SOYABEAN AS AN EMERGING CROP: A BASELINE SURVEY ON ITS POTENTIAL USES IN A MIXED SMALLHOLDER FARMING SYSTEM IN ZIMBABWE

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ABSTRACT

A diagnostic study was conducted to determine the potential uses of the soyabean crop and its residues in on-farm research in the Mushagashe smallholder mixed farming system. Farm sizes averaged 78.5 ha ± 6.3 (se) and ranged from 16 ha to 210 ha. Arable land averaged 10.7 ha ± 0.8 (se). Maize and groundnuts were the major crops grown in the area. Soyabean had been grown in the area for the past two seasons, and 17 % of the farmers were producing the crop. A lack of inputs was the major constraint to soyabean production. Poor soil fertility also affected crop production in general. As a result, 46 % of the farmers left some land fallow. Farmers aimed at maximizing manure output for use in their fields. All farmers owned cattle and 66 % of them engaged in dairy. Poor dry season nutrition was the major limitation to cattle production. Utilizing the soyabean crop to tackle some of the farmers' constraints appeared viable.

1. INTRODUCTION

Zimbabwe's farming system consists of the large scale commercial and the smallholder sectors. The communal, resettlement and the small-scale commercial (SSC) sub-systems comprise the smallholder sector. Soyabean (*Glycine max*) is an emerging crop in the smallholder sector. The number of small-scale commercial farmers who have gone into soyabean production increased from 75 to 189, between 1996 and 2000 (CSO, 2001). Production of the crop has, however, been predominant in the northern provinces of the country. Only 22 % of the country's small-scale commercial growers of soyabean were in the southern provinces of Midlands, Masvingo and Matabeleland South, in the year 2000. There has, however, been no significant difference in the crop's productivity between the northern and southern provinces, in the SSC sector. In Masvingo, yields averaged 0.7 tonnes per hectare in the year 2000. This was in comparison to the national average of 0.8 t/ha in the same year. Total harvests in the SSC sector rose from 48 tonnes to 147 tonnes, between 1996 and 2000. Retained grain increased from 22 to 45

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tonnes, during the same period. There has also been an accumulation of soyabean straw, whose level of utilization is unknown.

Crop residues are an important component of the mixed crop-livestock farming systems in Sub-Saharan Africa and other developing countries. Despite their limitations in nutritional quality, crop residues have traditionally been used as livestock feed, particularly during the dry season (Topps and Oliver, 1993). Maize (*Zea mays*) and groundnut (*Arachis hypogaea*) stovers, and sunflower (*Helianthus annus*) heads are the most common residues used. In some smallholder farming systems, crop residues are also used as fuel (Mupanda, 2000). The use of soyabean and its residues in Zimbabwe's smallholder farming system has not been documented beyond the sale of the grain to oilseed-processors (CSO, 2001). It is against this background that the introduction of a new crop in a farming system should be pursued by efforts intended to test the potential of its by-products in problem solving.

This study was conducted in a SSC farming system during the diagnostic stage of an on-farm research project, which aimed at incorporating the soyabean crop into solving identified problems. The diagnostic phase involves the description of farmers' natural circumstances such as soils and climate, and socio-economic circumstances such as farmers' resources, local institutions and markets. Several methods are used to carry out diagnostic activities. Rapid rural appraisal (RRA) and participatory rural appraisal (PRA) techniques are some of the methods used in modern day agricultural project cycles (Chambers, 1994). Rapid rural appraisal consists of a series of techniques aimed at generating an impressive amount of information in a relatively short space of time. Techniques employed in RRA include the review of secondary sources (literature, maps, aerial photos), familiarization visits, direct observation, key informant interviews, group interviews and short simple questionnaires among others. Participatory rural appraisal builds on RRA but goes much further. To RRA it adds a perspective of shared learning between the farmers and the outsiders. In PRA, locals undertake data dissemination, with outsiders facilitating rather than controlling the proceedings. Common PRA tools used in communication and knowledge transfer during the diagnostic stage include: (i) direct observation and building rapport with locals; (ii) key informant interviews; (iii) group discussions; (iv) ranking and scoring (wealth, problem); (v) drawing seasonal and labour calendars; and (vi) semi-structured interviewing. The choice of RRA/PRA tools to use in problem identification for on-farm research varies from one situation to another.

