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Improving dairy cattle productivity in smallholder farms in Uganda: Incorporating leguminous forages in farming systems

[1]Kabirizi, J.; [2]Mpairwe, D and [2]Mutetikka D.

[1]National Crop Resources Research Institute (NaCRRI),
P.O. Box 7084 Kampala, Uganda;
E-mail: jkabirizi@hotmail.com
[2]Faculty of Agriculture, Makerere University
P. O. Box 7062 Kampala, Uganda

Abstract

A study was conducted in Masaka district to determine the response and profitability of crossbred cows fed maize/lablab stover (ML) or elephant grass/forage legume mixtures (EGL). Supplemented were basel diets of either calliandra leaf hay (CLH) and/or lablab hay (LH) and a homemade concentrate (HMC). The results showed that cows fed EGL with 3 kg/day LH and 4 2 kg day $^{-1}$ HMC (Trt 1); EGL with 2 kg day^{-1} LH, 1 kg day^{-1} CLH and 4 kg day^{-1} HMC (Trt 2); sole elephant grass (sole EG) with ML, 1 kg/day CLH and 4 2 kg day^{-1} HMC (Trt 3) increased ($p<0.05$) total dry matter intake (TDMI) by 60, 61 and 73 percent compared to sole elephant grass (Trt 4) (7.0 kg cow^{-1} day^{-1}). Average daily weight gain (ADG) at 30 weeks postpartum was higher ($p<0.05$) 1.6, 1.5 and 1.9 times than cows on Trt 4 (129.2 g day^{-1}). Change in body condition score (from 8 weeks prepartum to 30 weeks postpartum) was lowest ($p<0.0001$) in cows on Trt 4 (-0.51) and highest (+0.56) in cows on Trt 3. Mean daily milk yield increased ($p<0.05$) by 33; 40 and 61% in cows on Trt 1, 2 and 3, respectively compared to cows on Trt 4 (6.7 lts-1cow-1 day^{-1}). Calving to conception interval was shorter ($p=0.05$) in cows on Trt 1, 2, and 3 (79, 73 78 days, respectively) than in cows on Trt 4 (101.4 days). The returns to investment per extra Ushs 1,000 spent as cost due to treatment was Ushs 1,175; 1,435 and 2,967 for Trt 1, 2 and 3, respectively. Based on results of the study, it was recommended that in order to cope with a shortage of feeds during the dry season, ML forages fed in addition to sole EG and supplemented with 1 kg day^{-1} CLH and 4 kg/day HMC (Trt 3) were superior to EGL based diets. This was associated with a total DMI, milk yield, ADG, a calving to conception interval and a return to investment of 12.1 kg day^{-1}; 10.8 litre^{-1} cow^{-1}day^{-1}, 247.5 g/day, 78 days and Ushs 2,967, respectively. The study showed that the small fields earmarked for food and fodder production do not offer space to produce lablab hay in large quantities.

Introduction

A major constraint to the smallholder dairy sector is the inadequacy of feed resource base available on farms (LSRP, 2000). Elephant grass fodder (*Pennisetum purpureum*) and crop residues, the major feed resource base for stall-fed cows are scarce and of poor quality, usually less than 8% Crude protein (CP). Kabirizi *et al.* (2004) reported that according to (NRC, 2001), protein and Metabolizable Energy (ME) shortages in the wet and dry seasons in smallholder production systems in Masaka district were 340 and 785 gm cow^{-1}day^{-1} and 35 and 53 MJ cow^{-1}day^{-1}, respectively.

