POLICIES FOR IMPROVED LAND MANAGEMENT IN UGANDA

ZEF Bonn

Title: Strategies, Cost and Benefit of Soil Fertility replenishment in Soils with different productivity potential in Uganda.

Sub-title: The potential of Velvet bean (*Mucuna pruriens*) and Azolla as compared to inorganic fertilizers in improving Maize and Rice productivity respectively and N balance under soils of contrasting production potential

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INTRODUCTION

Soil fertility as a constraint to agricultural Production in Uganda

Per capita agricultural production and crop yields per unit area of production in Uganda like in other Sub Saharan African (SSA) countries is declining (IBSRAM 1994; Sanchez et al., 1996; NEMA, 1996; FAO, 1999). The main contributing biophysical factors are nutrient/ soil fertility depletion (Vlek, 1993; Sanchez et al., 1997), low soil fertility particularly N and P deficiencies (Nye and Greenland, 1960; Bekunda et al., 1997; Ssali et al., 1986; Woomer and Muchena, 1996). Studies conducted by the department of agriculture in Uganda indicated N to be the most deficient nutrient followed by P and S (Stephen, 1970).

The extensive soil surveys of the late 1950's that covered the whole country revealed that only about a tenth of the total land area had soils with a productivity rating above medium, more than a quarter had soils rated as unproductive, hence leaving about one half of the land surface with soils rated as being of medium productivity (Harrop, 1970). A medium productivity rating implies that the soils will only yield good crops under good management (Chenery, 1960; Harrop, 1970; and Stephens, 1970). Foster 1981, reported that the soil fertility was associated with organic matter content.

In addition to the above, other factors includes; cultivation of marginal land, continuous cropping, poor soil and crop management practices and unfavourable government policies towards the smallholder farmers. The traditional systems of restoring and maintaining soil fertility are no longer able to cope with the rate of soil fertility decline. Smallholder farmers use low-input production technologies, without appropriate soil and water management practices, which together with the export of produce to urban areas have contributed to increased export of nutrients from the fields. Furthermore smallholder farmers lack financial resources to purchase sufficient fertilizers to correct the inherent low fertility levels and replace the nutrients exported with harvested produce; even socioeconomic factors do not favour fertilizer use by the smallholder farmers. Yet restoring soil N and P are major priorities not only for sustained productivity but also in the rehabilitation of eroded and damaged soils. There is little option but to use fertilisers to balance the loss of P and K. However N, can be supplied through inorganic fertilisers and Biological Nitrogen Fixation (BNF).

The problem of declining soil fertility can be addressed through an integrated nutrient management (INM) approach, which involves efficient use of available resources, and requires combining the sensible approach to nutrient recycling, soil conservation to retain the resources within the cropping system, together with the judicious and efficient use of fertilisers.

To modernise agriculture and attain the national goal of poverty eradication and food security soil fertility and soil/land management will have to substantially improve.

Strategies

The strategy to improve soil fertility and thus enhance land productivity will involve the use of both organic manure (e.g. green manure/cover crops, improved fallow) and inorganic fertilizers, improved crop husbandry practices and exploitation of biological nitrogen fixation. Farmers have to ensure that; the fertility in the top soil is not lost through erosion (using better soil and water management methods); nutrients leached are recycled (through fallows and crop rotations); nutrients removed are replaced (through use of organic and inorganic inputs) and, soil physical properties are well maintained (through use of appropriate soil and water conservation practices and rotations).

The objectives of the study are;

1. To determine mucuna biomass production and N accumulation (sole crop & when intercroped with maize) in soils of contrasting production potential
2. To assess N distribution in different soil organic matter fractions following the application of *Mucuna pruriens* residues
3. To evaluate maize growth, yield and N uptake in response to the application of *Mucuna pruriens* residues under soils of contrasting production potential
4. To evaluate rice growth, yield and N uptake in response to the application *Azolla* and *Mucuna pruriens* under soils of contrasting production potential
5. To determine the utilisation efficiency of N derived from *Mucuna pruriens* as compared to inorganic fertilizers
6. To calculate the system N balance following the application of *Mucuna pruriens* and *Azolla*
7. Determine the cost/benefit of using *Mucuna pruriens* and *Azolla* residues in soil fertility management under soils of contrasting production potential as compared to inorganic fertilizers
8. To determine biological nitrogen fixation by mucuna on soils of contrasting production potential

