USE OF *MUCUNA PRURIENS* TO IMPROVE SOIL FERTILITY FOR COTTON PRODUCTION IN UGANDA

Elobu, P[1]; J. Nalunga[2], P. Musunguzi[3], J.R. Ocan[1] and J. Olinga[1]

[1] National Semi Arid Resources Research Institute (NaSARRI), P.O. Soroti - Uganda

[2] National Organic Agricultural Movement of Uganda (NOGAMU), P.O. Box 70071, Kampala

[3] Makerere University (Soil Science Department), P. O. Box 7062 Kampala)

Abstract

Trials to test effectiveness of mucuna (Mucuna pruriens) in improving soil fertility for cotton (*Gossypium hirsitum* L.) *production were conducted at the National Semi Arid Resources Research Institute (NaSARRI) and on farmers' fields in Northern Uganda. During the 2008/2009 cotton season, trials were conducted at NaSARRI and Lira, whereas work was done in Gulu district during the 2010/2011 and 2011/12 cotton seasons. At NaSARRI and Lira, mucuna was intercropped with cotton at two densities (high and low) and periodically cut down to decompose under the cotton crop. Under the on-farm trials in Gulu, mucuna was planted and allowed to grow for 1-2 months before ploughing it down. Cotton was then planted on the post- mucuna plots for comparison with the control plots. Soil analyses before and after the growth of mucuna revealed changes in levels of various nutrients in the Gulu trials. Mucuna significantly ($P<0.05$) increased soil K but decreased Mg levels. Cotton yielded 1,195.0 kg/ha from the post-mucuna plots compared to 750.1kg/ha from the control plots in the Gulu trials. Mucuna cut from elsewhere and applied to cotton at NaSARRI significantly ($P<0.05$) increased cotton yields to 2472.2 kg/ha from 1,988.9 kg/ha under the no fertilizer controls (24.3 % increase). It can be concluded from the study that: (1) Mucuna is a potentially cheap and sustainable method of providing nutrients (especially K) to cotton and increasing seed cotton yields in areas where fertility is a limitation;. (2) Intercropping mucuna with cotton is not feasible and should be discouraged. (3) Mucuna needs to be established early and given sufficient time to form biomass before it may be ploughed back into soil and a subsequent crop planted.*

Keywords: Mucuna pruriens, Cotton, Gossypium hirsitum L., Intercropping, Potassium, Magnesium, Soil nutrients.

INTRODUCTION

Three major aspects describe cotton (*Gossypium hirsitum* L.) in Uganda (Baffes, 2009), namely: (1) It was introduced in 1903 and quickly established as a major export crop and number one foreign exchange earner, until it was surpassed by coffee in the 1950's. (2) It is a cash crop of strategic importance to the economy. (3) Its production is by small holder farmers with less than 10 acre holdings and contributes to the income of approximately 10% of the population. The main producing areas are in eastern, northern and western Uganda. In eastern Uganda, where poverty is high, a drop in rural poverty from 58.8 % in 1992/93 to 46.0 % in 2002/03 was closely linked to increase in cotton production in the region (IDA, 2007 http://go.worldbank.org/EZDHPI8D30).

Cotton production in Uganda is affected by many constraints such as: (1) High prevalence of pests. (2) Declining soil fertility. (3) Low adoption of appropriate technologies. (4) Limited availability and affordability of key production inputs by smallholder farmers. (5) Unreliable rainfall and (6) Fluctuating market prices (*Woelcke, J.; T. Berger and S. Park* www.ilri.cgiar.org/InfoServ/Webpub/fulldocs/WP50/ch29.htm). Losses due to the constraints amount to 100,000 bales of lint, an equivalent of US $ 20 million in export value.

Cropping systems in Northern Uganda consists of 4 to 5 crops grown in sequence and cotton is commonly planted in companion or sequence with other crops. Farmers use various methods to improve soil fertility and control pests, and these include use of cover crops and trap crops. Mucuna *(Mucuna pruriens)* has been widely used for improvement of soil fertility for a number of crops (Adedira *et al*., 2004). The plant with the help of nitrogen fixing bacteria resident in the nodules of its roots, fixes atmospheric nitrogen which can be used by plants as an organic fertilizer (http://mucunapuriens.org). In studies conducted in Eastern Uganda, Kaizzi *et al.* (www.ilri.cgiar.org/InfoServ/Webpub/fulldocs/WP50/ch30.htm reported that mucuna accumulated 192, 169, 204 and 77 kg N/ha at Sironko, Soroti, Kumi and Kapchorwa districts respectively. The study concluded that mucuna has the potential of increasing maize yields but the magnitude of yield response and economic benefits depend on the initial level of soil fertility. Adedira *et al*. (2004) evaluated the effect of mucuna intercropped with maize (*Zea mays* L.) on soil fertility and maize yield. Intercropping of maize with *Mucuna* at planting was advantageous because maize yields from plots that received 100, 50 and 0 kg N/ha, increased by 46, 60 and 87 % respectively compared to pure stands. Other reported effects were increased organic C, exchangeable Ca and Mg, and available N and P levels by 81, 14, 28, 48 and 25 per cent, respectively. There is need to evaluate such advantages of mucuna on other crops like cotton, under different farming systems in Uganda.

