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LEGUME BEST BETS TO ACQUIRE PHOSPHOROUS AND NITROGEN AND IMPROVE FAMILY NUTRITION 06-740

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TABLE OF CONTENTS

1.0 WEBPAGE Summary 3
2. RESEARCH REPORT 6
2.1 Authors – Research Team 6
2.2 INTRODUCTION 7
2.3 NARRATIVE SUMMARY 8

Objective 1: Determine sets of characteristics of 'best bet' legumes and legume combinations which address nutritional and soil requirements. 8
Participatory on farm trials/demonstrations, Ekwendeni catchment of Mzimba District, Northern Malawi 8

Participatory on farm trials/demonstrations, Mkanakhoti EPA, Kasungu District, Central Malawi 12

Participatory On farm trials by the Soils, Food and Healthy Communities project, Ekwendeni Mission Hospital, Ekwendeni Northern Malawi 17

Objective 2: Promote Best Bet Legumes in Diet to Improve Household Food Security and Nutrition, SFHC project, Ekwendeni Mission Hospital 18

Objective 3: Quantify the effect of legumes on soil P, N organic matter and yield of subsequent crops 20

Objective 4: Strengthen farmer, Research, Extension and NGO capacity in Legume production and Utilization including Gender Issues 21

Implications for policy 24

3. TEAM REPORT 26
3.1 Team Activities 26

FINANCIAL NARRATIVE REPORTS 33

Appendix : Photos, Figures, Tables 36

1.WEBPAGE Summary

The "Legume Best Bets to Acquire Phosphorous and Nitrogen and Improve Family Nutrition" project is being implemented in Northern Malawi at Ekwendeni, and in Central Malawi at Mkanakhoti Extension Planning Area in Kasungu. Non-governmental partners, farmer research groups and extension teams have partnered with researchers to investigate 1) legume diversification for improved soil nutrition and family health; and 2) participatory development approaches. Nutrition education has markedly enhanced farmer use of new legumes such as pigeon pea (*Cajanus cajan*) intercropped with groundnuts or soybeans.

- **Training outputs:** one graduate student Austin Phiri has completed his MS degree, another student Keston Njira has submitted his MSc thesis and Wezi Mhango defended her PhD dissertation.
- **An on-farm soil test kit** provided immediate soil pH and texture results to facilitate discussions with farmers and soils were analyzed in the lab, documenting soil texture and organic matter characteristics among field sites
- **70% of participating farmers are expanding production of doubled up legume best bets in Ekwendeni, and** 90% of farmers experimenting with pigeonpea in Kasungu are interested in growing the multipurpose legume again.
- **Farmer to farmer exchange through visits between Ekwendeni and Kasungu** sites have enhanced local knowledge of integrated soil fertility management (compost, legume residue incorporation, combining with small amounts of fertilizer) and use of legume grains to diversify family diets through new recipes.
- **On-farm research trials** were carried out in 2008 and 2009, including 86 mother trials and 40 baby trials in Ekwendeni, 70 mother trials and 250 baby trials in Kasungu. These trials simultaneously tested biological performance and documented farmer assessment of legume technologies. Under investigation is the quantity of nitrogen fixation obtained with different legume diversity and intercrop patterns, overall cropping system performance and soil improvement from legume best bet technologies. The two growing seasons demonstrate strong interactions with weather, as dry conditions in 2008 reduced crop growth, limited

calorie production to ~70% of normal, and reduced production of nitrogen-rich residues. Crop yield in 2009 in contrast benefited from a high rainfall year and maize yields where ~150% of normal. Pigeonpea growth was outstanding, to the extent it competed with maize growth in the farmer cropping system (ratooned, second year pigeonpea intercrop with maize). Tradeoffs between soil building best bets (e.g. high population of long-duration pigeonpea) and nutritional best bets (high population of short duration groundnuts and maize) will be documented.