METHODOLOGY

Research sites

The research is being conducted at eight sites in six districts namely; Nemba & Kasheshe (Sironko district), Lubembe (Tororo district), Nakisenye (Pallisa district), Agonyo II (Soroti district), Odwarat (Kumi district) and Kongta (Kapchorwa district). The sites are located on different soil mapping units, parent materials and with soils of varying productivity rating as indicated in Table 1. below. The sites are located at an altitude of Agonyo II (1060m asl), Odwarat (1070 m asl), Lubembe (1083 m asl), Nemba (1120 m asl), Kibale (1132 m asl), Nakisenye (1138 m asl), Bulegeni ARDC (1430 m asl), Kasheshe (1432 m asl) and Kongta (1890 m asl).

Table 1. Research site characteristics

Research site	Mapping Unit*	FAO-UNESCO analogies*	Parent Rock or Parent material*	Productivity rating*
Odwarat	Amuria Catena	Plinthic Ferralsols with Xanthic Ferralsols	Lake deposits from B.C granite, gneisses etc	Low
Bulegeni ARDC, Kasheshe & Nemba	Sipi Catena	Andosols	Volcanic Ash & Rocks	High to medium
Nakisenye & Lubembe/Doho	Mazimasa complex	Plinthic Ferralsols with Xanthic Ferralsols	Lake deposits from B.C granite, gneisses etc	Low
Kongta	Benet Series	Humic Andosols & Umbric Andosols	Elgon Volcanics	Medium
Agonyo II & Kibale	Buluri Catena	Ferralsols	B.C gneisses and granite	Low to medium

*Adopted from Chenery (1960), Harrop (1970), Aniku (1999) and Ssali (2000)

Trials

Two types of trials were set up;

i. Farmer managed trials/on-farm trials were set up with twenty randomly selected farmers at each of the following sites; Agonyo II, Odwarat, Nemba & Kasheshe, Lubembe/Doho, Kongta and Nakisenye. The treatments during the 2000b and 2001a season are indicated in Tables 2 and 3 for the maize and rice systems respectively.
ii. Researcher managed trials were set up at two government farms namely, Bulegeni Agricultural Research Development Centre (ARDC) and Kibale Technology Verification Centre (TVC). The trials are managed by the researcher. The treatments during the 2000b and 2001a season are indicated in Tables 2.

Table. 2. Treatments for the maize system during 2000b and 2001a season

On-farm trials		Reseacher managed trials	
Season		Season	
2000b	2000a	2000b	2000a
Maize (control)	Maize (control)	Maize (control)	Maize (control)
Maize	Maize + N1 + P	Maize	Maize + $^{n}P_0N_1$
Maize	Maize + N1 + P	Maize	Maize + $^{n}P_0N_2$
Maize + Mucuna (relay) + P	Maize + P + Mucuna R	Maize	Maize + $^{n}P_1N_0$
Maize + Mucuna (relay)	Maize + Mucuna R	Maize	Maize + $^{n}P_1N_1$
Mucuna fallow	Maize + Mucuna R	Maize	Maize + $^{n}P_1N_2$
Weedy fallow	Maize	Maize + Mucuna (relay) + P	Maize + mucuna residues*
		Maize + Mucuna (relay)	Maize + mucuna residues*
		Mucuna fallow	Maize + mucuna residues*
		Weedy fallow	Maize

Where:

Mucuna R = mucuna residues

P, P_1 equivalent to 25 and 40 kg P/ha respectively

N_1, N_2 equivalent to 40 and 80 kg N/ha respectively

^{*15}N labelled mucuna applied in 3m x 2.4 m microplots

^{*n} labelled fertilizer applied in 3m x 2.4 m microplots

The maize variety used in the trial was Longe 1 and *mucuna* was relay planted one month after the maize crop. The number of replicates at the researcher managed trial were four and the main plot size was 6m x 4.5m.

