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Integration and dissemination of green manure cover crops in small scale farming systems: Successes and constraints in eastern Uganda

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Abstract

The integration of *Mucuna, Lablab* and *Crotalaria* into the farming systems of eastern Uganda was studied in the year 2000. Quantitative and qualitative survey methods of data collection were used with 52 households including former experimenting farmers, and their neighbours. *Mucuna, Lablab* and *Crotalaria* were consistently used for 7 seasons, with a mean seasonal use of 15, 10 and 7 experimental farmers, respectively. The quick restoration of soil fertility on the farms, presence of support technologies like clean cassava planting materials, and the selling of green manure seed enhanced crops use. The use of *Crotalaria* however, dropped from 34% in the first season to 10% in the last season. Constraints to the integration included drought, labour bottlenecks, and storage difficulties particularly for *Lablab* and *Crotalaria* seed. The crops had been adapted for domestic and farm uses, with the women dominating their dissemination. Aspects of non-adoption and dis-continuance of the crops were traced to poor farmer group management and lack of information. Soil fertility improvement, sale of seed and size of land were among the factors advanced to explain the integration of crops. Participatory extension can reinforce the existing successes, while an in-depth adoption study of the green manure can be part of further research.

Key words: Adaptation, legumes, planting materials, soil fertility management

Introduction

Increasing soil-nutrient depletion, declining soil fertility and crop yields are common features of farming in sub-Saharan Africa (Stoorvogel and Smaling, 1990; Smaling *et al.*, 1997). Integrated nutrient management (INM) strategies have been considered as promising options for soil fertility management, because of their suitability under local biophysical, economic and social conditions (Smaling *et al.*, 1997; Smaling *et al.*, 1996). Integrated nutrient management (INM) technologies bridge the gap between high external input and the extreme forms of traditional low external input agriculture and are therefore recommended for the resource poor farm households who form the majority of farmers in eastern Uganda (Miiro *et al.*, 2001). This region is characterized by a high population density (230 persons/square kilometre), continuous cultivation with minimal nutrient replenishment and reduced fallow periods (Wortmann and Eledu, 1999). There is need therefore to enhance soil fertility management.

Crotalaria *(Crotalaria ochroleuca)*, Mucuna (*Mucuna pruriens*), and Lablab (*Dolichos lablab*) green manures were introduced in Imanyiro subcounty, Iganga district during 1994 to 1996 as alternative soil fertility improvement technologies for improving crop yields and control of weeds in maize-bean cropping systems as observed from earlier studies (Wortman *et al.,* 1998).

Fischler and Wortman (1997) reported that the green manure cover crop technologies were adapted by the farmers in a number of ways including planting *Mucuna* at the same spacing as maize such that after uprooting the cover crop, the maize would be planted in the same holes. *Canavalia* was reportedly experimented as a green manure in maize and beans and as a cover crop in bananas. *Crotalaria* was grown in young cassava, coffee and pineapple and used as mulch. *Crotalaria* seed was mixed with bean seed to control bean bruchids, and its leaves served as a vegetable (Wortmann *et al.*, 1999). To support the participatory research process, some technologies such as improved varieties of cassava, maize and bean seeds were also introduced. Farmers were facilitated and encouraged to form a credit society.

About four years (1996-2000) have passed since the three green manure cover crops *(Crotalaria, Mucuna and Lablab)* were recommended and disseminated to farmers in this area. There is thus a need to establish the consistent use, integration, scaling up and diffusion of the green manure cover crops and constraints associated with these utilisation. An empirical study to assess integration and adaptation of green manure cover crops among participant farmers was instituted to gain insights into the initial overflow effects to neighbours and other farmers. Pertinent research questions included: to what extent had green manure cover crops been integrated and adapted within the farming systems of the farmers who participated in the research? What reasons led to the integration? Was there any on-farm up-scaling and spreading of the technologies to other farmers? What were the benefits and constraints of using the cover crops? What were the reasons for the spread of the green manure crops or other related technologies? How were the neighbours and dropout farmers affected by the technologies? To what extent had dissemination of the technologies taken place. The research was undertaken as part of the CIAT project on improving INM practices on small-scale farms in Africa using Participatory Learning and Action Research (PLAR).

