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The Effect of Integrating Forage Legumes in Smallholder Crop/livestock Farming Systems on Food, Fodder and Animal performance

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Abstract

In a farmer participatory process, farmers in Uganda identified intensive dairy cattle farming based on improved breeds and Napier grass (*Pennisetum purpureum*) basal forage as a potentially viable enterprise to enhance income of resource poor households. Inadequate year-round fodder supply partly due to land shortage is a major constraint in this production system. Napier grass productivity declines during the dry season resulting in a decline in animal performance and household income. To alleviate this concern, a participatory on-farm study on maize/*Lablab purpureus (*lablab) intercropping was done to evaluate the effects of intercropping lablab with maize crop on stover and maize grain production and document farmers' experiences in testing food/forage technologies.

The study results showed that fodder dry matter and maize grain yields and cob size were increased by 26, 7 and 6%, respectively in maize/lablab intercropping systems compared to maize monocrops (4,373 kg/ha/yr; 2,912 kg/ha/yr; 134 g respectively). Mean percentage crude protein (CP) content of maize/lablab residues was higher (8.4%) in intercrops than monocrops (4.0% CP). Maize/lablab intercropping increased phosphorus and calcium content compared to maize monocrop. Cows that were offered residues from maize/lablab intercrop in addition to Napier grass as a basal diet during the dry season produced about 13% more milk than cows on sole Napier grass (7.7 $\pm$0.02litres/cow/day).

Major benefits identified by farmers during a participatory technology evaluation survey were: weeds were suppressed by lablab plants thereby reducing on labour and cost required to weed the fields; lablab plants conserved soil moisture; maize stover yield and quality, food security and household income improved. Major lesson learnt from the study was that testing forage legume/food technologies with resource poor farmers is a very big challenge. It requires patience and institutional support. However, it improves adoption of the innovations.

This study revealed that lablab could be introduced as a component crop in an intercropping with maize to improve fodder and food availability.

Key words: Fodder, food; forage legume; intensive smallholder dairy farms

Introduction

The Uganda government and a number of Non Government Organizations have introduced intensive dairy cattle to improve nutrition, incomes and food security among resource poor households especially the women and disadvantaged groups. This is in line with the country's Plan for Modernization of Agriculture (PMA) policy whose objective is to eradicate poverty through agricultural transformation (Anon, 2005). The dairy enterprise contributes about 70% of the total farm agricultural income; 40-50% of the livestock Gross domestic product (GDP) and 17-19% of the agricultural GDP (Anon, 2005). Milk provides affordable nutrients to improve the general well-being of the children and those affected with HIV/AIDS.

Inadequate year-round feed supply is a major constraint to improved dairy cattle production un Uganda (Kabirizi, 2006). Elephant grass (*Pennisetum purpureum*) fodder is recommended as a basal forage for intensive cattle because of its high biomass dry matter yield compared to other grasses. However, a review of previous studies has shown that its quality and quantity declines during the dry season resulting in protein and energy deficits (Kabirizi, 2006). Maize crop is a major food and cash crop in Uganda. However, the utilization of maize stover is constrained by low (4%) crude protein content. The possibility of intercropping maize or elephant grass fodder with forage legume to improve fodder yield and quality and animal production was therefore tested with farmers during the period of 2003-2005 (Kabirizi, 2006).

Specific objectives

1. To determine the effects of intercropping maize or elephant grass with forage legumes on fodder and/or grain production in smallholder dairy farming systems.
2. To evaluate profitability and response of crossbred dairy cows fed forages originating from maize or elephant grass/forage legume intercropping systems supplemented with calliandra leaf hay and/or lablab hay and a homemade concentrate.
3. To assess the benefits and constraints from improved forage technologies to the production system and household welfare and document lessons learned from working with resource poor smallholder dairy farmers.

Materials and methods

The study was carried out in 4 villages in Masaka district located between 0^0 $15^'$ and 0^0 $43^'$ South of the equator and between 31^0 and 32^0 East longitude of Uganda. Thirty two households (8 households per village) were selected to participate in the trials. Selection of participants was based on the farmer's willingness to participate in the research and availability of land and labour to plant and manage the fodder fields.

Study 1: Effect of intercropping maize or elephant grass (*Pennisetum purpureum*) with forage legumes on grain yield and fodder production

Maize was intercropped with *Lablab purpureus* cv Rongai and elephant grass was intercropped with *Centrosema pubescens*, *Macroptilium atropurpureun* and *Desmodium intortum* using methods described by Kabirizi (2006). Yields of maize/lablab stover (ML), maize stover from monocrop, maize grain, elephant grass/legume mixture (EGL) and elephant grass fodder from monocrop were estimated on whole plant basis using 4 quadrates of 1 m x 1 m randomly selected from each of the 6 households in each village. The harvested material was weighed and then separated into elephant grass, maize stover and forage legumes and the weight recorded. Sub-samples of about 0.3 kg of each component were taken and oven dried at 60^0C to constant weight. The dried samples were used for dry matter (DM) estimation and crude protein (CP) using methods described by A.O.A.C. (2001). Maize/lablab stover was harvested, air-dried and later stored on well ventilated racks that were constructed by the farm owners.

