Short Communication

Nutritive value of forages and diets in some small-scale dairy farms in Kiambu County, Kenya in the short rains season

Valor nutritivo de los forrajes y las dietas en algunas granjas lecheras de pequeña escala en el condado de Kiambu, Kenia, durante temporada de lluvias cortas

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Abstract

Sixteen selected small-scale dairy farms were investigated in Kiambu County (Kenya) during the short rains season to develop a snapshot of the types of rations fed, milk yields obtained and sources of fodder. On average farmers had 1 ha of land and 2.2 lactating cows yielding 8.93 kg milk/cow/d with feed intake of 10.5 kg DM/d. Only 35% of feed consumed was produced on farm. Boma Rhodes grass hay and green Napier grass were the main forage components (37.9 and 28.3% of total DM). Protein forages used were the herbaceous legumes lucerne and desmodium (19.9 and 15.9% CP, respectively) and leguminous shrubs (*Leucaena*, *Calliandra* and *Sesbania* with 21.1% CP and 43.4% aNDFom, on average). Grasses had higher aNDFom digestibility (47.1%) than legumes (39.7%). Napier grass, Boma Rhodes grass, lucerne and desmodium had fiber digestibility of 51.9, 48.6, 46.8 and 32.6%, respectively. The energy and protein balances (actual vs. requirements) of the cows were on average -19.3 and -16.4%, respectively, indicating that cows utilized body tissues to produce the levels of milk obtained. Mutiple correspondence analysis showed that a milk yield higher than 9.1 kg/d was associated with a level of Boma Rhodes grass <5 kg DM/d, concentration of non-fibrous carbohydrates in the diet >22.0% (DM basis), concentrate level >2.63 kg/cow/d and CP% in the ration >9.1%. To improve milk yields during this season farmers should harvest grass forage at a younger age, include leguminous forage in the diets and increase the level of concentrates fed. These strategies should be demonstrated on farms to show possible benefits.

Keywords: Dairy rations, East Africa, smallholder farms, tropical forage.

Resumen

Se investigaron dieciséis pequeñas fincas lecheras seleccionadas en el condado de Kiambu (Kenia) durante la temporada de lluvias cortas para desarrollar una línea base de los tipos de raciones ofrecidas, la producción de leche obtenida y las fuentes de forraje. En promedio, los agricultores tenían 1 ha de tierra y 2.2 vacas lactantes que producían 8.93 kg de leche/vaca/d con una ingesta de alimento de 10.5 kg de MS/d. Solo el 35% del alimento consumido se produjo en la granja. El heno de pasto Boma Rhodes (*Chloris gayana*) y el pasto Elefante (*Cenchrus purpureus*) fresco fueron los principales componentes forrajeros (37.9 y 28.3% del total de MS). Los forrajes proteicos utilizados fueron las leguminosas herbáceas alfalfa y desmodium (19.9 y 15.9% PC, respectivamente) y las leguminosas arbustivas (*Leucaena*, *Calliandra* y *Sesbania* con 21.1% PC y 43.4% FDN tratada con amilasa y corregida por cenizas, en promedio). Las gramíneas presentaron mayor digestibilidad de FDN (47.1%) que las leguminosas (39.7%). El pasto Elefante, Boma Rhodes, alfalfa y desmodium tuvieron una digestibilidad de la fibra de 51.9, 48.6, 46.8 y 32.6%, respectivamente. Los balances de

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energía y proteínas (actual vs. corregido) de las vacas fueron en promedio -19.3 y -16.4%, respectivamente, lo que indica que las vacas utilizaron reservas corporales para producir los niveles de leche obtenidos. El análisis de correspondencia múltiple mostró que una producción de leche superior a 9.1 kg/d se asoció con un nivel de Boma Rhodes <5 kg MS/d, concentración de carbohidratos no fibrosos en la dieta >22.0% (base MS), nivel de concentrado >2.63 kg/vaca/d y %PC en la ración >9.1%. Para mejorar la producción de leche durante esta temporada, los agricultores deben cosechar forraje de pasto a una edad más temprana, incluir forrajes de leguminosas en las dietas y aumentar el nivel de alimentos concentrados. Estas estrategias deben demostrarse en las granjas para mostrar los posibles beneficios.

