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Full Length Research Paper

Assessment of livestock feed resource-use patterns in low rainfall and aluminium toxicity prone areas of Rwanda

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Livestock rearing in Rwanda, including the Bugesera and Nyamagabe districts is practised under stalling. This livestock farming is due to high human population resulting to land shortage where land is devoted more to cropping than to livestock production. In the Nyamagabe district, animal feed is constrained by low rainfall whereas in the Nyamagabe is constrained by the acidic soil with aluminium toxicity. The objective of this study was to determine feed resources and the availability of each feed resource that was used by farmers in the dry and wet seasons. Focus group discussions of 20 farmer representatives from each district were concerned. In each district, 20 farmers identified criteria to rank the identified feed resources. Individual farmers gave score to each identified feed resource according to farmers' criteria and the scores were considered as quantities measured. In the low rainfall district (Bugesera), four exotic, three indigenous fodder species and six crop residues were identified with preference scores ranging from zero to ten. *Pennisetum purpureum* (Napier grass) was given the highest scores ranged between six and eight because of its availability all year round. The native grass received a median score of five for its availability year round. In acidic soil area (Nyamagabe district), five exotic fodder species, five indigenous fodder species and 11 crop residues were identified. Napier grass and *Commelina benghalensis* were scored high with a median score of eight. The preference ranking confirmed that overall Napier grass was the major fodder crop used throughout the two districts followed by some indigenous species and crop residues. The availability of quality and quantity of feeds has shown a shortage of livestock feed resources in both districts and it requires a suitable forage species adapted to these areas of low rainfall and acidic soils.

Key words: Zero grazing, preference ranking, seasonal calendar development.

INTRODUCTION

Forage production in Rwanda has become more labour-intensive because of the scarcity or complete loss of range. Crop residues, cut grass and browse are gathered to feed livestock kept in confinement (Kebreab et al., 2005). Feed resources are classified into four main categories for use in smallholder crop-livestock farming systems. These are grass and legumes (indigenous and improved grasses, herbaceous legumes and multi-purpose trees), crop by products, agro-industrial by products (e.g. rice bran, molasses, maize bran) and non-conventional feed resources (e.g. beer brewing) (Mekasha et al., 2003).

Livestock and agriculture have always been complementary in Rwanda, where more than 90% of the

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population depend on these activities for food and income generation. However, the growth of the population has led to increased settlements resulting in a decrease of grazing land. This has led to the adoption of a zero grazing system (animals are kept and solely fed in a shed) as the dominant system in Rwanda including the Bugesera and Nyamagabe districts. In the Bugesera district, grasslands have disappeared due to the long dry season, increased density of human population and mismanagement of communal grazing land. In the Nyamagabe district, the decrease of the grasslands is the result of a combination of many factors such as human density, continuous erosion due to the steep slopes in the area and high aluminium concentration and low pH in the soils. To address the above constraints, the zero grazing system is the main response to achieve resilient crop-livestock production and hence improvement of household livelihoods. The aim of this study was to identify animal feed resources used by the farmers in the low rainfall and acidic soil areas of Rwanda. The objectives were to assess the feed resources used under low rainfall, acidity and Al-toxic stress conditions and to assess the quality in the wet and dry seasons in terms of type of feed resource.

MATERIALS AND METHODS

Site selection

The study was conducted in the Bugesera and Nyamagabe districts of Rwanda. The criteria for selection were exposure to low rainfall and acidic soils; the latter coupled with aluminium toxicity. The other aspects were that crop and livestock production should be the major economic activities in the areas. Three sectors (government administrative unity under district) of the Bugesera district that were selected were Nyamata, Mareba and Musenyi. They were selected based on their crop-livestock integration systems and the facilities (roads and transport) to access the area. Selected sectors in the Bugesera district are highly populated with limited space for cattle grazing. Due to the high population (292380 of the population versus 1303 km^2 of land), the large number of cattle (89359 heads), which used to be in the Bugesera district and overgrazed the area has been reduced to 20950 cattle in the whole Bugesera district (JICA, 2007). Even though the number of cattle decreased, feeding is still constrained by the long dry season in the Bugesera district.

In the Nyamagabe district one sector, Gasaka, was selected. It was a sector, which had a large number of dairy cattle owners and had serious animal feed scarcity. This was due to the land shortage (the total area of the district is 1090 km^2 and the population in 2007 was approximately 333587; MINALOC (2008) with acidic soil (pH 4.3 – 4.9). To represent the whole sector, three cells (government administrative division under sector) Murambi, Ngiryi and Kigeme were selected. The selection of these cells was based on the integration of crop-livestock production system and easy access to the area.