The broad objectives of this study were to identify major enterprises, resource constraints and describe the major management challenges faced by farmers in crop and livestock production. The specific objective was to determine the potential researchable areas in which soyabean, an emerging crop, could be used to address the problems faced in the mixed crop-livestock system in Mushagashe SSC farming area.

2. MATERIALS AND METHODS

2.1 Description of the study area

This study was conducted in the Mushagashe small-scale commercial farming area (19° 55′S and 30° 50′E). The area is in Masvingo Province in south-central Zimbabwe, about 40 km north of Masvingo town and 250 km south of Harare. Mushagashe is partitioned into the East and West zones by the highway linking Harare with Masvingo town. It is in agro-ecological region IV, which receives less than 600 mm in annual rainfall mostly during the summer season (November to March). The soils are sandy-loam and therefore of moderate fertility. Land use is characterized by mixed crop and livestock production. Some farmers in the area engage in dairy farming, and market their produce through the local milk collection centre. *Acacia* and Miombo tree species dominate the vegetation in the area.

2.2 Data collection

Data was collected between August and November in 2002. Preliminary data on the study area was obtained through familiarization visits; direct observation; review of aerial maps; and key informant interviews with the local farmer association committee members, resident agricultural extension personnel and non-governmental organizations involved in agriculture. Forty-one households, out of 189 were then randomly selected from Mushagashe East and West and used in this study. Twenty-one of them were drawn from the East. Data was collected through interviewing the farmers using a prepared questionnaire. The questionnaire captured data on socio-demographic characteristics, land holding, cropping patterns, livestock ownership, stockfeed resources and manure management practices.

2.3 Statistical analysis

Land holdings, herd and household sizes were compared for significant differences between the East and West, using the PROC T-TEST procedure of SAS (1997). Descriptive statistics (means, standard errors and range) and

frequencies were calculated for the following variables; land holdings, cropping patterns, livestock owned, constraints to cattle production, cattle supplementary feeding practices and resources, and manure management practices, using the Statistical Package for Social Scientists (SPSS), (1997). Household and cattle herd sizes were transformed into square roots before they were used in correlation computations using the same statistical package.

3. RESULTS

There were no differences ($P > 0.05$) in average household sizes, grazing area, arable land size and herd size between Mushagashe East and West. Data were, therefore, pooled for all statistical analyses.

3.1 Household demography

Members aged above 50 years headed 81 percent of the farms. Twelve percent of farm heads were aged between 40 and 49 years. The remainder, (7 %) were between 30 and 39 years old. Women headed 24 % of the farms. Fifty-four percent of household heads held master farmer certificates and 71 % had been educated up to at least Junior Certificate or Standard 5. The average household size was 9.4 ± 0.7 and ranged from 3 to 20 members.

3.2 Landholdings

Average farm sizes were 78.5 ha ± 6.3 and ranged from 16 ha to 210 ha. Grazing area per farm ranged from 10 ha to 200 ha (mean 67.5 ± 6.4 se). Arable land averaged 10.7 ha ± 0.8 and ranged from 3 ha to 30 ha. Eighty-five percent of the farmers left some land fallow. Most of them (46 percent) cited the need to restore soil fertility as the reason for leaving fallow land (Table 1). There was also a high positive correlation between household size and the size of cultivated land ($r = 0.89$; $P < 0.05$).

Table 1: Farmers' reasons for leaving land fallow

Reason	Respondents	
	Number	**Percent of n***
Improve soil fertility	19	46.3
Lack of inputs	8	19.5
Shortage of labour	6	14.6
Control pests and diseases	1	2.4
Increase size of grazing area	1	2.4
Total	**35**	**85.2**

** Total number of respondents (n) = 41*

3.3 Crop production

Maize and groundnuts were the major crops grown in the area. Sugar beans, soyabeans, rice and wheat were the other crops cultivated (Table 2). Soyabean had been grown in the area for the past two seasons. Of the seven soyabean growers, five held master farmer certificates. One of the two non-certificate holders had a school teaching qualification, and the other had been educated up to Standard 5. All respondents cited a lack of inputs (seed and *Rhizobium* inoculant) as the major constraint in soyabean production.