Palabras clave: África Oriental, alimentación de vacas lecheras, forrajes tropicales, pequeños productores.

Introduction

Kenya is becoming a middle-income country with an increasing demand for livestock products (Njarui et al. 2016) and is one of the largest producers of dairy products in Africa with about 4.3 million dairy cattle. Up to 80% of total dairy farms in Kenya are smallholder farms (Odero-Waitituh 2017), characterized by small landholdings (<2 ha), only a few cattle (1–3 dairy cows/ farm) and modest daily milk yields (Odero-Waitituh 2017). On small-scale farms, the mixed crop-livestock farming system is quite common, i.e. livestock and cash-crop production are an integral component of farming systems (Njarui et al. 2016). Consequently, the land available for feed production is insufficient to satisfy the dairy cows' requirements. Inadequate nutrition, due to scarcity and poor quality of on-farm feed resources, is the major constraint limiting growth and viability of dairy cattle farming in Kenya (Nyambati et al. 2003; Lukuyu et al. 2011; Njarui et al. 2011).

The main feeding system in the region is stall-feeding based on cut-and-carry forage (Odero-Waitituh 2017) and, usually, dairy cows are fed a combination of fodder grown on-farm plus crop residue and externally purchased forages and dairy meal (Lukuyu et al. 2009; Njarui et al. 2011; Kashongwe et al. 2017). Feed grown on-farm fluctuates seasonally in terms of both quantity and quality (Lukuyu et al. 2016a), usually being plentiful during the wet season but scarce in the dry season (Maleko et al. 2018). Therefore, at times of fodder scarcity during the dry season and the short rains season, most smallholder farmers are forced to purchase fodder like hay of 'Boma' Rhodes grass (*Chloris gayana*) and wheat straw (Lukuyu et al. 2009).

Lack of information on the composition and utilization of available feed resources continues to pose many problems in feeding livestock on small-scale farms (Lukuyu et al. 2011). The objective of this study was to document a snapshot of the main feeding systems in some selected small-scale dairy farms in 4 sub-counties of Kiambu County, Kenya, during the short rains season, evaluating the nutritive value (chemical composition, fiber digestibility) of the most common forages produced and purchased. Another aim of the study was to assess the adequacy of the diets and to identify possible nutritional limitations in an endeavor to develop suitable feeding strategies.

Materials and Methods

Description of the study area

The study was conducted in 4 target sub-counties in Kiambu County, Kenya, i.e. Lari, Limuru, Gatundu South and Gatundu North. Members of the Extension service conducted a survey of 147 smallholder dairy farmers supplying milk to a cheese cooperative. A subsample of 16 farms was then selected as representative of the area, based on land surface, number of animals and milk production. The study was conducted from the beginning of November 2018 to the end of January 2019, with average rainfall of 60, 58 and 25 mm for November, December and January, respectively. The average daily temperature was 21 °C in November and 22 °C in both December and January. Relative humidity was on average 70% during the entire period.

Data collection and laboratory analysis

A questionnaire was provided to the farmers. The questionnaire was divided into different sections to obtain details regarding the farmer, the animals, milk production and the feeding system including types of fodder and the utilization of forages and concentrates. Samples of fodders used (whole-plant material, i.e. leaf and stem) were collected, giving a total of 79 samples. All samples were dried in a forced-air oven for at least 48 h at 60 °C until constant weight before grinding to pass a 1 mm Fritsch mill (Fritsch, Idar-Oberstein, Germany). All samples were analyzed for: dry matter (DM) (method 945.15; AOAC 1995), ash (method 942.05; AOAC 1995), crude protein (CP) (Dumas method; Kirsten and Hesselius 1983), ether

extract (EE) (method 920.29; AOAC 1995), amylase-treated ash-corrected neutral detergent fiber (aNDFom) (Mertens 2002) and ash-corrected acid detergent fiber (ADFom) (method 973.18; AOAC 1990).

