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Seasonal variation of livestock feed resources in semi-arid and humid environments of Rwanda

Mupenzi Mutimura[1,2*] · Cyprian Ebong[2] · Idupulapati M. Rao[3,4] · Ignatius V. Nsahlai[1]

[1]University of KwaZulu-Natal, School of Agricultural, Earth and Environmental Sciences, Department of Animal Science and Poultry Science, Pietermaritzburg Campus, Private Bag X01, Scottsville, 3209, South Africa
[2]Rwanda Agriculture Board (RAB), Department of Animal Production, P.O. Box 5016 Kigali, Rwanda;
[3]International Centre for Tropical Agriculture (CIAT), A. A. 6713, Cali, Colombia.
[4] Current address: United States Department of Agriculture, Agricultural Research Service, Plant Polymer Research Unit, National Center for Agricultural Utilization Research, 1815N, University of St., Peoria, IL 61604, USA.
[*] Corresponding author's email: mupenzimutimura@gmail.com

Abstract In most of sub-Saharan African countries, including Rwanda, the predominant agricultural production is from a mixed crop-livestock farming system because of small size land holding. The objective of this study was to assess the seasonal availability of livestock feed resources in semi-arid and humid environments of Rwanda. Structured questionnaire was designed and administered to 102 households from each environment (Totalling 204) practising mixed crop-livestock farming system. Humid environment had more other activities than farming compared to semi-arid. Semi-arid area had more households with dairy cows than humid environment. Household heads above 40 years and uneducated were more likely to establish fodder species for livestock. Farmers in humid environments were more likely to apply fertiliser on forages as one of the management practices than in semi-arid areas. Household heads with above 20 years of experience in livestock rearing and uneducated household heads were also more likely to apply fertiliser on forages. Farmers in semi-arid environments were two times more likely to establish forages in farmland than in humid environments. Various feed resources were identified in both environments. However, Napier grass was the most frequent feed resource across all season in both areas. Its availability differed ($p<0.01$) between the two environments during the rainy season and during the dry season ($p<0.05$) where the humid had the highest quantity compared to semi-ardid. In addition, various crop residues were also used in both areas during the rainy and dry seasons. This suggests that feed availability is based on seasonal crop harvesting which can lead to feed shortage in a time of crop failure. Also, high use of crop residues can compromise livestock productivity due to low quality, suggesting the need to characterise the available feed resources in smallholder farms of semi-arid and humid environments for better choice of feed.

Keywords Crop-livestock integration, Household characteristics, Fodder species, Forage niches, Dairy cows

Introduction

Feed shortage has been a major constraint to livestock, especially for dairy production in Rwanda. The severity of the feed shortage varies with seasons, but the effect of season on household feed resource inventory has not been adequately investigated and documented. Conventionally, advisory service providers encourage farmers to conserve fodder during season of surplus, but smallholder farmers lack sufficient to produce surplus fodder for conservation. Crop residues are value feed resources , but feeding these materials to cattle competes with conservation agriculture where crops residues are valuable materials for mulch for crop production (Turmel *et al.,* 2015). Studies have shown that feeding crop residues to cattle reduces nutrient availability for crop production in smallholder and reduction of crop residues for cattle feed was recommend for a viable agriculture in Africa (Baudron *et al.,* 2014), so that more crop residues be retained in the field for green manure (Castellanos-Navarrete *et al.,* 2015). Farmers in Rwanda, particularly in the semi-arid and humid areas with acidic soils, use a diversity of off-farm feed resources to sustain livestock production particularly dairy cows under cut-and-carry forage system including the use of non-conventional feeds resources (Mutimura *et al.,* 2015). Farmers have also resorted to using marginal niches of the farmscape including crop boundaries and edges for terraced landscapes (Franzel *et al.,* 2014) to produce fodder using improved highly productive agroforestry tree species which have promoted and adopted for more than two decades (Roothaert and Paterson, 1997) and planted fodder grasses which has been practised for about 100 years in Africa (Lenné and Wood, 2004). A number of management practices have been encouraged to improve productivity of these planted fodder species, but adoption has been low. The reasons for low adoption have not been adequated investigated and documented. Invariably farmers have diversified their livelihood options because they cannot survive decently on agriculture as the only source of food and income security of the household. The objective of the study was to determine seasonal feed supply, coping mechanism to feed shortage, the relative importance of various factors that influence adoption of improved fodder and management practices on smallholder dairy farms in the humid and semi-arid agroc-ecologies of Rwanda.