Selection of communities

Farmer groups were chosen in both districts. Farmers who practiced zero grazing system were recorded at a sector level. From this record, in each district, twenty farmer representatives were randomly selected and later we contacted them from their respective cells for the participatory diagnosis. The targeted farmers were mixed crop-livestock producers or they were cattle (especially crossbred cattle for milk production) owners. Among selected farmers were those who have been in the area for many years and practised farming.

Participatory rural appraisal (PRA)

Participatory rural appraisal techniques used in this research were concerned gender analysis, wealth ranking and feed calendar development. Preparatory meetings were held with the livestock owners selected in each district. In the Bugesera district, meetings were held at the Nyamata sector where the convenient place was for all selected farmers from three sectors. In the Nyamagabe district, these meetings were held at the Ngiryi cell in the Gasaka sector where the middle place was for all selected farmers within the sector. The aim of these meetings was to explain the objectives of the research and the study, expected outputs, as well as the use and modalities of Participatory Rural Appraisal (PRA) tools. Prior arrangements were made before the PRA exercise in each district. This involves talking to agriculture and livestock providers found in each district and visiting selected farmers at their homes. Livestock providers during that time were the representative of Ministry of Agriculture (MINAGRI) at sector level, heifer project international and send a cow Rwanda. The two latter organisations provide dairy cows to farmers in collaboration with the MINAGRI. These meeting were held during the dry season (month of August 2007) when farmers were almost available because it was non-cropping season.

Feed calendar development

Among the Participatory Rural Appraisal (PRA) techniques, feed calendar development was used in the two districts of the study area to determine the availability and use of animal feed, differentiated by wet and dry seasons. A feed calendar was drawn up by community members, in which the feed types used by farmers each month of the year were identified. A group of twenty farmers in each district listed all feed resources that they use during the year. Separately each individual farmer was asked to score each identified feed (from zero = not available to 10 = highly available) according to their criteria.

A seasonal feed calendar was also developed. A matrix of feed resources (columns) corresponding to the months of the year (rows) was drawn on a paper. The group of farmers was given ten beans that were allocated between feed resources for each month according to their importance. A feed resource could receive a score of 0 to 10 based on its importance in a particular month. The importance of this exercise was to know the different types of feeds use at different periods of the year. It indicated the shortages and availability in a given month and then throughout the year. This exercise was followed by a matrix scoring where farmers indicated the availability of each feed resource in percentage according to the wet and dry seasons.

Statistical analysis

According to Mekoya et al. (2008), the scores for the feed resources can be considered as quantities measured. These data can be analysed by descriptive statistics (Sheskin, 2007). In this case, box plots were used for the comparison of median scores of different feed resources according to farmers' criteria. The use of median is an appropriate measure as the samples were not normally distributed (Massart et al., 2005).

RESULTS

Animal feed resources and farmers' preference ranking

During workshops with farmers, the availability and utilisation of feeds throughout the year was defined using feed calendars. In the Bugesera district, farmers identified thirteen feed resources whereas in the Nyamagabe district twenty-one feed resources were identified. Farmers' criteria for feed resources ranking were the availability, palatability, stomach fill, ease to cut, increased milk yield, adaptation to acidic soil and drought tolerance, ease of storage and speed of regrowth. In the analysing information collected, only availability, palatability, increased milk yield and adaptation to acidic soil and drought tolerance were considered as major criteria. The box plots from the two districts showed differences according to the considered criteria (Figures 1 and 2). In both districts, some of the feeds used by farmers were indigenous (e.g. indigenous grasses dominated by *Brachiaria* sp., trees like *Ficus* sp., *Albizia* sp.). Others were crop residues (e.g. leaves of cabbage, maize stovers). Furthermore, there were exotic grasses (e.g. Napier grass, *Setaria* sp., *Tripsacum* sp.), legumes (e.g. *Mucuna pruriens*) and tree legumes (e.g. *Calliandra* sp., and *Leucaena* sp.).