Study 2: Elephant grass/legume or maize/lablab residues, calliandra leaf hay and/or lablab hay and a homemade concentrate as dry season feed resources

The diets used in a feeding trial are shown in Table 1. The diets were randomly assigned to the 32 farmers in a Randomized Complete Block Design (RCBD) with 4 replications.

Table 1: Experimental treatments

Treatment	Basal forages	Supplements
1	EGL	2 kg/cow/day LH + 1 kg/cow/day CLH + 4 kg/cow/day HMC
2	EGML	1 kg/cow/day CLH + 4 kg/cow/day HMC
3	Sole EG	None (farmers' practice)

EGL=elephant grass/legume mixture; EGML = elephant grass fed with maize stover/lablab; LH= lablab hay; CLH = calliandra leaf hay; HMC= homemade concentrate; Sole EG= Sole elephant grass fodder

Elephant grass/legume mixture and sole elephant grass were harvested every morning and chopped into pieces of about 5 cm long. The homemade concentrate comprised of: 16% CP. Animals used in this study were crossbreeds (indigenous cows x Holstein-Friesians), 26-28 weeks in-calf at the start of the feeding trials and had calved once. However, data collection started when the cows were 28 weeks in-calf. The farmers carried out all recommended animal health management measures. The feeding trials lasted 12 months, each cow covering 2 months prepartum and 10 months postpartum.

Statistical analysis (Studies 1 and 2)

All parameters were subjected to statistical analysis using a General Linear Model procedure for Randomized Complete Block Design (RCBD) using SAS (1999). Comparisons of means were considered significantly different at ($p<0.05$) using the Least Significant Difference (LSD).

Study 3: Participatory technology evaluation survey

A participatory technology evaluation survey was conducted at the end of the study to assess the benefits and constraints from improved forage technologies to the production system and household welfare. The information given by farmers was documented.

Results and Discussion

Effects of intercropping forage legumes with maize or elephant grass on fodder and maize grain production

Intercropping elephant grass with forage legumes increased ($p<0.05$) elephant grass plant growth, total fodder dry matter (DM) yield and crude protein (CP) yield by 12; 22 and 44 percent, respectively when compared to the monocrops (Table 2).

Table 2: Effects of intercropping elephant grass or maize with forage legumes on mean grain and fodder dry matter production

	Cropping system		
Dry matter yield (kg/ha/yr)	**Monocrop**	**Intercrop**	**SEM**
Elephant grass			
Plant height (cm)	79±2[b]	88±2[a]	0.93
Elephant grass fodder	10,024±215[b]	10,753±259[a]	112.01
Total dry matter	10,024±215[b]	12,211±304[a]	224.46
Total crude protein	809 [b]	1,163.6[a]	35.9
Maize crop			
Maize stover dry matter	4,373.2 [b]	4,166.3[b]	200.6
Total fodder DM	4373±190[b]	5486±261[a]	174.7
Maize grain	2,912.1[b]	3,115.4[a]	138.1
Total crude protein	180.1[b]	432.4[a]	36.8

[abcd]Means within a row followed by different superscripts differ ($p<0.05$); SEM=Standard Error of the Mean; MS: Maize monocrop; ML= Maize/lablab intercrop

Fodder DM, grain yields and CP yield were increased ($p<0.05$) by 26, 7 and 14 percent, respectively when maize was intercropped with lablab compared to monocrops (Table 2).

The higher growth rate of elephant grass plants and total fodder DM yields in intercrops compared to monocrops could be attributed to the presence of forage legumes that improved growth of elephant grass and maize plants.. The forage legumes provided soil cover reducing water loss from soil by evaporation and minimizing the effects of weeds in the intercrops. However, improved total fodder DM yields in the intercrops could also have been due to additive and complementary effect of legumes and elephant grass that raised the productivity per unit of land.

Effect of feeding crossbred cows elephant grass/legume or maize/lablab forages with a legume hay and homemade concentrate on dry matter intake and milk yield

Calliandra leaf hay, Homemade concentrate (HMC) and lablab hay (LH) had higher CP (22.5, 16.7 and 15.8 percent, respectively) than elephant grass/legume mixture(EGL), sole elephant grass (EG) and maize/lablab (ML) forages (9.7, 7.2 and 6.2 percent, respectively). Crude protein content of EG was lower than 11-16%, the minimum level required for maintenance and production of dairy cattle (NRC, 2001). Although CP content of ML and EGL was improved through intercropping, the CP content was still below the minimum (10-16% CP) level required for effective microbial activity in the rumen for growth and lactation of dairy cattle (NRC, 2001). This means that EGL, EGML and EG forages are not capable of supporting maintenance and production requirements for dairy cattle.

Supplementing EGL basal diets with CLH in addition to LH and a HMC improved total dry matter intake (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).