Table 2: Crops grown, percentage of farms growing the crop and hectares (mean ± se*) cultivated for different crops in Mushagashe East and West during the 2000/2001 season

Crop grown	Percent of farms** with crop	Mean area ± se (ha)
Maize	100	8.2 ± 0.9
Groundnuts	95	1.6 ± 0.1
Sugar beans	20	0.9 ± 0.1
Soyabeans	17	1.2 ± 0.2
Rice	15	1.7 ± 0.4
Wheat	7	2.1 ± 1.4

** se – standard error*

*** n = 41*

3.4 Livestock ownership and use

All farmers owned cattle (range 3 to 42) and chickens (range 4 to 150). Other livestock owned were goats, sheep, turkeys and donkeys (Table 3). Cattle were considered the most valuable class of livestock because of the diverse roles they played in the farming system. Male members of the household owned more cattle ($P < 0.05$) than females (15.3 ± 1.9 se versus 4.5 ± 1.2 se). Sixty-six percent of the farmers engaged in dairy production. Milk sales, together with gardening, were the most common household income earners. All farmers relied on cattle for draught purposes. There was, however, no correlation ($r = 0.23$; $P < 0.05$) between cattle herd size and size of cultivated land. Ninety-eight percent and 83 % of the farmers penned their cattle overnight in the dry and wet seasons respectively. All farmers cited the need to accumulate manure as the reason for penning.

Table 3: Percentage of farms owning various livestock

Livestock	Percent of farms* with livestock	Ave. no. (±se) of stock owned
Cattle	100	19.6 ± 1.4
Chickens	100	20.9 ± 4.3
Goats	39	7.4 ± 1.9
Sheep	20	5.3 ± 1.1
Turkeys	20	3.4 ± 0.9
Donkeys	17	3.3 ± 0.4

**n = 41*

3.5 Constraints in cattle production

Time spent grazing and the distance travelled by cattle to grazing areas did not vary ($P > 0.05$) between the dry and the wet seasons. Ninety-nine percent of the farmers were satisfied with the size of their grazing land. However, deterioration in forage quality in the dry season (May to October) was cited by 90 % of the farmers as the major problem affecting cattle production (Table 4).

Table 4: Proportion of farmers facing various constraints in cattle production

Constraint	Percent of respondents* facing problem
Poor quality dry season forage	90.2
Water scarcity in dry season	24.4
Cattle health	2.4

* n = 41

In response to nutritional challenges, 98 % of the farmers offered supplements to their cattle. Sixty-six percent of the farmers prioritised certain classes of cattle when supplementing (Figure 3.1). Supplementation started in May for 63 % of the farmers. The rest (35 %) commenced supplementation in August.

3.6 Uses of crop residues in the farming system

Maize stover was used as cattle feed supplement by 98 % of the farmers. Soyabean grain, groundnut, wheat and soyabean straws were also used as supplements. Other feed resources used were commercial concentrates and

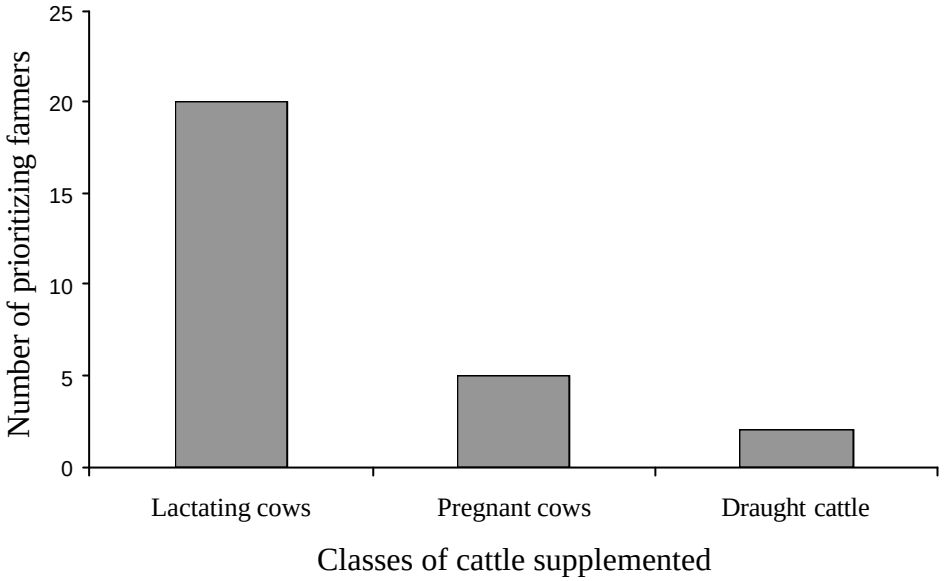

Figure 1: Priority ranking of different cattle classes offered supplements

bana grass silage (Table 5). All farmers who bought commercial concentrates engaged in dairy production.

