LEGUME RESEARCH NETWORK PROJECT NEWSLETTER

KENYA AGRICULTURAL RESEARCH INSTITUTE
P.O. BOX 14733, NAIROBI, TEL. 254-4440935, FAX 254-4449810
E-MAIL Address: jmureithi@africaonline.co.ke

Issue No. 10 **December 2003**

ABOUT THIS ISSUE

This tenth issue of the LRNP Newsletter presents result highlights for some of the on-going LRNP studies. The main areas of study covered by these articles include: resource use in a maize-legume intercrop system, integrating forage legumes in semi-arid regions of Kenya for improvement of livestock feeds and studies on the effect of intercropping different densities of green manure legumes (GML) on maize performance in the central highlands of Kenya. These studies are on-going and what has been presented in this Issue are preliminary results based on the data so far collected and analysed. Farmers' involvement in GML work continues to play a major role in LRNP activities. An interesting article on farmers' experience with GML in Kimutwa, Embu and Matanya LRNP sites is highlighted in this issue. This was in form of an educational tour where Kimutwa farmers from Machakos District had an opportunity of visiting their counter parts in Embu District. In attendance were also two farmers and the site supervisor for Matanya site, Laikipia District. The LRNP is again grateful for the financial and technical support it has continued to receive from the Rockefeller Foundation since its inception. The network also sincerely acknowledges the support it has continued to receive from Director, KARI.

Contents

EDITOR'S NOTE

The LRNP newsletter is published to provide a forum for highlighting Network activities and sharing research findings with network members and other projects, individual researchers and farmers who are involved in similar work in Kenya. This is a biannual newsletter and is published in June and December of each year. Your contributions and constructive comments are welcome and should be addressed to the Editors of LRNP Newsletter, CKK Gachene or LRNP Coordinator, JG Mureithi.

Effect of velvet bean (*Mucuna pruriens*) density and time of intercropping on the performance of maize in coastal lowland Kenya

HM Saha[1], LS Wamocho[2], FK Lenga[2]
and JG Mureithi[3]
[1]KARI Mtwapa, P.O. Box 16, Mtwapa
[2]Jomo Kenyatta University of Agriculture and Technology, P.O. Box 62000, Nairobi,
[3]National Agricultural Research Laboratory - KARI, P.O. Box 14733, Nairobi

Introduction

The average on-farm yield of maize in coastal lowland Kenya is only about 1.0 tons of grain per hectare, whereas yields of up to 5.4 t ha^{-1} have been realized on-station. Several surveys and PRAs conducted in the region identified the following constraints to crop production: low soil fertility, soils with low water holding capacity, weed infestation, pests and diseases, and low adoption of agricultural technologies. Low soil fertility was identified as one of the most important factors contributing to the low maize yields. Most soils in the region are sandy (> 80% sand), with a few pockets of sandy loams and clay loams. Due to their sandy nature, the soils in the region are prone to leaching. They have low organic matter content (< 1.0 %) and low CEC (< 15 me/100 g soil). As a result of low household incomes, less than 10% of the farmers in the region use inorganic fertilizers to improve soil fertility. Use of inorganic fertilizers is, therefore, not a sustainable method of improving soil fertility in coastal lowland Kenya.

In search for sustainable methods for improving soil fertility, the Legume Research Network Project (LRNP) screened 23 herbaceous legume species in 1995 and 1996 for their potential as soil amendments. The results showed that velvet bean (*Mucuna pruriens*) produced high biomass yield (1120 g DM m^{-2}) and formed almost 100% ground cover in three months. This legume also produced a large proportion (over 90%) of active nodules. The legume was evaluated further from 1997 to 2000 as a component of an integrated nutrient management (INM) system. The legume was used in combination with farmyard manure and/or fertilizer N. The most striking result of the INM study was a significant reduction in grain yield where maize was intercropped with velvet bean. The yield decline was likely to have been caused by severe competition between maize and velvet bean for resources. This forms the basis of the current study on resource use under maize-green manure legume (GML) system. The broad objective of the study is to understand better resource use in maize-GM legume system in order to maximize nutrient and moisture uptake and improve spatial use of light for increased maize yields. The results will help in the formulation of farmer-recommendations on the appropriate legume plant densities and time of under-sowing GML for efficient use of nutrients, soil moisture and light in maize-GML system. The specific objectives of the study are:

1). To determine the appropriate legume plant density and time of under sowing GML to maize for improved nutrient and moisture use
2). To evaluate the potential of GML for suppressing weeds and hence reduce crop - weed competition for nutrient and moisture
3). To gain an understanding on nutrient uptake and the vertical distribution of soil moisture and light in a maize - GML intercrop

Methodology

The study is being undertaken at KARI Mtwapa, coastal Kenya, to devise ways of improving resource use by the components of maize-GML systems. The site is at 15 masl and is characterized by sandy loam to sandy clay soils which are low in organic matter content. The mean annual rainfall for the area is 1200 mm. The GML used for the study is velvet bean (*Mucuna pruriens*).

The factors being evaluated in this study are: plant density for intercropped velvet bean (40,000, 30,000, 20,000 plants ha^{-1}), and time of intercropping the legume with maize (0, 2, 4 weeks after planting maize). The control treatments include sole cropped maize and sole cropped velvet bean. In addition, a treatment on rotation is included for the purpose of comparing maize-legume intercropping and rotation systems. The experimental design is randomised complete block, with treatments replicated four times. Maize in control plots receives inorganic fertilizer at the recommended rates of 46 kg P_2O_5 ha^{-1} and 60 kg N ha^{-1}. The maize-velvet bean system, when used continuously, is expected to be self sustaining in terms of nitrogen supply and therefore maize for intercropping or rotation is treated with P and N at full- and half-rate, respectively. The study has been conducted for three seasons and is expected to end after the fourth season. Data is being collected on soil moisture, ground cover, photosynthetically active radiation (PAR), plant nutrients, legume biomass production, and maize grain and stover yields. Reported here are preliminary results for the first two seasons on the performance of maize in maize-velvet bean systems.

Preliminary results

The results of the 2002 long rains (LR) season showed that number of harvestable ears, stover yield, grain yield and loss of grain yield were significantly affected by time of intercropping the legume into maize (Table 1). The density by time interaction effects on harvestable ears, stover yield, grain yield, and loss of grain yield due to intercropping were not significant. Delaying the intercropping of velvet bean by at least two weeks after planting (WAP) maize caused a 20-30% increase in maize grain yield and reduced loss of grain yield resulting from intercropping by 47-68%. The maize grain yield realized when the intercropping of velvet bean was delayed by at least two weeks was 84 -90% of the yield from sole cropped maize. Significant increases in the number of harvestable ears (8%) and stover yield (39%) were achieved only after delaying the intercropping of velvet bean by four weeks. When velvet bean was intercropped four weeks after maize, the number of harvestable ears was 101% that of sole cropped maize while the stover yield realized was 75% of the yield from sole cropped maize.

During the 2002 short rains (SR) season, there was a significant density by time interaction effect on maize grain yield (Table 2) and yield loss resulting from intercropping (Table 3). The highest maize grain yield and lowest grain loss were realized where velvet bean was planted either at a density of 40,000 plants per ha^{-1} and four weeks after maize, or at 20,000 plants per ha^{-1} and at least two weeks after maize. When velvet bean was planted at the same time with maize, legume density had no significant effect on maize grain yield and yield-loss due to intercropping. However, maize grain yield was significantly increased when velvet bean was planted two weeks after maize and at densities lower than 40,000 plants ha^{-1}. At velvet bean densities of 20,000 plants ha^{-1}, a two weeks delay in legume planting led to a significant reduction

Table 1: **Effect of varying the time of intercropping velvet bean on number of harvestable ears, stover yield, grain yield and loss of grain yield – 2002 LR season**

Time of intercropping velvet bean (WAP*)	Harvestable ears (Ears m^{-2})	Stover yield (t ha^{-1})	Grain yield (t ha^{-1})	Loss of grain yield [f] (%)
0	3.58 [b]	2.08 [b]	3.31 [b]	30.2 [b]
2	3.70 [ab]	2.48 [ab]	3.98 [a]	16.1 [a]
4	3.85 [a]	2.89 [a]	4.29 [a]	9.7 [a]
Sole maize**	3.80	3.83	4.74	0
LSD ($\alpha_{0.05}$)	0.19	0.52	0.65	13.63
CV (%)	6.1	24.6	19.8	86.7

* Weeks after planting maize
f Maize grain yield under intercropping compared to that of sole cropped maize
** For comparison

in yield loss caused by intercropping. When legume planting was delayed by two weeks, inter-species competition seemed to have been critical only at high legume densities (30,000 and 40,000 plants ha^{-1}). A four weeks delay in intercropping velvet bean seems to have reduced inter-species competition significantly such that a reduction of legume density from 40,000 plants ha^{-1} to 20,000 plants ha^{-1} caused no further yield advantage.

Both legume density and time of intercropping had no significant effect on the number of harvestable ears and maize stover yield during the 2002 SR season. The density by time interaction effect on the two parameters was also not significant.