Materials and methods

Study site

The study was conducted on 204 households in two districts (102 households per district) located in two contrasting climatic regions of Rwanda. Bugesera district (30° 25'E; 2° 30' S) is located in a semi-arid region according to Köppen classification; $AW_{3\text{-}4}$ classification, with less rainfall varying between 650–900 mm per annum and temperature ranging from 24^0C to 28^0C (Bazimenyera *et al.,* 2014). The vegetation is a savannas woodland with xerophilous thickets. Soils in Bugesera is of sandy loam, dominated by ultisoils texture with lower amounts of soil organic matter with pH > 5.5. Mixed crop-livestock system is prevalent in the district. Drought stress and small land holdings are the major constraints to improve crop-livestock production in Bugesera district. Nyamagabe district is located in (29° 56'E; 2° 47' S) a humid zone classified (Köppen classification; $CW_{2\text{-}3}$); with an average annual rainfall of 1800 mm and an average temperature of 16.5^0C (Stainback *et al.,* 2012). The area is also characterised by acidic soil with aluminium toxicity (Mutimura and Everson, 2012a). In the Nyamagabe district, vegetation was composed by grassland, which was created by pastoralists and managed through burning, ensuring younger grass for their grazing animals. Due to high population and problem of erosion, grasslands have disappeared. However, some grasses are found under planted trees for erosion control. These are dominated by *Brachiaria* spp. and other species grown in the acidic soils like *Eragrostis* spp., *Hyparrhenia* spp., and *Digitaria* spp. The remaining natural vegetation in the Nyamagabe district is the Nyungwe forest, which is mountain forest. As grasslands have disappeared and that there is severe soil depletion, keeping animals in a shed has become an important activity to provide milk for home consumption, cash and manure for crop fertilisation. Growing grasses and tree legumes is a part of the crop-livestock production system in the Nyamagabe district.

Sampling and data collection procedures

In semi-arid areas, 26 households per sector (Local administration division under the district) were selected from four sectors. In the humid zone 102 households were selected from two sectors. The survey tools were structured questionaires to collect data of household characteristics (age, gender, education levels, experiences in crop and livestock farming), knowledge of feeds and feed production; area planted to crops, fodder and grazing; seasonal feed supply; reasons for adopting or not adopting fodder technologies and fodder conservation, land (holdings and use) and livelihood strategies. Before the survey, six enumerators including scientists and extension workers were trained for three days to conduct the interviews in vernacular (Kinyarwanda) language. Households were sampled using snowball technique (Patton, 1990). This helped to collect data on household characteristics, frequency distribution of dairy breeds, planted fodder species, willingness to grow forages and farmer' preferences on landscapes for growing forage species, as well as feed resources which were used by farmers.

Statistical analysis

Data collected from survey were analysed statistically as non-parametric using SAS system 9.3 (2010). Data on household characteristics and frequency distribution of dairy breeds between semi-arid and humid environments were analysed using PROC FREQ procedures of SAS and the comparison between household characteristics and environments was done using Chi-square. In addition, all data on ranking and number of livestock owned by household in both environments were analysed using PROC GLM procedures of SAS (2010). Furthermore, ordinal logistic regression (PROC LOGISTIC procedures) of SAS (2010) was used to estimate the probability of farmers being familiar with planted fodder species, willingness to grow forages and their management as well as farmer' preferences on landscapes for growing forage species. These procedures were also used to understand choices of farmers in landscapes for planted forages. The logit model fitted predictors such as environment, gender, age, education and experience of farmers in livestock rearing were used. The logit model used was as follows:

$$\ln\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ..\beta_t X_t + \varepsilon$$