As a way of addressing the issue of soil fertility and inputs under an organic perspective therefore, this study was established with the purpose of determining the effectiveness of mucuna for the sustainable improvement of soil fertility and appropriate management methods for cotton production.

MATERIALS AND METHODS

Cotton trials involving the use of mucuna were conducted at the National Semi Arid Resources Research Institute (NaSARRI) and on farmers' fields from 2008 to 2012. On-station trials were conducted during the 2008/2009 cotton season under a conventional system involving use synthetic pesticides and inorganic fertilizers. On-farm trials were conducted with organic pesticides and no fertilizers in the districts of Lira during the 2008/2009 cotton season and Gulu during the 2010/2011 and 2011/2012seasons.

At NaSARRI there were five treatments: two where cotton was planted concurrently and intercropped with mucuna at high and low densities. The third was sole cotton supplied with mucuna grown in a separate plot, and the fourth was sole cotton with the recommended inorganic fertilizer application. The fifth was a pure cotton control without any fertility intervention. Details of these treatments and plant spacings for cotton and mucuna are shown in Table 1. Mucuna was later cut at about 15 cm above the ground, chopped into smaller pieces and applied to the cotton plots as mulch. This process was repeated as long as ratooned mucuna was ready for cutting and application. Plots measured 10x5 m and the trial was laid in a RCBD replicated four times. Pests were controlled using five sprays of Acetamiprid nicotinyl (Golan) for sucking pests, and three sprays of Cypermethrin against bollworms. Data on plant heights, numbers of squares and bolls were recorded and cotton from the middle rows were later picked and weighed.

In Lira district three treatments shown in Table 2 were studied. Two of them involved intercropping cotton with mucuna as described for NaSARRI and one was a control. Mucuna was managed as described for NaSARRI. Plots measured 20x40 m and the trials were not replicated on the farmers' fields but each of the four farmers was a replicate. No fertilizer was applied, weeding was done three to four times by hand and cotton pests controlled using herbal extracts prepared from hot chilli (*Capsicum frutescens*), pawpaw (*Carica papaya*), lantana (*Lantana camara*) and neem

Trials in Gulu were modified and simplified following the difficulties associated with management of mucuna from the Lira trials. Mucuna was planted first around May and given ample time to form sufficient biomass before it was cut and incorporated to the soil through ploughing in July. Cotton was then planted to two plots per site. One plot (the control) had nothing earlier planted to it but had been ploughed once while the other side was where mucuna was incorporated. Plots measured 20x35 m and each of the four farmers during each cotton season was a replicate. Eight farmers from different sub-counties shown in Table 3 participated in the Gulu trials. Soil fertility levels and changes from each site were monitored through regular soil sampling and laboratory analysis. Samples were obtained from two depths (0-30 cm and 30-45 cm) and taken to Makerere University Soil Science laboratory for analysis according to methods described by Okalebo *et al*, 2002. The first sampling was before planting of mucuna the second at mucuna cutting and incorporation and the last at cotton harvesting. Crop management and data collections were done as described above for Lira.

RESULTS AND DISCUSSIONS

Changes in soil nutrients

Most of the soil fertility characteristics such as organic matter, N, P, pH, etc were not significantly changed by use of mucuna, so are not presented. Table 4, however, shows that K and Mg were significantly ($P<0.05$) affected by mucuna in Gulu district during the 2010/2011 season. Potassium was increased while Mg was reduced. Other studies such as Adedira *et al*. (2004) reported significant increases in organic C, exchangeable Ca and Mg, and available N and P levels by use of Mucuna under maize trials. Mg reduction in our study could have arisen from K-induced Mg deficiency. Page and Bingham (1965) in greenhouse studies reported that continuous, heavy applications of K may have an adverse effect upon the Mg nutritional of cotton.