Maize grain and stover yields were significantly affected by season. The grain yield realized in the LR season (3.86 t ha^{-1}) was higher than for the SR season (3.10 t ha^{-1}). However, contrary to expectation, stover yield was lower in the former (2.49 t ha^{-1}) than in the latter season (3.97 t ha^{-1}). The possible explanation for the different trends for grain and stover yields in the two seasons is the seasonal variation in rainfall (Fig. 1). Rainfall received during the 2002 LR season was slightly higher (450 mm) than that received in the 2002 SR season (400 mm). However, within the first two months of maize growth, rainfall distribution was better in the latter than in the former season. The dry spell that was experienced between the second and fourth week of the 2002 LR season could have drastically reduced the vigor of maize plants while the uniform rainfall distribution between

Table 2: Effect of velvet bean density and time of intercropping on maize grain yield (t ha^{-1}) – 2002 SR season

Velvet bean density (Plants ha^{-1})	Time of intercropping velvet bean (Weeks after planting maize)			Mean
	0	2	4	
40,000	2.59 ^{c}	2.77 ^{c}	3.53 ^{ab}	2.96
30,000	3.12 ^{abc}	3.10 ^{abc}	2.64 ^{c}	2.95
20,000	2.93 ^{bc}	3.64 ^{a}	3.61 ^{ab}	3.39
Mean	2.88	3.17	3.26	

LSD ($\alpha_{0.05}$) = 0.70

Table 3: Effect of velvet bean density and time of intercropping on maize grain yield loss (%) – 2002 SR season

Velvet bean density (Plants ha^{-1})	Time of intercropping velvet bean (Weeks after planting maize)			Mean
	0	2	4	
40,000	30.7 ^{c}	25.9 ^{c}	5.4 ^{ab}	20.6
30,000	16.5 ^{abc}	17.0 ^{abc}	29.4 ^{c}	21.0
20,000	21.6 ^{bc}	2.4 ^{a}	3.4 ^{ab}	9.1
Mean	22.9	15.1	12.7	

LSD ($\alpha_{0.05}$) = 18.8

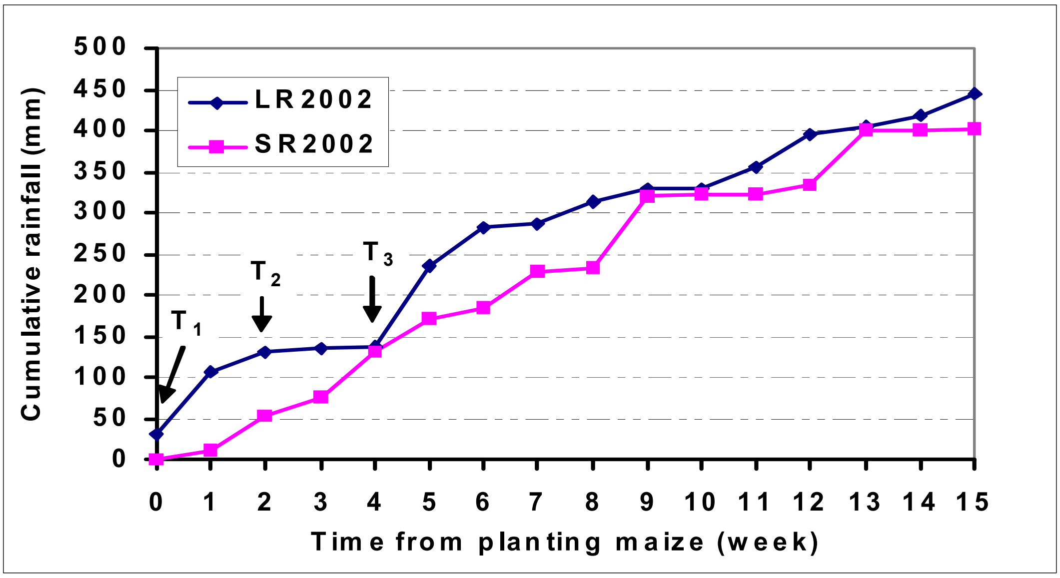

Figure 1: Cumulative rainfall from the time of planting maize during 2002 LR and SR seasons (T_1, T_2 and T_3 show the times of intercropping velvet bean relative to maize)

the first and eighth week of the 2002 SR season could have favoured vigorous growth of maize plants. This was likely to lead to high maize grain and stover yields during the 2002 SR than in the 2002 LR season. The larger maize plant canopy (providing larger photosynthetic area) in the 2002 SR season probably resulted in higher grain yield than yields for the 2002 LR season were it not for the negative effect of the dry spell that occurred between silking and early grain filling (9^{th} – 12^{th} week) in the latter season. The rainfall received between the 10^{th} and 13^{th} week in the 2002 LR season boosted grain filling, and this led to the production of higher maize grain yield than that realized in the 2002 SR season.

During the 2002 SR season, maize plants produced tillers and also showed variations in vigor. The more vigorous plants tended to produce bigger and more tillers than the less vigorous ones. Tillering and stover yields were therefore recorded as measures of plant vigor. Maize grain and stover yields were positively correlated with number of tillers (correlation coefficients 0.71 and 0.68, respectively). Maize grown following sole cropped velvet bean (i.e. in a rotation system) produced more tillers and higher stover yield than that following sole maize or maize/velvet bean intercrop (Table 4). This could have been caused by higher soil fertility in rotation plots than in the intercropping or sole maize plots.

Weed infestation

Critical weed competition in maize occurred within the first 3-4 weeks after crop emergence. Weed data collected over three seasons, LR 2002 – LR 2003, showed that the inclusion of velvet bean in a maize cropping system led to a significant reduction in weed dry matter (DM) production within the critical period for crop-weed competition (Fig. 2). Total weed DM production in intercropped plots was reduced by 58.2% by the third season while the DM production of nut grass (*Cyperus rotundus*) was reduced by 98.5%.

There was a significant density by time interaction effect on weed DM production within the critical period of crop-weed competition. The three velvet bean densities did not differ in their effect on weed DM production when the legume was planted at the same time with maize, but they differed significantly when legume planting was delayed by two or four weeks. These results show that the best option for weed suppression would be to plant velvet bean at a density of 40,000 plants ha^{-1} at the same time with maize or two weeks later.

Table 4: Effect of cropping system on maize tillering, grain and stover yield, 2002 SR season

Cropping system	Tillering (tillers per plot)	Grain yield (t ha^{-1})	Stover yield (t DM ha^{-1})
Velvet bean/maize rotation R_3*	11.8 ^{a}	4.73 ^{a}	7.11 ^{a}
Velvet bean/maize rotation R_1	8.8 ^{ab}	4.52 ^{ab}	6.12 ^{a}
Velvet bean/maize rotation R_2	7.3 ^{b}	5.10 ^{a}	7.02 ^{a}
Maize/velvet bean intercrop D_1T_3	2.5 ^{c}	3.53 ^{cd}	4.53 ^{b}
Maize/velvet bean intercrop D_1T_1	1.8 ^{c}	2.59 ^{d}	3.65 ^{b}
Maize/velvet bean intercrop D_1T_2	1.5 ^{c}	2.77 ^{cd}	3.80 ^{b}
Maize sole crop	1.5 ^{c}	3.73 ^{bc}	4.28 ^{b}
LSD ($\alpha_{0.05}$)	4.0	0.96	1.35
CV (%)	54.3	16.8	17.4

* Time of planting sole cropped velvet bean during 2002 LR season:
R_1 = velvet bean for rotation planted at the same time with maize; R_2 = velvet bean for rotation planted two weeks after maize; R_3 = velvet bean for rotation planted four weeks after maize

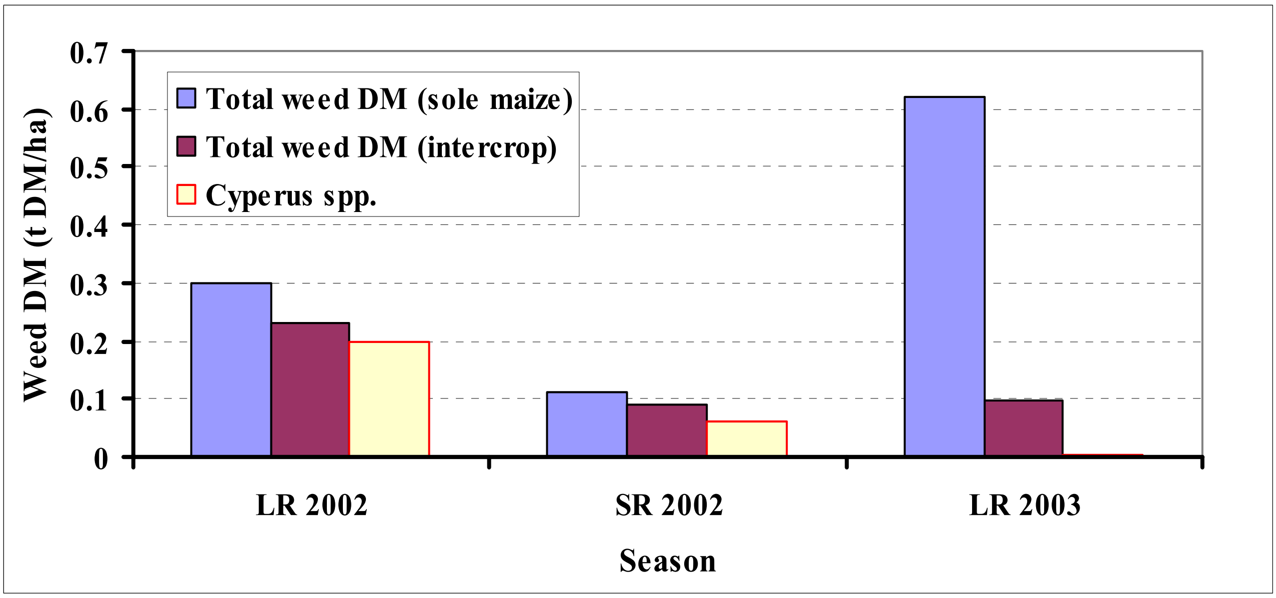

Figure 2: Effect of inclusion of velvet bean in a maize cropping system on weed DM production within 3 weeks after maize emergence

Way forward
The above preliminary results indicate that maize in a maize/velvet bean cropping system is likely to perform better when the legume is introduced at least two weeks after the cereal than when the two are planted at the same time. The study will be repeated for the next two seasons and the following activities and analysis will be undertaken: crop performance and plant nutrient uptake, determination of root-length density, PAR, ground cover, yield, weed infestation and weather data.