Where π: is the probability of being familiar with planted fodder species, willingness to grow forages, their management and landscapes for planted forages; $\frac{\pi}{1-\pi}$: Odds ratio which referred to the odds of being familiar with planted fodder species, willingness to grow forages, their management and landscapes for planting forages; β_0: Intercept; $\beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ..\beta_t X_t$: Regression coefficients of environment, gender, age, education and experience of farmers in livestock rearing; ε: Random residue error. During the computing of each predictor $(\beta_1..\beta_t)$, the odds ratio was interpreted, for examples, as the proportion of farmers having planting fodder species versus those who did not do it. In addition, a similar model was used for other binary data set recorded in the study.

Results

Household characteristics

Household characteristics (gender, age, education and major activities of farmers) in semi-arid and humid environments are shown in Table 1. Household head did not differ ($p>0.05$) between gender across both environments. Within each environment, majority of households were headed by males. The level of education among household heads was not significantly different ($p>0.05$). In addition, age of household head did not differ ($p>0.05$) between environments but between categories of age, high percentage of farmers were more than 40 years old.

Furthermore, major activities carried out by household differed ($p<0.05$) between semi-arid and humid environments. Although farming seemed to be the major activity in both areas, however, humid environment had more other activities than farming compared to semi-arid. Formal employment and casual labour were among other activities carried by household head in humid environment. However, in both areas, experience in livestock rearing did not differ ($p>0.05$). In addition, in both environments, a majority of households had less than 20 years of experience in livestock rearing (Table 1).

Livestock enterprises

Number and type of livestock owned by a household in semi-arid and humid environment are presented in Table 2. Eight livestock enterprises were identified in both environments. The indigenous cattle and goats were more in semi-arid than in humid zone ($p<0.05$). Conversely, the average number of pigs per household was higher in the humid that in the semi-arid zones ($p<0.05$). Average herd size of the other livestock species did not differ across zones ($p>0.05$).

Cattle ownership by smallholder farmers in both environments is much more oriented towards dairying. These animals are kept in a shed and fed on cut-and-carry forage system than other livestock species. Fig. 1 shows percentage distribution of dairy breed categories in semi-arid and humid environments. The two environments differed ($p<0.05$) in dairy cattle breed types where the semi-arid had higher percentage of cattle than the humid area environment.

Milk yield of different cow genotypes differed ($p<0.05$), however, effects of environment and interaction of breed and environment did not differ ($p>0.05$; Table 3). Jersey cows had higher milk yield than the other cattle genotypes. Pure Friesian and Ankole-Friesian crosses did not differ in milk yields in both environments ($p>0.05$).

Factors affecting likelihood of adopting improved fodder technologies

Estimated odds ratio suggested that farmers less than 40 years of age were less likely to plant fodder species than those more than 40 years old (Table 4). In addition, educated farmers are less likely to plant fodder species than uneducated farmers. Furthermore, all predictors of willingness to plant fodder species did not show significant difference (p>0.05). With respect to the management of fodder species, semi-arid environment was far less likely to apply fertiliser than humid environment. In addition, educated farmers were less likely to apply fertiliser than educated ones. In addition, farmers with less than 20 years of experience in livestock rearing were less likely to apply fertiliser on fodder species than those above 20 years of experience.

Landscape preferences for fodder production

Odds ratios of landscape (niche) preferences including farmland, terraces and farm boundary are presented in Table 5. Estimated odds ratios showed that farmers in semi-arid area were two times more likely to plant fodder species on farmland than in humid area (estimated odds ratio 2.01 with 95% confidence interval 1.07; 3.77).

Major feed resources in smallholder farms in semi-arid and humid areas

Six and eight major feed resources were identified in semi-arid and humid environments, respectively (Table 6). Ranking of these feed resources showed that Napier grass was the most common all seasonal feed resource available to households from both areas. This grass ranked the first in the rainy and dry seasons across the two environments. However, its availability differed (p<0.01) between the two environments during the rainy season and during the dry season (p<0.05). Napier grass was more available in the humid than the semi-arid environment. Furthermore, roadside grass was more (p<0.05) available in humid than in the semi-arid areas during the rainy season. Although other feed resources did not differ (p>0.05) between environments and seasons, humid area showed much more diversity in feed resources than in semi-arid area.