Table 3. Treatments for the maize system during 2000b and 2001a season

On-farm trials		Reseacher managed trials	
Nakisenye		Lubembe/Doho Rice Scheme	
Season		Season	
2000b	2000a	2000b	2000a
Maize (control)	Rice (control)	Rice (control)	Rice (control)
Maize	Rice + P	Rice + P + K + N	Rice + P + K + N
Maize + Mucuna (relay)	Rice + Mucuna R	Rice + Azolla	Rice + Azolla
Maize + Mucuna (relay) + P	Rice + Mucuna R	Rice + Azolla + P + K + N	Rice + Azolla + P + K + N
Mucuna fallow	Rice + Mucuna R	Rice + N	Rice + N
Weedy fallow	Rice	Rice	Rice

P_1, K, N_1correspond to 25 kg P/ha, 25 kg K/ha and N_1 60 kg N/ha respectively.

Biological Nitrogen Fixation (BNF) by mucuna

The trial to evaluate BNF using 15N dilution method were set up at the two researcher managed sites. The plot size used were 5m x 4.5m and 3m x 2.4m for the main plot and microplots respectively. Three plants (weeds, lofa and maize) were used as reference crops. ^{15}N labelled ammonium sulphate was used as a source of labelled N. Mucuna received 20 Kg N/ha at 5% ^{15} N a.e while the reference plants received 100 Kg N/ha at 1% ^{15} N a.e. The labelled fertilizer stock had ^{15}N abundance of 10.19%. The labelled fertilizers was applied in solution form in four equal splits at two weekly intervals.

PRELIMINARY RESULTS

Site characterisation

All sites/farmer fields were characterised by analysing soil samples collected from 0-20 cm depth, for pH, organic matter, extractable P, K, Ca and texture using routine method at KARI Soils and Plant tissue analytical laboratory (Foster, 1971). Results (data not indicated) from the routine analysis of the soil, indicated that, a considerable percentage of farmers had fields with analytical values below the critical low level and response to soil amendments is expected so it was decided that the plots be split into two with one half receiving K and P in addition to N and the other half N.

Maize (grain & stover) and Mucuna biomass production

Maize (grain and stover) yield obtained for the different treatments is indicated in Tables 3, 4 and 5 for Bulegeni ARDC and Kibale TVC and in Tables 6, 7 & 8 for the farmer managed trials. It is observed that maize yield was significantly affected (decreased) by intercropping with mucuna at Bulegeni ARDC but not at Kibale. Significant difference (p=5%) were observed when the sites two site mean are compared, the same applies for the on-farm sites at 5% level. This is attributed to the differences in soil productivity as determined by different soil physicochemical characteristics.

The amount of mucuna biomass (dry matter) produced after 22 is indicated in Tables 3, 4 & 5 (for Bulegeni ARDC and Kibale TVC) and Tables 6, 7 & 8 for the farmer managed sites/on-farm trials. It is observed from the Tables 3 – 7 that, significant differences (p = 5%) in mucuna biomass production at the different sites were obtained.

Table 3. Maize & Mucuna yield (kg/ha) at Bulegeni ARDC and Kibale TVC for 2000b season

Treatment	Site					
	Bulegeni ARDC			Kibale		
	Grain	Stover	Mucuna	Grain	Stover	Mucuna
Mucuna fallow			11810			9031
Maize sole crop	2946	3758		848	1357	
Maize + P+ mucuna	1424	1587	12351	1170	2173	7513
Maize + mucuna	1340	1427	10565	723	1056	7894
$LSD_{5\%}$	1488	1311	ns	ns	ns	ns

Table 4. Maize & Mucuna yield (kg/ha) mean for Bulegeni ARDC and Kibale TVC for 2000b season

Site	Grain	Stover	Mucuna
Bulegeni ARDC	1803	1924	11576
Kibale	882	1560	8146
t –test	Significant at 5%	ns	Significant at 1%

Table 5. Maize yield (kg/ha) treatment mean across the two sites (Bulegeni ARDC & Kibale TVC) for 2000b season

Site	Grain	Stover	Mucuna
Mucuna fallow			10421
Maize	1969	2335	
Maize + P + Mucuna	1172	1755	9933
Maize + Mucuna	887	1136	9229
LSD	ns	ns	ns