Effect of intercropping different densities of green manure legumes on maize performance in the central highlands of Kenya.

J.N. Gitari[1], S.K. Karumba[1], D.N. Mugendi[2] and J. Kung'u[2]
[1]KARI, Regional Research Centre, Embu, P.O Box 27 Embu .
[2]Department of Environmental Foundations, Kenyatta University, P.O Box 43844 Nairobi,

Introduction
Intercropping is a cropping system that has been described as the simultaneous growing of two or more crops in the same field during the same growing season (Willey, 1979). Intercropping of maize with legumes is a common farming practice among smallholder farmers of Eastern and Southern Africa. Maize-common bean (*Phaseolus vulgaris*) intercrop is the most common system and is widespread in Kenya, Tanzania, Ethiopia, Malawi and Zambia. Maize-groundnut (*Arachis hypogaea*) intercrops are common in Tanzania, Ethiopia, Malawi and Zambia whilst maize-soybean (*Gycine max*) intercrops are a common feature of the farming systems in Ethiopia and Zambia. The least widespread intercropping systems are the maize-cowpea (*Vigna unguiculata)*, maize-pigeon pea (*Cajanus cajan*) as well maize-green grams (*Vigna radiata*) intercrops which are found in Kenya and Tanzania (Waddington, *et al*., 1990).

In the central highlands of Kenya, the most common type of cereal-legume intercropping systems are the maize-common bean, maize-cowpea, maize-pigeon pea as well as maize-garden pea (*Pissum sativum*) (Jaetzold and Schmidt, 1983). For soil fertility improvement and maintenance such traditional systems have low potential for adding nitrogen (N) to the system due to the low N-fixing ability coupled with the high harvest N index of these legumes. N benefit can therefore be improved by replacing the grain legumes with green manuring crops such as mucuna or crotalaria (Yost *et al*., 1985 and Gachene *et al*., 1999). The quantity of N_2 fixed by the legume component in the cereal-legume intercrop depends on the species, morphology, density of the legume in the mixture, and the competitive abilities of the component crops (Ofari and Stern, 1987). The objective of this study was therefore to determine the performance of maize intercropped with different densities of three green manure legumes used as a source of N to the subsequent maize crop. This study is on going and preliminary results are given in this article.

Materials and methods
The experimental site is located at Field 7 of Embu Agricultural Staff Training (EAST) college, neighbouring KARI, Embu Regional Research Center. It is located on latitude 0^0 30'S and longitude 37^0 27'E at an elevation of 1480 m above sea level. The average annual rainfall is 1252 mm and is received in two distinct rainy seasons; the long rains (mid March to June) with an average rainfall of 650 mm and the short rains (mid October to December) with an average of 450 mm. The area has a mean annual temperature of 19.5^0C, a mean maximum of 25^0C, and a mean minimum of 14.1^0C. The site is in agro-ecological zone UM3 (upper midland). The soils are mainly humic Nitisols derived from basic volcanic rocks. They are deep, red, friable clay with moderate to high inherent fertility (Jaetzold and Schmidt, 1983).

Planting of both maize and legumes was done on April 16, 2003. Maize variety Pionner Hybrid 3252 was used for the study. The spatial arrangement of the maize/legume intercrop was by proportional areas allocated to each crop at sowing according to Willey (1981). Legumes were planted at two densities designated as low and high planting density. The low density legume intercrop was at 50:50 component population which was achieved by having equidistant alternate rows of the maize and the legume. Likewise, the high density of the legume was double that of the low density and was achieved by having two legume rows equidistantly placed between the maize rows. The low and high seeding rate of crotalaria was 30 and 60 kg ha^{-1}. Mucuna and lablab low densities were 42,000 and 62,500 plants per ha^{-1} respectively, while the high densities were double that of the low seeding rate. Mucuna and lablab were planted in hills with an intra-row spacing of 25 cm, two plants per hill, while crotalaria was drilled along the row. Triple super phosphate fertilizer was applied to both maize and legumes during planting at 20 kg P ha^{-1}. All other crop husbandry practices such as weeding, thinning, and stalk borer control were carried out as need arose. The size of each plot was 4.5 m wide and 6.0 m long. The net plot was 15 m^2 and consisted of the entire plot excluding the two outer rows and the first and last hills in each row. All the biophysical data collected was subjected to analysis of variance (ANOVA) using SAS (1998) statistical package. Means were separated by least significance difference (LSD) procedure at the $P<0.05$ level of significance.

Preliminary results

Germination and establishment

There was good germination for all the three legumes. The germination of crotalaria and lablab occurred within five days while that of mucuna took between 7 and 10 days after planting. After germination, the seedling vigour of the three legumes was good. There was, however, a reversal in the seedling vigour for the lablab plants whereby they started to appear weak, stunted with some yellowing after the growth of the first trifoliate leaves and continued for the rest of the growing season. This occurrence was more prevalent in the sections of the field where the soil appeared to be less fertile.

Legume Dry Matter (DM) accumulation

The results for legume DM accumulation for each of the three legumes are presented in Table 1. The results show that crotalaria had the highest DM production followed by mucuna and then lablab. Biomass production in crotalaria was 1.3 and 4.8 times that of mucuna and lablab, respectively. Planting of the legumes at different densities had an influence on the rate of DM accumulation in each of the three legumes (Table 1). Legume DM accumulation was significantly higher in crotalaria and lablab planted at a high density compared to those at a low density. Thus, planting each of the three legumes at twice the planting density increased the DM production by 25, 48 and 166 per cent in mucuna, crotalaria and lablab, respectively. The resultant extra DM was therefore attributable to the increased legume stand due to the increased density.

Table 1. Dry matter (DM) production in three different green manure species planted at different population densities

Legume density	Legume DM (Mg ha^{-1})		
	Mucuna	Crotalaria	Lablab
Low	2.0^{a}	2.3^{a}	0.3^{a}
High	2.5^{a}	3.4^{b}	0.8^{b}
Mean	2.3	2.9	0.6
$LSD_{0.05}$	NS	0.6	0.3

Effect on maize plant height, grain and stover yields
The presence of mucuna as an intercrop in the maize stand did not affect the performance of this cereal crop. Maize plant height in the plots where mucuna was intercropped at either the low or the high density recorded a similar height (Table 2) to that of the pure maize stand. Similar observations were observed with regard to maize grain or stover yields. None of these three parameters assessed showed any significant difference to that of the pure maize stand. The results of intercropping maize with a low or a high density of crotalaria are presented in Table 3. The results showed that intercropping maize with crotalaria did not affect the performance of the maize crop. Neither maize plant height nor the grain or stover yields were adversely affected by the presence of crotalaria at this density. By contrast, intercropping maize with a high density of this legume had a negative effect on the performance of maize. Maize in the high density crotalaria plots was shorter and produced lower grain yields when compared to that of the pure stand of maize. These differences were, however, not significantly different from each other. Among the three parameters that were assessed, only stover yields in the high density legume plots gave significantly lower yield than that of either the pure stand or the lower legume intercropping density. The presence of lablab as an intercrop with maize at either the low or the high population density did not affect the growth and development of the maize crop. The results of maize plant height, grain or stover yields (Table 4) indicated that none of these parameters assessed was significantly affected by the presence of the legume

Table 2. Effect of different densities of *Mucuna pruriens* on maize plant height , grain and stover yields

Legume density	Maize plant height (cm)	Maize grain yield (Mg ha^{-1})	Stover yield (Mg ha^{-1})
None	228^a	5.7^a	6.8^a
Low	223^a	5.7^a	6.4^a
High	223^a	6.0^a	6.1^a
$LSD_{0.05}$	NS	NS	NS

Table 3. Effect of different densities of *Crotalaria ochroleuca* on maize plant height , grain and stover yields

Legume density	Maize plant height (cm)	Maize grain yield (Mg ha^{-1})	Stover yield (Mg ha^{-1})
None	228^a	5.7^a	6.8^a
Low	228^a	6.3^a	6.3^a
High	224^a	5.5^a	5.0^b
$LSD_{0.05}$	NS	NS	1.1

Table 4. Effect of different densities of *Lablab purpureus* on maize plant height , grain and stover yields

Legume density	Maize plant height (cm)	Maize grain yield (Mg ha^{-1})	Stover yield (Mg ha^{-1})
None	228^a	5.7^a	6.8^a
Low	215^a	5.9^a	6.4^a
High	211^a	5.4^a	7.0^a
$LSD_{0.05}$	NS	NS	NS

Discussion and conclusions

Germination and establishment

Mucuna and crotalaria normally exhibit a fast rate of seedling establishment in the Upper Midland 3 and Lower Midland 3 agro-ecological zones of mount Kenya region (Gitari *et. al.*, 2000a). In the current study, good seedling establishment was also recorded in the two species. The lack of good establishment that occurred in lablab may partly be attributed to the inability of the species to withstand any biotic or abiotic stresses that may have occurred (Yost, *et. al.*, 1985; Gitari *et. al.*, 2000b).