Discussion

Household characteristics including gender, education and experience in livestock rearing of household head did not differ between semi-arid and humid environment. This suggests that these characteristics were not affected by agro-ecology, because local condition determines the choice of livelihood options (Rahman and Akter, 2014). However, major activities done by household head differed between the two agro-ecologies. Although farming was the major activity in both areas, humid environment had more other activities than farming compared to semi-arid. Formal employment and casual labour were among other activities carried by household head in humid environment. This could be attributed to climatic conditions where variation of different production system could create other employments. Similar observations were identified in the sub-humid where farmers have much employment due to variable resources compared to semi-arid areas (Zindove and Chimonyo, 2015). Furthermore, another reason could be the limited land holdings which compelled farmers to diversify activities more than in the semi-arid area. Nonetheless, farming activity was the first major activity found in both areas. Other studies have reported that agriculture is the most common sector which contributes to poverty reduction (Wu *et al.*, 2014) in smallholder low-income farms in developing countries.

Types of livestock enterprises in semi-arid and humid were similar. However, farmers owned higher numbers of indigenous cattle and goats in the semi-arid than in the humid zone. Differences in the number of indigenous cattle and goats owned by farmers between the two agro-ecologies could be justified by the farmers' preference based on the climatic conditions. Semi-arid area is more prone to dry spells which over the years has compelled farmers to raise only tolerant animal to harsh environment, in deed indigenous cattle and goats are more preferable in this area because of their role in the food security of households (Zindove and Chimonyo, 2015). In addition, ownership of pigs was different between semi-arid and humid environments. Household in humid area owned 5 times more pigs than in semi-arid area. This could be attributed to climatic conditions including cool weather and food crop allowing good health of pigs (Berton *et al.,* 2015). Other livestock enterprises did not show differences between the two agro-ecologies and it is suggested that both environments consider livestock as valuable assets for household income generation.

Furthermore, among livestock enterprises, cattle fall among the most important enterprises being promoted by the government of Rwanda under a special programme "One cow per poor family–GIRINKA" (RARDA, 2006). A previous study showed that the main reason for smallholder to keep cattle was milk production for primarily home consumption and secondly for cash through milk sales (Kamanzi and Mapiye, 2012). Dairy cattle were more in the semi-arid than humid areas. This might be due to the historical fact that the semi-arid areas used to be pastoral areas while the humid zone was mainly for stall-feeding. However, as human population pressure increased in semi-arid area, grazing land became scarce compelling farmers also to reduce cattle numbers for stall feeding system. This reduction of cattle herd was coupled with planting of forages that are adapted to cut and carry system for feeding. In addition, a high percentage of these cattle are crossbreds with Friesian and Jersey or with unknown breeds. High number of these crossbreds could be due to the use of artificial insemination (AI; Wurzinger *et al.,* 2006) though some farmers still use bulls for natural service resulting to unknown cattle genotypes because farm records are lacking.

Milk yield differed among cattle genotype but not between semi-arid and humid environments, suggesting that the management and type of breed are major factors affecting milk yield in smallholder farms of Rwanda. In the context of Rwandan climate and smallholder farmers prevailing conditions, Jersey cows have shown high milk yield than the rest of these breeds. This is because Jersey can tolerate heat stress, consume more feed (Rhoads *et al.,* 2009) and have low whole animal maintenance needs (I.V. Nsahlai, pers. comm.). It is suggested that under "GIRINKA programme" increasing number of Jersey can contribute to increased milk yield, thus increasing smallholder farmers' income. However, the achievement of this production depends on improving feeds and feeding under farm conditions.

