Research Application Summary

Legume biomass transfer for enhancing productivity of maize in *Striga* infested farmlands: The case of Iringa district, Tanzania

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Abstract

The projects' major aim was to increase maize productivity in Striga infested soils in Iringa district in Southern Tanzania. Two villages (Mangalali and Kiwere) in which maize is a major crop and in which *Striga asiatica* is a major problem were selected as case studies. The conceptual framework was based on the use of nitrogen-fixing legumes (three species each of edible and non-edible types) as the main intervention for the improvement of soil fertility levels, planted in a short duration rotation with maize. The effect of the legumes was compared to nitrogen applied using urea fertilizer. Legume species were chosen over other options as a natural resource for soil fertility improvement. Farmers were the key actors at all stages of the studies under the guidance of local extension workers. The legume or maize biomass produced in each individual plot in the first season was incorporated into the soil prior to planting maize variety Situka on all the plots in the second season (2011/12). Two graduate students were supported under the project to pursue studies leading to the award of MSc. Both students were registered at Sokoine University of Agriculture in Morogoro, Tanzania and were the key implementers of project activities. The titles for the MSc dissertations of the students are: (i) The influence of legume biomass on soil fertility status and maize performance in Striga infested soils of Iringa (by Ms Rebeca Hepelwa), and (ii) On-farm evaluation of legumes'biomass and IR-maize for the management of Striga in Iringa district, Tanzania (by Mr. Mabula David).

Key words: Legume, maize, *Striga*, Tanzania

Résumé

L'objectif principal du projet était d'augmenter la productivité du maïs dans des sols infestés de *Striga* dans le district d'Iringa au sud de la Tanzanie. Deux villages (Mangalali et Kiwere) dans lesquels le maïs est une culture importante et où*Striga* *asiatica* est un problème majeur, ont été choisis comme études de cas. Le cadre conceptuel étaitbasé sur l'utilisation des légumineuses fixatrices d'azote (trois espèces chacune des types comestibles et non comestibles) comme l'intervention principale pour l'amélioration des niveaux de fertilité des sols, plantées dans une courte rotation de temps avec du maïs. L'effet des légumineuses a été comparé à l'azote appliqué à l'aide d'engrais d'urée. Les espèces de légumineuses ont été choisies en dehors d'autres options comme une ressource naturelle pour améliorer la fertilité des sols. Les agriculteurs sont les principaux acteurs à toutes les étapes des études sous la direction d'agents de vulgarisation locaux. La biomasse des légumineuses ou du maïs produite dans chaque parcelle individuelle pendant la première saison a été incorporée dans le sol avant la plantation de la variété de maïs *Situka* sur toutes les parcelles pendant la deuxième saison (2011/12). Deux étudiants de troisième cycle ont été soutenus dans le cadre du projet afin de poursuivre des études conduisant à l'obtention du diplôme de maitrise. Les deux étudiants étaient inscrits à l'Université Sokoine organisant une faculté d'agronomie à Morogoro, en Tanzanie et ont été les exécutants clés des activités du projet. Les titres de leurs mémoires de maitrise sont les suivants: (i) L'influence de la biomasse des légumineuses sur l'état defertilité des sols et le rendement du maïs dans des sols infestés de *Striga* d'Iringa (par Mlle RebecaHepelwa), et (ii) Evaluation au niveau de l'exploitation de la biomasse des légumineuses et IR-maïs pour la gestion de *Striga* dans le district d'Iringa, en Tanzanie (par Mr. Mabula David).

Mots clés: légumineuses, maïs, *Striga*, Tanzanie

Background

The parasitic weeds *Striga* spp. occur in 8 out of 21 regions of Tanzania causing 40-90% yield losses in maize and other susceptible cereals (Mbwaga *et al*., 2000). Soils from selected villages in Iringa district were described by Msaky *et.al*. (2007) to be of low fertility characterized by very low organic carbon (0.01-0.07%) and very low nitrogen (0.028-0.86%). Nitrogenous fertilizers are known to reduce the severity of *Striga* infestation and improve maize yields even under severe infestation (Mbwaga *et al*., 2000) but most farmers cannot afford cope with the high fertilizer costs. This study aimed at developing a sustainable system for improving soil fertility to reduce *Striga* occurrence and severity. The main objective is to increase maize productivity in *Striga*-infested areas of Iringa district, while the specific objectives are to:

i. Assess the effect of selected leguminous plants on *Striga asiatica* severity and yield of maize;
ii. Determine the influence of legumes on field occurrence of *Striga asiatica* and soil seed bank dynamics;
iii. Quantify the relative contribution of selected edible and non-edible legumes to the improvement of soil fertility and soil physical condition, and
iv. Disseminate recommendations on incorporation of legumes in the maize-based cropping systems of Iringa.