Dry Matter (DM) accumulation

The rate of DM accumulation in each of the three green manure legume species was not affected by the presence of the maize crop. Dry matter accumulation is crucial for success of any herbaceous legume as a candidate for green manuring. In the central highland of Kenya, mucuna and crotalaria GM species are able to accumulate substantial amounts of DM within 2-3 months of growth (Gitari, *et al.*, 2000a; Mureithi *et al.*, 2003). During the legume screening study that was carried out in the area, floral formation for the two species was noted to occur within 126 and 93, days after emergence, for mucuna and crotalaria, respectively. The time to flowering may, however, be greatly influenced by the prevailing weather in a particular season whereby the occurrence of soil moisture deficiency leads to quicker flowering of the plants (Skerman, 1977). In this study, both crotalaria and lablab recorded significantly higher DM if planted at a high planting density. However, the DM of lablab was still below 1.0 Mg ha^{-1} even when the population density was high. The final biomass of legume to be intercropped with maize will therefore be determined by the amount of rainfall at the respective site. Similar work in Uganda by Fischler (1996) also indicated that biomass accumulation of mucuna and crotalaria were a function of prevailing weather in a particular growing season. The current study has shown that in the mid altitude areas of the central highlands of Kenya region, a legume herbage of about 2 to 4.0 Mg ha^{-1} may be expected from mucuna or crotalaria intercropped with maize during a normal growing season.

Performance of maize under different legume densities

The results of this study have confirmed that legume green manuring (GM) is a feasible mode of providing N to a growing maize crop in central highland of Kenya region since these legumes may be intercropped with maize without affecting the maize grain yield but still raising adequate biomass for incorporation in the subsequent season. In very wet cropping seasons, total N available through GM legume may reach over 300 kg ha^{-1} but on average about 30-90 kg N ha^{-1} may be realized during a normal growing season (Buckles *et al.*, 1998, Gitari *et al.*, 2000b). Of the three GM legumes that were planted, only crotalaria planted at a high density of 60 kg ha^{-1} was observed to lower the yield of maize significantly. Planting both mucuna or lablab at high densities does not appear to have any adverse effect on maize crop. The resultant biomass from the GM legumes has been shown to increase maize yields of the subsequent season by 39% in eastern Uganda (Fischler., 1996). The current study has shown that the planting populations of these green manure legumes can be manipulated in order to maximize the legume DM while maintaining the recommended maize planing population.

Conclusion and recommendation

Mucuna pruriens and *Crotalaria ochroleuca* have proved to be suitable herbaceous legumes for intercropping with maize so that the resultant legume herbage may be incorporated as green manure in the subsequent cropping season. The results also indicated that maize planted at the same time with these legumes was not adversely affected with regard to grain or stover yields. In situations where moisture may be limiting, it may be necessary to adjust the planting density of crotalaria so as to minimize any competition for nutrients or moisture which could affect the final maize yields of the intercropped stand. The study is on going and proper recommendations will be made once all the data has been collected and analysed.

References

Buckles, D; B. Triomhe, and G. Sain. (1998). Cover crops in hillside Agriculture. Farmers innovation with Mucuna. CIMMYT Document (Mexico D.F : CIMMYT)

Fischler, M. 1996. Research in green manures in Uganda: Results from experiments conducted in 1995. Report submitted to the Rockefeller Foundation, Nairobi.
Gachene, C.K.K., C.A. Palm and J.G. Mureithi. 1999. Legume cover crops for soil fertility improvement in the East African region. Report of an AHI Workshop on 18-19 February 1999 at Nairobi, Kenya.
Gitari, J.N., E.A. Dyck and P Maina. 2000a. Legume screening for soil fertility improvement, food and fodder utilisation in medium altitude areas of Mount Kenya region. In: J.N. Mureithi C.W. Mwendia, F.N. Muyekho, M.A. Anyango and S.N.Maobe (Eds.). Participatory Technology Development for Soil Management by Smallholders in Kenya. Special publication of Soil Management and legume research Network Projects. Kenya Agricultural Research Institute, Nairobi, Kenya. Pp 121-131.
Gitari, J.N., J.G. Mureithi, S.K. Karumba and K. Mwaniki. 2000b. Legume green manuring for maize production on smallholder farms in the eastern and central Kenya region. In: J.G. Mureithi C.K.K Gachene, F.N. Muyekho, M. Onyango, L. Mose and O. Magenya (Eds.). Proceedings of the 2nd Scientific Conference of the Soil Management and Legume Research Network Projects held in June 2000 at Mombasa, Kenya. Participatory Technology Development for Soil Management by Smallholders in Kenya. Kenya Agricultural Research Institute, Nairobi, Kenya. Pp 121-128.
Jaetzold, R. and H. Schmidt 1983. Farm Management Handbook of Kenya. Vol. II/C. East Kenya. Ministry of Agriculture. Nairobi, Kenya.
Mureithi, J.G., C.K.K. Gachene and J. Ojiem. 2003. The role of green manure legumes in smallholder farming systems in Kenya: The Legume Research Network Project. *Journal of Tropical and subtropical Agroecosystems*, 1: 57-70.
Ofari, F. and W.R. Stern. 1987. Cereal-legume intercropping systems. Adv. Agron. 41:41-90.
Skerman, P.J. 1977. (eds) *Tropical Forage Legumes*. Food and Agricultural Organization. Production and Protection Series. No. 2. pp 609.
Statistical Analysis System. 1988. SAS/STAT User's Guide, Release 6.03 Edition. SAS Institute, Cary, NC, U.S.A.
Waddington, S.R., A.F.E. Palmer and O.T. Edje, eds. 1990. Research methods for cereal/ legume intercropping: Proceedings of a workshop on research for cereal/legume intercropping in Eastern and Southern Africa. Mexico. D.F.: CIMMYT.
Willey, R.W. 1979. Intercropping: Its importance and research needs. Field Crops Abstracts 32, 1-5; 73-85.
Willey, R.W. 1981. A scientific approach to intercropping research. In: Proceedings of the International Workshop on Intercropping, held on January 10-13, 1979 at ICRISAT HQ, Hyderabad, India.
Yost, R.S., D.O. Evans and N.A. Saidy, 1985. Tropical legumes for N production: growth and N content in relation to soil pH. Tropic. Agric. 62:20-24.

Enhancing livestock feed supply and maize production by integrating selected forage legumes in semi-arid region of eastern Kenya

DMG Njarui,
KARI Katumani, P.O. Box 340 Machakos

Introduction

Eighty percent of the farms within the semi-arid eastern region of the country belong to small-holder farmers who practice mixed-farming; growing of crops and keeping livestock. Due to frequent drought, pasture productivity is low. However, farmers do not normally adjust their livestock numbers to match the available pasture and this lead to overgrazing and trampling of pastures. Consequently, the soil is eroded and the pasture re-growth is poor. Some farmers have planted forages, mainly Napier and guinea grass, for improved dairy cattle but the yields are low due to poor soil fertilization and low rainfall.

Therefore, it is imperative to develop a production system that increases availability of livestock feeds and improve soil fertility for enhanced crop and forage production. Forage legumes can improve livestock feed supply, reduce rate of soil fertility decline and enhance crop yield when integrated in the mixed crop-livestock farming system of the semi-arid region of eastern Kenya. Growing forage legumes, as short-term fallow might be more appropriate since they can be used as livestock feeds and can restore fertility for subsequent crop. Also integrating forage legumes with fodder grasses is likely to lead to increased total feed production of higher nutritive value. This on-going research work focuses on the contribution of four herbaceous legumes; Seca stylo (*Stylosanthes scabra* cv. Seca), Siratro (*Macroptilium atropurpureum* cv. Siratro), Lablab (*Lablab purpureus* cv. Rongai) and velvet bean (*Mucuna pruriens*) to livestock feed supply and soil fertility improvement when grown in rotation with maize in a fallow system and when inter-cropped with two fodder grasses. Also the phosphorus requirements and appropriate planting pattern of these legumes inter-cropped with fodder grasses is being determined in this study.

The objectives of this study are to:

- Evaluate the productivity of two legumes, lablab and velvet beans when grown in rotation with maize in short-term fallow system
- Assess the effects of lablab and velvet bean on improvement of soil N when grown in short-term fallow for maize production
- Evaluate the effects of inter-cropping on total dry matter production and nutritive value of Seca stylo and siratro under Napier and guinea grass
- Determine the effects of P on establishment and dry matter production of four herbaceous legumes, namely velvet bean, lablab, Seca stylo and siratro
- Evaluate the effects of two planting patterns of Seca stylo and siratro in intercropping system with Napier and guinea grass on total dry matter production

Materials and methods

The research work is being conducted at National Dryland Farming Research Centre (NDFRC) Katumani (1^{o}58'S, 37^{o}28'E). Elevation is 1600 m above sea level. Mean annual rainfall is 724 mm occurring in a bimodal pattern, the long rains from March to May and the short rains from October to December and with peaks in April and November respectively. Inter-seasonal rainfall variation is large with coefficient of variation ranging between 45-58 %. The long dry season is from June to September and the short dry season from January to February. The mean temperature is 19.6^{o}C. Evaporation rates are high and exceed the amount of rainfall in all the months except in November. The soils are chromic luvisols and are generally low in organic matter content, nitrogen and phosphorus, with a pH of 6.5. The following experiments are being undertaken:

Experiment 1: Evaluation of two herbaceous forage legumes as short-term seasonal fallows in maize production system for improved livestock feed supply in semi-arid eastern Kenya

Nine treatments consisting of 3 land use systems and three legume management are included in this study (Table 1). Legume management include 100% , 50% and 0% of the biomass incorporated in the soil.