Odds ratio estimates on age and education level of household head in both environments highly differed. High estimated odds ratio showed that farmers above 40 years old were likely to have planted fodder species. This could be linked to the importance that older farmers give to livestock husbandry, especially concerning feeds and feeding. Also, another reason might be the mixed crop-livestock farming system practised in both environments which compels farmers to use some improved fodder as a way of soil fertility management. Furthermore, high estimated odds ratio for uneducated household heads suggested that educated farmers carried out activities other than livestock farming. High estimated odds ratio suggests that farmers in humid environment are more likely to apply fertilisers as one of management practices for sustainable forage production than those from semi-arid zone. This could be linked to land tenure and intensive farming which obliges farmers to fertilise crop. This agrees with Davis and D'Odorico (2015) who reported that farmers practise intensive livestock farming system to maximise production on small land holding. These differences of forage management between the two environments could also be attributed to soil fertility level. Unlike semi-arid, the humid area is prone to acidic soils and aluminium toxicity (Mutimura and Everson, 2012a) and these abiotic factors hinder any crop production including forages. In addition, odds ratio estimates for level of education suggest that uneducated farmers are likely to apply fertiliser on forages. This again could be attributed to the fact that these farmers are mainly involved in farming. As the major activity of interviewed farmers was farming, many studies have reported that soil management including application of fertilisers, especially manure is the core concern for smallholder farmers (Turmel *et al.,* 2015). This is also shown by the high odds ratio estimates for experience in livestock rearing where farmers with more than 20 years are likely to apply fertiliser on forages compared to less experienced farmers.

On the other hand, establishment of forages was associated with farmers' preferences of landscapes in semi-arid and humid environments. This is shown by higher estimated odds ratio for farmland in semi-arid than in humid areas. This could be because of land availability in semi-arid compared to humid area (Mutimura and Everson, 2012b). It might also be to the "One cow per poor family programme - GIRINKA" which requires farmer to have established forages to receive a dairy cow (Klapwijk *et al.,* 2014). In addition, farmland could also be provided for planting fodder trees when the land is inappropriate for food crop production. Some studies have also reported that farmers were providing marginalised land incompatible for either crops or livestock production to establish trees (Ndayambaje *et al.,* 2013). Furthermore, farmers in humid area are more likely to establish fodder on terraces as landscape preference than semi-arid area. The provision of land on terraces for planting forages could be explained by the topography in the area which requires the construction of terraces as means of reducing soil erosion from steep slopes.

Various feed resources were used by farmers in semi-arid and humid environments including crop residues, natural grass and planted grass. Looking at high number of crop residues in comparison with planted grass and natural grass, it underscores shortage of feeds, especially during periods when food crops are not yet harvested. The use of a diversity of crop residues has been reported to be associated with feed shortages in a given eco-environment (Mekasha *et al.,* 2014). Quantitative differences in availability have been observed in Napier grass and roadside grass between semi-arid and humid environments. This could be linked to the amount and longevity of rainfall in humid area which produces high biomass of these grasses. Although the quantity of Napier grass reduces during the dry season, it is still the first choice of farmers, underscoring the importance of planted forages in smallholder farmers. In addition, collecting dried natural grass for feeding animal during the dry season can hinder livestock production because it produces materials that are low in metabolisable energy to sustain the animal and ultimately decreases its production (Ortez-Arriola *et al.,* 2014). Despite these grasses, a high number of crop residues used did not differ between the two environments. However, the use of crop residues during the rainy and dry seasons, suggests that fodder grasses are not enough to feed livestock in both environments. It has been similarly noted that when there is climate variability, farmers in sub-Saharan Africa tend to use different locally available feed resources as the coping mechanisms to sustain livestock production (Sharka *et al.,* 2013). Among crop residues, maize stover was indicated as the second to Napier grass in both seasons, especially in semi-arid area. The use of maize stover has been reported in many regions including East-Africa where this feed is very important in livestock feeding system (Jaleta *et al.*, 2015). Other crop residues with high importance in the semi-arid area were banana pseudo-stems used during dry season whereas in humid area, bean haulms were used in both seasons. Notwithstanding the fact that these crop residues were used in livestock feeding, the resilience of feed shortage differs between the two locations.