Availability

In the Bugesera district, Napier grass (*Pennisetum purpureum)* was scored highest in terms of availability (Figure 1a). Many farmers gave scores to the Napier grass ranged between six and eight with a median score of seven. It was followed by *Tripsacum* and *Setaria*, which were scored, between five and seven with a median score of six. Natural grass and banana stems were scored between four and seven with a median score of five. The lowest median score (zero) for the criterion of availability in the Bugesera district was given to leaves of cabbage and *M. pruriens* (Figure 1a).

In the Nyamagabe district, there was difference between feed resources. Many farmers highly scored between seven and nine to the Napier grass and *Commelina benghalensis* with a median score of eight (Figure 2a). It was followed by *Panicum*, maize stover and *Albizia amygdalina* which received scores between six and eight with a median score of seven. Natural grass and banana stems had a median score of six. The lowest median score (zero) was obtained by bean peelings and banana beer residues (Figure 2a).

Palatability

The comparison of different feed resources in the Bugesera district showed difference between Napier grass and other feed options in terms of palatability (Figure 1b). The scores given to the Napier grass varied between seven and nine with a median score of eight. This was the highest score for the criterion of palatability. Napier grass was followed by maize stover that received a median score of seven. Sweet potato vines, *Setaria* sp. and sweet potato had for each a median score of six. The median score of the native grass, *Tripsacum* and bean peelings was the same (five) for their palatability in the Bugesera district (Figure 1b). The lowest scores that varied between zero and two with a median score of one was given to leaves of cabbage for their low palatability in the Bugesera district.

In the Nyamagabe district, Napier grass had scores varied between seven and nine with a median score of eight. It was followed by suckers of sorghum and bean peelings, which had for each a median score of seven. These were followed by *Panicum* sp., cooked banana peeling and sweet potato vines, which their scores ranged, between five and seven with a median score of six for each (Figure 2b). The native grass received scores between three and seven with a median score of five whereas *Ficus* sp. and *M. pruriens* were the lowest scored with a median score of one for their palatability in the Nyamagabe district.

Increase milk yield

Feed resources in the Bugesera district identified for the criterion of increase of 'milk yield showed differences' (Figure 1c). Maize stover was scored higher than the rest of feed resources and was given scores ranged between four and six with a mean score of five. It was followed by the natural grass which scores were ranged between three and five with a median score of four. Sweet potato vines were among the best-scored feed resources because its scores were ranged between two and five with a median score of three. The Napier had a median score of one for this criterion whereas the lowest median score (zero) was given to banana stems, *Setaria*, leaves of cabbage and bean peelings.

Likewise, in the Nyamagabe district maize stover obtained the highest scores ranged between seven and nine with a median score of eight. It was followed by *C. benghalensis*, which received scores, varied between five and eight with a median score of seven. Native grass and banana peelings were scored between four and seven with a median score of six (Figure 2c). The Napier grass had a median score of one for the criterion of 'increasing milk yield'. The lowest median score (zero) was given to *Tripsacum* sp., rice straw, banana stem, cooked banana peelings, *Ficus* sp., *A. amygdalina* and banana beer residues.