Table 6. Means for maize & Mucuna yield (combined for the all farmer managed sites) during the 2000b season

Treatment	Grain	Stover	Mucuna
		Kg/ha	
Mucuna fallow			5728
Maize sole crop	2512	2513	
Maize + P+ mucuna	2478	2456	6549
Maize + mucuna	2261	2284	5728
LSD	ns	ns	ns

Table 7. Means for maize & Mucuna yield combined for the different treatments for farmer managed sites during the 2000b season

Site	Grain	Stover	Mucuna
		Kg/ha	
Agonyo II	2715	3299	6628
Odwarat	1471	2495	7837
Nemba	2334	5002	6481
Kasheshe	2655	5564	6091
Nakisenye	3228	4934	6628
$LSD_{5\%}$	1410	2700	3181

Table 8. Maize yield (kg/ha)at Agonyo II, Odwarat, Nakisenye, Nemba and Kasheshe for the 2000b season

Treatment	Site									
	Agonyo II		Odwarat		Nakisenye		Nemba		Kasheshe	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Maize only	2853	3634	1654	2739	3099	4497	2642	5887	2858	5766
Maize + P+ mucuna	2903	3327	1423	2431	3386	5245	1816	3975	2691	6010
Maize + mucuna	2168	2410	1257	2244	3190	5111	2857	6194	2381	4915
$LSD_{5\%}$	376	539	269	ns	ns	ns	ns	ns	ns	ns

Table 9. Mucuna biomass yield at Agonyo II, Odwarat, Nakisenye, Nemba and Kasheshe for 2000b season

Treatment	Site					
	Agonyo II	Odwarat	Nakisenye	Nemba	Kasheshe	Kongta
Mucuna	6867	7727	7642	6678	5627	2599
Maize + P+ mucuna	6621	8153	5758	6379	6089	2761
Maize + mucuna	6409	7341	6311	6388	6555	2434
LSD	ns	ns	ns	ns	ns	ns

Biological nitrogen fixation (BNF) by Mucuna

The quantity of atmospheric nitrogen fixed by mucuna at the two researcher managed sites determined by using the ^{15}N Isotope dilution techniques was found to be 42.5% and 41% of the total N in mucuna at Bulegeni ARDC and Kibale respectively. Basing on soil mapping units & characteristics, rainfall and altitude, the results for Bulegeni ARDC can be taken to represent Nemba, Kasheshe and Kongta research sites, while those for Kibale represents Agonyo II, Odwarat and Nakisenye. Considering average mucuna yield at the different sites and the average N content of 2.5%, the estimated amount of nitrogen added to the system is indicated in Table 10 below

Table 10 Atmospheric nitrogen added by mucuna to the system

Research site	Mucuna yield (kg/ha)	Total N yield (kg/ha)	N derived from atmosphere (kg/ha)
Agonyo II	6867	172	70.5
Odwarat	7727	193	79.1
Nakisenye	7642	192	78.7
Nemba	6678	167	71.0
Kasheshe	5627	141	59.9
Kongta	2599	65	27.6
Bulegeni ARDC	11810	295	125
Kibale	9031	226	96.1

Considering the low input agriculture for the majority of the smallholder farmers, mucuna contribute a significant amount of N from the atmospheric N, which will definately reduce on the negative N balance for the agroecosystems.

Rice (grain & straw) yield

The effect of Azolla, inorganic fertilizers and their combination on the rice yield (grain & straw) at Lubembe/Doho Rice Scheme is indicated in Table 11. The grain yield is 60% of the paddy rice. It is observed from Tables 11 that, there was a significant increase in rice yield due to use of Azolla and inorganic fertilizers.

Table 11. Rice yield (kg/ha) at Lubembe/Doho Rice Scheme during the 2000b season

Treatment	Grain	Straw
Control	2209	6671
Rice + P + N + K	3356	10249
Rice + Azolla	2725	7950
Rice + P + N + K + Azolla	3042	9511
Rice + N	2939	8707
$LSD_{5\%}$	490	1741

Data for farmers (n=11)where Azolla was specifically introduced purposely for the investigation, i.e Azolla was in the targeted plots only.

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