In vitro aNDFom digestibility (48 h) (NDFd) was determined using a Daisy II Incubator (Ankom Technology, Macedon, NY, USA) according to Robinson et al. (1999). The inoculum was prepared with rumen fluid collected from 2 cannulated non-lactating Holstein cows fed a diet based on a mixture of grass hay and compound feedstuff (80:20; DM basis). Cannulated animals were handled as outlined by the Directive 2010/63/EU on animal welfare for experimental animals, according to the University of Milan Welfare Organisation and with authorization number 904/2016-PR from the Italian Ministry of Health.

Diet formulation and adequacy

The CPM-Dairy Ration Analyzer (version 3.0.7bs), based on the paper of Tedeschi et al. (2008), was used to determine the suitability/adequacy of the diets. Animal settings were fixed for each farm utilizing the average number of cows and milk production. Body condition score (on a scale from 1 to 5) and body weight were set at 2.35 and 409 kg, respectively; these values are the average of literature reports for dairy cows bred on small-scale farms in Kenya (King et al. 2006; Lukuyu et al. 2016b; Muraya et al. 2018). Milk fat and protein concentrations were set at 3.6 and 3.0%, respectively, as the mean values registered by the experimental farms. Environmental parameters were also changed considering the conditions (temperature and humidity) registered during the period of the study.

The values obtained by proximate chemical analysis were used to characterize the feeds used in the diets. Amounts of feeds supplied to milking cows were entered for each farm according to data collected with the questionnaire, and the resulting mean diet of each farm was formulated.

Statistical analysis

The complete dataset was analyzed using SAS 9.4 (2012); some descriptive statistic procedures, e.g. frequency (Freq), distribution (Chart) and means (Mean), were performed. The relationship between dietary characteristics (components and chemical composition) and milk yield was evaluated through Multiple correspondence analyses (Proc CORRESP). Differences in chemical composition and NDFd digestibility between Napier grass and Boma Rhodes grass samples were evaluated by GLM procedure.

Results and Discussion

Farm characteristics and main feed components in diets for lactating cows.

The main characteristics of the selected farms are presented in Table 1. The average farm area was 1.0 ha. In agreement with the results reported by Odero-Waitituh (2017), the average number of cattle (mostly Holstein) was 4.4 (range 2–11), of which 2.2 were lactating. Average milk production was 8.93 kg/cow/d with a wide range (3.5–11.9 kg/cow/d). Dry matter intake (DMI) was on average 10.5 kg/cow/d, resulting in a dairy efficiency of 0.85 kg milk/kg DMI. On average, only 35% of total dietary DM was produced on-farm. Napier grass and Boma Rhodes grass were used on all farms, with Napier grass produced on-farm, while Boma Rhodes grass was purchased as hay.

Napier grass was used as cut-and-carry fresh fodder on 75% of farms and as silage on the remaining 25% of farms. The frequency of use of ensiled Napier grass was only slightly higher than the average percentage (16.6%) reported by farmers in Nyandarua County of Kenya (Muia et al. 2011) and in the central and southern plateau areas of Rwanda and Tanzania (Kamanzi and Mapiye 2012; Maleko et al. 2018). In agreement with data reported by Reiber et al. (2010) for Honduras, high costs (such as ensiling materials and high labor demand), low milk price and lack of forage choppers were the main reasons given by farmers as key impediments to the adoption of this strategy. In contrast, Boma Rhodes grass was used mainly as hay (87.5% of farms), with only 12.5% feeding it fresh.