Low soil fertility and drought tolerance

In the Bugesera district, farmers identified 'drought

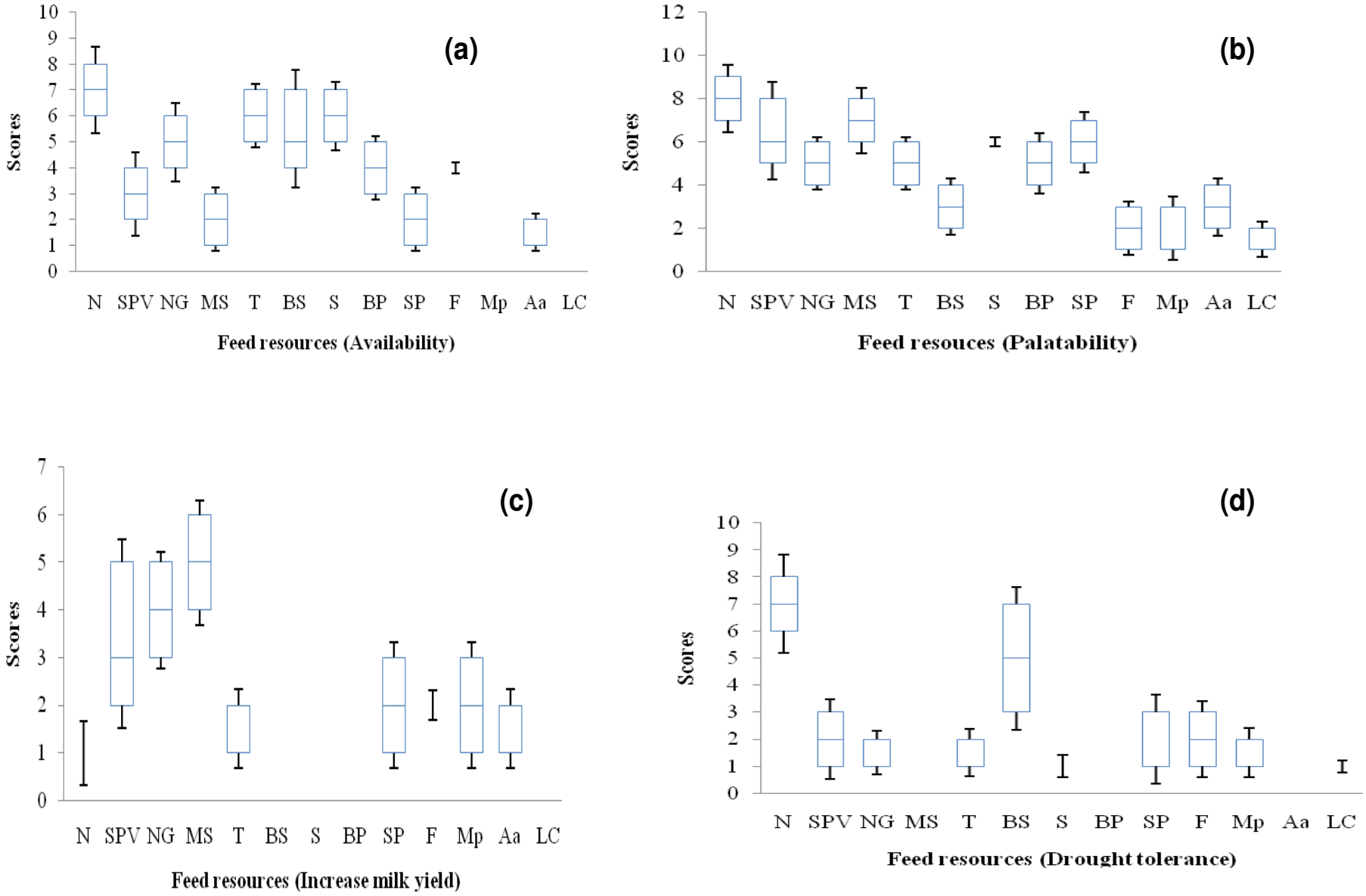

Figure 1. Box plot of feed resources from farmers' preference ranking in the Bugesera district according to criteria. (a) Availability (b) Palatability (c) Increase milk yield (d) Drought tolerance. Key for feed resources in the Bugesera district, N, Napier; SPV, sweet potato vines; NG, natural grass; MS, maize stover; T, tripsacum; BS, banana stems; S, setaria; BP, bean peelings; SP, sweet potatoes; F, ficus; Mp, *Mucuna pruriens*; Aa, *Albizia amygdalina;* LC, leaves of cabbage.