Previous studies have shown that intercropping elephant grass with legume (EGL) and maize with lablab (ML) improved biomass availability but forages from these systems, as sole feed were deficient in CP and energy and should be supplemented in order to meet maintenance and lactation requirements of dairy breeds (Mpairwe, 1998; Kabirizi *et. al.* 2004). The most economic way to improve performance of dairy cattle fed low quality rations such as those from intercropping systems is by supplementing them with high protein herbaceous legumes (Mpairwe, 1998) and/or a legume hays to provide by-pass protein (Kaitho, 1997; Hinderichsen *et. al.* 2004). Small quantities (up to 1 kg cow^{-1} day^{-1}) of calliandra leaf hay fed as supplement to natural grasses and crop residues increased total and digestible DM intakes and milk yields (Kaitho, 1997). Kabirizi *et al.* (2000) reported improved dry matter intake and milk yields when crossbred cows were fed elephant grass basal diet and supplemented with 2-3 hg day^{-1}cow^{-1} of lablab hay and 3-4 kg cow^{-1} day^{-1}of a concentrate. The effects observed were attributed to improved rumen fermentation and fibre digestibility in the dairy cows (Ferguson, 1996). However commercial concentrates are often too costly and uneconomical for smallholder dairy farmers in Uganda to adopt (LSRP, 2000). Utilization of homemade formula using locally available ingredients is an option for reducing costs. The objective of this study therefore, was to investigate the effects on total dry matter intake, milk yield, reproductive efficiency and economic benefits of feeding crossbred dairy cows EGL and ML forages with lablab hay and/or calliandra leaf hay and a homemade concentrate supplement.

Materials and Methods

Study area

The study was carried out in Masaka district located between 0^0 15' and 0^{0}43' South of the equator and between longitude 31^0 and 32^0 East. The district has two rain seasons (March to May and September to November). With the exception of a few years of declining rainfall, the average annual precipitation is between 1100-1200 mm in 100-110 rainy days and average humidity is 61.2% (Anon, 2003). The average minimum and maximum temperature is 15.8^{0}C and 30.3^{0}C, respectively. The soil texture varies from place to place ranging from red laterite to sandy loam and loam but is in general productive.

Selection of Farmers, Experimental Design and Treatments

The farm owners were volunteers identified during a baseline survey (Kabirizi *et al.* 2004). The thirty two (32) households were selected according to the following criteria: i) having a minimum of 0.5 ha of well established and managed elephant grass field (ii) availability of land and labour to plant and manage the fodder fields and; iii) having a 7-months in-calf cow (parity =1) at the start of the feeding trials.

Based on total scores obtained for the different forages and energy supplements, and recommendations from previous on-station studies (Kabirizi, 1996; Kaitho, 1997; Mpairwe, 1998; Katuromunda *et al.*, 2001), the technologies below were randomly allocated to the households in a Randomized Complete Block Design (RCBD) with 8 households as replicates per treatment: Elephant grass-legume mixtures (EGL) supplemented with lablab hay (3 kg cow-$^{-1}$ day $^{-1}$) (LH) and homemade concentrates (HMC) (4 kg cow^{-1} day^{-1}) (Treatment 1); EGL supplemented with LH (2 kg cow^{-1} day $^{-1}$), CLH (1 kg cow^{-1} day $^{-1}$) and HMC (4 kg cow^{-1} day $^{-1}$) (Treatment 2); Maize-lablab stover fed in addition to sole elephant grass fodder (SML) supplemented with CLH (1 kg cow $^{-1}$ day $^{-1}$) and HMC (4 kg cow^{-1} day $^{-1}$) (Treatment 3) and; sole elephant grass fodder (sole EG) (Farmer's practice -control) (Treatment 4)

Production, Harvesting and Conservation of Forages

The basal forages, EGL and ML and the supplements (LH and CLH) were produced using methods described in Kabirizi (2004). The legumes in the mixtures comprised of *Macroptilium atropurpureum* (siratro); *Centrosema pubescens* (centro) and *Desmodium intortum* (Green leaf desmodium). Maize bran

(82 kg), cotton seed cake (17 kg) and mineral lick (1 kg) were used to formulate a homemade concentrate (16% CP). The commercial concentrates (such as Nuvita Dairy Meal) that were obtained from the market. The project supplied each farmer (Treatments 1, 2 and 3) with enough ingredients for a month throughout the study period. Tables 1 and 2 show the quantities and the chemical composition of the ingredients that were used to make a HMC.

Table 1: Proportions (kg/100 kg) of the various components in the homemade concentrate

Ingredient	% DM	CP (% in DM)	Proportion in DM (kg)	% CP contribution	Average price per kg	Total Cost (U Shs)
Maize bran	83.8	10.7	82.0	8.8	150	12,570
Cotton seed cake	93.6	45.2	17.0	7.10	300	5,100
Maclick Mineral powder	-	-	1.0	-	1700	1,700
Total	-	-	100	15.9	-	**19, 370**

1 US $ = 1920 U Shs; Cost of commercial concentrates (Nuvita) is Ushs 300 per kg

Table 2: Chemical composition (%) of maize bran (MB), cotton seed cake (CSC) and Maize bran mixed with cotton seed cake (HMC)