Purchased dairy meal was used on the majority of farms (93.8%) with an average of 3.29 ± 1.50 kg fed daily per lactating cow (Table 2). Protein supplements were provided by herbaceous legume crops cultivated on-farm, e.g. lucerne (*Medicago sativa*) (37.5% of farms) and desmodium (*Desmodium intortum*) (18.7% of farms) or leguminous shrubs, e.g. leucaena (*Leucaena leucocephala*) (25.0% of farms), calliandra (*Calliandra calothyrsus*) (18.7% of farms) and sesbania (*Sesbania sesban*) (12.5% of farms).

Table 1. Main characteristics of the selected farms in Kenya (n=16).

	Land area (ha)	Cattle (no.)	Milking cows (no.)	Milk yield (kg/hd/d)	DMI (kg/hd/d)	Dairy efficiency (kg milk/DMI)	Total DM produced (%)	Total DM purchased (%)
Mean	1.0	4.4	2.2	8.93	10.5	0.85	35	65
Min	0.4	2	1	3.50	7.8	0.37	20	34
Max	4.0	11	4	11.90	13.2	1.19	66	80
SD	1.00	2.31	0.98	2.70	1.43	0.27	12 .0	12.0

Chemical composition and nutritive value of the main feed components

The chemical composition of the feed components used in diets for lactating cows is shown in Table 2. As expected, legume forages had higher CP than non-legume forages. Leguminous fodder shrubs (calliandra, leucaena and sesbania) also had high protein concentrations (mean 21.1% CP) and quite low mean fiber concentrations (aNDFom = 43.4%, ADFom = 33.2%).

Comparing the main grasses, Boma Rhodes grass had significantly higher aNDFom concentration than Napier grass (70.1 vs. 63.0%; P=0.02), while protein concentration was not significantly different (P=0.115). Ash concentration in Napier grass was greater than that in Boma Rhodes grass (15.5 vs. 11.3%; P=0.049).

The purchased dairy meal was the same compound feedstuff for all farms and contained (% DM) on average 12.0% ash, 13.5% CP, 6.8% EE, 27.7% aNDFom and 40.0% non-fibrous carbohydrates (NFC). However, farmers and technicians reported that "Finding adequate concentrate on the local market is very hard." Therefore, more advice on appropriate quantities and types of concentrates to feed in relation to the stage of growth of the forages and stage of lactation of the cows is required. The most common concentrates utilized in the area are maize germ and wheat bran; supply in the local market is unreliable, so farmers would like to produce a concentrate mix on farm, and need advice on ingredients to use, quantities to include, mixing instructions and amounts to feed.

Fiber digestibility of fodders was quite variable. On average, grasses had higher fiber digestibility than the herbaceous legumes (means 47.1 vs. 39.7%, respectively) and Napier grass had slightly higher fiber digestibility than Boma Rhodes grass (51.9 vs. 48.6%). There was a negative relationship between NDFd (%) and height at harvest (cm) in Napier grass samples: NDFd = -0.079*height at harvest + 66.6 (r^2=0.48) (Figure 1). The average NDFd value for Napier grass was similar to the 54.7% reported by Mutimura et al.

Table 2. Chemical composition (% DM) and aNDFom digestibility (%) of the feed components used on dairy farms in Kenya.

	No.	DM	Ash	CP	EE	aNDFom	ADFom	NFC	NDFd
Herbaceous legume crops									
Lucerne	6	22.5	12.9	19.9	2.07	37.2	33.0	27.9	46.8
Desmodium	3	20.9	13.8	15.9	2.46	56.9	45.5	10.9	32.6
Leguminous fodder shrubs									
Calliandra	3	27.0	7.00	22.1	1.92	39.2	27.9	29.8	49.0
Leucaena	4	27.1	8.5	23.6	2.65	40.6	33.2	24.7	57.5
Sesbania	2	18.5	13.2	17.5	3.35	50.4	38.4	15.6	48.1
Non-legume crops									
Napier grass	16	20.0	15.5	8.57	1.95	63.0	43.7	11.0	51.9
Boma Rhodes grass	16	71.5	11.3	6.12	1.58	70.1	45.2	10.9	48.6
Maize crop residues	2	21.4	10.4	7.40	2.46	54.8	40.0	24.9	44.0
Sunflower plant	1	21.4	11.6	8.03	2.67	42.3	38.4	35.4	55.2
Rice straw	1	90.4	14.3	4.11	1.35	66.4	42.7	13.8	43.7
Wheat straw	1	92.5	13.4	6.04	1.58	69.7	46.3	9.30	38.4
Inter-cropping									
Napier grass & desmodium	2	16.8	17.2	9.00	2.56	58.8	42.9	12.4	54.3
Concentrates									
Dairy meal	15	92.2	12.0	13.5	6.78	27.7	13.4	40.0	49.3
Maize germ	5	91.8	4.3	9.84	11.4	33.2	14.3	41.3	54.0
Wheat bran	2	91.6	4.7	13.4	3.18	43.2	14.0	35.5	70.1