Materials and methods

The study was conducted in five villages from Buyemba and Mayuge parishes in Imanyiro sub-county, Mayuge district, Uganda. The target population included all the farmers who participated in the trials and were still practicing the use of green manure cover crops, farmers who dropped out of the trials, and neighbouring farmers to the former. The sample consisted of purposively selected twenty-one (21) members of the farmer participatory research group who were still practicing and each participant's immediate farming neighbour irrespective of the direction of 22 neighbours, and nine (9) farmers who dropped out from the initial participant group thus a sample size of fifty-two (52) was used. Focus group discussions (FGDs) were held with 2 separate groups of 6 men and 6 women to understand the dynamics and effects (benefits and constraints) of the green manure crops in the farming community. In addition, a formal survey questionnaire was administered with participating and non-participating farmers to capture the extent of integration of the green manures in terms of numbers of users of each of the green manure cover crops since they were introduced in 1994, as well as adaptations/innovations with the technologies. The survey also captured the diffusion or spread of the technologies from the initial participating farmers to neighbouring and other farmers in the community as well as the respondents' socio-economic characteristics. The study covered farmers' experiences between 1994 and 1996.

Survey data was analysed using simple descriptive and comparison statistics assisted in desegregating the different crops, farmer groups, time differences, and other variables likely to affect integration, up-scaling and spreading of the technologies.

Results

Integration of green manure cover crops into farming systems of participant farmers

The integration of green manure cover crops into the farming systems of the participant farmers involved the consistent use of the green manure crops by the farmers who participated in the original experiments established by determining the proportion of the farmers who grew *Mucuna, Lablab*, and

Crotalaria between the long rains season (season A) of 1997 to season A of the year 2000 (Fig. 1). *Mucuna* registered a high level of continued use among the original participating farmers. The initial proportion of users was 76% in season A of 1997 while in season A of 2000 there were 62%. *Mucuna* was followed by *Lablab*, and *Crotalaria*. For each of the 15, 10 and 7 farmers who tested and were still practicing the growing *Mucuna, Lablab*, and *Crotalaria*, respectively the average number of those who continued growing for all the 7 seasons was 12, 8, and, 4 for each respective crop.

Factors that affected the integration of the green manure technologies

All farmers (21) who participated in the original trials and were part of the study indicated that they were continuing with the use of either, one, two or all of the three green manure cover crop species. Qualitative interviews with the participating farmers indicated that the main reason for continuing with the green manure cover crops was their key role in restoring soil fertility.

Other reasons included: (1) The provision of complimentary technologies such as cassava and banana planting materials, bean seed, agro-forestry tree species as incentives to encourage farmers to attend to the experiments, but also as part of a systems approach to solving the other problems farmers had given by the researchers; (2) The integration of the farmers' indigenous technical knowledge (ITK) with in the research protocols; (3) The sale of the green manure seed from the trials was also an incentive for farmers to attend to their experiments especially seed harvesting which was a difficult activity. The seed sales also encouraged intensified growing of the cover crops for quality planting seed; and (4) Use of the cover crops for other purposes: such as foliage from the cover crops as a livestock feed. Table 4 shows the changes in the level of soil fertility of farmers' fields at all topographical levels (along the catena) as perceived by the farmers, after growing two or all of three green manure cover crops.

Constraints of integrating the green manure cover crops into the farming systems

According to the 21 participating farmers, the main constraint of growing green manure cover crops was the prevailing drought conditions. This brought about temporary breaks in growing of the cover crops among the farmers. Secondly, farmers indicated that the limited use of the green manure cover crops to only soil fertility improvement and not as food for humans constrained integration. It was also reported that the opportunity cost of leaving land under fallow with *Crotalaria* was high as the successful harnessing of *Crotalaria* seed required that the legume stays longer in the field. There was difficulty in obtaining clean seed of *Lablab*, because it was easily attacked by pests. Farmers endeavored to control the pests by spraying with an artificial pesticide.