	Type of ingredient		
Components (% DM)	MB	CSC	HMC
Dry matter (%)	84.8	90.6	89.6
Organic matter	92.33	90.8	91.3
CP	8.8	45.2	16.7
IVOMD	66.1	67.1	77.7
Ash	7.2	7.4	6.9
Phosphorus	0.18	0.14	0.24
Calcium	0.19	0.3	0.47
Neutral Detergent Fibre	23.4	19.2	18.99
Acid Detergent Fibre	5.9	13.9	6.7
*Metabolizable Energy (MJ kg^{-1} DM)	9.9	10.1	11.7

ME was estimated using regression equations by Close and Menke (1986).
ME= 0.15 *IVOMD

The CP contents, Ca and P levels in the HMC were above the levels recommended for production and growth of a dairy cow (NRC, 2001).

Animal Management and Time of Supplementation

The types of animals used in the study were crosses between the indigenous cows and Holstein-Friesians with an average milk yield of 10 litres day^{-1} at peak period (4-10 weeks postpartum). The approximate exotic blood level of the animals based on records from "Send a Cow Heifer Project" was 75-83% and had calved once. To ensure that the animals had sufficient feed, only households with one cow were selected for this study. Initial liveweight for each cow was taken at the start of the feeding trials, 8 weeks before calving. The farmers carried out tick control and good animal health care as recommended by the Project. The feeding trials lasted 10 months (August 2002 to July 2003), including 2 months prepartum and 8 months postpartum.

Feed Management

In Treatment 1, the farmer harvested fresh EGL every morning at a cutting height of 60-100 cm. *Ad-libitum* amounts of chopped pieces of material (5 cm long) were offered to the cow. In-calf cows were supplemented with 1 kg cow^{-1} day^{-1}of HMC mixed with LH (3 kg cow^{-1} day^{-1}). The mixture was fed to the animals in the morning before other feeds were offered. After calving, the quantity of HMC was increased to 4 kg cow^{-1} day^{-1}, and mixed with one kg of chopped LH (5-10 cm). Half the mixture was given during the morning milking time and the other half during the evening milking. In Treatment 2, EGL was fed to the cows as described in Treatment 1. In-calf cows were offered a mixture of 1 kg cow^{-1} day^{-1}CLH + 2 kg cow^{-1} day^{-1} LH + 1 kg cow^{-1} day^{-1} of HMC) in the morning before other feeds were offered. The amount was increased to 1 kg cow^{-1} day^{-1} of CLH + 2 kg cow^{-1} day^{-1}of LH + 4 kg day^{-1} HMC when the cow calved. Half the amount (3.5 kg cow^{-1} day^{-1}) was given during the morning milking time and the other half (3.5 kg cow^{-1} day^{-1}) during the evening milking.

In Treatment 3, ML and sole EG were chopped into pieces of about 5 cm long using hand shears before feeding them to the animals. Chopped ML was mixed with fresh EG and offered *ad libitum*. In-calf cows were offered a mixture of (1 kg cow^{-1} day^{-1}CLH + 1 kg cow^{-1} day^{-1} of HMC) in the morning before other feeds were offered. After calving, the amount was increased to (1 kg cow^{-1}day^{-1} of CLH + 4 kg cow^{-1} day^{-1} HMC). Half the amount (2.5 kg cow^{-1} day^{-1}) was given during the morning milking time and the other half (2.5 kg cow^{-1} day^{-1}) during the evening milking. Animals had free access to ML since it was available in large quantities. In order to assess the effects of Treatments 1, 2 and 3 on dairy cattle productivity, 8 households (one cow per household) were selected where no intervention was introduced (Treatment 4). In all treatments, animals had access to water and mineral blocks *ad libitum*.

Data collection

Every fortnight body weight was measured using heart girth tapes; and body condition score (BCS) on a scale of 1-9 (Nicholson and Butterworth, 1986). Each household was provided with a-100±0.1 kg spring-dial hoist scale to weigh daily quantities of feeds offered to the animals (feed intake). Samples of feeds offered were taken once every month, weighed and analyzed for proximate principles (AOAC, 2001). Milk recording for each cow started 7 days after calving (day 0). Records of mean daily milk yield per cow from the control group (Treatment 4) were used as bench marks for assessing the impact of a steady supply of feeds. Milk records from previous lactation were not used because recording on most of the households was reliable.