CP= crude protein; EE = ether extract; aNDFom = amylase-treated ash-corrected neutral detergent fiber; ADFom = ash-corrected acid detergent fiber; NFC = non-fibrous carbohydrates; NFDd = in vitro aNDFom digestibility. All these values are reported as %.
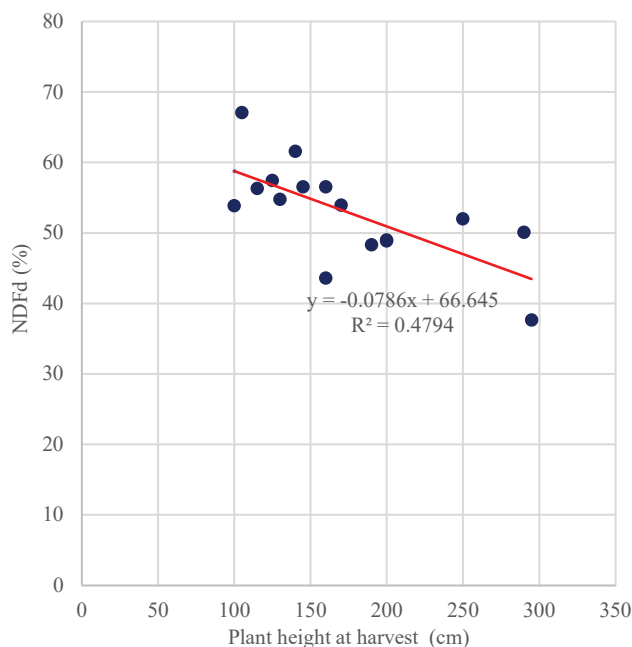
Figure 1. Linear regression between plant height at harvest and fiber digestibility in Napier grass samples.

(2015) for several Napier grass samples collected in Rwanda and the negative relationship between the height at harvest and NDFd in Napier grass samples was in agreement with the results of Tessema and Baars (2003). Based on the obtained regression, the estimated NDFd of Napier grass cut at 150 cm should be about 54.2% versus 42.4% when cut at 300 cm, with a strong decrease in the nutritive value of the forage. This finding is not

unexpected as plants would be more mature if allowed to grow to a greater height so that the CP would decline and fiber concentration increase, both trends resulting in reduced nutritive value. Among the herbaceous legumes, lucerne fiber was more digestible than desmodium fiber (46.8 vs. 32.6%). The fiber in shrub legumes had a mean digestibility of 51.5%, which is not surprising as predominantly leaf and thin stems are fed. Among the concentrates fed, wheat bran had a very high fiber digestibility (70.1%).

Diet composition and adequacy

Boma Rhodes grass was the main component (mean 37.9% of total DM) of diets fed to lactating cows, followed by Napier grass (28.3%) and dairy meal (22.5%) (Table 3). Overall, these 3 components comprised almost 90% of the diet. On average, only small areas of lucerne (0.03 ha) and desmodium (0.07 ha) were grown on the farms, so their level of inclusion in diets was low (mean 3.8% of total DM). Finally, shrub legumes provided only 1.8% of total DM, and the mean area planted was very low (0.01 ha).

