A potential strategy for research to improve small stock nutrition under the traditional farming system in Botswana

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Abstract

Small stock plays an important role in the rural economy of Botswana. The majority of small stock is reared under traditional farming systems. Nutrition is one of the limiting factors. This paper discusses how crop residues and browse plants may be incorporated in the production system. Methods of treatment of crop residues are discussed, with emphasis being placed on the use of ammonia. The paper further discusses the use of microorganisms to treat crop residues and use of recombinant DNA technology as future possibilities of applying technology to improve nutrition of small stock in Botswana.
Keywords: Nutrition; Small stock; Biotechnology; Botswana

Introduction

Nutrition is one of the most serious limitations to livestock production in Botswana. The limitations are due to lack of feed in terms of quality, quantity and seasonal availability. For large parts of Africa including Botswana, the main priority is usually not to increase the availability of animal proteins but to ensure availability of staple food crops. Therefore, scarce resources such as arable land and fertilizer are used for the production of food (and cash) crops while livestock depend largely on marginal land and crop residues (Zemmelink, 1995). Livestock production in Botswana is based on extensive grazing of natural rangelands that can be classified as marginal (APRU, 1979, Buck *et al,* 1982). The rangelands have high variability in soil fertility, and floristic composition, structure and nutritional value of the vegetation (White, 1993). Botswana is a semi-arid country, with mean annual rainfall ranging from 200 mm in the southwest to 700 mm in the north. Most rain falls during the summer months of October to April, often as localized showers and storms. Annual rainfall is variable and droughts are recurring hazards, and water is scarce (White, 1993).

Sheep and goats are commonly known as small stock in Botswana. They play an important role in the rural economy in Botswana (National Development Plan, 8). Most farming households in Botswana keep small stock, particularly goats, and therefore the situation still holds true to the saying of 'the goat is the poor man's cow', as is for the many developing countries (Morand-Fehr and Boyazoglu, 1999). Small stock is kept as source of protein (milk, meat), hides, quick cash incomes, and have important role in cultural/social events such as weddings. They are slaughtered more frequently than cattle to provide meat for home consumption with little or no refrigeration. The low demand for labor and capital as compared to cattle could ensure that small stock contributes more to economic diversification than other livestock enterprises (El Aich and Waterhouse, 1999). Goats are naturally browsers and are therefore able to utilize shrubs, while sheep on the other hand are grazers. Such feeding behavior, disease and heat tolerance enables goats to effectively cope with the stressful nature of the marginal lands of semi-arid countries such as Botswana (Katongole *et al,* 1996). Their lower *per* head nutrient requirement means that sheep and goats fit the limited resources of small farms and marginal lands (Ntseane, 1993). The aim of the paper is to briefly review the traditional farming system in Botswana with special reference to small stock

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and the available technologies that are relevant and have the potential application of improving small stock nutrition in the current setup.

Traditional farming system

Traditional livestock system is usually associated with subsistence farming. A variety of livestock is involved in mixed grazing on unenclosed communal pasture. There is therefore competition for grazing between different species of animals (cattle, sheep, and donkeys). There are no limits to the number of animals that can be grazed on the land (APRU, 1980). The system depends on the common use of grazing land. The majority of small stock owners keep very few animals with an average flock size of 28 for goats and 14 sheep, and own few or no cattle (CSO, 1999). During the growing season (November to March), the animals are shepherded from early morning till late afternoon and are housed or enclosed in a kraal at night to avoid destroying crops and for need to supervise them by herders.

Traditionally in Botswana, livestock particularly cattle reflects the status of individuals in society, therefore attempts to improve grazing by reducing stock numbers and rational grazing are often frustrated by lack of cooperation between neighbours. The small flocks of sheep and goats are usually reared around compounds/households in the villages, at the lands and cattleposts. For those who own more animals, livestock is usually entrusted on labour that is supervised by infrequent visits. The owner is invariably absent from his/her livestock, living in the local village or more distant township often in paid employment. The herders are often poorly trained in livestock husbandry and poorly paid, and as a result provide poor management. Animal productivity levels remain low under traditional farming system. Table 1 shows the distribution of sheep and goats (for year 1994/95) in the traditional and commercial systems compared to cattle. The traditional system is economically important as it accounts for a larger proportion of the country's livestock industry in terms of both human and livestock population (Seleka, 1999).