Farmer and the enumerators constantly observed the animals for signs of heat and related sexual activities. They also recorded calf body weight and sex at birth; dates on heat and services; methods of service (natural or artificial) number of repeat inseminations to conception as confirmed by pregnancy diagnosed by rectal palpation by the veterinarian, two months after mating.

Economic analysis

The gross margin for each treatment was calculated based on extra costs incurred when they were incorporated in the production systems in relation to the income realized from sale of milk, maize grain, dressing percentage of slaughter during the study time and calves etc. Gross margin = Total revenue - Variable costs (veterinary services, cost of feeds and labour). Extra cost and income of supplementing dairy cows as shown in the different treatments was calculated and compared to practice where there was no supplementation by control farmers. The ratio of extra income to extra cost was calculated to get return per extra shilling spent as cost due to treatment. Cost structure and revenue structure for each item was calculated as a percentage of the total cost or revenue.

Statistical Analyses

All records were stored in Excel database. The various data were subjected to the analyses of variance (ANOVA) procedure for RCBD experiments using the General Linear Model (GLM) procedure in SAS (Statistical Analysis Systems 1999).

The model used in the analysis was:

$Y_{ijk} = \mu + T_i + S_j + (TS)_{ij} + \epsilon_{ijk}$; where:

Y_{ijk} = overall performance (k^{th} cow in the j^{th} season receiving the i^{th} Treatment);

μ = the overall mean;

T_i = the i^{th} Treatment, i = 1, 2, 3, 4;

S_j = the j^{th} Season, j = 1, 2 (wet and dry);

$(TS)_{ij}$ = the interaction between the i^{th} Treatment at j^{th} Season;

ϵ_{ijk} = the random error.

Comparisons of means were considered significantly ($p<0.05$) different using the Least Significant difference (LSD).

Table 3 Dry matter intake of basal forages, average daily weight gain, body condition and daily milk yield of crossbred dairy cows

Parameter	Treatments				
	1	2	3	4	SEM
Dry Matter Intake (DMI) (kg cow^{-1} day^{-1})					
Total Dry Matter Intake	11.1^{c}	11.3^{b}	12.0^{a}	7.0^{d}	0.03
Total Dry Matter Intake (% Body weight)	2.4^{c}	2.4^{b}	2.6^{a}	1.9^{d}	0.01
Total Dry Matter Intake (g^{-1} kg^{-1} BW$^{0.75}$)	111.3^{c}	111.8^{b}	120.5^{a}	83.2^{d}	0.36
Total Crude Protein Intake (g cow^{-1} day^{-1})	1343^{b}	1443^{a}	1269^{c}	503^{d}	29.60
Total Metabolisable Energy Intake (MJ cow^{-1} day^{-1})	112.6^{c}	114.3^{b}	116.3^{a}	60.7^{d}	0.30
Total P intake (g cow^{-1} day^{-1})	31.1^{c}	32.3^{b}	36.6^{a}	14.7^{d}	0.12
Total Ca intake (g cow^{-1} day^{-1})	54.3^{b}	46.2^{c}	63.7^{a}	17.5^{d}	0.25
Average Daily Gain calving to 8 wks postpartum (g day^{-1})	-170.8^{ba}	-137.5^{ba}	-110.4^{a}	-183.3^{b}	11.73
Body Weight Change 8 wks prepartum 30 wks postpartum (g day^{-1})	31.1^{a}	28.1^{ba}	37.1^{a}	19.4^{b}	1.89
Milk yield (lts cow^{-1}day^{-1})	9.1^{c}	9.7^{b}	10.9^{a}	6.9^{d}	0.04

^{abcd} Least square means within a row with different superscripts differ ($p<0.05$)

1= EGL + 3kg cow^{-1} day^{-1} lablab hay (LH) + 4 kg day^{-1}cow^{-1} Homemade concentrate (HMC)

2= EGL + 2 kg cow^{-1} day^{-1} LH + 1 kg cow^{-1} day^{-1} Calliandra leaf hay + 4 kg cow^{-1} day^{-1} HMC

3= Sole elephant grass (Sole EG) and Maize +lablab stover + 1 kg cow^{-1} day^{-1} CLH + 4 kg cow^{-1} day^{-1} HMC;