Table 1. Treatments sequence for fallow establishment and maize

Treatments	First season (Mar-May, 2002)	Second season (Oct-Dec, 2002)	Third season (Mar-May, 2003)	Fourth season (Oct-Dec, 2003)
1	legume fallows	maize	legume fallows	maize
2	natural fallow	maize	natural fallow	maize
3 (i)	No fallow (maize + N)	maize + N	maize + N	maize + N
(ii)	No fallow (maize + no N)	maize + no N	maize + no N	maize + no N

Experiment 2: Productivity of forage production systems based on intercropping of two selected herbaceous forage legumes with Napier and guinea grass

Treatments consist of two fodder grasses, Napier grass (*Pennisetum purpureum* cv. Bana) and Guinea grass (*Panicum maximum)* intercropped with two legumes, Seca stylo (*Stylosanthes scabra* cv. Seca), and Siratro (*Macroptilium atropurpureum* cv. Siratro) and 3 fertilizer applications, 0, recommended N (100 kg N ha^{-1} yr^{-1}) and recommended farm yard manure (FYM) (8 tons FYM ha^{-1} yr^{-1}). In addition to the grasses/legumes intercrops, plots of sole fodder grasses were also established, one top dressed with FYM and the other not applied with any fertilizer.

Experiment 3: Effect of phosphorus application on productivity of four selected tropical herbaceous forage legumes

The treatments consist of four herbaceous legumes, Seca stylo, siratro, lablab (*Lablab purpureus*) and velvet beans (*Mucuna pruriens*) and 4 rates of phosphorus fertilizer application, 0, 20, 40 and 60 kg P ha^{-1}. The design is randomised complete block in a split plot arrangement with 3 replications. The main plots are legume species and the sub-plots are the 4 rates of P application.

Experiment 4: Effect of planting pattern of two herbaceous legumes in fodder grasses on productivity of grass-legume inter-crops

Eight treatments consisting of two fodder grasses, Napier and Guinea grass intercropped with two legumes, Seca stylo and siratro are included in the study. The legumes were planted as single row and double rows between rows of the fodder grasses.

Measurements

Measurements are being taken on weed population, composition and DM, grasses/GM legume biomass production, maize yield, soil and plant tissue analysis. Crude protein, Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), lignin and rumen degradability.

Preliminary observations

Experiment 1: Evaluation of two herbaceous forage legumes as short-term seasonal fallows in maize production system for improved livestock feed supply in semi-arid eastern Kenya

Fallow establishment and performance

Establishment and growth of fallows from the legumes was good and plants populations for both velvet bean and lablab averaged 10 plants m^{-2}. Velvet bean produced the highest DM while the natural fallow had the lowest (Table 2). Average DM production for lablab, velvet bean and natural fallow was 2.75, 4.83 and 1.94 t ha^{-1}, respectively. Consequently, more herbage was incorporated from velvet bean than lablab fallow at 50 and 100%

Table 2. Dry matter yield from lablab, velvet bean and natural fallows and equivalent amount incorporated in the soil

Treatment (type of fallow)	DM yield (kg ha^{-1})	Level of incorporation (% of total yield)	Equivalent amount of DM incorporated (kg ha^{-1})
Lablab	2762	100	2762
Lablab	2706	50	1353
Lablab	2778	0	0
Velvet bean	4736	100	4736
Velvet bean	4891	50	2435
Velvet bean	4868	0	0
Natural fallow	1943	100	1943

level of incorporation.

Grain and stover DM yield

Grain and stover yield were not significantly different for maize top-dressed with N and unfertilized maize but the yields were higher where the maize was top dressed with N fertilizer. Maize grain yield with or without N was 2445 and 2193 kg ha^{-1}, respectively while the corresponding maize stover yield was 2986 and 2518 kg ha^{-1}.

Experiment 2: Productivity of forage production systems based on intercropping of two selected herbaceous forage legumes with Napier and guinea grass

Establishment and growth

At the end of the first season, establishment of Napier grass was 100% in all plots and 47% for Guinea grass. Initial growth of both grasses was good and the legume intercrop had no significance effect on the tiller numbers, height and canopy cover of both grasses (Table 3). Establishment for Seca stylo and Siratro were also good and plants averaged 22.5 and 15.1 plants m^{-2}, respectively and were not significantly affected by the type of fodder grass. Similarly, spread, height and ground cover were not significant when inter-cropped with either Napier or Guinea grass.

Total DM yield of legumes and grasses

Dry matter yield at the end of establishment phase for combined Napier grass/legumes and Guinea grass/legume intercrop and sole grass are shown in Table 4. The total dry matter yield of Napier grass/legumes intercrop was not significantly higher than that of sole Napier grass. Napier/Siratro intercrop produced the highest DM while Napier/Seca stylo intercrop had the lowest yield. Total DM yield of Guinea grass/Seca stylo intercrop was significantly ($P<0.05$) higher than the yield from sole Guinea grass but not from Guinea grass/siratro intercop. The contribution of legumes to total DM produced was highest in Guinea grass and accounted for 35 and 44% compared to 20 and 15% in Napier grass for Seca stylo and Siratro respectively (Table 4).

Experiment 3: Effect of phosphorus application on productivity of four selected tropical herbaceous forage legumes

Effect of phosphorus on establishment

Plant numbers and height was not affected by amount of P applied in all the legumes. For velvet bean, increasing P level from 0 to 60 kg P ha^{-1} progressively increased the canopy height although not significant (Table 5). Application of phosphorus had no significant effect on plant spread. For Seca stylo, the 40 and 60 kg P ha^{-1} produced marginally more spread than at 0 and 20 kg P ha^{-1} while for siratro the spread was more at 0 and 20 kg P ha^{-1}. For lablab, the spread was low at 0 kg P ha^{-1} (25 cm) and increased with

Table 3. Overall mean tiller numbers, height and ground cover of Napier and Guinea grass when intercropped with Seca and Siratro at 12 week during establishment

Napier grass	Mean	CV (%)	SED
Established stool (%)	100	-	-
Number of tillers per stool	15.1	39.9	4.6
Height of stool (cm)	35.0	31.6	11.1
Ground cover (%)	40.7	33.7	13.7
Guinea grass			
Established stool (%)	47	-	-
Number of tillers per stool	11.9	47.5	5.7
Height of stool (cm)	37.0	32.9	12.1
Ground cover (%)	11.2	71.6	8.0

Table 4. Overall yield of fodder grasses and legumes when intercropped at Katumani, eastern Kenya

Legumes used for intercropping	Dry matter yield (kg ha^{-1})	
	Napier grass + legume	Guinea grass + legume
Seca stylo	1571 (20)*	1663 (35)
Siratro	1892 (15)	1265 (44)
Sole fodder grass	1732	923
Mean	1732	1347
CV	38.7	39.1
SED	548	430
LSD (P<0.05)	Ns	904

*Number in parenthesis represent % DM of legume in the mixture

Table 5. Effect of phosphorus application on plant height (cm) of four forage legumes at 12 weeks during establishment

Legumes	Phosphorus application (kg ha^{-1})				Mean	CV (%)	LSD
	0	20	40	60			(P<0.05)
S. scabra cv. Seca	14.7	15.0	13.0	11.2	13.5	10.1	2.7
M. atropurpureum cv. Siratro	6.4	5.0	6.8	6.0	6.1	16.0	ns
L. purpureus cv. Rongai	43.0	41.7	44.2	44.4	43.3	13.4	ns
M. pruriens	30.8	36.5	40.3	41.1	37.2	14.0	ns

application of 20 kg P ha^{-1} (41 cm) but above this rate, spread remained almost the same.
On ground cover, significant effect on P application was recorded in siratro only where the cover was more at 20 and 40 kg P ha^{-1} (Table 6). For Seca stylo, ground cover was the same at 0 and 20 kg P ha^{-1} (12%) and decreased to 9.3% at 40 and 60 kg P ha^{-1}. There was no definite trend in ground cover for lablab while ground cover for velvet bean was similar at 0 and 20 kg P ha^{-1}, increasing to 99% in plots with 40 kg P ha^{-1}.

Effect of phosphorus on nodulation
There was no significance (P<0.05) differences on number of nodules by applying different rates of P for all legumes. However in Seca stylo and lablab there were more nodules at 40 kg P ha^{-1} while in Siratro more nodules were found at 20 kg P ha^{-1}. In velvet bean, there was no trend and the number of nodules varied slightly between treatments. This legume had the lowest nodules at all level of P application.

Effects of P application on DM
There were no significance differences on P application rates on DM yield for siratro, lablab and velvet bean. In both siratro and velvet bean plots, P application rates at 60 kg ha^{-1} produced the highest DM while for lablab, DM yield increased by increasing P level from 0 to 20 kg P ha^{-1} and declined marginally when the rates were increased to 40 and 60 kg ha^{-1} (Table 7).