Table 1: Number of goats, sheep and cattle for the year 1994/1995 under the traditional and commercial farming systems

Farming System	Goats	Sheep	Cattle
Traditional	2.61 million	325, 200	2.3 million
Commercial	16, 960	11, 690	146, 970

Source: CSO 1999.

Animal Feeds

The majority of small stock owners in Botswana are classified as poor (CSO, 1999). Limited access of many of these farmers to external inputs leaves the production of animal feeds at a low priority in Botswana, as is the case for many developing countries. According to Zemmelink (1995), if good land could be used for livestock production, combined with the same input of fertilizers and appropriate machinery as is used in developed countries, both quality and quantity of animal production could be much improved. However this is not possible in Botswana and many other developing countries.

Many different feed stuffs are used for feeding small stock in Botswana, these can be classified as dry roughages, green forages, pasture and range plants, concentrates (grains and bran), protein supplements, and mineral and vitamin supplements (Aganga, 1999). Analysis of nutrient composition of most livestock feeds in Botswana has been carried out (Macala *et al*, 1995). Due

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to high temperatures, unreliable rainfall and soils of poor fertility, forage from natural rangelands in Botswana is of low nutritive value, and is characterized by high crude fibre, low crude protein, low dry matter digestibility, low calcium and potassium (APRU, 1990a). Supplementary feeding using grains and concentrates increases production, but it is not commonly economical for the majority of small stock farmers in Botswana to supplement range animals as increased costs of feeding these feeds are usually not commensurate with output in saleable animal products (Aganga, 1999). In addition the use of grains compete with humans for these resources. Thus small stock production is solely based on grazing of natural rangelands.

During the dry seasons, the diet for small stock and other animals is based on crop residues and low digestible mature C4 type grasses. Feed availability during this period, could be improved where feasible and economical, by harvesting of surplus growth of pasture at an early stage of maturity, followed by suitable preservation (Shelver et al., 1989). However, this is not possible as the pasture is communal, the available fields are used for growing crops for human consumption and the resources are not just there. Nutrition of small stock in Botswana can immediately be improved by strategic use of crop residues and improving their quality by various methods of treatment.

Crop residual

Sorghum and maize are the major cereal crops in Botswana, followed by millet, groundnuts and pulses. During favorable rainfall years, considerable quantities of crop residues (cereal stovers) are produced which could supplement ruminants during the dry season, that normally depend on natural rangelands (Macala, 1993). Yields ranging from 2-4 tonnes per hectare of crop residues have been reported in smallholder farms (APRU, 1990a). Crop residues are available to majority of small stock farmers who are mixed livestock-arable farmers. Crop residues have not been fully exploited by small stock farmers as a supplementary feed in Botswana. The most common method of usage by the majority of these farmers is to allow the animals to graze the standing crop. The main disadvantages of this method are decrease in both yield and nutritive value, and wastage during grazing (Mosienyane, 1983).

Crop residues can appeal to small stock farmers as an alternative feed, but they must be used with little or no cost incurred. It is usually cheapest when crop residues are used on the farm where the crops are grown, for transportation can increase the real costs (Raymond *et al,* 1986). Major constraints limiting the efficient utilization of crop residues by small-scale livestock producers have been listed as lack of labour for harvesting and collection of the residues, and transportation from the fields to the site where the animals are kept (Macala, 1993). Although labour constraints for specific operations or for the specific times of the year are often cited as a limiting factor in increasing productivity in Botswana, labour used for sheep and goat production is supplied by family members (Ntseane, 1993). According to Ntseane (1993), low labour requirements and limited skill necessary to maintain a small flock, makes it possible for a household to generate an economic return from family labour that has little or no opportunity cost. The majority of small stock owner use animal draft power for cultivation and transportation.

Improving digestibility of cereal stover

Crop residues have generally contributed little to the rations of productive livestock because ruminants poorly digest it and its intake is relatively low (Raymond *et al,* 1986). Low digestibility is due to the presence of lignin that is closely associated with hemicellulose, forming a matrix surrounding the orderly cellulose microfibrils. This gives the straw enough strength to hold up heavy ears of ripening grain. Cereal stover can vary widely in feeding value depending on the crop grown, the variety and how much it was weathered before it was picked. Numerous extensive reviews have been written about improving nutritive value of straw and other low quality roughages

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(Sundstol et al., 1978, Sundstol and Coxworth, 1984, Sundstol, 1988). It has been known for almost 100 years that digestibility of highly lignified materials may be improved by physical and chemical treatment. There are however very few reports of such attempts in Botswana (APRU 1990b).