4= Sole EG (Control); SEM: Standard Error of the mean

BWC: Body weight change; ADG: Average dairy gain

Results and Discussion

Dry matter intake of basal forages and supplements by crossbred dairy cows

Total dry matter intake (TDMI) of the basal forages and supplements by crossbred dairy cows is shown in Table 3

CLH and HMC were offered to the cows throughout the study period. However due to land shortage and high labour requirements, farmers could not produce sufficient quantities of LH to last 6 months. LH was therefore offered whenever it was available. The cows consumed all supplements (CLH, LH and HMC) that were offered. At the start of the feeding trials, the cows on treatment 3 rejected ML. Farmers sprinkled water mixed with "rock salt" commonly known as "Magadi" on ML to improve its palatability. After they got used to it there was a dramatic increase in both DM intake and overall animal performance. Total DMI, increased ($p<0.05$) 1.60; 1.63 and 1.73 folds in cows on treatments 1, 2 and 3 respectively compared to cows on treatment 4. This means that treatments 1, 2 and 3 were superior in terms of TDMI compared to the farmer's practice of feeding sole elephant grass fodder.

TDMI was superior to feeding sole EG. The higher TDMI in cows on treatments 1, 2 and 3 compared to 4 was due to provision of proteins and energy from LH, CLH and HMC and ML for favourable microbial activity in the rumen (Mpairwe, 1998; Hinderichsen *et al.*, 2004). Increased DMI attributed to addition of legume hay and a concentrate to low quality roughage concurs with other studies (Aregheore and Perera., 2004).

Total CP intake increased ($p<0.05$) by 1.86, 1.88 and 1.93 times in cows on treatments 1, 2 and 3 respectively compared to cows on treatment 4 (Table 1). According to NRC (2001), the ME requirement for growth and production of cows similar to those used in this study was 95 MJ cow $^{-1}$day^{-1}. The estimated ME provided by treatment 4 was approximately 60.1 MJ cow^{-1}day^{-1}. Therefore the estimated deficit was 35 MJ cow^{-1}day^{-1} for maintenance and lactation requirements.

Effect of supplementing CLH and/or LH and a HMC to crossbred dairy cows fed EGL or EG with ML forages on body weight, body condition and milk yield

Body weight (BW) changes of crossbred dairy cows fed EGL or EGML basal forages supplemented with LH and/or CLH and HMC is shown in Table 3. Overall, lower body weight of animals that were fed on EGL diets was partly due to low DMI at the time of calving. Most of the cows calved at the peak of the dry season (November) when the legume content and total fodder DM yields were low compared to cows fed on EGML forages. Although there was a shortage of elephant grass fodder during the dry season, cows that were offered EGML forages benefited from ML stover that was abundantly available throughout the study period. Findings from this study have confirmed previous results that showed that feeding cows at high levels (quantity and quality) before calving results in better BW at calving and after calving (Keady *et al.*, 1999).

Supplementing EGL basal diets with CLH in addition to LH and a HMC improved total DMI by 7.4% compared to when the diet was supplemented with only LH and HMC. Supplemented cows produced higher ($p<0.05$) milk yield than control cows (Table 3 and Figure 1).