Table 5: Percentage of farmers offering various crop residues and other resources as cattle feed supplements

Crop residue/ feed resource	Percent of farmers* using the resource
Maize stover	98.6
Groundnut straw	68.3
Commercial concentrates	31.7
Bana grass silage	24.4
Soyabean grain	17.1
Soyabean straw	9.8
Wheat straw	5.4

** n = 41*

Ninety-eight percent of the farmers added some roughage into cattle overnight pens. Of these, 69 % added crop residues. Eighty-six percent believed adding dry material increases manure quantity and quality. The rest (12 %) added the material to reduce dampness in the bedding.

3.6 Uses of soyabeans in the farming system

All soyabean growers (17.1 %) used the grain to feed livestock. Twelve percent (12 %) fed the grain to dairy cattle. The rest (5 %) offered the grain to draught cattle. Twelve percent milled the grain, and mixed it with maize before feeding. The remainder (5 %) fed whole grain without mixing with other ingredients. All 41 respondents were not aware of presence of anti-nutritional factors in soyabeans.

Soyabean straw was used as cattle feed by 9.8 % of the farmers. All of them found the straw to be too fibrous. Half of them (4.9 %) ammoniated it and the rest hydrated it with salted water before feeding it to cattle. Ammoniation was effected by sprinkling straw with a urea solution. There was no set standard on the amount of urea to add. Twelve percent of the farmers used soyabean straw as bedding in cattle pens and 5 % had no use of it.

4. DISCUSSION

The farming system in the Mushagashe small-scale farming area comprised mainly crop and livestock enterprises. Maize, the staple food, was allocated the largest hectrage. Results of the survey showed some challenges faced by farmers in the area.

Lack of labour, inputs and poor soil fertility were the major constraints affecting crop production. The high positive correlation between household size and cultivated hectrage agrees with observations by Chimonyo *et al.* (1999), that households with more members cultivated larger hectrages. The need to restore some soil fertility was cited as the major reason why most farmers left fallow land. This was in contrast with other findings (Shumba, 1984; Chimonyo *et al.*, 1999) where fallow land sizes were attributed to draught power shortages. In Mushagashe, lack of correlation between the size of cultivated land and cattle herd sizes confirmed adequacy of draught power in the area. Poor soil fertility emerged as the major challenge faced by the farmers in the crop enterprise.

As a soil fertility management measure, farmers utilized cattle manure. Almost all farmers penned cattle overnight throughout the year. This management practice, in a fenced area where cattle rustling was not reported as a problem, was done to accumulate manure. Farmers showed desire to increase manure off-take by adding crop residues into pens. Manure composting with fibrous material has been shown to improve manure quality and quantity (Sikora, 1988).

Cattle were considered the most valuable class of livestock. All farmers used cattle for draught and some engaged in dairy production. Milk sales were the most important household income earner. Dry season deterioration in quality of feed resources was the major constraint in the cattle enterprise. This was consistent with previous studies where inconsistent supply of quality feed has been reported to affect sustained draught power (Chimonyo *et al*, 1999) and milk production (Jingura, 2000) in Zimbabwe's smallholder sector. Protein and energy are the most limiting nutrients.

Less than half the farmers bought some dairy commercial concentrates for supplementing cow diets. All of them engaged in dairying. Such an investment emphasized how important dairy production was in the community. However, due to prohibitive costs of commercial concentrates, most farmers relied on crop residues and planted pastures for cattle feed resources. This agrees with common observations in Zimbabwe (Mupeta, 2000; Jingura; 2000) and elsewhere in Sub-Saharan Africa (Topps and Oliver, 1993). Prioritization of feeding according to classes of cattle reflected limitations in the quantities of feed resources available to the farmers. In addition, maize stover and groundnut straw, the major residues utilized in the area are known to be deficient in critical nutrients (Jong, 1993).