Physical treatment

Physical treatment primarily increases feed intake while digestibility is unaffected or decreased (Sundstol, 1988). Physical treatment of straw has been extensively reviewed (Donefer, 1977 cited Sundstol, 1988). The only form of physical treatment that has been tried in Botswana is chopping. The Rural Industrial and Innovation Centre (RIIC) in Botswana has produced prototypes of the mechanical choppers, which can be operated manually, or be powered by petroleum engines or using electricity. The choppers have not been widely used, but are gaining acceptances in the farming community especially by dairy and small-scale farmers where it has been promoted. Small stock farmers can form groups of 2-5, and contribute some money to buying choppers. Research on the economics of using choppers by small-scale farmers and their impact on small stock production is urgently required. There are other forms of physical treatment that include boiling under high pressure or steaming. However, according to Donefer (1977) cited by Sundstol (1988), because of the equipment and investment required, boiling under pressure and steaming treatment is relatively expensive and is not feasible at farm levels and questionable at commercial levels.

Chemical treatment

Attempts to improve nutritive value of straw and other low quality roughages by chemical treatment has been made as far back as 1895 by Lehmann (Sundstol et al., 1978). Chemical treatment of straw has been reviewed (Sundstol, 1988). The two most commonly used chemicals are sodium hydroxide and ammonia.

Sodium hydroxide treatment

The treatment of straw with alkali can increase digestibility to a range as high as most of the hay and some of the silage made (Raymond et al., 1986). Sodium hydroxide is used in a concentrated solution (27% w/v) in water, and is added at the rate of 50 kg of sodium hydroxide (just under 2000 litres of solution) *per* ton of straw to give rapid delignification. The solution has to be uniformly distributed and well mixed with the straw before it is put into store. As there is little movement of alkali once the straw is in the store, any straw that does not get wet does not have its digestibility improved. The treatment works by solubizing lignin, thus causing disruption of fibre by swelling and this improves the digestibility of the fibrous roughages. According to Raymond et al. (1986) on farm methods have being used, generally give less increased digestibility than would be indicated in experimental results (with *in vivo* digestibility generally below 60%) because of the practical difficulty of mixing the alkali uniformly with the straw.

The problem with this method is that 27% sodium hydroxide solution is corrosive and must be handled and applied with great care. It is our view that the use of sodium hydroxide may be hazardous in terms of health to the owners and may pollute the environment if widely adopted by small stock farmers, the majority of whom are not well educated. Animals fed with sodium hydroxide treated straw produce more urine than usually so as to excrete the extra sodium ions. This implies that more water, which can be scarce during drought, becomes a pressing need for the animals to compensate for this. However, research may need to be undertaken to elucidate these phenomena in goats since this species is well known for its high capacity for physiological water conservation mechanism. Trials were carried out in Botswana in the early 1980s to improve

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digestibility of crop residues using sodium hydroxide (2-4%) (APRU, 1900a). Treatment with sodium hydroxide increased digestibility of sorghum, millet and maize stover, the highest being millet with 35%. However, there was no further evaluation of the method on farms or on large scale and trials were abandoned for unknown reasons.

Ammonia treatment

An alternative method to the sodium hydroxide treatment is the use of anhydrous ammonia (Sundstol et al., 1978), a weaker alkali. Ammonia can be used in pure form (anhydrous), in water solution (aqueous), in solid compounds such as urea or urine (Sundstol and Coxworth, 1984). Most straws, stovers, and other low quality roughages contain 0.5 and 1.0 percent nitrogen (N). After ammonia treatment, the nitrogen content of the material may be raised by 0.8 to 1.0 percentage units equal to an increase of 5-6 percentage units in crude protein content i.e the N content of the feed is roughly doubled (Sundstol *et al,* 1978). If treatment of straw with ammonia is done properly in organic matter digestibility increase by 10–12 (Sundstol and Coxworth, 1984). According to Sundstol and Coxworth (1984), the advantages of ammonia treatment method include being simple and relatively inexpensive depending on the technology used. Ammonia has a preservative effect and the treatment does not cause any pollution of soil and water. Ammonia in the straw has two effects; it improves the fermentability of the straw in the rumen by breaking some of the ligno-hemicellulose bonds and it provides non-protein-nitrogen for growth of microorganisms in the rumen when the forage is consumed. Although urea ensilaging of straw can be economic and effective, the technology has not been widely taken up by smallholder farmers (Leng, 1991).

