. The toxic effects of these compounds depend on their concentration in a fodder species and level of intake of the fodder. The most widely occurring anti-nutrient in plants is a group of polyphenolic compounds commonly called as tannins. Tannins limit animal performance by suppressing intake and digestibility of forages [12]. They bind feed proteins and enzymes to form feed protein-tannin complexes, which are resistant to both rumen microbial and enzymatic degradation. They also lower enzyme activity [13]. These compounds also enhance the loss of endogenous proteins, which affect overall nitrogen metabolism in the animal. It may also be noted that at lower levels (2–4%) of tannins, these could have beneficial effects on ruminant animals -- suppress bloat in ruminants and reduce excess degradation of high quality protein in the rumen. This helps in increasing the amount of rumen undegradable protein, which is finally made available to the host animal for supplying essential amino acids [14].

It must be emphasised that the purpose of pointing out the potential toxic effects of these compounds is to be aware of their presence rather than to discourage the use of fodder legumes by ruminant animals [4]. These compounds will be diluted in the main feed and will rarely exhibit their toxic effects since fodder legumes are generally not used as a sole feed for ruminant animals. It is also important to note that a number of ruminant animals, particularly sheep and goats have capability to adapt slowly to most anti-nutrients. Some possible mechanisms which make these anti-nutrients innocuous are their degradation by rumen microbes, inactivation by endogenous secretions and detoxification by liver [15, 16].

In order to minimise the detrimental effects of tannins and phenolic compounds in fodder legumes, several suggestions have been put forward, some of which can be applied in the traditional smallholder areas. Among these are the post-harvest processing techniques such as sun-drying and wilting of forages before they are fed to animals [17]. Conservation of fodder into bags or ensiling them in silo pits with other feed resources has also proved beneficial in minimising the detrimental effects of tree fodder legumes [18, 19]. Efforts to eliminate the effects of tannins and other anti-nutrients through heat processing have proved unsuccessful [20]. The use of tannin-complexing compounds like the polyethylene glycol has been proved beneficial in some countries [21, 22, 23]. Another approach for enhancing the use of fodder legumes is through mixing of fodder with other feed resources such as crop residues. This helps to dilute the overall concentration of tanniniferous compounds in the diets thereby minimising their effects. The other potential way may be to harvest the legumes and feed to animals in the stall in a controlled manner. Research conducted in Ethiopia and Australia has shown the presence of microbes in the rumen of some animals which have the capability to degrade mimosine to harmless products [24] and these can be successfully transferred to other livestock species [25]. There is a need for researchers to work on this approach so that more microbes may be identified to enhance the utilisation of fodder legumes in ruminant animals.

6. POTENTIAL TECHNOLOGIES FOR INCREASED USE OF FODDER LEGUMES ON SMALLHOLDER FARMS

In order for smallholder farmers to start using fodder legumes as a source of feed for ruminant animals in the dry season, they must be taught to identify important tree species that have the potential to be used as fodder in their localities. There is also a need to propagate selected fodder legumes in arable farming systems. Farmers must be trained to establish trees that have potential as animal feeds in their food crop fields. This may be done through alley planting of trees in cereal or legume fields. This is where lines of fodder trees are inter-spaced within the cropping area. The trees may also be established on farm boarders to form live fences which can be used to protect food crops from animal pests. The other alternative is to have fodder trees planted on contour lines or ridges in which case they will assist in protecting the soil against wind and water erosion. In some parts of Africa, fodder trees are planted in fallow or open lands as a way of reclaiming waste areas and at the same time to obtain fodder for farm animals. This may be done by establishing a three strata fodder production system where improved grass and legume species are planted on the ground with shrub and tree species forming the second and third strata. The aim should be to plant a mixture of grass and legumes species which can be used as a source of quality fodder for animals and of high protein legumes for human populations. The forages generated from such fodder gardens are not only of high nutritive value but also offer diversity to the diet provided to animals in the dry season. The other technique for increasing the use of fodder trees may be through selected removal of trees in the natural pasture and replacing them with fodder species. This will go a long way in promoting browsing in animals and hence the higher and better use of fodder legumes in the dry season. The fodder generated from planted trees may be grazed *in situ* by

animals using controlled grazing techniques or may be cut and carried to animals in stalls. This will be determined by the local grazing system preferred by the farmer and also by the availability of labour on the farm. Other technologies that have been developed to enhance the use of fodder trees and shrubs include integrated tree cropping system, agro-forestry systems and food-feed intercropping systems.

7. CONCLUSION

Zambia has a great diversity of trees and shrubs, which can be used, as a source of feed for ruminant animals. A number of these trees and shrubs have been introduced in crop farming systems mostly to assist in maintaining soil fertility and crop yields. Many of these tree species can be used as a source of protein and minerals for ruminant animals, especially in the dry season when the natural pasture and crop residues used are devoid of such nutrients. Presence of anti-nutrients, in particular tannins in fodder trees and shrubs can limit animal performance, particularly when tree/shrub foliages are fed in large quantity. A number of technologies are available that can increase the use of foliage from trees and shrubs. These need to be introduced to smallholder farmers so that they may start using these valuable feed resources for increasing animal productivity.

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