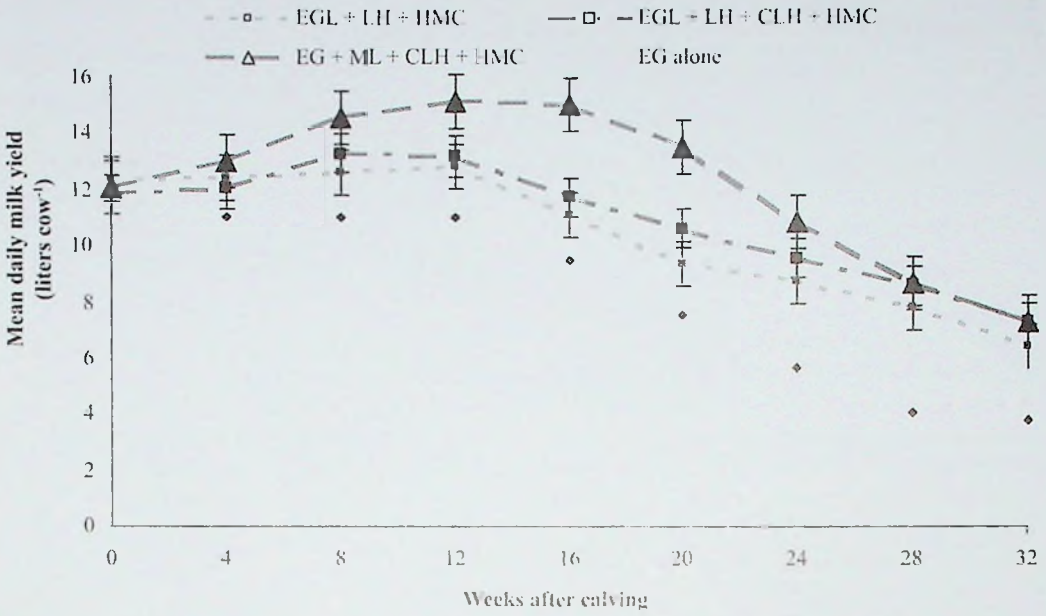


Figure 1:Lactation curves (Mean ±SED) for cows fed EGL or sole EG with ML forages supplemented with CLH and/or LH and a HMC

The superior milk yield recorded in cows that were offered EGML compared to EGL basal diets was due to extra CP, ME and mineral intake (Table 3) and adequate feed supply throughout the study period, which enabled the cow to meet the increased nutrient requirements of lactation. The higher milk yield in cows offered EGML compared to cows that were offered EGL basal forages means that for a smallholder dairy farmer with limited land for food and fodder production, integration of lablab in maize cropping system is one way of improving feed quality and quantity and therefore improve milk yield during the dry season. Additional supplementation of EGL + LH + HMC diet with CLH produced about 22% more milk than when the EGL diet was supplemented with only LH and HMC. Calliandra leaf hay had a higher CP content (22.5%) compared to LH (15.8%) and this improved DMI, milk yield and overall performance.

Effect of supplementing CLH and/or LH and a HMC to crossbred dairy cows fed EGL or EG with ML forages on reproductive performance of crossbred dairy cows

The effects of supplementing with CLH and/or LH and a HMC on growth rate of the calves are summarised in Table 4. Birth and weaning weights and average daily weight gain (ADG) of calves were higher ($p<0.05$) in supplemented than unsupplemented cows. Overall, calves from cows fed on EGML + CLH + HMC diets had higher ($p<0.05$) birth and weaning weights and average daily gain (ADG) than calves of cows fed on EGL basal forages.

The higher birth and weaning weight of calves from supplemented cows compared to unsupplemented cows could be attributed to higher DM intake (TDMI, protein, minerals and energy) that catered for both the dam and the growth of the foetus. Previous studies (Carstens *et al.*, 1987) showed that the protein-restricted cows were found to have lower BCS at calving and produced less colostrum volume, produced weaker calves, had reduced thermogenic capacity and took longer to come on heat than cows fed adequate protein.

Table 4: Effects of supplementing CLH and/or LH and a HMC on reproductive performance of crossbred cows fed EGL or sole EG with ML forages

Parameter	Treatments				
	1	2	3	4	SEM
Performance of calves					
Birth weight of calves (kg)	30.4^{b}	30.5^{b}	33.6^{a}	29.4^{b}	0.45
Range	(27-36)	(28-33)	(30-36)	(27-33)	
Weight at weaning (2mths)	50.1^{b}	49.3^{b}	55.0^{a}	49.4^{b}	0.58
Range	(48-53)	(47-52)	(50-59.5)	(47.5-54.0)	
ADG of calves (g calf^{-1}day^{-1})	329.2^{b}	315.6^{b}	366.4^{a}	342.7^{ba}	5.55
Reproductive performance of cows					
1st oestrus (days)	50.4^{ba}	54.3^{a}	40.5^{b}	61.0^{a}	2.52
Range	(42-60)	(43-65)	(22-60)	(30-90)	
Days from calving to conception	79.3^{b}	73.0^{b}	77.5^{b}	101.4^{a}	3.28
Range	(60-95)	(51-85)	(60-96)	(66-136)	
Number of inseminations	1.6^{b}	1.5^{b}	1.1^{b}	2.3^{a}	0.13
Range	(1-2)	(1-2)	(1-2)	(1-4)	

^{a,b,3} Least square means within a row with different superscripts differ ($p<0.05$)