In Botswana, the main reason for this may be that farmers are not aware of such a method. The cost of urea is about P150,00 per 50 kg a bag and with the amounts of straw that get wasted, this method could improve seasonal availability of feed for the farmers. Urea is applied at the rate of 40g per 1kg of stover dissolved in water. Therefore 50kg urea has the potential of treating 1.3 ton of stover. In Botswana the most readily available form of ammonia is urea as feed grade and fertilizer grade urea. According to Leng (1986) fertilizer grade urea is quite safe to use when making urea/molasses block. Therefore it may also be suitable for upgrading nutritive value of stover especially if it dissolved in water instead of paying a high premium for the feed grade version. Farmers who already use urea as soil amendment would need to consider the relative merits of using it for stover treatment versus soil fertilization. However, stover treatment is rapidly converted into an economic output such as milk or meat and is independent of climatic conditions, whereas it might not rain after soil fertilization (Øygard, *et al,* 1999).

Treatment of crop straw with ammonia has been tried in Botswana (APRU, 1990a) but it was found to have no economic effect or difference in feed intake between ammoniation of stover and supplementation with bran. There is need to resume investigations of ways of improving digestibility of straw, especially using ammonia since the economic considerations may have change. In India and China, straw forms an important part of livestock feed and has improved livestock productivity. It is collected from the field, chopped and stored for feeding animals during periods when range grazing is not available (Kristjanson and Zerbini, 1999). Sorghum straw was found to contribute between 20 and 45% of the total dry weight fed to dairy animals in western Maharashtra (Thole *et al,* 1988 cited by Kristjanson and Zerbini, 1999). Consequently there has been increase in the market price of straw relative to grain.

Potential of trees as source of proteins

There has recently been an increased interest in browse trees in Botswana (Aganga *et al,* 1998; Aganga and Wani, 1999; Adogla-Bessa *et al,* 1999). Browse plants produce leaves, seeds and pods or seeds that can be used as feeds for small stock particularly goats that are natural browsers.

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Acacia species, which belongs to the family *Leguminosae,* is the most important single genus of browse plants in Botswana. *Acacia* species are quite rich in proteins and minerals (Aganga *et al,* 1998). Other browse plants that are rich in proteins and minerals include families – *Capparidaceae* (Boscias), *Combretaceae* (Combretum) and *Tiliaceae* (Grewias). Seasonal availability of browse plants varies, however, some such as *A. tortills, G. flava* and *T. sericea* are present all year round. The browses are often of good nutritive value with leaves containing 10 – 29.89% crude protein, 0.5 – 2.5% calcium and 0.05 – 0.16 phosphorus. Agroforestry is well developed in countries such as New Zealand, it may be time to consider incorporating the cultivation of browse trees as protein source. The potential for such is enormous in the rangelands (Leng, 1991). Plant biotechnology may be very important to the use of trees as a forage components, as there is a considerable variability in seed production among trees, plant tissue culture from high yielding varieties could be a considerable advance.

Future possibilities of improving nutrition

Microbial treatment of crop residues

An alternative strategy to the improvement of digestion of fibrous forages is by growing non-toxic fungus on it. The aerobic white rot fungi *Basidiomycetes* degrade lignin more rapidly and extensively than any other studied microbial group (Leng, 1991). The problem with this approach is that although protein is produced and digestibility of the forages is increased, a considerable proportion of the total biomass is lost, particularly when white rot is allowed to proceed to mushroom formation stage. Microbial treatment offers alternative to chemical treatment of straw. However, it requires identification of suitable microorganisms particularly fungus that would work under conditions such as found in Botswana.

Selection of rumen microorganisms

The utilization of forages by ruminants depends on unique capacity of anaerobic rumen microorganisms (bacteria, protozoa, fungi as well as viruses and phages (bacterial viruses)) to produce enzymes which breakdown fibre, starch, sugars, and proteins. The principal organisms are bacteria that ferment plant cell-wall carbohydrates. The population density of each group can be highly variable depending on the diet (Leng, 1991). The low digestible forages and crop residues are characterized by slow rate of microbial breakdown in the rumen and therefore reduced outflow rate of feed residues from the rumen, which as a result depresses feed intake (Rege, 1994). Low digestible feeds do not have sufficient nutrients available to rumen microorganisms, this also reduces microbial growth efficiency, which in turn reduces microbial biomass and eventually reduces digestibility and feed intake, particularly of fibrous feeds (Leng, 1991).