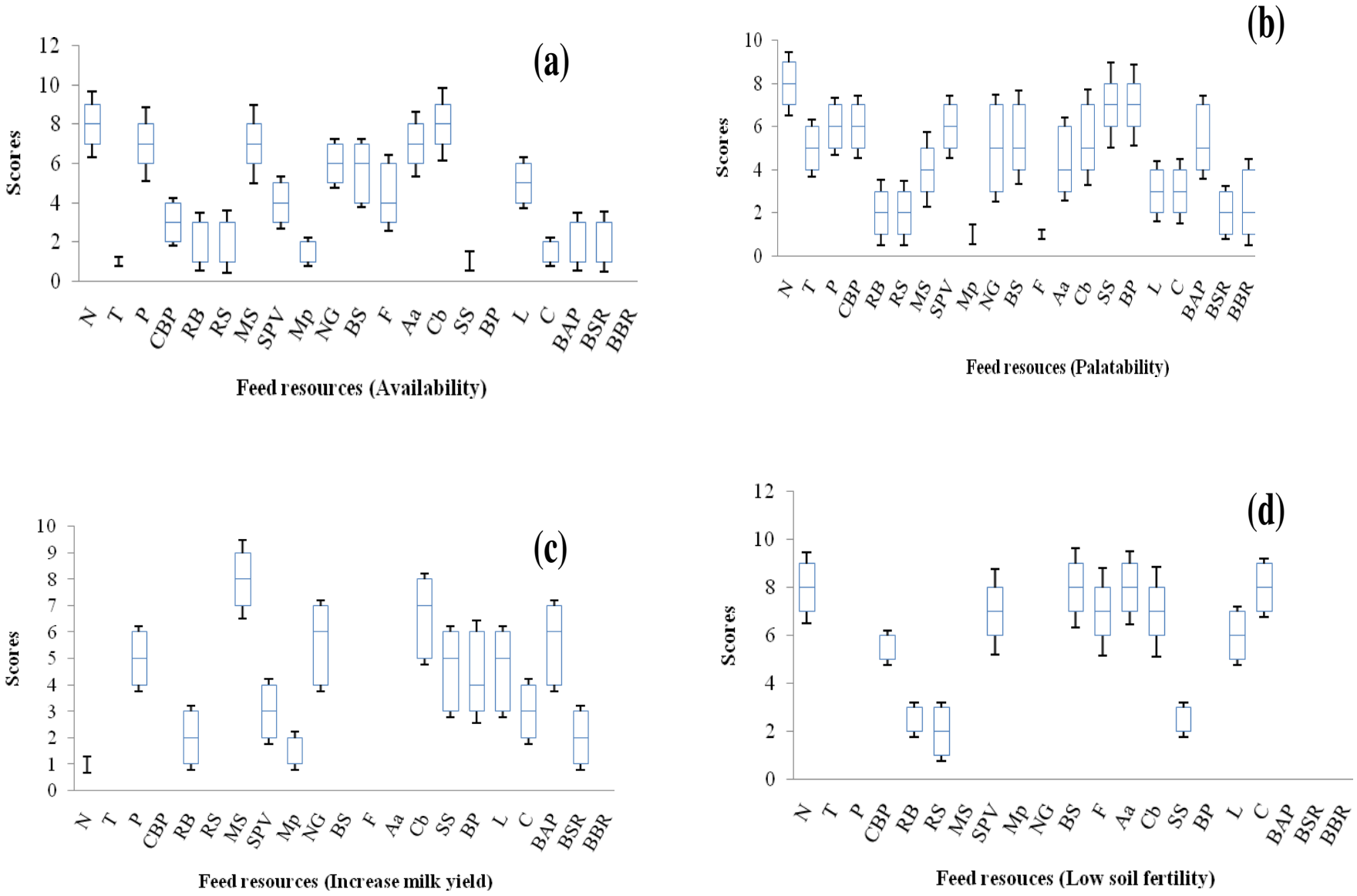

Figure 2. Box plot of feed resources from farmers' preference ranking in the Nyamagabe district according to criteria. (a) Availability (b) Palatability (c) Increase milk yield (d) Low soil fertility tolerance. Key for feed resources in the Nyamagabe district, N, Napier; T, *Tripsacum*; P, *Panicum*; CBP, cooked banana peelings; RB, rice bran; RS, rice straw; MS, maize stover; SPV, sweet potato vines; Mp, *Mucuna pruriens*; NG, natural grass; BS, banana stems; F, *Ficus* sp.; Aa, *Albizia amygdalina;* Cb, *Commelina benghalensis ;* SS, suckers of sorghum; BP, bean peelings; L, *Leucaena* sp. ; C, *Calliandra* sp.; BAP, banana peelings; BSR, beer sorghum residues; BBR, banana beer residues.

Table 1. Matrix scoring of feed availability by farmers in the Bugesera district.

Feeding system	Wet season (%)	Dry season (%)
Napier grass	100	70
Sweet potato vines	85	40
Native grass	100	60
Setaria	35	5
Tripsacum	30	10
Ficus sp.	5	45
Albizia amygdalina	0	35
Maize stover	35	0
Bean peelings	70	0
Leaves of cabbage	5	5
Sweet potatoes	20	15
Mucuna pruriens var. Utilis	15	15
Banana stems	0	80

tolerance' as a criterion (Figure 1d) whereas in the Nyamagabe district farmers mentioned low soil fertility tolerance (Figure 2d). Farmers' preference for feed resources based on identified drought tolerance in the Bugesera district showed that Napier grass had scores ranged between six and eight with a median score of seven. It was followed by banana stems, which received scores, varied between three and seven with a median score of five. Sweet potato vines and *Ficus* sp. received scores varied between one and three with a median score of two for this criterion of drought tolerance (Figure 1d). The lowest median score (zero) was given to maize stovers and bean peelings for their tolerance to drought in the Bugesera district. These crop residues were scored based to their crop origins (maize and bean). Furthermore, *A. amygdalina* was not given any score because, farmers said that they did not know if it could tolerate drought or not.