- **Innovative extension** underway includes nutrition education through recipe days, on-farm adaptation of legume varieties and residue management practices, and farmer-to-farmer visits.
- Training materials developed include **3 Extension Bulletins on Legume Technologies and 10 Farmer Flyers on Legume Recipes.** This provides information on how to utilize legumes, and how to manage doubled up pigeonpea-groundnut and multipurpose legume technologies. Additional training materials on compost preparation and legume recipes are planned for 2010.
- Extension bulletins developed on agronomy and benefits of doubled up legumes and maize-pigeonpea intercrop system in maize based cropping systems. These have been distributed to stakeholders and participants at the 2010 COP meeting.
- **Research and extension plans for 2011** are a fourth year of on-farm trials, as multiyear rotation systems require evaluation over time. Farmer assessment is on-going and an iterative process.
- A new best bet comparison will be introduced in 2010, evaluating the biological impact and farmer assessment of combining a preplant roundup herbicide treatment with legume-maize best bets. Promising new varieties of pigeonpea and groundnuts in different combinations will also be investigated, as farmers have expressed strong interest in expanding the number and types of varieties grown.
- Our team will be working with Malawi Met service on documenting a range of weather scenarios typically encountered at Ekwendeni and Kasungu over the last 30 years will be another goal over the next few years, and investigating through simulation modeling and synthesis of past trials to evaluate which legume best bet

combinations do well within which scenarios, to better understand how best bets perform within different climate regimes.

- **Policy input:** An exciting development is input into Malawi government policy on agricultural subsidies, which have been broadened to include legumes for the first time, although pigeonpea was not included (groundnut, common bean and soybean were the initial targets). Follow up with the Ministry will be conducted in 2010 working with the new McKnight Scale Up project, to support policies that address the bottlenecks in seed systems and soil fertility recommendations supporting legume diversified technologies.

2. RESEARCH REPORT

2.1 Authors – Research Team

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Dr. Patson Nalivata, University of Malawi, Collaborating Scientist and MS Student Supervisor

2.2 INTRODUCTION

Smallholder farmers in East and Southern Africa face considerable development challenges. In Malawi, at least 1 million households have chronic food deficits, 50 percent of children under 5 are severely malnourished (wasted or stunted), and 60 percent of the population subsists on less that $1 per day. A series of droughts over the past decade have exacerbated the food shortage problem. Average farm sizes are around 1 hectare, necessitating continuous cropping primarily of maize, the main cereal crop. As a result, soil fertility, especially on sandy soils, is low. Low incomes mean that few farmers can afford to use purchased inputs (in the absence of subsidies), and there is limited knowledge of organic matter technologies such as composting.

Legumes have been widely used in many African countries in part to improve soil health and in part to improve family nutrition. Legumes contribute towards soil nitrogen through their ability to fix atmospheric nitrogen. Similarly some legumes have the inherent capacity to increase phosphorous through their symbiotic association with mycorrhiza. Legumes also contribute to protein when included in the diet of family households. Various traditional legume recipes have been developed over centuries and new ones are still being developed with the view to enrich the diets, particularly child weaning foods. In Malawi several legumes are grown for the foregoing reasons. Some such legumes include ground nuts *(Arachis hypogaea*), velvet beans *(Mucuna pruriens),* soybeans (*Glycine max*), Pigeon peas (*Cajanus cajan*), Bambara nuts (*Vigna subterranea*), and Cowpeas (*Vigna unguiculata*), among others. Grains from these legumes have been used in various recipe combinations for the purposes of enriching the diets of family households.

A project entitled “Legume Best Bets to Acquire Phosphorous and nitrogen and Improve Family Nutrition” is being implemented in Malawi using participatory approaches. The project is funded by the McKnight Foundation under the Grant Number 06-740. It covers the Northern and Central Regions of Malawi. In the North, it is being implemented in Ekwendeni area of Mzimba District in collaboration with the Soils, Food and Healthy

Communities (SFHC) Project of Ekwendeni Mission Hospital. The participating farm households are patrilocal with half of them being female headed. In Central Malawi, the project is being implemented in Mkanakhoti Extension Planning Area (EPA) of Kasungu Agricultural Development Division (KADD) in Kasungu District. The Malawi Enterprise Zone Association (MALEZA) is the main collaborating partner. In both study sites, farmers have organized themselves into Farmer Research and Outreach groups which have leadership structures that guide in decision making and in the implementation of development activities.

2.3 NARRATIVE SUMMARY

The project started in November 2006. This report covers the third year (2008/09) of the Best Bets project.

OVERALL OBJECTIVE: **To improve household food & nutrition security by increased legume production and utilization and improved soil quality.**

Objective 1: Determine sets of characteristics of 'best bet' legumes and legume combinations which address nutritional and soil requirements.