Soyabean was an emerging crop. The high literacy level of the few soyabean growers in the area could suggest that literate constituents are likely to be the early adopters of new innovations. However, all farmers were not aware of presence of anti-nutritional factors in soyabeans. All soyabean growers fed the grain to cattle, in a raw state. Dairy cattle were the most preferred. Soyabean feed rations per animal were generally not measured. The farmers reported an improvement in milk output from cows fed on soyabean. However, apart from milling, no other treatment was done to the grain prior to feeding cattle. More benefits could be realized if farmers roasted the beans, for example, prior to feeding. Besides inactivating anti-nutritional factors, roasting has been reported to improve aroma and flavour (Bates, 1994) and increase intake. Roasting increases by-pass protein levels in soyabeans due to Maillard reactions (Snowdon, 1995). By-pass protein in full-fat soyabeans improves milk production in cattle particularly during early lactation (Faldet and Satter, 1991). Using locally grown and farm-roasted soyabean, as a substitute for high cost protein sources is likely to cut input costs in the Mushagashe farming system.

Roasting soyabeans meant for livestock requires precise control of temperature and processing time (McNaughton and Reece, 1980). Under-heating produces incomplete inactivation of the anti-nutritional factors.

Excessive heating can reduce the bioavailability of the amino acids lysine and arginine, thereby lowering protein quality (Holmes, 1988). All respondents did not have specialized equipment for roasting soyabeans on their farms. Faced with the potential of improving milk yield by feeding roasted soyabeans to their dairy cows, there appeared a need to work with the farmers in Mushagashe to devise an affordable technology that would enable them to measure adequacy of roasting the beans.

Soyabean growers in the area reported soyabean straw to be too fibrous to use as stockfeed. However, faced with a critical deficit of cattle feed, 4.9 % of the farmers ammoniated or hydrated the straw in order to improve acceptability when feeding to their animals. While watering the straw softens the physical structure of the straw, ammonia treatment has the added advantage of increasing the nitrogen content of the roughage in the form of non-protein nitrogen. The potential use of soyabean straw as animal feed is worthy to consider in view of the fact that ruminants are adapted to utilize the cellulose in high fibre materials. Low digestibility (Restlé *et al*., 2000) and poor nutritive value (Jong, 1993) have been the primary factors limiting greater utilization of soyabean straw. Numerous studies (Lufadeju *et al*., 1987; Rasby *et al*., 1989; Trach *et al*., 1998) have investigated the effect of ammoniation on the nutritive value of various non-leguminous cellulosic materials. There is little information in the literature, however, which can be used as a basis for making recommendations concerning the feeding value of chemically altered soyabean straw (Rasby *et al*., 1989). Against a background of stockfeed deficits and piling up of soyabean straw in Mushagashe, it would be interesting to research on the potential of ammoniating the straw before feeding it to cattle. If ammoniating soyabean straw for cattle feeding proves successful, it is likely to increase the feed resource options available to farmers.

The use of soyabean straw in Mushagashe can be multi-fold. Since soil fertility is poor in the area, soyabean straw can be incorporated into farm-based nutrient cycling models as composting material. The high carbon content in soyabean straw can assist in creating a suitable carbon to nitrogen ratio if it is composted with nitrogenous wastes like manure. Crop residues contain major quantities of plant nutrients, and if composted soyabean straw could also be an effective means of maintaining the organic and nutrient fraction of the soil.

5. CONCLUSION

The study exposed some constraints faced by farmers in crop and cattle production in the Mushagashe area. Poor soil fertility, lack of inputs and labour were the major problems affecting crop production. Soyabean

production was largely affected by a lack of inputs. In the cattle enterprise, poor nutrition was the major challenge. Feed quality and quantity were not enough, particularly during the dry season.

Findings in this study present an opportunity, in which soyabean could be used in on-farm research in order to address some of the problems identified in Mushagashe. Researchable areas that could be pursued using soyabeans are in cattle nutrition and soil nutrient replenishment.

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6. REFERENCES

BATES, L.S., (1994). *Dry heat processing of full-fat soybeans and other ingredients.* Technical Bulletin Vol. F11-1994. American Soybean Association. USA.

CHAMBERS, R., (1994). Participatory Rural Appraisal (PRA): Analysis of Experience. *World Development* **22:** 1253-1269.

CHIMONYO, M., KUSINA, N.T., HAMUDIKUWANDA, H. & NYONI, O., 1999. A survey on land use and usage of cattle for draught in a semi-arid environment. *Journal of Applied Science in Southern Africa,* 5(2**)**: 111-121.