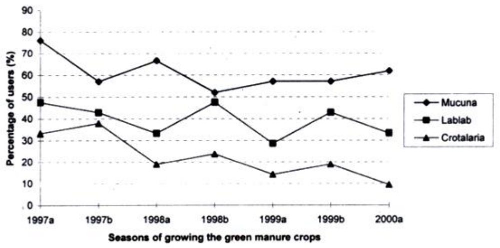

Figure 1. Trend of growing green manure cover crops by farmers between the seasons of 1997a and 2000a.

Farmers were also concerned that *Mucuna* a fast growing, proliferous cover crop produced seed that could not be eaten. The crop also had climbing tendencies when intercropped with other crops adding to labor demands of managing the main crops such as bananas and coffee. The crops affected by the climbers would not yield well. Farmers indicated that the labour demands of *Mucuna* needed a committed person who valued its benefits to grow it.

The immediate neighbouring farm-households (22) to the participant farmers indicated that they were aware of the existence of the green manure cover crops, but had not used them. The reasons for this included:- lack of adequate information on the crops, lack of land and time to plant them, lack of seeds, as well as lack of husbandry skills for the crops.

The 9 farmers who dropped out shared their reasons for dropping most of which were managerial, administrative, organisational and socio-economic concerns. The reasons were: -

- Poor leadership of the farmers research groups leading to inequity in opportunities for selling the green manure seed
- Failure to sell seed from the green manure cover crops
- Lack of a reliable market for the green manure seed
- Lack of funds to buy planting seed for the green manure cover crops
- Failure to provide credit to the farmers as promised by the research team
- Initiation of a women's credit organisation called FINCA funded by the United States Agency for International Development (USAID) in the area diverted some of the participants to other business activities other than the green manure trials
- Difficulty in scaling up green manure cover crops on the small farming land available as well as insecure land tenure
- Social problems such as death of a relative, or attending to a sick family member.

Despite these problems, this set of farmers expressed interest in the technology, and intended to resume on acquiring seed at an affordable price and on surety of a market for the seed. Another objective of resuming was to improve the fertility of their soils.

On-farm scaling up and adaptation of green manure crop use

Over 60% of the participant farmers had not expanded their fields under green manure cover crops due to lack of sufficient land and the need to reserve land for food production. Lack of security of land tenure and labour constraints were the other reasons. However, there were rotations of the green manure cover crops and use as intercrops with the food crops. On average, the green manure crops were planted in the same field 4 times, the range was 1 to 10 times.

Forty three percent (43%) of the participant farmers indicated that they had tried using the green manure cover crops in new ways besides what the researchers had demonstrated during the trials. Sixty seven percent (67%) of those who used the green manure crops in new ways had innovated with *Mucuna*, while 22% had innovated with *Crotalaria*. The ways in which the participant farmers adapted and innovated with the technologies are shown in Table 1.

For *Crotalaria* the basic recommendation was to use it as an intercrop with maize and as a one-season cover crop - a one season fallow crop, whose crop residues at maturity were to be used as a mulch in

Table 1. Farmers innovations with the green manure cover crops.

Green manure cover crop	Recommended utilisation method	Modification in utilisation	Non-agronomic modifications
Crotalaria	Intercrop with maize or as a one season fallow crop	Ploughing into the soil	Leaves were used as a vegetable and as a medicine for stomach pains
	When mature, uproot and mulch in maize, beans, sorghum, millet, cotton, etc.	Intercrop with beans to control nematodes and other bean diseases	
	Thresh pods to get seed.	Seed put together with bean seed during storage controls bean storage pests	
	Mulch		
Mucuna	Use it as a one season fallow crop, uproot at planting and mulch in the following crop	Intercrop with maize	Efforts to crash seed to make chicken feed
	Keep seed for future use		Mixing its dried leaves with maize bran to make chicken feed
	Use as cover crop in banana plantations		Fresh vegetation used as a feed for goats and cattle
Lablab	Grow for two seasons as a fallow crop, uproot at planting and mulch in the following crop		Seed and the leafy vegetation edible
	Use as a fodder crop and as cover crop in banana plantations		Seed cooked like beans for source
			Dried and powdred leaves also as a source