Table 3: Intake of forages and supplements and milk yield of crossbred dairy cows

	Diets			
Parameter	**EGL+LH+ CLH+ HMC**	**EGML+CLH+HMC**	**Sole EG**	**SEM**
Total DMI (kg)	11.3[b]	12.0[a]	7.0[d]	0.03
Total crude protein intake (g/cow/day)	1443[a]	1269[c]	503[d]	29.60
Milk yield (lt/cow/day)	9.7[b]	10.9[a]	6.9[d]	0.04

[abcd]Means within a row followed by different superscripts differ ($p<0.05$); SEM = Standard Error of the mean DMI= dry matter intake; EGL = elephant grass/ forage legume mixtures; EGML=Elephant grass fodder fed together with maize/lablab stover; LH = Lablab hay; HMC = Homemade concentrate; EG = sole elephant grass fodder;

EGL+ CLH + LH + HMC yielded ($p<0.05$) about 7% more milk than cows fed on EGL + LH + HMC diet. Cows fed on EGML (elephant grass fed with maize/lablab residues)+ CLH + HMC produced higher milk yield throughout the study period. Increased total dry matter intake (TDMI) with supplementation could be due to increased CP intake (Table 3) that were deficient in control diet and as a consequence improved nitrogen supply in the rumen since the consumed supplemented diets contained high levels of CP (15.8-22.5%). Total DMI and CP intake were improved by 1.5 and 7.4 percent, respectively when cows offered EGL basal diet were supplemented with CLH, HMC and LH compared to HMC + LH only. Ebong et al (1999) urged that drying calliandra foliage increases the DM content and amount of protein bypassing the rumen as well as decreasing the content of anti-nutritional factors. The results therefore indicate that additional supplementation with CLH is beneficial to dairy cows especially where farmers do not have enough land and labour to produce sufficient quantities of lablab hay. The lower mean daily milk yield observed in control animals throughout the entire lactation period could be attributed to low intake of CP and ME observed in this diet (Table 3) and inadequate feed supply especially during the dry season.

Benefits and constraints from improved forage technologies to the production system and household welfare

In the post trials evaluation survey, over 96% of the farmers identified improvement in: feed availability, food security, milk yield and income as the major benefits from forage legume interventions (Table 5).

However, high cost of forage legume seed and labour and initial slow growth of legumes in EGL, land shortage and low DM yields of forage legumes in EGL were major factors that would constrain wider adoption of the forage legume technologies.

Table 5: Benefits and constraints identified by dairy farmers as a result of incorporating forage legume technologies in farming systems

Benefits	Men (n=46)	Women (n=54)
Improved animal performance	87.0	92.6
Less burden of searching for legumes	54.3	92.6
Improved food and feed security	65.2	96.3
Improved household nutrition	58.7	90.7
Maximum utilization of resources	43.5	90.7
Improved household income	87.0	37.0
Constraints		
Lablab plants smothered banana plants	98.1	95.7
Initial slow growth of forage legumes	96.3	93.5
High cost of storage facilities	90.7	73.9
High labour and capital demands	100.0	97.8

The technology referred to is indicated in brackets: ML= maize/lablab intercrop; CLH = calliandra leaf hay; LH = Lablab hay

Improvement in feed supply resulted in an improvement in animal performance during the dry season and reduced incidences of animal diseases and veterinary costs because the dry season coincided with the time of the year when plenty of maize/lablab stover was available. The higher percentage of women than men who mentioned improved feed and food production shows the importance of identifying the target group that is likely to benefit more by adopting a particular technology. Women in Uganda are involved in all processes of dairy cattle and fodder production therefore; any positive contribution such as improved all-year-round feed availability from this participation in research is likely to benefit both the individual households and the entire community as well. With its spreading habit, fast early growth, and ability to grow with little soil moisture; lablab plants were effective in smothering grass weeds and quickly provided an effective ground cover to protect the soil from erosion.

Planting forage legumes in rows and weeding legume seedlings required extra care and labour because the seeds are very small compared to seed of food crops the farmers were already used to. Harvesting and transporting fodder from the fields, drying and chopping lablab foliage and maize/lablab stover was reported to be labour intensive. The initial slow growth of forage legumes in elephant grass/legume intercrop resulted in a quick invasion of weeds and created a requirement for more labour and money.

Lessons learnt

The study showed that farmers' knowledge and experience can be incorporated into the search for solutions and that farmers' capacity and expertise for conducting collaborative research is built up and becomes a valuable resource for future research programmes. Testing of forage legume technologies with resource poor farmers is a big challenge but rewarding. It requires patience, commitment from all stakeholders and institutional support.

Conclusions and Recommendation

The results of the study showed that incorporating forage legumes in crop/livestock farming systems is important to resource poor farmers for it would provide improved fodder production to fill the feed gap during the dry season while improving maize grain and/or fodder production from the same piece of land. The most important contribution of EGML + CLH + HMC diets was not only the superior improvement in animal performance but also the improvement in feed and food supply. This type of feeding is therefore important for areas which experience long dry seasons during which elephant grass fodder is scarce.

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