Experiment 4: Effect of planting pattern of two herbaceous legumes in fodder grasses on productivity of grass-legume inter-crops

Effect of legume rows on grass establishment
The performance of Napier grass when intercropped with Seca stylo and siratro as single or double rows is shown in Table 8. Napier grass establishment was good and averaged 99%. Height, number of tillers and ground cover were not influenced by the legumes either as single row or double rows. Plant establishment, tiller numbers, height and ground cover for Guinea grass is shown in Table 9. Stool establishment was poor and averaged 47.8%. Inter-cropping Guinea grass with Seca stylo as double row significantly (P<0.05) produced the highest number of tillers but the height and canopy

Table 6. Effect of phosphorus application on ground cover (%) of four forage legumes at 12 weeks during establishment

Legumes	Phosphorus application (kg ha^{-1})				Mean	CV (%)	LSD
	0	20	40	60			(P<0.05)
S scabra cv. Seca	12.0	12.0	9.3	9.3	10,7	16.5	ns
M. atropurpureum cv. Siratro	26.7	32.0	32.0	22.7	28.3	11.8	6.7
L. purpureus cv. Rongai	53.3	44.0	49.0	66.7	53.3	16.7	ns
M. pruriens	93.3	93.3	98.7	96.0	95.3	4.6	ns

Table 7. Effect of phosphorus application on dry matter yield (kg ha^{-1}) of four forage legumes at end of establishment phase (end of first wet season)

Legumes	Phosphorus application (kg ha^{-1})				LSD
	0	20	40	60	(P<0.05)
S. scabra cv. Seca	1171	1108	1081	795	221
M. atropurpureum cv. Siratro	1127	1127	1267	1309	ns
L. purpureus cv. Rongai	2057	2356	2171	2188	ns
M. pruriens	4552	4329	4935	5009	ns

Table 8. Overall mean tiller numbers, height and ground cover of Napier grass when intercropped with Seca stylo and Siratro as single and double rows at 12 weeks during establishment

Parameter	Mean	CV (%)	SED
Established stool (%)	99	-	-
Number of tillers per stool	14.1	32.0	3.7
Mean stool height (cm)	18.1	22.2	3.3
Ground cover (%)	15.2	55.8	6.9

Table 9. Effect of planting single and double row of Seca stylo and Siratro on tiller number, height and ground cover of Guinea grass at 12 weeks during establishment

Treatments	Established stool (%)	Number of tillers	Height (cm)	Ground cover (%)
Guinea grass/Seca-single row	39.0	8.4	25.0	2.9
Guinea grass/Seca-double rows	48.6	10.0	24.8	4.9
Guinea grass/siratro-single row	50.5	8.7	31.1	3.9
Guinea grass/siratro-double rows	53.3	3.0	14.9	3.7
Mean	47.8	7.9	24.8	4.0
CV (%)		23.4	39.1	32.5
SED		1.5	7.9	1.1
LSD		*	ns	ns

cover was not affected by the legume or number of rows of legume planted.

Effect of grasses on legume establishment
Legume performance when planted as a single row or double rows between rows of Napier and Guinea grass is shown in Table 10. Plant numbers, spread, height and ground cover for both Seca stylo and siratro were not influenced by Napier or Guinea grass when planted as single or double rows.

Total dry matter yield of grasses and legumes
Number of rows of legumes planted between the fodder grasses did not influence DM yield. Overall mean dry matter yield of fodder grasses and legumes when intercropped as single and double rows is shown in Table 11. Overall mean DM yield of Napier/Seca stylo intercrop was significantly higher than that of Napier/Siratro intercrop. For Guinea grass the overall means when intercropped with Seca stylo or siratro were not significant and the yield difference was small.

Conclusion and way forward
From the results analysed so far, there is very little that can be concluded since for most experiments, the first rainy season was the establishment phase. Initial observations from Experiment 3, indicated that application rates of 0, 20, 40 and 60 kg P ha^{-1} to Seca stylo, siratro, lablab and velvet bean did not influence the number of nodules. However, it is important to continue recording relevant measurements in all the experiments, during the production phase and also analyse the data collected. This will

Table 10. Overall mean plant numbers, spread, height and ground cover of Seca stylo and Siratro when intercropped with Napier and guinea grass as single and double rows at 12 week during establishment

Seca stylo	Mean	CV (%)	SED
Plant numbers (m^{-2})	26.5	23.4	5.1
Mean spread (cm)	12.7	41.2	4.2
Mean height (cm)	20.6	8.1	1.4
Ground cover (%)	7.2	45.1	2.7
Siratro			
Number of tillers (m^{-2})	17.1	24.7	3.4
Mean spread (cm)	61.8	24.1	12.1
Mean height (cm)	10.3	12.0	1.0
Ground cover (%)	31.7	30.6	7.9

Table 11. Overall mean dry matter yield (kg ha^{-1}) for fodder grasses and legumes when intercropped as single and double rows

Treatments	Mean
Napier grass/Seca stylo	2223
Napier grass/Siratro	1573
Mean	1898
CV	16.9
LSD (P<0.05)	642
Guinea grass/Seca stylo	1115
Guinea grass/Siratro	1196
Mean	1155
CV	29.2
LSD (P<0.05)	Ns

give a clear contribution of herbaceous legumes to fodder production and soil fertility improvement for maize production.

Introduction of forage legumes into natural pastures of semi-arid rangelands of Kajiado District: preliminary results

PN Macharia, KARI – NARL, P.O. Box 14733, 00800 Nairobi. Email: kss@iconnect.co.ke

Introduction
Livestock production is the dominant farming enterprise in the semi-arid rangelands of Kenya, which are occupied mainly by livestock keeping semi-nomadic pastoralists. However, livestock keeping is limited by the availability of grazing resources in terms of quantity and quality especially during the dry periods of the year. One way of increasing the grazing resources of natural pastures of semi-arid rangelands is to integrate forage legumes into the pastures, with the aim of diversifying the sources of forage and at the same time increasing the amount of protein available for the grazing animals. To this effect, a research study was initiated in March, 2002 in Mashuru Division of Kajiado District with an overall goal of introducing forage legumes into natural pastures of semi-arid rangelands as a means of raising the livestock production in the division. The study which is ongoing is being implemented through legume screening, nodulation studies and legume/grass integration experiments.

Three possible niches for the integration of the legumes into the natural pastures of Kajiado District already exist. The main niche being targeted is the exclusive grazing areas *(Olepololi)* which are situated near the Maasai homesteads and of which the pasture is reserved for calves, lactating cows and sick animals. These areas usually occupy about 1.3-2.0 ha per homestead. Another niche is the grazing paddocks that have been fenced by the livestock keepers who have large tracts of land. Other exclusive grazing areas located in depressions and valley bottoms are reserved for dry season grazing and form the third important type of niche for the introduction of the legumes into the natural pastures.

Materials and methods

Study site
The study is being conducted at Sultan Hamud in Mashuru Division of Kajiado District in south-eastern Kenya. The area which is in agro-climatic zone (ACZ) V is classified as semi-arid (Sombroek *et al*., 1980) and is characterized by low and erratic bimodal annual rainfall of about 500 mm. The short rainfall season occurs between October and December and the long rainfall season between March and May. The soils are mainly sandy clay to sandy clay loam in the uplands while clay soil dominates the plains and valleys. The woody vegetation is dominated by *Acacia* and *Balanites* species while the forbs layer is dominated by the grasses *Dichanthium insculpta, Digitaria macroblephara, Hyparrhenia filipendula, Themeda triandra, Chloris roxburghiana* and the shrub *Indigofera spinosa.*

The semi-nomadic Maasai people who live in the area practice nomadic pastoralism as a major strategy for exploiting the graze and browse resources available in the area. After subdivision of former group ranches into individual land holdings of between 10 and 60 hectares (depending on ranch membership), sedentary pastoralism has taken root, whereby only livestock migrate during the dry season but the homestead remains.

Experimental set-up and legume materials

Legume screening studies
Five forage legume species are being used namely *Neonotonia wightii* (Glycine), *Stylosanthes scabra* var. *seca* (Shrubby Stylo), *Macroptilium atropurpureum* (Siratro), *Lablab purpureus* cv. Rongai (Dolichos), and *Mucuna pruriens* (Velvet bean). Data on soils, root development, litter fall and biomass production is being collected. The biomass data is being collected at two and four month's intervals at ground level and at 15 cm heights. To complement the field screening data in terms of number, weight, location and coloration of nodules, a nodulation study was conducted in a glasshouse using the same soil

and experimental legumes as in the field experiment. Also, data on biomass of shoots and roots, and lengths of tap and lateral roots was collected.

Legume/grass integration studies
Based on preliminary results/observations from the screening studies, a legume/grass integration experiment was set up in October, 2002 by planting Glycine, Siratro and Stylo in mixed stands with the natural grass as well as in pure stands (control plots). The legumes in mixed plots were planted along clear bands after the legumes failed to establish in plots prepared through raking and furrowing of the soils before planting. Biomass production data is being collected at two defoliation intensities (15 and 30 cm height) and at three defoliation frequencies (2, 3 and 6 times/year). Plant samples have been collected for determination of dry matter and nutritive quality. Other data being collected includes leaf litter production, soil fertility and soil moisture.

Legume integration methods
Due to the poor establishment of legumes through raking and furrowing in the integration experiment, another experiment was set up in November, 2003 with the aim of testing four legume integration methods namely banding, furrowing, raking and sowing (legumes and grasses at the same time). The experimental legumes are Glycine, Siratro, Stylo and *Rhynchosia malacophylla* (a locally growing legume).