Average dietary chemical composition of rations fed to lactating cows was as follows (% aNDFom): ash 11.0 ± 1.20, CP 8.93 ± 1.54, EE 3.14 ± 0.93, aNDFom 55.7 ± 5.46, ADFom 36.5 ± 4.11, NFC 22.4 ± 3.45 and starch 10.1 ± 2.97. The mean net energy for lactation (NEL) in the diets was 0.99 ± 0.14 Mcal/kg DM. Forages supplied on average 71.8% of total dietary DM. The estimated possible milk yield was much lower than the reported milk production

Table 3. Average use of feed components in diet (% DM) and average area used for the main crops (ha) on the selected farms.

	% in diet DM	Produced on-farm	Area used (ha)	Farms using fresh	Farm using silage	Farm using hay
Non-legume crops						
Napier grass	28.3	yes	0.43	12	4	
Boma Rhodes grass	37.9	3 farms	0.20	2		14
Maize crop residues	6.7	yes	0.24		2	
Sunflower plant	1.5	yes	0.01			
Rice straw	18.2	no				
Wheat straw	12.4	no				
Herbaceous legume crops						
Lucerne	3.8	yes	0.03	6		
Desmodium	3.8	yes	0.07	3		
Shrub legumes						
Leucaena	2.2	yes	0.01	4		
Calliandra	2.4	yes	0.01	3		
Sesbania	0.9	yes	0.01	2		
Concentrates						
Dairy meal	22.5	no				
Maize germ	12.4	no				
Wheat bran	12.8	no				

(4.49 vs. 8.93 L/d) and the energy and protein balances (as fed vs. requirements) of the cows were on average -19.3 and -16.4%, respectively. This result is in agreement with the study of Morenz et al. (2012), which showed that the Cornell Net Protein and Carbohydrate System (CNCPS) model (Ver. 5) underestimated the milk production in tropical cattle as compared with the measured value. In the present study, most cows were Holsteins and low body condition score (BCS) characterized the cattle in the studied farms; body tissue mobilization to support milk production could partly explain the difference between predicted and observed values of milk production (Cowan 1982).

In the present study, daily weight loss of cows could not be measured and, consequently, entered into the model. We hypothesized that the model underestimated possible milk production from the diets fed since energy derived from tissue mobilization was not included, resulting in actual milk production exceeding calculated milk production. Overall, the results of the study confirm that the application of feeding standards in tropical conditions should be evaluated carefully since animals, diets and management are different from those found in temperate regions (Molina et al. 2004); accurate measures of animal variables such as BCS change and weight change are needed for a better evaluation of the model prediction.

Multiple correspondence analysis

The results of the Multiple correspondence analysis conducted to underline the most significant factors related to higher milk production are reported in Figure 2. A milk yield higher than 9.1 kg/d was associated with an inclusion level of <5 kg Boma Rhodes grass DM/cow/d, concentration of NFC >22.0% of DM and an energy level for lactation >0.96 Mcal/kg DM, suggesting that energy is the primary constraint and limiting factor for milk production. This is supported by the weight loss by cows during lactation. Due to the high fiber concentration in Boma Rhodes grass, diets with >5 kg/d Boma Rhodes grass were characterized by 60.0% aNDFom vs. 52.1% aNDFom for diets with <5 kg/d Boma Rhodes grass. On the other hand, the main factors associated with a milk yield <9.1 kg/d were: low concentrate intake (<2.63 kg DM/d), dietary aNDFom>55.0% DM and dietary CP<9.1% DM. In agreement with our study, recent research (Makau et al. 2020) showed that feeding concentrate (dairy meal) to dairy cows improved daily milk production and concentrate should be fed to allow cows to reach their genetic potential. Similarly, Maleko et al. (2018) reported