annual crops. Farmers innovated with *Crotalaria* by using it as mulch in coffee, and incorporation of the *Crotalaria* residues into the soil. They also used *Crotalaria* seed, to protect beans against storage pests such as bean weevils. *Mucuna* was recommended to be used as a one season fallow crop, where a crop would be planted and mulched with *Mucuna* after harvesting the green manure. Using Mucuna as a cover crop in banana plantations was also recommended. Intercropping *Mucuna* with maize was one of the adaptations in the use of the green manure besides the following non agronomic innovations: crashed *Mucuna* seed was experimented as a poultry feed. Dry *Mucuna* leaves were mixed with maize bran to make chicken feed, while its fresh vegetation was used as a livestock feed (goats and cattle). *Lablab* was recommended to be used as *Mucuna*, as well as a fodder crop. Using lablab as human food was the major innovation mainly by eating its leaves both as a fresh and a processed/dried vegetable. The seeds were also boiled like the common bean and eaten as a source of protein. *Canavalia* was used as an intercrop in coffee, maize and bananas. Vetiver grass, which was meant to stabilise soil bunds against soil erosion, was used as a thatching material for houses.

Sources of seed and seed sales

Farmers ensured that they had enough seed of the green manure crops by saving from previous season harvests (Fig. 2). Sixty seven percent (67%) of the farmers indicated that they saved *Mucuna* seed, while 24% indicated that they saved *Lablab* and *Crotalaria* seed. However 75% of the farmers indicated that they had also obtained seed from fellow farmers. Fifty-five (55%) and forty six percent (46%) of the farmers obtained seed for *Mucuna* and *Lablab,* respectively from other farmers.

Eighty one percent (81%) of the participant farmers indicated that they had sold some of their green manure seed. Fourty seven percent (47%) of the farmers had sold seed to the leader of the Farmer Participatory Research Group, while 24% had sold to CIAT, and 6% to their fellow farmers. Eighty-nine percent (89%) of the participating farmers who had sold green manure seed had sold *Mucuna* seed, while 38% had sold *Lablab* and *Crotalaria* seed each. *Mucuna* was sold at an average price of $0.52 a kilogram, and ranged from $0.28 to $1.7. The price for Lablab seed ranged from $1.14 to $5.71, while the average was $3.23 per kilogram. A kilogram of Crotalaria seed was sold at a mean price of $1.71. The exchange rate used was 1,750 Ugandan Shillings per United States dollar.

About 1908kg of *Mucuna* seed were sold, with an average of 159kg of seed per farmer. The total amount of *Lablab* seed sold was 43.5kg, with an average of 10.87kg of seed per farmer. Twenty-six (26) kilograms of *Crotalaria* seed had been sold with an average of 5.2kg per farmer.

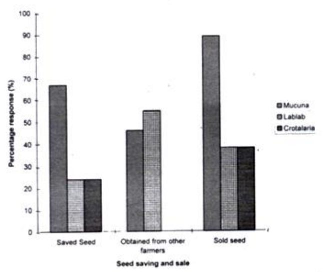

Figure 2. Green manure ***cover crop seed saving, access and sale among farmers.***

Farmer to farmer dissemination of the green manure cover crops

Ninety five percent (95%) of the participant farmers had shared information on green manure crops with other farmers 290 in total. Each participant farmer had on average shared with 17 farmers. The other farmers who were using the green manure crops after participating farmers shared with them were 86 for *Mucuna* (Table 2). Fifty three (53) farmers were using *Lablab*, while 31 farmers were estimated to be using *Crotalaria*. Table 3 shows that 66% of the participant farmers indicated that women participated in the sharing with others about the green manure cover crops, while 38% were men (Table 3). Sixty six (66%) of the participant farmers said women in the community were reached most, and 57% said that small holder peasant farmers were reached most followed by subsistence farmers (43%).