Macropitilium atropurpurem (Siratro) grown along bands in the natural pasture

Results and discussions

Legume screening studies
Preliminary results from the screening experiments showed that Glycine, Siratro and Stylo performed well under the semi-arid conditions. They are self-seeding perennials with the ability to overcome the long dry season which occurs between May and October. They have deep tap roots and thus can utilize soil moisture from deep soil horizons as compared to the annual legumes and grasses (Table 1). They also performed well in terms of biomass production, addition of organic matter through litter fall (especially Siratro) and showed their potential to regenerate after heavy grazing. This is due to the fact that the growing buds of Glycine and Siratro were in a crown located between 0 and 3 cm below the soil surface, which later grew to the surface to become the new generation stems. The cattle were unable to graze Stylo to ground level, leaving about 5 cm of stems above the ground surface due to its tough and woody stems. Regeneration of Stylo occurred from buds located on the stems as it had no crown buds below the soil surface. Glycine, Siratro and Stylo were also firmly rooted in the soil, thus cattle were unable to uproot them. Therefore, the three legumes were identified as best bets for integration into the natural pastures of the area.

Table 2 shows comparative dry matter (DM) production of Velvet bean, Dolichos, Glycine, Siratro and Stylo (var. seca) planted in six LRNP sites in Kenya. The results indicate that the Sultan Hamud site, despite its low annual rainfall surpassed Gachoka and Machakos sites in DM matter production of Velvet bean, Siratro and Glycine (Gachoka site). It is to be noted that the DM production of the legumes in all other sites was harvested at ground level, whereas at the Sultan Hamud site, the harvesting was done at 15 cm above ground.

Legume/grass integration studies
These preliminary results indicates that plots planted as pure stands of Glycine, Siratro and Grass, have been performing better in terms of DM production than plots planted as mixed stands (Figure 1).

Table 1: Rooting characteristics of the experimental forage legumes after 5 months of growth and dominant grasses at Sultan Hamud site

Species	Common name	Description	Rooting system	Rooting depth (cm)
Neonotonia wightii	Glycine	Herbaceous perennial legume	Tap root with few but big lateral roots located up to about 60 cm	80
Macropitilium artropurpureum	Siratro	Herbaceous perennial legume	Tap root with few relatively small lateral roots located at 0-15 cm depth	95
Stylosanthes scabra var. *seca*	Shrubby Stylo	Erect shrubby perennial legume	Tap root with relatively few lateral roots spread evenly along the tap root	85
Rhynchosia malacophylla	Rhynchosia	Herbaceous perennial legume	Thick tap root with relatively big but few lateral roots (about 2) located at 15-20 cm depth	100
Lablab purpureus cv. Rongai	Dolichos	Twining herbaceous annual legume	Tap root with most lateral roots located at 0-15 cm	30
Mucuna pruriens	Velvet bean	Long-lived annual legume	Thick tap root with most lateral roots located at 0-15 cm	60
Chloris roxburghiana	Horsetail grass	Tufted perennial grass	Fibrous roots with majority concentrated at 25-30 cm depth	70
Themeda triandra	Red Oat grass	Tufted perennial grass	Fibrous roots with majority concentrated at 25-30 cm depth	80

Table 2: Comparative DM production (g/m²) of forage legumes at two months after planting at various LRNP experimental sites in Kenya

LRNP Site	Plots location	Mean annual rainfall	Velvet bean	Dolichos	Glycine	Siratro	Stylo (Seca)	Source
Kitale	Agricultural Centre	1100	348	722	Np	Np	Np	Kirungu *et al.* (1997)
Kisii	Research Station	2000	384	588	Np	Np	Np	Maobe *et al.* (1997)
Mtwapa	Research Station	1200	322	215	Np	210	Np	Saha *et al.* (1997)
Gachoka	Farmer's field	950	31	Np	2	Np	2	Gitari *et al.* (1997)
Machakos	Farmer's Training Centre	750	40	50	10	0	Np	Gachene and Makau (1997)
S/Hamud	Farmer's field	500	55	38	8	9	0*	Macharia *et al.* (2003)

Np = Not planted; * = Stylo had not reached 15 cm height at two months of growth.

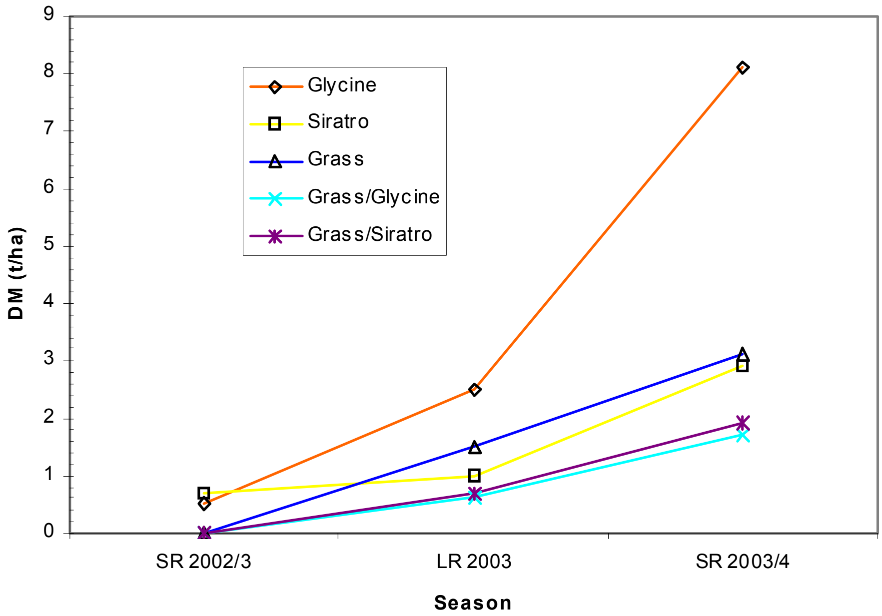

Figure 1: Seasonal cumulative DM production (t/ha) of Glycine and Siratro as pure and mixed stands harvested at 15 cm height

In mixed plots, Glycine had the lowest DM production due to its poor germination and slow establishment (both in pure and mixed plots). However in pure stands, it had more than doubled the DM production of Siratro by the second season (LR 2003). This can be attributed to its sprouting of many and longer stems than Siratro. Stylo also established well in pure stands than in mixed plots.

Legume integration methods

Preliminary observations on legume establishment and hence biomass production indicates that integration of the legumes through sowing, banding and furrowing (in that order) are superior to the raking method.

Conclusions and recommendations

The ability of Glycine, Siratro and Stylo to withstand heavy grazing is a desirable attribute when introducing forage legumes into natural pastures. Glycine and Siratro showed this potential due to their firm rooting characteristics, location of growth buds below the soil surface and their ability to produce many trailing stems (especially Glycine). Stylo as well showed the potential to withstand heavy grazing due to its tough and woody stems that are difficult to be uprooted. The growth buds located on the stems ensured its regeneration after grazing. But there is need to quantify the amount of stems and leaves that the livestock can graze from Stylo plants as the old stems may be too tough and woody for the animals.

Glycine, Siratro and Stylo are perennial in their growth habit, and were thus able to survive the long dry season. Their deep penetrating tap roots may have enabled them to source soil moisture from deep soil horizons. The perennial aspect of the legumes is important to farmers, as obviously they may not prefer legume species which they have to plant every other season unless they would plant a small area for "cut and carry" system. The three species are also self-seeding as the seeds germinated on their own once the wet season set in. This is a desirable characteristic with respect to propagation within pastures.

It may be concluded from these preliminary results that Glycine, Siratro and Stylo performed better under the prevailing climatic and edaphic conditions. The species qualify as potential forage legumes for integration into the natural pastures with the aim of enhancing soil fertility, DM production and nutritive quality of pastures in the rangelands of Kenya.

It should be noted that the results presented in this overview paper are preliminary. Biomass data collection is continuing, while soil and nutritive quality analysis has not been finalized. Thus definite conclusions will be made once all the data has been collected and analysed.

Literature cited

Gachene, C.K.K. and M. Makau. 1997. Screening legume cover crops for dry season survival in a semi-arid environment of Kenya. In: *Mureithi, J.G., C.W. Mwendia, F.N. Muyekho, M.A. Onyango, and S.N. Maobe (Eds.). Participatory technology development for soil management by smallholders in Kenya.* Kenya Agricultural Research Institute, pp 77-86

Gitari, J.N., E.A. Dyck, and P. Maina. 1997. Legume screening for soil fertility improvement, food and fodder utilization in medium altitude areas of Mount Kenya region. In: *Mureithi, J.G., C.W. Mwendia, F.N. Muyekho, M.A. Onyango, and S.N. Maobe (Eds.). Participatory technology development for soil management by smallholders in Kenya.* Kenya Agricultural Research Institute, pp 121-132

Kirungu, B.A.M., J.I. Kasiti, E. Dyck and P. Shiundui. 1997. Screening of potential soil improving legumes for use in the maize based cropping systems of the Trans Nzoia District of Kenya. In: *Mureithi, J.G., C.W. Mwendia, F.N. Muyekho, M.A. Onyango, and S.N. Maobe (Eds.). Participatory technology development for soil management by smallholders in Kenya.* Kenya Agricultural Research Institute, pp 45-62

Macharia, P.N., J.I. Kinyamario, W.N. Ekaya and C.K.K. Gachene. 2003. Screening forage legumes for integration into natural pastures of semi-arid rangelands of Kenya. Paper presented at the VIIth International Rangeland Congress, Durban, South Africa, 26th July – 1st August

Maobe, S.N., E. Dyck and A. Rondicho. 1997. Legume screening for soil fertility improvement in a high potential area in south west Kenya. In: *Mureithi, J.G., C.W. Mwendia, F.N. Muyekho, M.A. Onyango, and S.N. Maobe (Eds.). Participatory technology development for soil management by smallholders in Kenya.* Kenya Agricultural Research Institute, pp 63-76

Saha, H.M., M.N. Njunie and N.M. Tsanje. 1997. Legume screening for soil fertility improvement in the coastal lowlands of Kenya. In: *Mureithi, J.G., C.W. Mwendia, F.N. Muyekho, M.A. Onyango, and S.N. Maobe (Eds.). Participatory technology development for soil management by smallholders in Kenya.* Kenya Agricultural Research Institute, pp 87-100

Sombroek, W.G., H.M.H. Braun, and B.J.A. van der Pouw. 1980. Exploratory Soil Map and Agro-Climatic Zone Map of Kenya. Scale 1:1 million. E1 Report, Kenya Soil Survey, Nairobi.