1= EGL + 3kg cow^{-1} day^{-1} lablab hay (LH) + 4 kg day^{-1}cow^{-1} Homemade concentrate (HMC)

2= EGL + 2 kg cow^{-1} day^{-1} LH + 1 kg cow^{-1} day^{-1} Calliandra leaf hay + 4 kg cow^{-1} day^{-1} HMC

3= Sole elephant grass (Sole EG) and Maize +lablab stover + 1 kg cow^{-1} day^{-1} CLH + 4 kg cow^{-1} day^{-1} HMC;

4= Sole EG (Control); SEM: Standard Error of the mean

BWC: Body weight change; ADG: Average dairy gain

Differences ($p<0.05$) in reproductive performance of crossbred dairy cows were observed as a result of feeding cows on EGL or EGML diets supplemented with CLH and/or LH and HMC. Interval from calving to first oestrus and second oestrus was shorter ($p<0.05$) in supplemented than unsupplemented cows. Average number of services/conception was higher ($p<0.05$) in unsupplemented than supplemented cows. The interval between calving to conception was shorter (73-78 days) in supplemented cows compared to unsupplemented cows (101 days). Significant differences ($p<0.05$) were observed in intervals between calving to first and second oestrus, calving to conception and average number of services/conception within supplemented cows.

In the present study, the longer interval between calving and observation of first postpartum visual oestrus in unsupplemented cows indicate sub-optimal reproductive performance. Because of inadequate energy and CP intake, unsupplemented cows took longer to commence cyclic ovarian activity than well-fed supplemented cows. Similarly decreased calving to conception intervals in supplemented cows was attributed to higher CP and energy intake as shown in Table 3. Diets similar to sole EG fodder where ME intake during the prepartum period is low result in poor body condition at calving, prolonged postpartum anoestrus, and a decrease in the percentage of cows exhibiting oestrus during the breeding season. The provision of protein, mineral and energy supplements is therefore a prerequisite for a successful management to good reproductive performance of dairy cows.

In addition to nutrition, there are a number of constraints that affect reproductive efficiency in many smallholder dairy production systems in Uganda. The major deficiencies are poor heat detection, mating of cows at a wrong time and the tendency of farmers to assume that a cow will become pregnant once it is inseminated or served with a bull. They therefore neglect to look

for returns to service and find out many months later that the cow is not pregnant, by which time valuable production time has been lost.

This study has shown that appropriate use of forages from elephant grass or maize intercropping systems with forage legumes supplemented with homemade concentrates will result in improved performance of crossbred dairy cows in smallholder dairy systems. Farmers can therefore improve food security and alleviate feed shortages through appropriate and efficient use of home produced feed resources and concentrates. Results of this study have shown the importance of supplementing with a legume hay and homemade concentrate on body weight, body condition, milk yield and reproductive efficiency of dairy cattle fed low quality forages.

Economic analysis of feeding crossbred dairy cows forages from EGL or sole EG with ML cropping systems supplemented with Calliandra leaf hay and/or lablab hay and a Homemade concentrate

Table 5 shows additional costs and returns (Ushs cow^{-1} lactation^{-1}) due to treatment during the study period (October 2002 to June 2003). Average cost of veterinary services and AI or use of a bull were higher in unsupplemented cows than cows on EGL or EGML forages. Sale of milk contributed over 90% of the household income when EGL were incorporated in the farming systems compared to about 70% for EGML forages. However, sale of maize grain improved household income by about 25% when ML forages were integrated in the farming systems. The ratio of extra income/extra cost was higher for EGML than EGL forages. Veterinary and AI costs were higher in unsupplemented diets when compared with supplemented diets. On-farm mixing of feed led to saving Ushs 110 per kg of homemade concentrate when compared to Ushs 300 per kg of commercial concentrates in addition to improved animal productivity and daily income. The study showed that, diets formulated from locally available protein and energy ingredients are cost-effective and have potential for use as replacement to the conventional dairy meal in maintaining a high milk production and improving farm profits in the dry season. Therefore, under smallholder dairy production systems where shortage of high quality forages and high cost or/and substandard commercial concentrates are major constraints, the use of EGML with CLH and HMC supplements is the cheapest way of ensuring year-round feed supply, improving overall animal performance, household food security and farm profits compared to EGL basal diets.