that the lack of adoption of proper supplementation practices led to limited milk production to below the genetic potential of dairy animals in Tanzania. The feedstuffs used by dairy farmers in the present study appear to have an excess of fiber and a lack of NFC. Hence, this study indicates that farmers should feed a concentrate mix rich in starch and highly digestible fiber as well as adequate protein concentration. Level of concentrate fed to cows should also be increased as Australian research indicates that, for each 1 kg grain fed to Holstein cows, milk yield will increase by 1 liter (Cowan et al. 1977; Davison and Elliott 1993). An example of the composition of such a feedstuff could be 40% maize meal, 30% wheat bran, 15% soybean meal, 10% maize germ and 5% mineral-vitamin supplement. Preliminary feedback from farmers, who have used a similar concentrate mixture, indicated an average increase in milk yield of 25% as compared with the previous feedstuff formulation. Unfortunately, the main limit to higher use of concentrates by farmers is the high costs of components and limited availability, e.g. soybean meal (high cost and low availability). Generally, as previously reported, CP concentration in the dairy meal fed was very low due to the lack of high protein feed components.

This study has also shown that insufficient energy intake during the short rains season limits the milk production of dairy cows on small farms. Factors contributing to this situation are low digestibility of the fibrous forage and low concentrate intake. Hence there is a need to produce more digestible forages, which could be achieved by harvesting at an earlier stage of growth of the plant and through a proper conservation process if the forage is destined to be stored for feeding later in the dry season. Another possible solution is growing mixtures with legumes, i.e. as a grass-legume mixture, in addition to harvesting prior to grass maturity, i.e. when first seed heads appear. For example, combinations of Napier grass with desmodium have been shown to increase milk production over Napier grass alone (Mutimura et al. 2018), but the increase depends on the quality and amount of forage fed. In the surveyed farms of the present study, only a small percentage of farmers (12.5%) used a forage system based on inter-cropping of Napier grass-desmodium, suggesting that there is significant room for improvement. However, it has to be stressed that the CP concentration of forage harvested from areas of inter-cropped Napier grass-desmodium was not high (9.0%), being slightly below the 10.8% (DM basis) reported by Bayble et al. (2007) for Napier grass in association with desmodium harvested at
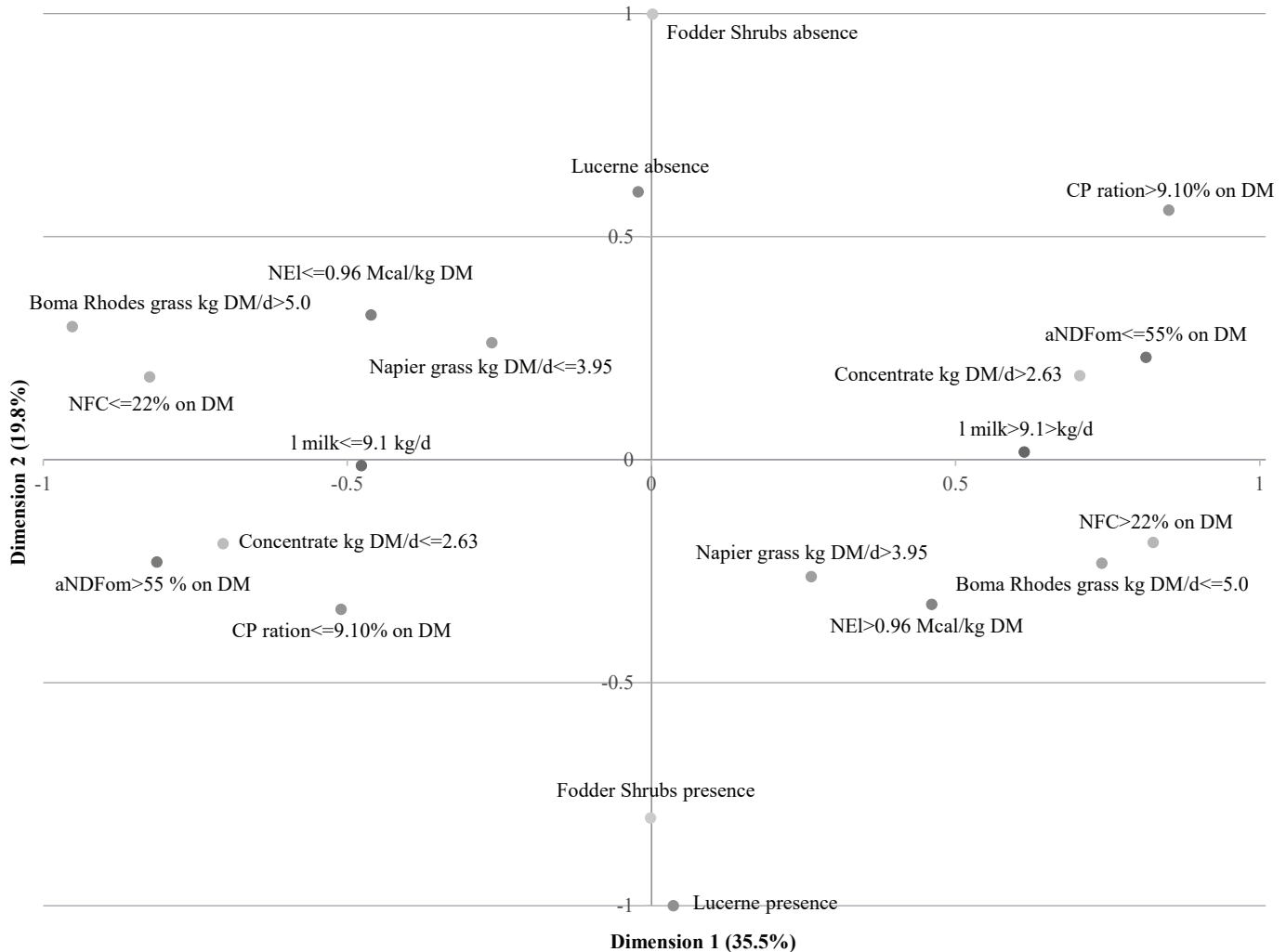
Figure 2. Main dietary factors associated with milk production higher or lower than 9.1 kg/hd/d.