Visit to Legume Research Network Project Site in Embu by Kimutwa Farmers

M Kimanthi and CKK Gachene,
Dept. of Soil Science, University of Nairobi,
P.O. Box 29053, Nairobi

Introduction

Farmers from Kimutwa (Machakos District) Legume Research Network Project (LRNP) site visited their counter parts in Embu on 2/1/04. The purpose of the trip was to expose the farmers to green manure legume (GML) technologies being undertaken in Embu. The farmers in Embu have been exposed to GML technologies for a longer time than Kimutwa farmers. In addition, the two sites are under different agro-climatic zones; sub humid in Embu and semi arid in Machakos. This gave the farmers an opportunity to share experiences gained so far in the two eco zones.

The trip had been organised by the LRNP. Fifteen (15) out of sixteen (16) farmers from Kimutwa participated in this trip. The farmers first assembled at the KARI Regional Research Centre, Embu where welcoming remarks were given by the Deputy Director, Dr. Kihanda. This was followed by a brief presentation on LRNP activities by the Assistant Project Coordinator of the LRNP. Two farmers and the site supervisor from Matanya LRNP site had also been invited to share their experiences on GML technologies with Kimutwa and Embu farmers. The following is a brief of the visit.

Farmers' experience on green manure technologies in Matanya area

Farmers were informed that GML activities were started in 1995 and that the legumes adopted for the Matanya area are lablab (*Lablab purpureus)*, soybean (*Glycine max*), lima (*Phaseolus lunatus*), vetch (*Vicia benghalensis*), butterbean (*Phaseolus coccineous)* and mucuna (*Mucuna pruriens)*. The legumes are either planted as sole crop or are inter-cropped with maize or potato. The need to adopt these legumes are as a result of poor rains which are erratic and insufficient to support cereals and legumes grown in the area. Lima, butter bean and lablab perform well since they are drought tolerant. These legumes are used as an alternative to common beans. Farmers were also informed that there is an increase in potato yields when the crop is inter-cropped with vetch. Potato yields are higher when compared with the control.

A field day had been held in mid 2003 to train the local farmers on utilization of some of the legumes as food. Such utilisation days in Matanya have sensitized the farmers on the importance of GML for increased land productivity. During the briefing, one of the farmers from Matanya narrated on how he had increased plot size for each legume from 25m^2 to 100m^2 after realizing the benefits of using the legumes for soil fertility improvement and for increased crop yields. He further indicated that many farmers had adopted the legumes in their farms because of other additional benefits such as weed control and moisture conservation. One of the major challenges facing the site is to provide farmers with enough seeds.

Experiences from Karurina farmers, Embu District

Farmers narrated how they were introduced to GML technologies by the LRNP team. Participants were also informed that some farmers have been planting GML for the last seven years. The Karurina farmers went a step further to form a Farmer field school (FFS) for upscaling GML technologies and that the farmers have since graduated. The school was formed with the assistance of LRNP and researchers from KARI Embu. Further discussions were held during the field visit to Karurina site.

Guided tour in the Research Station and Karurina LRNP site

Farmers were first taken around the KARI farm to see the activities that were being undertaken in the institution. These included trials on sweet potato varieties, climbing beans, maize varieties, tissue culture bananas and napier.

Farmers had also the opportunity of visiting Mr. Gitari's Ph.D. site at Embu Agricultural Staff Training Centre which neighbours KARI-Embu station. Mr Gitari is one of the six LRNP students who are undertaking PhD studies in the Kenyan public universities. (highlights of these studies were given in Issue No. 6 of the LRNP Newsletter). Farmers were particularly keen to see treatment differences. These were demonstrated in plots where legume biomass (mucuna and crotalaria) had been incorporated in the soil. Maize was observed to be greener and more healthier in these plots compared to plots without GML biomass. However, lablab plots were not as good when compared with mucuna and crotalaria treatments. According to Gitari, lablab did not produce enough biomass when compared with the other two GML species. Few questions were asked on the type of maize variety used, whether the legumes used in the trials have other uses apart from soil fertility improvement, and on possible competition of the legumes with food crops considering that Kimutwa farmers had dropped crotalaria in their trials due to moisture competition of this legume with maize crop. Potential of using GML for controlling weed was quite visible in the plots.

A visit was made to Mrs. Mwaniki's farm, one of Karurina farmers who has been using GML for the last 7 years. Mrs. Mwaniki's seven years experience of using mucuna in her farm fascinated the farmers. Field observations and sharing of the experiences at her farm was the climax of the visit. Crop performance was so good that Kimutwa farmers decided to experiment on bigger plots during the long rain season of 2004. Mrs. Mwaniki had been rotating mucuna with food crops in her farm, mainly for both maize and potato production. The system was such that once maize had been harvested from a maize - mucuna intercrop, potato was grown in the same plot during the subsequent season to benefit from the mucuna biomass. Maize was again intercropped with mucuna in another plot which previously was under mucuna. Almost all the parcels of land in Mrs Mwaniki's farm had been or were under mucuna. To ensure continuous supply of mucuna seed, Mrs. Mwaniki was bulking seed of the legume where it was grown and allowed to twirl on old pawpaw trees.

Conclusion and way forward

The trip was an eye opener to Kimutwa farmers and they were really inspired by the GML activities carried out in Embu area. A decision was made to increase the acreage for GML in Kimutwa area while at the same time more farmers were to be encouraged to join the group (by the time of writing this article, ten more farmers had already joined the 16 farmers in Kimutwa). Farmers also decided to bulk seed of the GML for their own use in small plots adjacent to the trial plots.

The status of legume seed availability and distribution by December 2003

Species	Seed received from sites (Kg)	Amount issued out (kg)	Amount in store (kg)
Canavalia ensiformis	610	369.1	240.9
Crotalaria juncea	21.5	13.4	8.1
Crotalaria ochroleuca	280.5	269.7	10.8
Desmodium unicinatum Silver	22.9	11.4	11.5
Lablab purpureus (Brown	576.5	512.3	64.2
(Black)	51.2	25.5	25.7
Phaseoulus lunatus	77	66.25	10.75
Macroptilium atropurpurem	91.35	90.1	1.25
Mucuna pruriens (White)	1618.4	1227.8	390.6
(Black)	514.5	359	155.5
Stylosanthanes	9.9	9.2	0.7
Neontonia wightii	78	77.1	0.9
Vigna unguiculata: (Cowpea K80)	19	19	-
(Cowpea M66)	32	23.7	8.3
Vicia villosa	11.7	11.7	-
Phaseolus coccineus (Black)	40.5	27	13.5
(White)	35.4	26.4	9
Vicia benghalensis	27	16.5	10.5
Vicia dasycarpa	5.7	4.8	0.9
Vicia sativa	7.3	6	1.3

Publications

Mureithi JG, Gachene CKK and Wamuongo J, 2003. Legume cover crops research in Kenya: Experiences of the Legume Research Network Project. Highlights of phase I research activities (1994 - 2000), KARI Technical Note Series No. 12, February 2003. KARI Hqs, Nairobi, 26p. Copies available at LRNP Coordination office.

Nyambati EM, Mureithi JG and Wamuongo JW, 2003. Soil fertility improvement technologies for western Kenya. Synthesis report of the Soil Management Research Project (1994-2002), KARI Technical Note Series No. 13, March 2003. KARI Hqs, Nairobi, 61p. Copies available at LRNP Coordination office.

Mureithi JG and Gitahi F, 2004. Legume Screening Database Instructional Manual. LRNP, NARL - KARI, Nairobi, Kenya, 23 p. Make request for a copy (with the accompanying CD) to LRNP Coordination office.

Conferences/Meetings/Workshops

4th International Crop Science Congress, 26th Sept - 1st Oct 2004, Brisbane, Austarlia. Theme. New directions for a diverse planet. Contact Congress managers, 4icsc04@im.com.au

International conference on Eco-agriculture, 27th Sept - 1st Oct 2004 Contact Sara J. Scherr, sscherr@futureharvest.org, Nairobi, Kenya

The Soil Science Society of East Africa will hold the 22nd Conference from 29th November - 3rd December 2004 in Arusha, Tanzania. The Theme of the Conference is Land Resource Management to Enhance 'Livelihood' of Land Users in East Africa. For more information, contact Chairman SSSEA, Sokoine University of Agriculture, Dept. of Soil Science P.O. Box 3008 Morogoro, Tanzania. Email:mmkilasara@yahoo.com, kilasara@suanet.ac.taz or soil@suanet.ac.taz

III World Congress on Conservation Agriculture, 3rd to 7th Oct 2005, Nairobi, Kenya. Theme: Linking productivity, livelihoods and consrvation. Contact Congress Secretariat, P.O. Box MP 167, Mt Pleasant, Harare, Zimbambwe, actsecre@africaonline.co.zw