It is important to start screening for microorganisms with greater capacity to degrade fibre and its components, so that greater amount of nutrients from the feed becomes available to the animals. There are potentially three ways (Leng, 1991) to achieve this: (a) selection of microorganisms, particularly fungi with high fibrolytic enzyme secretion or that secrete fibrolytic enzymes of high specificity; (b) creation by recombinant DNA technology of microorganisms with greater spectrum of enzyme secretion, for example, create lignolytic capacity in cellulolytic organisms and vice versa; and (c) create microorganisms with enhanced fibrolytic activity by recombinant DNA technology. Genes encoding cellulases have been cloned from a variety of cellulose digesting bacteria, which occur naturally in the rumen and other ecosystems (Hazelwood and Mann, 1989). The ligninase gene has also been cloned and sequenced (Tien and Tu, 1987). Techniques for incorporating DNA encoding specific enzymes into anaerobic bacteria are well established. The prerequisite for this is that whatever the organisms, they should be able to grow in and maintain space in the rumen (Leng, 1991).

With the current level of scientific development, Botswana is still at an infancy stage in the use of recombinant DNA technology in terms of technical expertise and infrastructure. The most

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suitable and appropriate research will be the selection of anaerobic microorganisms particularly fungi with fibrolytic enzyme secretion or that secrete fibrolytic enzymes of high specificity or any other desired phenotype. Botswana has a vast genetic resource in terms of both domestic and wildlife species that are raised on marginal lands with extreme dietary conditions. Selection of bacterial strains for improved cellulolytic activity appears to be less vital as it is fungi that are relatively more important in the breakdown of the most resistant components of forages, particularly low quality forages (Leng, 1991). According to Leng (1991), research has shown that rumen fungi but not bacteria have unique enzymes that give them the ability to weaken and degrade the most limiting structural barriers to degradation. The selection criteria should also include the measurements of the rate of solubilization of fibrous carbohydrates by the selected fungi and weakening of the forage stems following a period of incubation (Leng, 1991).

Use of Tannins

Apart from valuable nutrients, browse plants contain tannins. Some condensed tannins protect plant material from digestion in the rumen. The condensed tannin-protein complex disassociates in the abomasum due to low pH, releasing amino acids for absorption in the intestine. Dietary proteins are able to escape rumen fermentation through this mechanism. Improvement can be made on rumen escape dietary protein by identifying plants whose proteins are protected naturally. A study by Aganga et al. (1998) reported varied crude protein, protein degradability and tannin level of some of the browse plants in Botswana. A future possibility is to consider the use of recombinant DNA technology to identify genes that code for protective tannins and transfer them to forages such as *Lablab purpureus* to produce transgenic plants that will have reduced protein loss through rumen fermentation. The challenge to nutritionist and microbiologists would be to define for the plant molecular biologist which tannin phenotype is desirable for improving nutritive value. Already a gene for low-molecular weight pea seed protein PA1 that is high in rumen undegradable cysteine has been isolated, sequenced and transferred to lucerne (Robinson and McEvoy, 1993).

Development of detoxification mechanisms in rumen microorganisms

In order for plants to survive insect, fungal and bacteria attack, a system that uses secondary compounds that detracts these organisms from colonizing the leaf tissues has evolved. Many secondary plant compounds are toxic to the rumen microorganisms, or directly or indirectly toxic to the animals following microbial metabolism in the rumen (Leng, 1991). This according to Leng (1991) restricts the feed base of ruminants, and at times prevents stocking of land. The presence of *D cymosusm* in any area often discourages farmers to use land for livestock farming. For example, the resettlement of Remote Area Dwellers in Xhabo, in the Central Kgalagadi District is threatened by the presence of *D cymosusm* as farmers are reluctant to use land because of high livestock mortality rates due to plant poisoning. *D cymosum* is often associated with plant poisoning in livestock in the sandveld such as in Gantsi, Ngamiland, Kweneng and Kgalagadi districts.

A possible detoxification system of great importance to Botswana will be the one that deals with *Dichapetalum cymosusm* (Tswana name: Mogau), a deciduous perennial shrub. The plant occurs in the warm, sub-tropical, usually dry regions of Southern Africa (Meyer and van Rooyen, 1996) and the distribution covers Botswana, the Transvaal province of the Republic of South Africa, Namibia, and Zimbabwe. During the dry season between August and October, and the end of rains in March and April, *D cymosusm* is the only plant with green leaves, which attract livestock. Relatively high fluoroacatate concentration – the toxic principle of the plant are present in younger leaves of *D cymosusm* (231.9 mg/kg fresh mass) and the concentration is much lower in older leaves (97.0 mg/kg fresh mass) (Meyer and Grobbelaar, 1990). The lethal dose of this

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compound is 0.06 – 0.02 mg/kg for dogs, 0.15 – 0.62 mg/kg for cattle and 0.25 – 0.50 mg/kg for sheep (Meyer and Grobbelaar, 1991). Animals convert fluoroacetate to fluorocitrate, which is a competitive inhibitor of the enzyme aconitase and this leads to the blockade of the Krebs cycle.

