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# Experiences of soil fertility management through legume based farmer participatory experimentation in Malawi

***A. Kabuli. and J. Kamoto***[1]
P/BAG A89,Lilongwe, Malawi
Farmer participatory researcher, Risk Management Project, Lilongwe, Malawi
[1] Lecturer, Department of social forestry, Bunda College of Agriculture, Malawi

## Abstract

**Soil fertility, participatory research, green manure, Best bet. Soil infertility is the most outstanding threat to agricultural productivity in Malawi. This is mainly due to low use of organic and inorganic materials to restore fertility. Consequently, farmers and researchers are developing alternative interventions to manage soil productivity. The Risk management project in Malawi is one such initiative that has recently joined in the search of soil fertility management technologies in Malawi. The overall objective of the project is to empower farmers to gain experience in experimenting and providing feedback of best bet legume technologies to rehabilitate degraded soils. This study was conducted in Chisepo in Central Malawi during the 2001/2002 and 2002/2003 seasons. Soils are mostly sandy and sand loamy soils. Annual rainfall is between 600-800mm. The study used the mother-baby trial approach in implementing the farmer and researcher managed trials. The legumes were grown on either sandy soils or sandy loam soils to compare soil rehabilitation benefits of the different technologies. Farmers were encouraged to incorporate the legume crop residues in order to maximize the residual nitrogen benefit to the cereal crop. Finally, feedback sessions were held with farmers to elicit farmer perceptions on the performance of the different legumes.**

**Key words:** Interactions, participatory research, soil productivity

## Introduction

Declining soil fertility ranks high among the factors limiting smallholder arable crop production in Malawi. This problem has been caused by diminishing land holding sizes as a result of the ever-increasing population growth rate currently at 3.2%. The problem has further been exacerbated by continuous cultivation as well as cultivation of fragile hill slopes with little or no application of inorganic fertilisers due to the escalating prices as a direct consequence of market liberalization and removal of subsidies.

In order to reverse the trend, researchers and farmers have been conducting extensive experimentation to develop alternative organic nutrient source for smallholder farmers in Malawi, ( Kanyama-Phiri *et al*, 1998; MacColl, 1989). Farmers uptake of these technologies has been discouraging to date although biologically some of these systems have been shown to enhance soil productivity through nitrogen fixation, carbon input and conservation of nutrients (Snapp *et al.*, 1998).

The Risk Management Project has been working in Malawi at Chisepo Extension Planning Area since 1999/2000 growing season. The projects aimed at developing sustainable resource-conserving farming methods in collaboration with smallholder farmers in Malawi by integrating simulation models as well as farmer participatory research. The project worked to expand farmer's soil fertility and resource management options, with special attention to resource strategies that can help maintain production even under the harshest conditions.

The study was conducted in Chisepo, Malawi, in 2001/2002 and 2002–2003 seasons. Chisepo is located in Kasungu Agricultural Development Division (KADD) north of Lilongwe, in the mid-altitude area of the Lilongwe-Kasungu plains. The most common soils are sandy loamy soils (60%) and sandy soils (30%). These soils are generally low in soil organic matter (0.25%), total nitrogen (0.1%) and range in pH from 5.6 to 5.8. The main crops grown in the area are maize and tobacco. Maize yields range from as low as 0.1 t /ha to 2.5 t /ha. Annual rainfall is 600–800mm (Kamanga, 2002).

## Methodology

The project worked with farmers in Chisepo area in 2002/2003 growing season with the aim of implementing the second phase of the project, which started in 1999/2000 growing season. The overall objective of the study was to allow farmers gain experience in evaluating and providing their perceptions of best bet grain and green manure technologies in rehabilitating poor degraded soil. Farmers were expected to experiment with these technologies with the hope that the process would help in restoring soil fertility status of their farming systems. The "Mother-Baby" trial approach was used in the process. This allowed quantitative data from researcher managed on-farm 'mother trials' to be systematically cross-checked with farmer-managed 'baby trials' with similar themes. The mother trials tested nine (9) different legume technologies either in rotation or intercropped with maize with full replication. The baby trials tested a subset of three technologies at a site, plus a control. Each plot was a 10m by 8m in the mother trials while plots were 10mby 10m in the baby trials