CSO (CENTRAL STATISTICAL OFFICE), (2001). Agriculture and Livestock Survey in Small-scale Commercial Farming Areas. Government of Zimbabwe. Causeway, Harare, Zimbabwe.

FALDET, M.A. & SATTER, L.D., (1991). Feeding heat-treated full fat soybeans to cows in early lactation. *Journal of Dairy Science* , 74:3047.

HOLMES, B., (1988). *Quality control of raw material and finished products in full-fat soya production.* Technical Bulletin Vol. AQ9–1988. American Soyabean Association. USA.

JINGURA, R.M., (2000). *Fodder production and use of farm-grown foods in the smallholder dairy sector: A participatory approach to designing feeding systems in Gokwe South District, Zimbabwe*. DPhil thesis. University of Zimbabwe.

JONG, J., (1993). (ed.) *Farm management Handbook.* Department of Agricultural, Technical and Extension Services. Harare, Zimbabwe.

LUFADEJU, E.A., OLAYIWOLE, M.B. & UMUNNA, N.N., (1987). Intake and digestibility of urea-treated Gamba (*Andropogon gayanus*) hay by cattle. In: Little, D.A. and Said, A.N. (eds). *Utilization of agricultural by-products as livestock feeds in Africa*. Proceedings of a workshop held at Ryall's Hotel, Blantyre, Malawi in September 1986. ARNAB, ILCA, Addis Ababa. Ethiopia. pp 7-14.

MCNAUGHTON, J.L. & REECE, F.N., (1980). Effect of moisture content and cooking time on soybean meal urease index, trypsin inhibitor content and broiler growth. *Poultry Science*, 59:2300-2306.

MUPANDA, K., (2000). *The potential of Solar Cookits in rural Zimbabwe: Results of the baseline survey carried out in Zvimba, Nerupiri, Nyanyadzi, Epworth and Seke-Dema.* Development Technology Centre Publication, University of Zimbabwe, Harare. 13pp.

MUPETA, B., (2000). Studies on the potential of ram press sunflower cake (*Helianthus anus*) as a source of protein for moderate milk production in crossbred (*Bos taurus* x *Bos indicus*) cows in the smallholder dairy sector of Zimbabwe. DPhil thesis. University of Zimbabwe, Zimbabwe.

RASBY, R., RUSH, I., WARD, J. & KLOPFENSTEIN, T., (1989). Ammonia treatment of low quality forages. Nebraska Cooperative Extension EC 89-265.

RESTLÉ, J., FILHO, D.C.A., BRONDANI, I.L. & CARVALHO, F., (2000). Soyabean straw (*Glycine max*) as a potential substitute for sorghum silage (*Sorghum bicolor*) in the feeding of confined calves. *(http://www.ufsm.br/ccr/revista/resumos/rv302/eng/rvi302_1050html)*

SAS (STATISTICAL ANALYSIS SYSTEMS) INSTITUTE, (1997). SAS guide to personal computers. SAS Institute, Cary, North Carolina, USA.

SHUMBA, E., (1984). Reduced tillage in communal areas. *Zimbabwe Agricultural Journal,* 81(vi):235-239.

SIKORA, L.J., (1998). Reduction of ammonia volatilization during dairy manure composting. Agricultural Research Service. United States Department of Agriculture, Tektran, USA. *(http://www.nal.usda.gov/ttic/tektran/data/html) 1998-12-18.*

SNOWDON, M., (1995). Full-fat soybeans for livestock. *Nutrition Newsletter* 95.1. Department of Agriculture, Fisheries and Aquaculture, New Brunswick.

SPSS, (1997). Statistical package for social scientists, Release 8.0. SPSS Inc. Illinois, Chicago, USA.

TOPPS, J.H. & OLIVER, J., (1993). *Animal Foods of Central Africa. Zimbabwe Agricultural Journal: Technical Handbook No. 2.* Department of Research and Specialist Services. Ministry of Agriculture, Harare, Zimbabwe.

TRACH, N.X., DAN, C.X., LY, L.V. & SUNDSTØL, F., (1998). Effects of urea concentration, moisture content, and duration of treatment on chemical composition of alkali treated rice straw. *Livestock Research for Rural Development*, 10(1).