120 d, at which stage the maximum protein yield per hectare was achieved. Unfortunately, farmers did not know the proportion of grass and legume at harvest and stage of maturity of the grass, and identified the lack of information about the optimal time for harvesting the main forage crops as a critical issue.

While about 20% of farmers used desmodium, other locally-produced protein sources were used, such as leucaena, calliandra, sesbania and lucerne, although at a low inclusion level. The introduction of leguminous forage crops such as lucerne or fodder trees can improve the quality of feed rations and milk production (Kashongwe et al. 2017) but it is important to feed them in adequate amounts. While feeding these legumes undoubtedly increased milk production on farms where they were used, the low inclusion levels in the diet would have limited the level of response obtained. Unfortunately, as underlined from the survey, the main constraint to increasing these protein sources is

the land size, which is minimal and used mainly for the production of Napier grass.

Conclusion

The study indicated that forages and overall diets fed to dairy cows on farms in the survey region during the short rains season varied substantially, resulting in a range in levels of milk produced. Obviously inadequate intake of energy was a key limitation to higher milk yields with cows losing weight during lactation. While fresh Napier grass is a good forage when harvested at the correct stage of growth and adequately fertilized with animal manure, it is still inadequate to support high levels of milk production. Producing Napier grass hay or silage during the wet season for feeding in the dry season could reduce the dependency on forage from the external market, especially for Boma Rhodes grass hay, which was of lower quality than Napier grass. To achieve milk

yields equal to the genetic potential of Holstein cows, it is essential to include high-quality concentrates in the diet to meet the energy and protein requirements for satisfactory milk production. These management strategies should be demonstrated on small farms so farmers can see the benefits both biologically and financially to increase adoption within the farming communities.

Acknowledgments

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(Note of the editors: All hyperlinks were verified 21 October 2021).

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