Finally, two sets of data was collected; one on agronomic data sets which included soil sampling for nitrogen status, texture, soil pH, and phosphorous status and crop performance as measured by grain yield and harvest indices. Socioeconomic data which is the major focus of this report was also collected which included farmers derived taxonomies for soil and fertility status, soil fertility technology performance evaluated across a range of agro-ecological zones and by farmers from different socioeconomic groups, perceptions of the various legume technologies as well as the constraints to increased adoption of the legume was also collected. This information was collected by using participatory rural appraisal (PRA) techniques and through a structured questionnaire administered to all the participating farmers.

## Results and discussions

### *Socioeconomic characteristics of farmers in the studied area*

The majority of the smallholder farmers working on the project were men (76.9%). Very few women farmers took part in the experimentation process and the main reason for this was lack of interest from the women farmers. Most of the women farmers were suspicious of the project at first, as they did not understand the benefits of hosting the trials. Additionally, women also experienced more constraints that their men counterparts in terms of land ownership, access to resources and ability to participate in project activities. Most farmers were illiterate and did not use manure in their farming mainly because of a reduction in stock levels of late due to theft. Very few farmers also applied inorganic fertilizer in their farms and this was mainly due to increased prices of the commodity of late as a result of the market liberalization and removal of subsidies. More socioeconomic characteristics as reported by farmers are indicated in Table .

### *Soil characterization and fertility management in Malawi*

Farmers classified soils based on what they saw and felt about that particular soil. There were certain inherent factors which farmers used to classify and characterize soil types. The most important ones were color, fertility, land type and depth of the soil. Characteristics such as slope, water holding capacity, ease of tilling, physical properties like stickiness or firmness were also used. The actual fertility status of the soil was also determined by the location and previous soil management techniques.

The most common soils in the area were sandy clay loam soils *Katondo* and sandy soils *Mchenga.* Farmers reported that most of the fields in the area are infertile due to continuous cropping, which had put pressure on land. However, the farmers were quick to suggest ways of managing and replenishing soil fertility such as applying compost manure to the fields, planting tree species and leguminous plants (e.g. *Tephrosia Vogelli),* incorporating crop residues during land preparations, leaving fields to fallow as well as applying inorganic fertilizer as shown in Table 2.

Based on their knowledge of characteristics of different types of soils and the performance of each crop, farmers matched different legume crops with different soil types. This idea helped both farmers and researchers in targeting the various legume soil fertility management technologies to different soil and land domains. This in the end helped in developing rules of thumb of where each of the legume technologies would fit best in terms of growth and contribution to soil fertility. Table 3 indicates some of the characteristics farmers in Malawi used to assess soil potential.

### *Farmer legume experimentation in Malawi*

Farmers through group activities used the mother and baby approach to experiment on options which would offer them benefits of soil fertility improvements. There were five (5) mother trials each managed by a group of 7-8 farmers. All nine (9) legumes indicated below were subjected to intercropping as well as rotation systems. The legumes introduced in 2002/2003 season were mucuna, pigeon peas, bambara nuts, soybeans, groundnuts, cowpeas (determinate and indeterminate), tephrosia, grahamiana and sunhemp. Each mother trial was set in a simple way intercropping maize with legumes or rotating maize with sole legumes. Farmers then chose from the mother trial four different legumes for setting the baby trials. Researchers then followed up on the farmers' perceptions with regard to the performance of each legume as well as agronomic data such as planting dates, planting patterns, soil types and other issues.

### *Performance criteria for legume assessment in the farmers' fields*

Group discussions were held with farmers to elicit their perceptions and feedback on the performance of the legumes they were experimenting. Farmers participated in ranking exercises that identified the different criteria for evaluating the performance of the technologies. There were four criteria that farmers identified to evaluate legume performance and these were yield level, drought tolerance, food and feed value, labor needs and suitability in intercrop systems.