A fluoroacetate metabolizing bacteria *Pseudomonas cepacia* has been isolated from stems of *D cymosum* by South African researchers (Meyer and Grobbelaar, 1991, Meyer and van Rooyen, 1996). The aim of the research has been to develop the detoxifying microorganisms for *D cymosusm*. Since the bacterial cultures frequently lose their ability to breakdown fluoroacetate after a few months, Meyer and van Rooyen (1996) isolated a fluoroacetate defluorinating plasmid. According to Meyer and van Rooyen (1996), the plasmid could be transferred to another bacterium occurring naturally to produce fluoroacetate-metabolizing bacteria, which can be reintroduced into the rumen. The system would give animals the ability to digest *D cymosum* without any detrimental effects. Certain grazing areas that have not been used due to this problem, may eventually become inhabitable. A possibility for such an approach was demonstrated when a microbe isolated from the rumen of Hawaiian goats, was introduced into rumen of Australian cattle feeding *Leucaena leucocephala* and was able to degrade 3,4-dihydroxy-pridine (Leng 1991, Robinson and McEvoy, 1993). Although this system offers hope, more work is still required, as genetically modified microorganisms should be able to grow in and maintain space in the rumen. This calls for collaboration between Botswana and South Africa, as there may be isolates of *P cepacia* in Botswana that may be quite useful.

Discussion

Small stock farming in Botswana is a complex system, which in most cases is integrated with subsistence cropping. Crop residues and browse plants form a valuable resource. Lack of feed resources during the dry seasons imposes a major constraint on maintenance of livestock. A relevant research question in Botswana, and to some extent other developing countries is not how to get animals to produce on low quality crop residues, but to what extent, how, where, and when such material could be used in the overall production (Zemmelink, 1995). In South Asia, crop residues in particular cereal straw, provide the bulk of livestock feed (Kristjanson and Zerbini, 1999).

Livestock technologies have had little impact on production and productivity at farm level (Udo, 1996). Too often the recommendation to apply specific technology tested under experimental conditions assumes the technology will be widely adopted and will increase production. There is need for Botswana scientists particularly animal nutritionists to investigate further technologies, which could improve digestibility of crop residues. These technologies should be attractive to smallholder farmers and be sustainable. The idea is to identify useful innovations and field-test them, while in the mean time identify real field problems for redirection of research (Scheire, 1993). The initial problem for researchers in Botswana is to find methods of treatment of crop residues that are both acceptable and effective at village level. The most feasible method of treatment of crop residues is to use urea as a source of ammonia. Urea treatment can certainly increase digestibility and feed intake.

The use of browse plants has mostly been used during drought, mainly by goats and wildlife but there are unsubstantiated observations of browsing by cattle too. However, browse trees have not been formally incorporated in feeding management of livestock. Before the message can be propagated to farmers, methods of cultivation, maintenance of trees and effective methods of harvesting should first be explored. Although browse plants have traditionally been used sparingly and sporadically, any recommendation for increased use could lead to extensive deforestation. Although improving production is important, emphasis should be placed on protecting the land and the environment. The approach should be to encourage growing indigenous browse plants to curb soil erosion and deforestation. Small stock particularly goats will benefit as trees grow. Agroforestry in other countries is well developed, and can be beneficial in rural communities.

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Introducing any form of technology to small stock farmers requires a systematic approach. The approach should start from the view that when a system is broken down, it losses its essential characteristics, and in turn losses its synergistic effect of interrelationships between various elements and the results could be loss of feedback control. Thus the development of appropriate technology requires knowledge of the perceptions and resources of farmers, and the role of a wider perspective than livestock production in itself.

References

Adogla-Bessa, T, Aganga, A A and Lekgari, L C 1999 Feed resources of Tswana goats under extensive management systems in Kweneng District of Botswana. In Aganga, A A, Chabo, R G, Kgosimore, M, Letso, M and Omphile, U J (eds) Proceeding of the sheep and goat workshop. Centre for In-service and Continuing Education, Botswana College of Agriculture, Gaborone, 19-24 April 1999. pp331-342.