Activities Year 4:

Participatory on farm trials/demonstrations, Ekwendeni catchment of Mzimba District, Northern Malawi

Introduction: Low soil fertility is one of the constraints to increased crop production in sub Saharan Africa. Maize is a staple food in Malawi and most countries in Southern Africa. However, maize production under smallholder farmers is limited by low nitrogen. The high cost of inorganic fertilizers prevents most farmers from using fertilizer or applying recommended rates. Legumes are capable of improving soil N through biological nitrogen fixation and incorporation of high quality residues. In Ekwendeni, legumes (e.g. groundnut, pigeonpea, soya bean) have been promoted by the SFHC project to improve soil quality and family nutrition (Bezner Kerr *et al.* 2007). The key research

questions in this study were to 1). to evaluate whether doubled up legumes will increase N balance and subsequent maize yield over sole legumes or legume-cereal intercrops; 2). investigate effect of diversified legume systems on soil organic matter pools. A comparison of research findings and potential legume technologies to be scaled up by farmers will help to design cropping systems that are likely to be adopted and also understand factors to successfully scale out the technology.

Narrative Summary

Methods: In the 2007/2008 season, and continuing for the second year of on-farm trials in 2008/2009, PhD graduate/Bunda Lecturer Wezi Mhango conducted research on 21 farmers' fields working with the SFHC project in Ekwendeni catchment, Northern Malawi. Groundnut, CG7 variety (annual legume); pigeonpea, ICEAP00040 (semi perennial legume); and maize, (MH18) (annual cereal); were planted in sole and intercrop systems to quantify biological nitrogen fixation (BNF) of the legume best bet combinations (Table 1). Fig 1 shows groundnut intercropped with pigeonpea "doubled up legumes." At planting, soil samples were collected from all fields of the participating farmers to characterize the soil chemical and physical properties. The student and the participating farmers also mounted rain-gauges in the study area and rainfall data was collected. During the season, the measurements made included: chlorophyll readings, nodulation, plant samples collected to assess residue quality and quantify BNF, general crop performance and yield. Nitrogen fixation by legumes was quantifies using the $^{15/14}$N Natural abundance method (Peoples et al., 1989).Crops were harvested and residues analyzed for nitrogen content. Residues were incorporated soon after harvesting in all plots to facilitate decomposition and also protect them from livestock grazing.

Farmer assessment of the technologies and priorities for knowledge generation was monitored through two surveys conducted early in the participatory on-farm research process and after two years of participation. Adaptability analysis was conducted to evaluate performance and adaptation of cropping systems to specific environments following according to Hilderbrand and Russell (1996).

Soil characteristics and Rainfall

Soils are sandy to sandy clay loams, with low organic matter (12±3.7 g kg^{-1}) and pH= 6.1. Total soil N and P average 0.07% and 10.5±1 mg kg^{-1} respectively, which documents the low soil fertility that farmers must manage. In 2007/08, rainfall was low (669 mm) and below expected range of 800-1200m per year (Fig 2). Heavy rainfall (45-50% of the total) fell early in the season that led to loss of one field due to flooding and presumably considerable nutrient leaching. This was followed by a drought (early termination of rains) approximately 2.5 months after planting. In contrast, the rainfall was well distributed and above the long-term average (829 mm) in 2008/09, providing sufficient moisture for growth of all crops. High variability of rainfall has been predicted by climate modeling, and this illustrates the challenges that farmers must adapt to and risky environments that require testing and research over multiple years.

Yield and BNF of diversified legume cropping systems, 2007/08 and 2008/09 season:

There was good establishment of legumes in both years, but most notably growth was outstanding in year 2 (2008/09). Preliminary results indicated effective nodulation of all legume genotypes in sole and intercrop systems. The average nodule number per plant at ~8 weeks after planting were 9, 92 and 119 for pigeonpea, intercropped groundnut, and sole groundnut respectively.

Adaptability analysis showed that under low yielding environments, sole groundnut and GNPP optimized calorie production than sole maize, MZPP or sole pigeonpea (Fig 3). Cropping system x season effects were significant on biomass production from legumes, $p>0.05$. Biomass was higher in 2008/09 than 2007/08 with adequate rainfall. However, in pigeonpea, cropping system and season effects were significant on vegetative biomass but no effect on grain yield. Overall, intercropping of GNPP or MZPP was efficient at utilizing resources with LER of 1.50 and 1.56 for GNPP and MZPP respectively.

The proportion of N derived from the atmosphere (%Ndfa) averaged 77% and 78% for pigeonpea and groundnut respectively. Cropping system had no effect %Ndfa of both legumes and N fixed by groundnut per plant basis (Table 2). Under a short rainfall season, the total amount of N fixed per area basis was 63% higher from sole groundnut

(annual legume) than sole pigeonpea (semi perennial legume), p=0.015 (Table 2). There was no evidence of higher total N fixation from doubled up legumes over sole cropped legumes. The drivers of N fixation were inorganic P, plant growth, plant density and interspecific competition. In pigeonpea, interspecific competition reduced biomass production and total BNF.