Cotton plant heights

During the 2008/2009 season, intercropping cotton with mucuna at low and high densities did not affect cotton plant heights at NaSARRI (Table 5). Mucuna brought in from outside and applied to cotton significantly increased cotton heights similar to effects of the recommended fertilizer rate. Height is a measure of cotton vigour and in most cases positively affects the number of cotton bolls and yield. Vigour is associated with high soil fertility. Use of mucuna could have improved soil fertility, vigour and hence cotton heights.

Seed cotton yields

Cotton yields at NaSARRI and Gulu are presented in Tables 5 and 6 respectively. At NaSARRI, intercropping cotton with mucuna at the two densities lowered cotton yields but the differences were not significant. Mean yields of 2,472.2 kg/ha were obtained from plots onto which mucuna imported from other plots were applied. Compared to yields from under the recommended fertilizer practice (2,527.8 kg/ha) there was no significant difference. These two yields were significantly higher than those obtained from the control plots. Mucuna compared well with the recommended fertilizer practice implying that the former can sufficiently replace the latter as may be required in an Organic Farming System. Similar observations have been made on other crops where mucuna was used. Ile *et al*, 1996 reported increases in leaf area, height, biomass, and yield of maize when sown after a mucuna crop and under a natural grass fallow with or without urea in the order: grass fallow with urea > mucuna fallow > fallow without urea. Grains constituted 27%, 20% and 15% of maize biomass on fallow with urea, mucuna, and fallow without urea plots, respectively. They concluded that sowing *Mucuna pruriens* var. *utilis* as a relay cover crop may reduce the need to apply synthetic N-fertilizer. The non significant difference between the control cotton plots and those intercropped with mucuna at the two densities in our study suggest a strong need for further investigations on how best to apply this plant to crops that may benefit from it in Uganda.

Results from Gulu showed a significant increase in seed cotton yields when grown after mucuna compared to the non-mucuna control plots. This was true only for the first cotton season. Increase in K from the mucuna plots (Table 4) was directly related to increased cotton yields from Gulu in 2010/2011 (Table 6). From planting to knockdown there was a 34 % increase in K level and this translated to a 59 % increase in seed cotton yields at the end of the season. K is a very important nutrient for cotton production because it directly affects yields and fiber quality (Bauer et al., 1998).

Conclusions

All the required data was not collected but what is available demonstrate that:

1. Mucuna is a potentially cheap and sustainable method of providing nutrients (especially K) to cotton and increasing seed cotton yields in areas where fertility is a limitation.

2. Intercropping mucuna with cotton is not feasible and should be discouraged until better management methods are developed. This calls for more investigations.

3. Mucuna needs to be established early and given sufficient time to form biomass before it may be knocked down and a subsequent crop planted.

Acknowledgements

Funds for this work came mainly from *Textile Exchange* through NOGAMU and from NARO under the ATAAS Project. Special thanks to all these organizations.

We thank all the staff of LOFM in Lira and CCI in Gulu. They were involved in the day-today collection of the data during the relevant seasons of the studies in their districts.

Special appreciations also go to all the farmers from Lira and Gulu districts for allowing use of their fields for this work and for managing the crops from planting to harvesting.

REFERENCES

1. Adedira J.A., M.O. Akande and F.L. Oluwatoyimba (2004). **Effect of Mucuna intercropped with maize on soil fertility and yield of maize.** Ghana Journal of Agricultural Science. Vol.37 2004. 15-22.
2. Baffes, J. 2009. **The cotton subsector of Uganda**. African Regional Working Papers Series No. 123. http://www.worldbank.org/afr/wps/WPS_123_Uganda_Cotton_Case_Study.pdf.
3. Bauer, P.J., O.L. May, and J.J. Camberato. 1998. Planting date and potassium fertility effects on cotton yield and fiber properties. J. Prod. Agric. 11:415–420.
4. Ile, E.; M.K. Hamadina, K. Zufa and J. Henrot . 1996. **Note on effects of a *Mucuna pruriens* var. *utilis* crop on the growth of maize (*Zea mays*) on an acid ultisol in southeastern Nigeria.** Field Crops Research Volume 48, Issues 2–3, October 1996, Pages 135–140
5. International Development Association (IDA), 2007. **Increased cotton production for Uganda.** http://go.worldbank.org/EZDHPI8D30
6. Kaizzi, C.K.; H. Ssali, A. Nansamba and L.G. Vlek Paul. **The potential benefit of velvet bean (*Mucuna pruriens*) and N-fertilisers in maize production on contrasting soils in Uganda** www.ilri.cgiar.org/InfoServ/Webpub/fulldocs/WP50/ch30.htm
7. Okalebo,J.R., K.W. Gathua and P.L. Woomer 2002. Laboratory methods of soil and plant analysis: A working Manual. TSBF-CIAT and SACRED Africa, Nairobi, Kenya.
8. L. Page and F. T. Bingham (1965). **Magnesium in cotton**. CALIFORNIA AGRICULTURE, November 1965.
9. Woelcke, J.; T. Berger and S. Park**. Land improvement and technology diffusion in Uganda: A bio-economic multi-agent approach** www.ilri.cgiar.org/InfoServ/Webpub/fulldocs/WP50/ch29.htm