Research Approach and Study Description

Edible legumes species: green gram (*Vigna aurietum*), cowpea *(Vigna unguiculata)*) and chick pea (*Cicer arietinum*) and non-edible legumes: Velvet bean (*Mucuna* spp.*)*, sunhemp (*Crotalaria ochroleuca*) and *Canavalia* spp, were used in the study as sources of nitrogen. A registered maize variety Staha, which is susceptible to *Striga*, was the main test genotype and an Imazapyr-Resistant-maize (IR-maize traded as StrigAway®), a herbicide-resistant maize variety coated with low doses of the herbicide Imazapyr which can kill *Striga* before it damages the crop, was included as control in the study.

The study design adopted a mother-baby approach. In the first season (2010/11), the complete set of 8 treatments (six legumes and two maize genotypes) were planted on general land (mother trial) on 9x5 metre plots in a randomized complete block design. A subset of the 8 treatments (baby trials) comprising of three legume species (one of which was non-edible) and the two maize genotypes, were planted on 5 farmers' fields in each village. In both the mother and baby trials, the legume and cereal biomass produced were incorporated into the soil after harvest and all plots were planted with maize variety Situka during 2011/12 season. Data collected from the mother trial was used for statistical analysis and that from the baby trials was used for comparison of general performance. The field experiments were complemented with laboratory studies conducted at Sokoine University of Agriculture. The studies included estimation of *Striga* seed counts in soil samples collected from the field experimental plots and estimation of the trend of nitrogen release by the legumes using incubation experiments.

Results

Biomass production was significantly different ($p < 0.05$) between species (Table 1) whereby sunhemp (34.1 t/ha), velvet bean (29.8 t/ha) and cowpea (29.7 t/ha) were comparable and most productive. The C:N ratio for velvet bean (12), sun hemp

Table 1. Legume biomass production and N release from various legumes over time.

Type of legume	Mean legume biomass production (t/ha)	Incubation time (weeks)			
		0	4	8	12
		Amount of N released (mg g^{-1})			
Control (maize)	-	12.78a	40.2a	38.5	25.6
Cowpea	29.7	35.57b	81.3ab	101.1a	107.4ab
Green gram	16.1	27.03ab	90.0b	111.7ab	137.3b
Velvet bean	29.8	28.25b	115.6bc	137.5abc	103.7a
Canavalia	2.9	24.79ab	87.7b	128.3abc	121.9ab
Sunhemp	34.1	37.84b	160.8d	155.5c	103.2a
Chickpea	10.0	29.68b	141.4cd	151.7bc	126.0ab
LSD	16.6	14.32	43.22	38.34	28.84
CV (%)	-	28.7	23.7	18.3	15.6
Grand mean	-	28.0	102.4	117.8	103.6

The means in the same column followed by the similar letter(s) are not statistically different at 5% level of significance.

(12.1) and chick pea (18.5) were relatively low implying that these legumes can decompose relatively fast resulting in high N mineralization compared to canavalia (21), cowpea (22.8) and green gram (24.6) which imply slow decomposition and low N mineralization.

For all legumes most of the N was released between 4 and 8 weeks (Table 1). Generally, sun hemp released N the fastest and recorded the highest amount by the fourth week (160.8 mg N kg^{-1}). By the 8th week, when most of the legumes released the highest quantities of N, sunhemp continued to release significantly highest quantities (155.5 mg N kg^{-1}) which was not significantly different from that of velvet bean (137.5 mg N kg^{-1}), canavalia (128.3 mg N kg^{-1}) and chick pea (151.7 mg N kg^{-1}). Despite the general decline in N release by the 12th week of incubation, some legumes released N quantities which were either relatively higher (eg. cowpea and green gram) or slightly lower (eg. velvet bean and sunhemp) than the levels recorded by the 4th week. The relative efficiency of the different legumes in N release was further reflected in the relatively large increases in soil N following cowpea, sunhemp and velvet bean in both study sites (Table 2). Both canavalia and chick pea released N at levels comparable to the other legumes. However, the establishment of the two legumes was poor. This resulted in low biomass production and the two legumes were generally considered unsuitable, for the purpose, in the study areas.

Table 2. Soil Nitrogen and Carbon before and after legume biomass incorporation.

Treatment in 2010/11	% Nitrogen				% Organic carbon			
	Mangalali		Kiwere		Mangalali		Kiwere	
	Before	After	Before	After	Before	After	Before	After
Control	0.14	0.11b	0.021	0.05ab	0.74	0.74a	0.31	0.59a
Cowpea	0.12	0.23de	0.023	0.15d	0.68	1.09b	0.19	0.73a
Green gram	0.12	0.17ab	0.026	0.07abc	0.87	1.09b	0.19	0.61a
Mucuna	0.14	0.24e	0.023	0.18d	0.71	1.16b	0.29	0.79a
Canavalia	0.10	0.20cd	0.021	0.09c	0.74	1.08b	0.28	0.63a
Sun hemp	0.14	0.23de	0.026	0.17d	0.77	1.06b	0.22	0.79a
Chickpea	0.15	0.16b	0.021	0.08bc	0.81	1b	0.27	0.58a
Urea	0.16	0.12a	0.023	0.08bc	0.84	0.7a	0.26	0.52a
Grand mean	0.13	0.18	0.023	0.10	0.771	0.99	0.25	0.66
CV (%)	16.2	10.1	26.9	21.3	18.1	9.5	31.3	23.4
P (0.05)	ns	***	ns	***	ns	***	ns	ns
LSD	0.04	0.02	0.01	0.04	0.24	0.30	0.14	0.27