Aganga, A A 1999 Goats and sheep feeds and feeding in Botswana. In Aganga, A A, Chabo, R G, Kgosimore, M, Letso, M and Omphile, U J (eds) Proceeding of the sheep and goat workshop. Centre for In-service and Continuing Education, Botswana College of Agriculture, Gaborone, Botswana. 19-24 April 1999. pp287-309.

Aganga, A A, Tsopito, C M and Morake, K M 1998 Tannin contents of indigenous browse plants of Botswana. Proceedings of XVIII International Grasslands Congress. Winnipeg, Manitoba Saskatoon, Saskatchewan, Canada. 8 – 19 June, 1997.

Aganga, A A and Wani, M 1999 *Dichrostachys cinerea* and *Acacia nilotica* as supplements to buffalo grass hay fed to Tswana goats. In Aganga, A A, Chabo, R G, Kgosimore, M, Letso, M and Omphile, U J (eds) Proceeding of sheep Proceeding of the sheep and goat workshop. Centre for In-service and Continuing Education, Botswana College of Agriculture, Gaborone, 19-24 April 1999. pp343–348.

Animal Production Research Unit (APRU) 1979 Livestock and Range Research in Botswana. Annual Report. Ministry of Agriculture. Government of Botswana, Government Printers, Gaborone, Botswana.

Animal Production Research Unit (APRU) 1980 Beef cattle Nutrition In; Livestock and Range Research in Botswana. Government Printers. Gaborone. pp109-116.

APRU 1990a Twenty years of animal production and range research in Botswana. Government Printers, Gaborone, pp65.

APRU 1990b Utilisation of Leucaena leucocephala dry leaves as supplement for growing Tswana goats fed sorghum stover during the dry season. In Livestock and Range Research in Botswana. Government Printers. Gaborone pp48-54.

Central Statistics Office 1999 Botswana Agricultural Survey Report 1995. Ministry of Finance and Development Planning. Printing and Publishing Services. Gaborone.

Buck, N, Light, D, Lethola, L, Mlambo, M and Muke, B 1982 Beef cattle breeding systems in Botswana: the use of indigenous breeds. World Animal Review. 43, 12-16.

Donefer, E 1977 Physical treatment of poor-quality roughages at commercial and farm levels. FAO, Animal Production and Health Paper 4, 17-23. Cited by Sundstol, F. 1988. Improvement of poor quality forages and roughages. Chapter 10. pp257–277. In Orskov, E R (Eds) Feed Science. Elsevier Publishers BV, Amsterdam

El Aich, A and Waterhouse, A 1999 Small ruminants in environmental conservation. Small Ruminant Research 34, 271-287.

Hazelwood, G and Mann, S 1989 Improving forage digestibility by genetic engineering. In Bioscience in Animal Production AFRC News. Vol 1,12-13.

Katongole, J B D, Madimabe, M J and Sebolai, B 1996 Morphological characterization of Tswana goats. Proceedings of the Third Biennial SRNET Conference, Kampala, Uganda – 5-9 December, 1994.

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Kristjanson, P M and Zerbini, E 1999 Genetic enhancement of sorghum and millet residues fed to ruminants. An ex ante assessment of returns to research. ILRI impact assessment Series 3. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp52.

Leng R A 1986 Drought feeding strategies: Theory and practice. Penambul Books. Armidale. pp44-54.

Leng, R A 1991 Application of biotechnology to nutrition of animals in developing countries. Food and Agricultural Organization Paper No 90, Publication Division, Rome, Italy.

Macala, J 1993 Crop residues and agro-industrial by-products as feed resources for ruminants. In The potential for increasing livestock productivity in Botswana. Tacheba, G, Mahabile, W and Dailey, J (eds) Proceedings of the Livestock Production Workshop, Gaborone. 14-17 October 1991. Government Printers, Gaborone. pp193-206.

Macala, J, Mosimanyana, B and Kiflewahid, B 1995 Nutrient composition of livestock feeds in Botswana. Ministry of Agriculture, Government Printers. Gaborone.

Meyer, J J M and Grobbelaar, N 1991 Fluoroacetate degradation in Dichapetalum cymosum. Journal of Plant Physiology 138, 122-124.

Meyer, J J M and van Rooyen, S W 1996 Genetically transformed Bacillus subtilis with deflourinating ability. South African Journal of Botany 62, 65-66.