Conclusions

Farming is one of the most important activities carried out by farmers in semi-arid and humid agro-ecologies. Agro-ecology, age and experience of household head were the most important in fodder management. In addition, farmland was the landscape preferred by livestock owners in semi-arid area to grow forages and this shows that fodder intensification is more likely to happen in this environment than in the humid. However, the humid environment had more diversity in feed resources used in both the rainy and dry seasons than semi-arid area. Generally, seasonal feed availability showed variation in the number of feed resources in semi-arid and humid environments. Nevertheless, both areas depended on Napier grass as the main green fodder while others were crop residues. This suggests that feed availability is based on niches and seasonal crop harvesting which can lead to feed shortage in a time of crop failure. Also, high use of crop residues can compromise livestock productivity due to low quality, suggesting the need to characterise the available feed resources in smallholder farms of semi-arid and humid environments for better choice of feed.

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Conflict of interest The authors declare they have no conflicts of interest

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Table 1 Socio-economy characteristics of households in semi-arid and humid environments

Class	Semi-arid (n= 101)	Humid (n= 102)	χ^2
Household head	%	%	0.88^{NS}
Males	38.9	36.5	
Females	10.8	13.8	
Education of household head			2.40^{NS}
Not attended school	13.9	19.3	
Primary school	30.2	26.2	
Secondary school	5.5	4.9	
Age of household head			0.32^{NS}
Less than 40 years old (<40)	10.5	8.9	
More than 40 years old (≥40)	39.3	41.3	
Major activity			10.64*
Farming	48.8	43.4	
Self-employed	2	2.9	
Formal employment	-	2.9	
Casual labour	-	1.9	
Farmers' experience in livestock rearing			1.21^{NS}
Less than years (<20)	32	35.9	
More than 20 years (≥20)	17.7	14.3	

χ^2: Chi-Square; NS: Not significant (P>0.05); *: Significant at P<0.05.

Table 2 Number (Mean ± Standard error) of livestock enterprise owned by individual households in semi-arid and humid environments

Class	Semi-arid	Humid	P-value
Indigenous cattle	2±0.1	1±0.1	0.0477
Indigenous chickens	6±0.8	4±0.9	0.1565
Indigenous goats	3±0.3	2±0.3	0.0492
Indigenous sheep	2±0.4	2±0.3	0.5647
Rabbit	5±2.9	5±2.3	0.9221
Pigs	2±1.2	11±3.2	0.0151
Exotic cattle	2±0.1	1±0.12	0.1260
Exotic goats	2±2.1	4±1.1	0.4076

Table 3 Daily milk yield (Mean ± Standard errors) per cow in semi-arid and humid areas

Breeds	Milk yield (L/day)
Friesian	6.7 ± 0.7^{b}
Friesian ×Ankole	6.2 ± 0.5^{b}
Ankole	3.3 ± 0.6^{c}
Jersey	10.8 ± 1.6^{a}
Significance:	
Breed	***
Environments[1]	NS
Breed ×Environment	NS

NS: P>0.05; ***: P<0.001; ^{abc}: Means in the same column with the same uppercase letter are not significantly different at P<0.05; [1] Semi-arid and humid environments.

Table 4 Odds ratio estimates and profile-likelihood confidence intervals of household experiencing shortage of planted fodder species

	Planted fodder species			Willingness to plant fodder species			Fertiliser application		
Predictors	Odds	LCI	UCI	Odds	LCI	UCI	Odds	LCI	UCI
Environment (Semi-arid vs Humid)	0.50^{ns}	0.19	1.31	1.61^{ns}	0.70	3.68	0.18**	0.06	0.53
Gender (Males vs Females)	0.67^{ns}	0.19	2.29	0.96^{ns}	0.34	2.73	1.52^{ns}	0.50	4.65
Age of household head (<40 vs ≥40 years)	0.23**	0.09	0.62	0.87^{ns}	0.32	2.35	0.90^{ns}	0.28	2.90
Education of household head (Educated vs Uneducated)	0.34*	0.13	0.90	1.43^{ns}	0.56	3.65	0.32*	0.12	0.88
Experience in livestock rearing (<20 vs ≥20 years)	0.42^{ns}	0.14	1.20	0.42^{ns}	0.14	1.20	0.25*	0.07	0.83

LCI: Low confidence interval; UCI: Up confidence interval; ns: Not significant at P<0.05; *: Significant at P<0.05; **: Significant at P<0.01; Higher value of odds ratio estimates indicate greater difference in preference between levels of predictors.