Conclusions

Although results of this study demonstrated the value of lablab hay as a supplement to low quality forages, the resources (land, labour and capital) required to produce sufficient quantities of lablab hay to supplement a dairy cow throughout the 4-6 months of the dry season may be beyond the means of a resource poor smallholder dairy farmer. This study showed that supplementing with CLH and HMC resulted in higher milk yield and higher returns to investment compared to when the cows were supplemented with only LH and HMC. The cost per kilogramme of CLH was also lower (Ushs 150) compared to LH (Ushs 210). There is therefore a need to promote the use of fodder trees as these do not require a lot of land and labour to manage. Fodder tree leaf hay requires less labour than lablab hay. It was estimated that in order to produce sufficient quantities of lablab hay to last of a dry season of about 6 months in Masaka district, the farmer would require about over 1.3 ha to produce about 540 kg DM lablab hay compared to about 200 kg DM CLH from 600 calliandra trees.

Table 5: Additional costs and returns (Ushs/cow) due to treatment during the study period (360 days)

Parameter	EGL+LH+ HMC	% of total cost or revenue structure	EGL+LH+ CLH+HMC	% of total cost or revenue structure	EGL+ CLH+ HMC	% of total cost or revenue structure	Sole EG	% of total cost or revenue structure
Cost of production and inputs								
Land preparation	100,000	4.4	100,000	4.2	100,000	4.2	100,000	6.9
Cost of inputs (seed)	82,000	3.6	132,000	5.6	176,000	7.4	60,000	4.2
Planting and manure application	120,000	5.2	140,000	5.9	90,000	3.8	30,000	2.1
Weeding	920,000	40.1	920,000	39.0	720,000	30.3	600,000	41.6
Harvesting, drying and conservation	230,000	10.0	230,000	9.8	430,000	18.1	0	0.0
Feeding, milking, cleaning	360,000	15.7	360,000	15.3	360,000	15.2	360,000	25.0
Homemade concentrate	270,000	11.8	270,000	11.5	270,000	11.4	0	0.0
Veterinary services (Average)	165,000	7.2	171,000	7.3	180,000	7.6	193,000	13.4
Artificial Insemination/use of bull	45,000	2.0	33,000	1.4	48,000	2.0	99,000	6.9
Total cost of production	**2,292,000**		**2,356,000**		2,374,000		**1,442,000**	
Estimated revenue per farm								
Maize grain	0	0	0	0	609,000	24.8	0	0
Milk yield	1,462,400	95.0	1,549,000	95.7	1,722,800	71.3	1,133,200	95.9
Extra liveweight gained	77,750	5.0	70,250	4.3	92,350	3.8	48,500	4.1
Total income (Ushs)	**1,540,150**		**1,619,250**		2,415,350		**1,181,700**	
Extra cost due to treatment	850,000		914,000		932,000			
Extra income due to treatment	358,450		437,550		1,233,850			
Ratio of extra income/extra cost as cost due to treatment	0.42		0.48		1.32			
Return to investment per Ushs 1000 spent	422		479		1,324			

Treatment 1=EGL + LH + HMC= Elephant grass + legume mixture supplemented with 3 kg/day lablab hay and 4 kg/day homemade concentrate; Treatment 2=EGL + LH + CLH + HMC= Elephant grass + legume mixture supplemented with 2 kg/day lablab hay, 1 kg/day calliandra leaf hay and 4 kg/day homemade concentrate; Treatment 3= ML + CLH + HMC =Sole EG + Maize +lablab stover supplemented with 1 kg/day CLH and 4 kg/day HMC; Treatment 4= Farmers' practice (control); 1 US $ = 1,920 Ushs

The overall conclusion from this study is that incorporating leguminous forages in smallholder crop/livestock farming systems could solve the problem of inadequate feeds and improve dairy cattle performance, household food security and farm income and maximize utilization of available resources. It was therefore recommended that crossbred cows similar to those used in this study could be sustained on forages from 0.5 ha of improved and well managed sole elephant grass and 0.2 ha season^{-1} of ML supplemented with 1 kg cow^{-1}day^{-1} of CLH and 4 kg cow^{-1} day^{-1} of HMC. Maize + lablab being a low fodder development technology compared to ELG is likely to be widely adopted when and if the rightful settings are developed including its promotion through extension leaflets and demonstrations.

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