N.B; * - Significant (p=0.05), **Significant (p=0.05), *** Very highly significant (p=0.05).
Means in the same column followed by the similar letter(s) are not statistically different at 5% level of significance following Duncan's Multiple Range Test.

Following incorporation of the legume and maize residues into the soil, reduction in *Striga* seed count were also recorded. Significant reductions occured where sunhemp was incorporated (35%), followed by IR-maize (28%), cowpea (20%) and velvet bean (18%). Much smaller leves were recorded for canavalia, chick pea and green grams.

Farmers ranking of the 2011/12 maize crop at physiological maturity stage indicated preference for cowpea (34.7%), Situka + urea (32.4%) and sunhemp (18.8%) as the first three based on physical apperance of the crop. After harvest, across the two experimental sites, average maize yields were significantly ($P \leq 0.05$) highest but comparable for cowpea (3.7 t/ha), sunhemp (3.6 t/ha), urea fertlizer (3.5 t/ha) and velvet bean (3.4 t/ha) in both villages (Fig. 1).

Research Application

- Among the legume used, all except canavalia and chick pea produced large quantities of biomass (10 tons or above) with sunhemp $\geq$ velvet bean $\geq$c owpea $\geq$ greengram;

- Incorporation of any of the legume species increased soil nitrogen levels, reduced *Striga* seed bank in the soil and severity of the Striga plants that occured. However, cowpea,

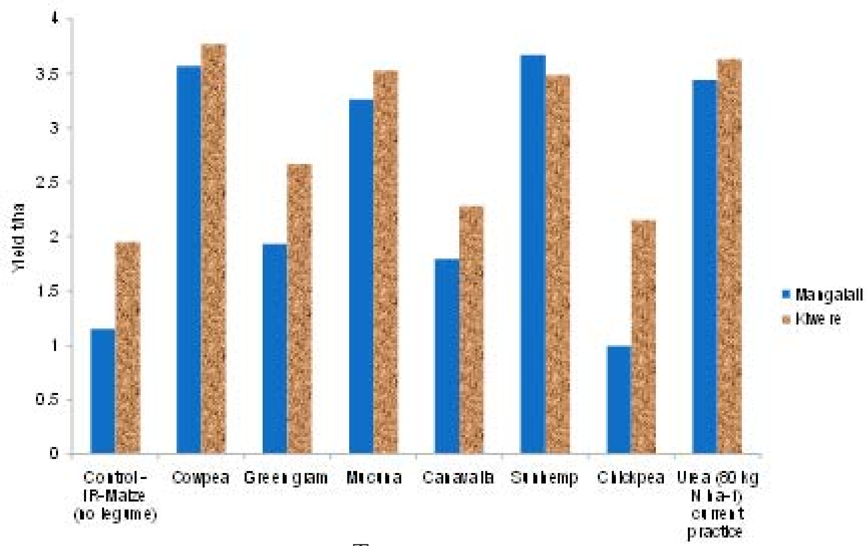

Figure 1. Maize (Var. Situka) yields following ± legumes for 2011/12 season for Mangalali and Kiwere villages).

velvet bean, sunhemp and green gram were more adapted to the growing conditions in the study sites compared to canavalia and chick pea;

- Nitrogen mineralization was faster in velvet bean and sunhemp being highest 4-8 weeks after incorporation as compared to 8-12 weeks for cowpea and green gram;

- The mineralization rates imply that some of the N released following legume biomass at the end of the season could be lost before the next crop of maize is planted. However, the increase in N levels in soils sampled 16 weeks after legume incorporation at the end of growing season, when it was dry, helped retain the nitrogen for use by the next maize crop;

- In areas with long rain seasons, the legumes can be planted very early in the season, incorporated into the soil and maize planted in the same season 4-8 weeks after incorporation of the legumes. Alternatively, two legume crop cycles can be realized in one season thereby increasing the N levels while improving the general soil condition;

- On the basis of maize yields recorded, legume residues of cowpea, velvet bean and sunhemp are viable alternatives to inorganic N fertilizers for poor resource farmers producing maize in *Striga* infested area. However, cowpea has the added advantage of producing edible leaves and grains thus contributing to food security and income generation.

- For long term benefits, it is recomended that rotation with suitable legumes, as identified in this study, are incorporated into the cropping systems in areas affected by *Striga*. This concept is the basis of the extension material being prepared.

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