Effects of diversified legume systems on soil properties and maize grain yield

Soil nitrate ranged from 11mg kg^{-1} in plots previously planted to MZPP to 16 mg kg^{-1} following sole groundnut or doubled up legumes technology with pigeonpea ratooned. Cropping system had no effect on soil nitrate and concentration of POM nitrogen. However, cropping system effects were significant on concentration of POM carbon. Sole pigeonpea increased POMC concentration by 15% over sole groundnut.

This study has shown that there is potential to increase maize yield under smallholder farms if legumes are included in cropping systems. Legume cropping systems increased maize yield by 20-41% over continuous maize except when pigeonpea was ratooned and intercropped with maize. The benefits were higher (40-68%) when legumes were combined with a small amount of inorganic fertilizer (0.25 of the recommended N rate) as compared to legumes systems alone. Maize yields were significantly higher following sole groundnut, groundnut+pigeonpea and sole pigeonpea than other cropping systems except maize with 92 kg N ha^{-1}. Ratooned pigeon pea reduced maize yield due to shading effects. It should also be noted that legume performance and biomass production in previous year (2007/08 season) was affected by inadequate rainfall. A key finding which is being disseminated through engagement with policymakers is that N-fertilizer equivalency from maize-legume rotation ranged from 0 to 31 kg N/ha; and in the integrated soil fertility management system maize plus 24 kg of N fertilizer the pigeonpea +groundnut rotation improved fertilizer efficiency by over 100% compared to sole cropped, continuous maize

Agronomic performance of technologies and farmers' preference: Groundnut/maize rotations optimized agronomic N inputs and grain production (Fig 5). However, farmers preference was for technologies that provide multiple benefits and not yield and soil

fertility alone. The top three technologies for wider adoption ranked in order of preference were GNPP/MZ, PP/MZ and MZ/MZ rotation.

Participatory on farm trials/demonstrations, Mkanakhoti EPA, Kasungu District, Central Malawi

1.Austin Phiri, first MSc student

Like in Ekwendeni, the participatory on farm trials/demonstrations in Kasungu were preceded by a baseline survey in order to identify preferred legumes, cropping systems and characterize soils. The baseline survey revealed that the major legumes grown in the area include soybeans, common beans and groundnuts which are widely grown for food and sale. These legumes are grown in pure stands. In general farmers of the Kasungu study area have been found to prefer legumes that are edible, early maturing, high yielding, soil fertility improving and resistant to pests and diseases.

On the strength of the above background knowledge, a participatory technology development approach involving Community Agriculture Workers was used to identify Legume Best Bets for the Kasungu study area. From this approach groundnut and pigeon pea were identified as having the potential for legume best bets technology testing.

The Master's student (Austin Phiri), conducted field trials during the 2007/2008 growing season, working with the Malawi Local Enterprise Zone Association (MALEZA) educators and farmers. The 'mother-baby' approach was used. Ten farmers were involved in the mother trial research and were treated as replicates.

The overall objective of his trial was to improve soil nitrogen and phosphorous using regume residues from groundnut and pigeonpea, applied singly or in combination, with or without Tunduru Rock Phosphate (TRP). A maize variety (ZM 621) was used as a test crop. Eleven treatments were imposed on each mother trial. Of the eleven treatments, one plot of Maize received 92 kg N per hectare using urea as a source of N while another plot did not receive anything to serve as a control. In the second year all plots except the

control received half rate (46 kg N/ha). The Nitrogen fertilized treatment received full rate (92 kg N/ha).

The second year results of this trial confirmed the findings from Ekwendeni that a doubled up technology has potential to give yields of comparable magnitude to inorganic fertilizer. Maize grain yield from the doubled up (pigeon pea + groundnut) plot which was top dressed with 46 kg N/Ha averaged 1321 kg/ha which is comparable to the 1,327 kg/ha obtained from the plot that received a full complement (92 kg N/Ha) of nitrogen from urea fertilizer. It is also interesting to note that those treatments that received Tundulu Rock Phosphate the previous year benefited from this rock. For example, maize yields from the Maize plus TRP and Maize plus Pigeon pea plus TRP yielded 1399, and 1472 kg/ha, respectively. Soils of the Kasungu study area are generally severely depleted of soil nitrogen and phosphorous and hence maize response to added N and P. As has been reported from the previous studies in the same area the maize yield from the control was below 1 ton per hectare.