On yield levels, farmers' experimentation focused on improving the yield of crops, especially maize through the use of legumes. Legumes incorporated into systems should

**Table 1. Socioeconomic characteristics of farmers in the study area**

| Variable | Figure |
|---|---|
| Household size | 5.20 |
| Consumer: worker ratio | 1.30 |
| Farm size (ha) | 1.90 |
| Male (%) | 76.90 |
| Literacy levels (%) | 84.60 |
| Fertiliser use on maize (%) | 30.00 |
| Fertiliser use on maize (kg/haN) | 19.00 |
| Manure use on maize (%) | 18.00 |

**Table 2. Farmer knowledge and practices of improving soil fertility in Malawi**

| Method | % Aware of the practice | % Farmers practicing |
|---|---|---|
| Legume residue incorporation | 62 (48%) | 55 (42%) |
| Application of animal manure | 20 (28%) | 18 (25%) |
| Agroforestry techniques | 4 (8%) | 2 (4%) |
| Fertiliser application | 7 (14%) | 4 (9%) |
| Composting making | 3 (6%) | 1 (2%) |
| Early land preparation | 3 (6%) | 3 (6%) |
| Fallowing | 5 (7%) | 3 (6%) |

**Table 3. Farmers' characterization of fertile versus infertile soils**

| Good soils | Poor soils |
|---|---|
| ---Vigorous and tall grass | ---Unavailability of grass growth |
| ---*Chilikumwamba* weed means soil is fertile | ---Unhealthy trees, shrubs and grass |
| ---Presence of some grass and plant material | ---Rocky and gravel ridden fields |
| ---Low sand content | ---Water logged soils. |
| ---Soft and easy to hoe | ---Presence of striga (witch weed) |
| ---Presence of organic matter/decayed matter | |
| ---Black in color | |
| ---Mixture of sand, clay and black soil | |
| ---Contains some sand for water percolation | |

**Table 4. Farmer rating of technology traits in Chisepo, Malawi[1]**

| Treatment | Weeding labor requirement | Seed availability | Contribution to food security | Contribution to cash sales | Contribution to soil fertility |
|---|---|---|---|---|---|
| Maize control | 3.1 | 3.3 | 2.2 | 2.3 | 1.5 |
| Maize+ pigeon peas | 2.5 | 1.9 | 3.6 | 2.8 | 2.7 |
| Maize+ Mucuna | 3.5 | 2.5 | 2.4 | 2.3 | 3.6 |
| Maize+ Bambara | 2.2 | 2.8 | 2.9 | 2.4 | 2.1 |
| Maize+ Cowpeas | 2.1 | 3.1 | 3.4 | 3.1 | 2.8 |
| Maize+ soybeans | 2.3 | 2.9 | 3.1 | 2.3 | 2.6 |
| Maize+ tephrosia | 2.8 | 1.5 | 2.0 | 1.9 | 1.8 |
| Maize+ sunhemp | 2.6 | 1.9 | 2.0 | 1.7 | 2.4 |
| Maize+ Grahamiana | 2.6 | 1.7 | 2.5 | 1.7 | 2.6 |

1. Rating: 1 = very low; 2 =low; 3 = high; 4 = very high

increase maize yields in the same season or in subsequent years. The impact of legumes on sol fertility restoration depends largely on the volume of biomass the legume produces (Gilbert 1998; ICRISAT/MAI 2001). Some farmers had good biomass production in the first year and this encouraged other farmers to view biomass as an important characteristic for identifying legumes that would perform well. Similarly, because of the drought that often occur in many parts of the country, some legumes are affected by moisture stress. Farmers preferred legumes that were more suited to dry conditions that frequently occurred and were capable of tolerating harsh conditions in the agro-ecological areas. Food and feed value was also an important criterion for farmers to assess a particular legume. Since most of the smallholder farmers households are food insecure and their soils badly degraded, legumes that had multiple uses of improving soil fertility while providing food benefits were ranked highly by farmers. Farmers owning livestock also liked legumes which could provide animal feed to improve the milking potential of cows. Labor requirements and availability also determined farmers' ability to adopt a particular legume. Similarly, legume suitability in intercrops was another criterion used to determine legume potential. This was in view of the declining land holdings in Central Malawi.

***Farmer perceptions of legume suitability for the different soil types***

The baby legume trial plots were laid out in each farmer's field of choice. A variety of legume crops were grown in all the baby trials. These legume crops were grown on different soil types. 44.9 % grow the legumes in sandy soil, 38.2 % in sandy clay loam soils and 13.5% in sandy loam soils. Most soils in the area were sandy and sandy clay loam.