Table 5 Odds ratio estimates and profile-likelihood confidence intervals of household growing fodder on different niches (landscapes)

	Landscapes								
	Farmland			Terraces			Farm boundary		
Predictors	Odds	LCI	ULI	Odds	LCI	ULI	Odds	LCI	ULI
Environment (Semi-arid vs Humid)	2.01*	1.07	3.77	0.61^{ns}	0.31	1.20	0.45^{ns}	0.15	1.33
Gender (Males vs Females)	1.13^{ns}	0.54	2.37	0.86^{ns}	0.39	1.89	1.07^{ns}	0.32	3.55
Age of household head (<40 vs ≥40 years)	1.09^{ns}	0.46	2.61	0.75^{ns}	0.30	1.89	1.67^{ns}	0.38	7.43
Education of household head (Educated vs Uneducated)	1.02^{ns}	0.52	2.02	0.71^{ns}	0.34	1.49	2.04^{ns}	0.69	5.98
Experience in livestock rearing (<20 vs ≥20 years)	0.97^{ns}	0.49	1.95	1.67^{ns}	0.78	3.55	0.33^{ns}	0.10	1.04

LCI: Low confidence interval; UCI: Up confidence interval; ns: Not significant at P<0.05; *: Significant at P<0.05; Higher value of odds ratio estimates indicate greater difference in preference between levels of predictors.

Table 6 Farmers' estimates of major feed resource availability (kg of fresh per day) in the dry and rainy seasons in semi-arid and humid environments

	Rainy			Dry		
Feed resources	Semi-arid	Humid	Sign.	Semi-arid	Humid	Sign
Crop residues						
Banana peels	21.6 (5)	30 (8)	NS	26.2 (5)	27.5 (8)	NS
BPS	-	36.6 (5)	-	22.5 (6)	41.6 (5)	NS
Bean haulms	6 (6)	50 (3)	NS	-	60 (3)	-
Maize stovers	52.5 (2)	45 (4)	NS	75 (2)	60 (2)	NS
Rice straw	-	30 (7)	-	-	30 (7)	-
SPV	22.5 (4)	33.7 (6)	NS	30 (4)	35.6 (6)	NS
Planted grass						
Napier grass	139.3 (1)	1261 (1)	**	111 (1)	557 (1)	*
Natural grass						
Roadside grass	24.2 (3)	50.3 (2)	*	37.1 (3)	51.3(4)	NS

The higher the mean rank the more importance of availability of feed resource in the season; BPS: Banana pseudo-stem; SPV: Sweet potato vines; NS: Not significant at P<0.05; **: Significant at P<0.01; *: Significant at P<0.05.

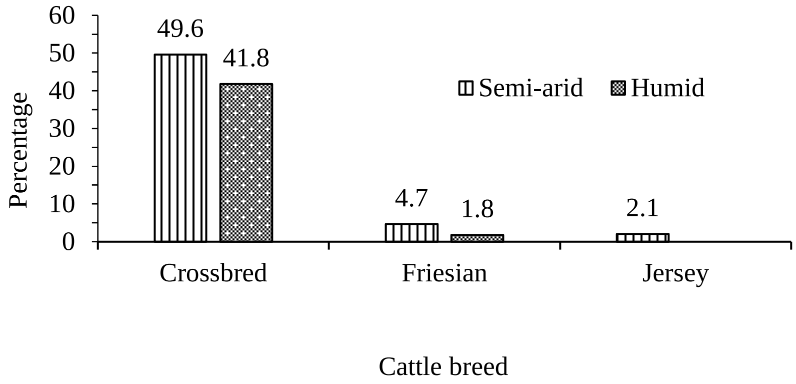

Fig. 1 Percentage distribution of dairy breeds in semi-arid and humid environments (Chi-square= 9.31; P= 0.0095)