Morand–Fehr, P and Boazoglu, J 1999 Present state and future outlook of the small ruminant sector. Small Ruminant Research. 34, 175–188.

Mosienyane, P 1983 Crop residues for livestock feeding livestock feeding. Bulletin of Agricultural Research in Botswana 1:3-9.

National Development Plan 8 1997 Ministry of Finance and Development Planning. Government Printers, Gaborone. pp252.

Ntseane, P 1993 The role of small stock in the welfare of the rural families In; The potential for increasing livestock productivity in Botswana. Tacheba, G, Mahabile, W, Dailey, J (eds) Proceedings of the Livestock Production Workshop, Gaborone.14-17 October 1991. Government Printers, Gaborone. pp193-206.

Øygard R, Vedeld, T and Aune, J 1999 Good practices in drylands management. The World Bank. Washington DC. pp56-59.

Raymond, F, Redman, P and Waltham, R 1986 Forage: conservation and feeding. (4th ed). Farming Press Ltd. Ipswich, Suffolk.

Rege, J E O 1994 Biotechnology options for improving livestock production in developing countries, with special reference to Sub-Sahara Africa. Proceedings of the second Biennial Conference of African Small Ruminant Research Network, AICC, Arusha, Tanzania – 7-11 December 1992.

Robinson, J J and McEvoy, T G 1993 Biotechnology – the possibilities. Animal Production 57, 335–352.

Schiere, H 1993 Research and extension in Livestock development. In: Animal production in developing countries. Occasional Publication No 16. Gill, M, Pollet, G E and Lawrence, T L J (eds) British Society of Animal production.Wyiwyg://14/http://www.geocities.com/RainForest/Canopy/3770/11resrch.html.

Seleka, T B 1999 Sustainability of Botswana's small ruminant industry in the 21st century. In Aganga, A A, Chabo, R G, Kgosimore, M, Letso, M and Omphile, U J (eds) Proceeding of the sheep and goat workshop. Centre for In-service and Continuing Education, Botswana College of Agriculture, Gaborone, 19-24 April. pp7-21.

Shelver, G D, Kernick, B L and Kistner, A 1989 Prospects for advances in ruminant nutrition based on the application of modern biotechnology. In: D Swart (ed) Proceedings of an information day held at the Animal Dairy Science Research Institute, Irene. Government Printer, Pretoria 1990. Technical Communication No 223. pp63-689.

Sundstol, F 1988 Improvement of poor quality forages and roughages. Chapter 10. Pp 257 – 277. In Orskov, E R (Eds) Feed Science. Elsevier Publishers B V, Amsterdam.

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Sundstol, F, Coxworth, E E and Mowat, D N 1978 Improving the nutritive value of straw and other low quality roughages by treatment with ammonia. World Animal Reviews 26: 13-21.

Sundstol, F and Coxworth, E M 1984 Ammonia treatment. Chapter 7. In Sundstol, F and Owen, E (Eds) Stran and other fibrous by – products as feed. Elsevier, Amsterdam, pp146-277.

Thole, N S, Joshi, A L and Rangnekar, D V 1988 Feed availability and nutritional status of dairy animals in western Maharashtra. In Sing, and, Schiere, J B (eds) Fibrous Crop residues as Animal Feed. ICAR (India Council of Agricultural Research), New Delhi, India. Pp 207 – 212 cited Kristjanson, P M and Zerbini, E 1999 Genetic enhancement of sorghum and millet residues fed to ruminants. An ex ante assessment of returns to research. ILRI impact assessment Series 3. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp52.

Tien, M and Tu, C-P D 1987 Cloning and sequencing of a cDNA for ligninase from Phanerochaeate chrysosporium. Nature 326, 520–523.

Udo, H 1996 Myths in livestock development. Address on the occasion of 'Livestock Development Day' of the 'Netherlands Centres for training in Animal Resources Management(NCTR)',Oenkerk.Wyiwyg://11/http://www.geocities.com/RainForest/Canopy/3770/10myths.html.

White, R 1993 Livestock development and pastrol production on commercial rangeland in Botswana. Botswana Society, Gaborone.

Zemmelink, G 1995 Allocation and utilization of resources at the farm level. Address on the occasion of the symposium 'A research approach to livestock production from a systems perspective, a farewell to Professor Dick Zwart' Wageningen. January 1995. Wyiwyg://5/http://www.geocities.com/RainForest/Canopy/3770/4Feed.html.

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