Farmers were asked why they chose particular soil types to grow specific legumes and the majority of the farmers reported that they grew the legumes on that particular soil type because that was the only accessible land, while 23.6% stated that they did that because it was only a trial and 2.2 % for soil improvement and easy tillage. Twenty (20) farmers representing 38.5% had their baby trial in sandy clay loam soils and 27 farmers representing 52% knew the soil types in their fields before being told by the extension worker

Farmer evaluation indicated that most of the legumes were grown in sandy soil mainly because the legumes did well in these fields. Additionally, most of the area where the study was conducted had soils that were rich in sand followed by the sandy clay loam soils. Legumes that fitted well in this type of soil were bambara, mucuna, pigeon peas and cowpeas. Legumes such as groundnuts and grahamiana were more suited to the sandy clay loam soils. Very few farmers grew legumes in clay and clay loam soils as most of it were water logged during rainy season. Pigeon peas, tephrosia and mucuna did not do well in these conditions.

***Farmer perception of benefits and opportunities of legumes***

Farmers were asked to give reasons for growing a particular legume crop in 2002/2003 growing season. The majority of farmers (48.2 %) indicated that they chose the legumes as a source of food followed by those who stated that they grew it to improve their soil fertility status. However, when asked how they knew the legume improved soil fertility, they indicated that extension staff employed by the project organized a field show where they saw maize yields increasing where previously there was a legume crop. Most farmers grew cowpeas than any other legume 23.6%, followed by mucuna and pigeon peas both grown by 19.1% of the farmers.

Traditional legumes were mainly grown for their food values. Cowpeas and bean leaves were eaten as vegetable relish while fresh; they were also boiled and dried for preservation for use in dry season when green vegetables were scarce. The fresh green pods were also boiled and eaten as snacks. Groundnuts were roasted salted and eaten also as snack and in some instances pounded into flour and used to season leaf vegetables. Farmers also used used legumes such as pigeon peas, soybean and mucuna as animal feed. Male farmers in particular stated that the legumes were fed top animals in order to boost milk production.

In terms of soil fertility potential of legume crops, farmers believed that Mucuna was the best for soil improvement based on the leafy biomass yield they had in 2001/2002 season and 11.2 % opted for growing mucuna for that reason. This was also reflected in the high rating mucuna had on contribution of legumes to soil fertility (Table 4 below).

Farmers were asked to mention the technology traits that fellow farmers considered before adopting these technologies and there were quick to point out that most of the legumes which did not demand a lot of labor, that contributed quite a lot to food security and were easily available in the villages stood a better chance of being adopted. Mucuna was rated high with its attributes of contributing a lot to soil fertility improvement while many farmers did not like it due to its limited utilization options. Pigeon pea was rated high both as a soil fertility replenishment legume and as a food security crop although other farmers were not happy with the availability of seed in the villages.

## Conclusions and lessons learnt

The results of this study have indicated that farmer involvement in developing new technologies increased their demand for more legumes given the perceived benefits and requirements. Farmers have knowledge about legumes and their contribution to soil fertility and food security. However, adoption and production of legumes in Malawi was still low. Farmers indicated lack of seed, lack of markets, poor soils, livestock damage and lack of labor as the factors limit legume production. These perceptions tuned farmers' choices of which technology to incorporate in their farming systems.

Our experience over the year with the project suggested that using participatory research process for development of relevant technological options creates a viable framework for farmer-researcher interaction in the development of relevant technology options for smallholder farmers which is lacking in many conventional research methodologies.

Implications from this study are numerous. First, legumes will not be adopted purely for soil fertility benefit. Farmers must perceive other, corollary benefits which include suitability in intercropping systems, additional grain for food, weed suppression and use of legumes for animal feed as well as fuelwood. Second, legume performance by field type may be a constraint to adoption especially for resource poor farmers who may not afford enough manure and land to boost legume production as well as practice the legume-cereal rotation. Third, legumes could play an important role in diversifying farmers cropping systems as well as diet in mostly maize based farming systems only if well managed and necessary investment made in its production.

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