In the Nyamagabe district, some feed resources (maize stover, *M. pruriens*, bean peelings, sorghum beer residues and banana beer residues) were not scored for the criterion of 'low soil fertility tolerance' The comparison of median score of the rest of the feed resources showed a difference among them (Figure 2d). Napier grass, banana stems, *A. amygdalina* and *Calliandra* sp. were highly scored (between seven and nine) with a median score of eight as forage options that were tolerant of low soil fertility in the Nyamagabe district. They were followed by sweet potato vines, *Ficus* sp. and *C. benghalensis* that were scored between six and eight with a median score of seven. The lowest median score (zero) with upper quartile of one was given to *Tripsacum* sp. and *Panicum* sp. (Figure 2d). According to farmers these grass species do not tolerate low soil fertility and must be grown using fertilizer (either organic or chemical) otherwise they will not yield high biomass. The criterion of low soil fertility tolerance for preference ranking was important because it is the main constraint in the Nyamagabe district and farmers found it difficult and expensive to buy fertilizers each cropping season.

Feed calendar development

During the group discussion, farmers participated in feed calendar development. The percentage of feed supplies in the Bugesera district showed that during the rainy season a wide range of forage options is available, with emphasis on Napier grass, sweet potato vines and road side grasses (Table 1).

However, in the dry season feed resources become scarce sometimes leading to death of cattle. Forage options used by farmers in the Bugesera district indicate that during the dry season Napier grass, native grass and banana stems were used (Table 1). Farmers lack the knowledge on how to conserve forage in the form of silage or hay.

The feed calendar development also showed the use of a wide range of feedstuffs in the Nyamagabe district. In contrast to Bugesera, in the lower soil fertility environment of Nyamagabe a wider range of forage was used in the wet season while crop residues and some fodder trees were used throughout the year. Twenty-one forage options were identified compared to thirteen in Bugesera. Contrary to Bugesera, in the Nyamagabe district *C. benghalensis* was the feed resource available throughout the year, indicating the scarcity of grasses for ruminants in the area. Napier grass, maize stover, *Panicum* sp., *A. amygdalina* and sweet potato were the other main feed resources used by farmers in combination with crop by-products. The seasonal utilisation of this wide range of forage options in the Nyamagabe district showed that during the wet season Napier grass, *Tripsacum*, *Panicum*, cooked banana peelings, roadside grasses (native grass), banana stems, *Ficus* sp., *A. amygdalina*, *Calliandra* sp. and

Table 2. Typical matrix scoring of feed sources by farmer in the Nyamagabe district.

Feeding system	Wet season (%)	Dry season (%)
Napier grass	50	25
Tripsacum	50	0
Panicum	50	15
Cooked banana peelings	50	50
Rice bran	15	15
Rice straw	15	15
Maize stover	15	25
Sweet potato vines	20	35
Mucuna pruriens	10	0
Native grass	50	0
Banana stems	50	50
Ficus sp.	50	50
Albizia amygdalina	50	45
Commelina benghalensis	50	50
Suckers of sorghum	0	25
Bean peelings	0	50
Leucaena sp	35	35
Calliandra sp	50	50
Banana peelings	25	25
Sorghum beer residues	20	20
Banana beer residues	15	15

C. benghalensis was each utilised at 50% in animal ration (Table 2). Among these, some were used in the dry season at the same rate as in the wet season (e.g. cooked banana peelings, *Calliandra calothyrsus*, *C. benghalensis*, banana stems and *Ficus* sp.) whereas bean peelings were mostly used in the dry season.

DISCUSSION

Livestock feed resources and feed calendar development

The assessment of feed resources showed a diverse range of feedstuffs used in the Bugesera andNyamagabe districts. However, in the Bugesera district where the dry season is more pronounced, the number of feed resources (thirteen) was smaller than in the Nyamagabe district (twenty-one). Even though the latter had a large range of feed resources, the issue of soil acidity in the area made many of these feed options scarce. For example, in six months *Tripsacum* sp. and roadside grasses were not available. The use of high number of feed resources was found by Mapiye et al. (2006) and reported that in Zimbabwe, this high number of feed resource was an indication of animal production. In South Africa, although feed resources are not scarce but the use of crop residues is limited by their low crude protein (Kadzere, 1995).