Table 1: Treatments during testing of mucuna on cotton at NaSARRI, 2008/2009 season

Treatment	**Planting time**	**Cotton spacing**	***Mucuna* spacing**	***Mucuna*/fertilizer management**
Pure cotton control with no soil fertility intervention	August	90x30	---	---
Cotton intercropped with *Mucuna* at low density	July for *Mucuna* and August for cotton	90x30	90x80	*Mucuna* cut, chopped and applied as mulch to cotton in August and September
Cotton intercropped with *Mucuna* at high density		90x30	90x40	
Pure cotton with external *Mucuna* applied	August	90x30	---	Regularly mulched with chopped *Mucuna* from an outside plot
Pure cotton with recommended fertilizer rate	August	90x30	---	250 kg/ha of NPK applied at planting and top dressed with 100 kg/ha of urea at flowering

Table 2: Treatments during testing of *Mucuna* on cotton in Lira and Gulu districts

Treatments at Lira	**Planting time**	**Cotton spacing**	***Mucuna* spacing**	***Mucuna* management**
Pure cotton control with no soil fertility intervention	July	90x30	---	---
Cotton intercropped with *Mucuna* planted at low density	June for *Mucuna* and July for cotton	90x30	90x80	Cut and mulched to cotton in August and September
Cotton intercropped with *Mucuna* planted at high density		90x30	90x40	
Treatments at Gulu				
Pure cotton control with no soil fertility intervention	July	90x30	---	
Pure cotton planted to plots where *Mucuna* was grown, cut and incorporated to the soil	May for *Mucuna* and July for cotton	90x30	30x30	Cut once and incorporate to the soil in the plot after full biomass formation then plant cotton

Table 3: Locations of on-farm Mucuna trials in Lira and Gulu districts

District	**Sub-county**	**Season of trials**
Lira	Aromo	2008/2009
Lira	Aromo	2008/2009
Lira	Apala	2008/2009
Lira	Ogur	2008/2009
Gulu	Koro	2010/2011
Gulu	Lakwana	2010/2011, 2011/2012
Gulu	Paicho	2010/2011, 2011/2012
Gulu	Lalogi	2010/2011, 2011/2012
Gulu	Angako	2011/2012
Gulu	Awach	2011/2012

Table 4: Changes in potassium and Magnesium levels after 1-2 months under *Mucuna* and before planting cotton in Gulu, 2010/2011

Soil sampling time	Potassium (Cmol/kg)	Magnesium (Cmol/kg)
At start (Baseline)	0.286 b	0.0689 a
At knockdown	0.384 a	0.0467 b
Mean	**0.335**	**0.0578**
Lsd	*0.063*	*0.02112*
CV (%)	*19.3*	*37.7*

Table 5: *Mucuna* effects on cotton plant height at harvest and on seed cotton yields at NaSARRI, 2008/2009 season

Treatment	Height (cm)	Yields (kg/ha)
Pure cotton control with no intervention	72.8 b	1988.9 b
Cotton intercropped with *Mucuna* planted at low density	69.9 b	1,733.3 b
Cotton intercropped with *Mucuna* planted at high density	67.0 b	1,488.9 b
Pure cotton with external *Mucuna* applied	93.0 a	2,472.2 a
Pure cotton with recommended fertilizer rate applied*	91.4 a	2,527.8 a
Mean	**80.7**	**2,176.8**
Lsd	*14.6*	*351.8*
Cv (%)	*17.1*	*15.9*
Means with the same letters are not significantly different (P=0.05)		

**Recommended fertilizer rate (250 kg/ha of NPK applied at planting and top dressed with 100 kg/ha of urea at flowering)*

Table 6: *Mucuna* effects on seed cotton yields (kg/ha) in Gulu district in 2010/2011 and 2011/2012 cotton seasons

Treatment	2010/2011	2011/2012	Mean
Post-*Mucuna* plots	1195.0 a	535.9 ns	828.9 a
Control plots	750.1 b	409.4 ns	560.8 b
Means	***975.6***	***472.7***	***694.9***
Lsd	***205.8***		***168.1***
CV (%)	***22.7***		
Means with the same letters are not significantly different (P=0.05)			