Discussion

There was a decline in the proportions of farmers growing *Lablab* and *Crotalaria*, while *Mucuna* experienced a slight rise in the proportion of growers in season A of the year 2000. The major explanation for these declines is drought stress. Internal averages based on the number of farmers growing the particular technology reveal a higher level of consistent use over the 7 seasons (15, 10 and 7 for *Mucuna, Lablab* and *Crotalaria*, respectively). This can be attributed to the increases in soil fertility brought about by the use of the green manure cover crops. This was also an indicator of farmers' extent of integrating the green manure cover crops into their farming systems. Given the four years (which is close to the five year period permitted for adoption of soil technologies) had elapsed since the actual trials had been completed; the present level of green manure crop use by the participant farmers shows integration of the technologies. The apparent position of *Mucuna* is due to its prolific nature, and easy harnessing of seed, which can also be used in the next season. The relatively constant low level of *Lablab* use is mainly due to the ease with which its seed were attacked by pests making

Table 2. Use of green manure crops by secondary farmers told by participating farmers.

Green manure	Number of respondent	Total number of other users	Mean number of other users	Standard deviation (SD)	Range
Mucuna	12	86	7.17	6.32	23
Lablab	7	53	7.57	7.74	22
Crotalaria	2	31	15.5	13.44	19

Table 3. Household member participation in sharing about green manure cover crops and most reached group (n=21).

Household member	Frequency (f)	Percentage (%)
Women	14	66.0
Men	8	38.0
Children boys	1	4.8
	Member of the comunity reached most	
Women	14	66
Men	8	38
Children boys	2	9.5
	Types of farmers reached most	
Type of farmer		
Small scale peasants	12	57
Subsistence farmers	9	43

seed saving for the next season difficult. Thus, seed to replant is rarely available especially when the drought affected the harvest.

Crotalaria had the lowest proportion of farmers continuing to grow it, and registered an increasing decline of this proportion due to difficulties in getting seed. The crop takes longer period to mature (7 months). This possibly could not fit in an area with land scarcity. These trends of use (intermittent falls and rises) did not however, imply that farmers were giving up with the green manure crops. Qualitative discussions with the farmers revealed objective intentions to grow the crops when the conditions are conducive, such as availability of seed and rain.

Despite the above observations, there were improvements in the level of soil fertility of farmers fields at all topographical levels as perceived by the farmers after growing either, both or all of the 3 green manure cover crops. The positive changes in soil fertility after using the green manure cover crops at all levels can be attributed to the their biological nitrogen fixing (BNF) capacity, the high biomass and release of nutrients during the decomposition process (Fischler, 1997). It is observed that soil fertility changes at the hill top were only up to only the "fertile" level (Table 4) possibly due to physical nature of the soils at hill tops. These soils are characterised by gravel, and thin layers of top soil due to their erodibility, particularly if there is little soil cover. The soil fertility changes at the foot hill changed from poor to very fertile, because of the likelihood of deposition of soils eroded from hill sides and the deep layer of top soil. A good proportion of farmers with fields at the flat terrain also reported a change in the fertile level, confirming the potential of the green manures to restore fertility of such soils which are usually exhausted due to over cultivation.

The reasons farmers indicated for continuing to use green manure cover crops do reflect that a priority need of the farmers is the productivity of their soils (Wortmann *et al.*, 1999). Fischler (1997) reported high on-farm trial maize yields after use of *Mucuna, Lablab* and *Crotalaria* as soil fertility replenishing technologies. Provision of other support technologies may genuinely explain their response as often farmers have other needs, which if not met may affect their acceptance of a new technology. The support technologies were many and helpful, possibly providing the participants a choice menu and thus appealing to their commitment to the research/development process. Use of their indigenous knowledge in some of the aspects of research fitted well with the concepts of participatory research where solutions must consider what the would be users know and build on it making the whole process potentially sustainable (van Veldhuizen, *et al.*, 1997). The sale of the green manure cover crop seeds was a strong incentive, which even though it was not the original motive of the project, might have attracted farmers to work hard. Farmers are always looking for sources of funds so they can meet other needs in the setting that can only be met by money. The use of the cover crops for other purposes

Table 4. Level of soil fertility (indicated at %respondents) before and after planting green manure cover crops along the catena of farmers' fields (n=21).