Results indicated that in Bugesera the Napier grass was the most preferred feed, followed by sweet potato vines, indigenous or naturalised grasses and maize stover. The feed calendar confirmed the perception that Napier grass is a major fodder crop used throughout Rwanda. This supports Nyaata et al. (2000) who stated that in central Kenya many smallholder dairy farmers fed Napier grass to their cattle during the dry season. The criteria for farmers' choice of Napier include its forage availability throughout the year, palatability, low soil fertility and drought adaptation. Many farmers were not sure which forage option resulted in higher milk yields. However, some acknowledged that forage resources like banana stems were low quality feeds for animals. They were not usually fed to animals but during the dry season, they were utilised to help cattle to cope during this period. Similar results were found by Ffoulkes and Preston (1978) who reported that the low digestibility of banana stems is due to its low protein content (< 1%) and this led to reduced dry matter intake. In the Bugesera district, farmers mentioned Napier grass as the main planted fodder used in the zero grazing system. In this study, farmers preferred Napier grass for fodder as a basal diet because it is adapted to a wide range of local climatic conditions. It can be used for other purposes like house construction and as stakes for climbing beans, and it can be used for erosion control on steep slopes (Nyaata et al., 2000).

In Nyamagabe, *C. benghalensis,* Napier grass, *Panicum,*

A. amygdalina and maize stover were scored high. The preference of *C. benghalensis* by farmers supports results found by Lanyasunya et al. (2008), where it was stated that it is good supplementary forage for ruminants. Mixed with grasses it can improve feed intake and hence is a good feed supplement for livestock.

When comparing districts, maize stover was the only resource feed to be highly scored by farmers for the criterion of 'increase milk yield'. This is because maize is harvested at a fresh stage for home consumption and fresh stovers are fed to animals. However, even though maize stover was preferred by farmers, this crop residue has low nutritive value (Chinh and Viet, 2001). In both districts, maize stover was used as a complementary feed resource without any chemical treatment. Other crop by-products used in the Bugesera and Nyamagabe districts were sweet potato vines. Farmers reported that they increased milk. These observations were in line with Etela et al. (2009) who stated that in poor farming systems sweet potato foliage could be used to feed livestock. Some improved forage legumes like *M. pruriens* were identified by farmers as a forage option, but were not ranked highly as important forage. This is because *M. pruriens* is not yet disseminated in many areas of Rwanda and farmers do not know much about it. However, the importance of *M. pruriens* has been reported by Peters et al. (2001) and stated that it is adapted to various ranges of climatic conditions (e.g. humid and wet-sub humid tropics, central America and west Africa), it is a good forage and can improve soil fertility. The low rating of this fodder species may be because the perception of issues is often different between farmers and scientists. In many areas of semi-arid Africa, drought is perceived by farmers as the major constraint reducing their farm production, whereas for scientists, soil depletion is identified as the main constraint (Slegers, 2008). However, in our case, the two factors (low rainfall and soil depletion) were identified in the Bugesera and Nyamagabe districts respectively as the major factors affecting the availability of livestock feeds. Forage species adapted to these factors limiting animal feed availability are highly recommended in the low rainfall and acidic soil areas of the study.

Conclusion

Animal feed resources identified in the Bugesera and Nyamagabe districts showed that they were scarce. Although farmers identified thirteen feed resources in the Bugesera district and twenty-one in the Nyamagabe district, their availability during the year was limited. For example, in the Nyamagabe district low quality feed such as commelina and banana stems were fed to animals up to 50% for each in the diet during the rainy and dry seasons. In the Bugesera district, banana stems were used at 80% in the ration of cows during the dry season.

The grasses like Napier grass that should constitute most of the ruminant diet was used at 25% in the diet during the dry season in the Nyamagabe district. In addition, the use of low nutritive value feeds (e.g. banana stems, leaves of trees like *Albizia* sp., *Ficus* sp.) confirmed the need for intervention in the forage options in the study areas. Fodder crops that are of good quality and can adapt to the particular climate constraints found in each district are likely to be important. For example, in the Bugesera district the fodder crops could be a tolerant of the long dry period whereas in the Nyamagabe district, they might be tolerant of the combination of soil acidity and aluminium toxicity.

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