Topography	Level of soil fertility				
	Very poor	Poor	Average	Fertile	Very fertile
	Before planting the green manure cover crops				
Hill top	-	19	4.8	-	-
Flat land	9.5	33.3	4.8	14.3	-
Gentle slope	4.8	4.8	-	-	-
Foot hill	-	4.8	-	-	-
	After planting the green manure cover crops				
Hill top	-	-	-	23.8	-
Flat land	-	-	4.8	42.9	14.3
Gentle slope	-	-	-	4.8	4.8
Foot hill	-	-	-	-	4.8

as farmers are able to spread risks to other shocks such as lack of animal feed, or vegetable source for home use was another additional measure.

The immediate neighbours could have adopted, if they had practical knowledge and training on the importance of the green manure cover crops as well as how they are utilised. However, the attempts to innovate among the participant farmers shows a higher level of innovativeness compared to their neighbours (assuming that there were no other forms of innovativeness with other technologies among neighbours). This could additionally explain the non-adoption of green manure cover crops among the neighbours. If neighbours had a high level of innovativeness they would have been more curious about the technologies and thus moved higher on the innovation-decision process. This process range is through knowledge or awareness, persuasion, implementation and then confirmation stages (Rogers, 1983). It is also possible that a socio-economic gap was created between the participant and their non-participant neighbours as a result of the technologies, leading to resentment among neighbours towards trying out the technologies.

The experiences of the drop out farmers are a reflection of the consequences of an innovation as observed by Rogers (1983). The behaviour of the leadership and the inequalities involved in the distribution of green manure cover crop seed may be classified as an undesirable and unanticipated consequence of the technology. This can lead to a social gap between the drop out farmers, and the research effort. The entire milieu of reasons for dropping out of the research hinges around the way the management of the research activity (including the roles of the farmers, their leaders, the researchers, the resources and the methodology).

Despite the lack of expansion of the area under use of the cover crops on the participants fields, the frequency of use of the technology was high (an average of 4 times in fours years after the trials). This expressed increased appreciation of the role of the technologies in restoring the soil fertility, and one of potential sustained use among the farmers.

Innovations or what Rogers (1983) calls re-inventions of the green manure technologies occurred among the participant farmers. Rogers (1983) argues that re-invention occurs at the stage of implementation of the innovation-decision stage and that its an action taken by an adopter. This puts the 43% of the farmers who had innovated with the green manure cover crops on a possible list of adopters. Re-invention is regarded as beneficial to the adapters, due to the flexibility it provides in the process of adopting a technology. Additionally re-invention may encourage customisation of the innovation, making it fit the local conditions, this is also part of the participatory research process. The re-invention and innovation provides for self reliance of the users and through the processes of experimenting may lead to a system of innovativeness (Reijntjes *et al.*, 1992).

The management of green manure seed seemed to take a central role in the growing of the green manure cover crops, as seed was the only product of the green manure cover crops from which money could be earned directly. The profitability of an innovation is said to increase its adoption (Rogers, 1983). There were indications of farmer frustrations with failure to harvest seed of *Lablab* and *Crotalaria*, whose seed fetched more money than the proliferous *Mucuna*. Most importantly, seed saving was important if the green manures were to be grown in coming seasons.

Diffusion of the green manure cover crops spread from the participant farmers to other farmers in the community, justifying the role of farmer to farmer sharing. Indeed farmer to farmer information exchange is the most common way of information spread among farming communities (Campbell and Garforth, 2001). Ninety five percent of the farmers indicated to have told some one else about the green manure cover crops. A total of 290 other farmers had been told. The mean number of those who were observed practicing per participant farmer was 7 for each of the green manure crops. What may have prompted this may be the good soil improvement results and better crop yields after using the cover crops observed among the participant farmers. The role of women in households in disseminating the information can be explained by their important role contributing to most of the agricultural activities, and possibly due to their information exchange networks which function better than those of men (Campbell and Garforth, 2001). This probably explains why more women were reached as compared to the other gender.

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