Initially, baby trials were established with 24 farmers in the study area, expanded to 100 baby trials in 2008/09. Farmers selected up to 5 treatments to manage: intercropping pigeon pea, groundnut and maize and application of leaf biomass, TRP and UREA in different combinations, where the primary cropping systems of interest to farmers were the doubled up legumes and pigeonpea intercrops, as described below. This interest was based in large part on the observations of farmers who visited Ekwendeni and saw legume 'best bet' options there.

Baby Trials were based around the treatments of most interest to farmers: 1) Maize only (Control), 2) Maize + Urea fertilizer at 92 Kg N/ha (recommended rate), 3) Maize + *Pigeonpea* intercrop at 92 Kg N/ha, 4) *Pigeonpea + groundnut doubled up legume intercrop and* 5) Maize + *groundnut intercrop.*

The data was collected at mid- and end of the growing season, plant samples for maize and ground nut during tasselling/podding stages and harvesting (analysed for N, P, K); stand count at harvest; average cob length; cob, grain, stover, groundnut haulms' and

unshelled groundnut dry weight in a net plot. Data analysis is in progress and a summary of results to date are presented below.

2. Keston Njira, second MSc Student

Another MSc student (Keston Njira) is also studying under the same Mc Knight Best Bets project in Mkanakhothi EPA, Kasungu. His key research question is to compare whether sole cropped and doubled-up legume technologies fix significantly different amounts of N and to investigate the effect of cropping systems on legume crop yields and subsequent maize yields. On-farm trials were conducted on 15 farmers' fields in the 2008/09 cropping season. The main objective was to evaluate the effect of sole and doubled-up technologies on biological nitrogen fixation and crop yields. The treatments included sole cropped soybean, groundnuts and pigeon pea and legume-legume (doubled-up) intercrops of pigeon pea with soybean and pigeon pea with groundnuts. Control treatments were of unfertilized maize and maize with recommended full rate of nitrogen fertilizer (92 kg N ha^{-1}). A list of the 2008/09 treatments and results are shown in Table 3 and 4. The trials were continued for the second season (2009/10) with the main objective of evaluating the legume residual effects of the sole and doubled-up legumes on subsequent maize yields.

Legume residual effects on subsequent maize grain yields

There were significant differences ($p<0.09$) in maize grain yield as influenced by the residues incorporated. These are residues of the preceding crop in a given plot. Maize with zero fertilizer application produced 854 kg ha^{-1} that was significantly lower than all treatments that included legumes in the previous season and all treatments that received fertilizer N supplement. The treatment that included sole groundnut residues and received a supplement of 46 kg N ha^{-1} produced the highest maize grain yield (2126 kg ha^{-1}). There were no significant differences between maize grain yields produced by the doubled-up legume system and sole crop legume system though grain yields were slightly lower in the double-up legume system. Pigeon pea plus soybean system with 23 kg N ha^{-1} and 46 kg N ha^{-1} fertilizer N supplements produced 1697 kg ha^{-1} and 1711 kg ha^{-1} maize grain respectively. Pigeon pea plus groundnuts system with 23 kg N ha^{-1} and 46 kg N ha^{-1} fertilizer N supplements produced 1506 kg ha^{-1} and 1488 kg ha^{-1} maize grain

respectively. Sole inoculated soybean system with 23kg N ha^{-1} and 46kg N ha^{-1} fertilizer N supplements produced 1935 kg ha^{-1} and 1875 kg ha^{-1} maize grain respectively. Sole ground nuts system with 23 kg N ha^{-1} and 46kg N ha^{-1} fertilizer N supplements produced 1978 kg ha^{-1} and 2126 kg ha^{-1}. Sole pigeon pea system with 23kg N ha^{-1} and 46 kg N ha^{-1} fertilizer N supplements produced 1780 kg ha^{-1} and 1703 kg ha^{-1}. The slightly lower yields in the doubled systems could be attributed the effect of termites that were observed to be affecting these plots more especially during the dry spells that were very prevalent within the cropping season. Termites could be thought of getting attracted to these plots as they were having more residues than the rest. There were no significant differences between 92 kg N ha^{-1} and 46 kg ha N ha^{-1} maize systems and different legume-maize rotations with fertilizer N as illustrated in figure 7. There were also no significant differences between different rates of inorganic fertilizer N within each system. This could be attributed to reduced effect of the Urea fertilizer due to volatilization that was induced by the frequent dry spells. Hence N derived from organic matter might have a larger effect. All treatments that included ratooned pigeon pea were affected by the growth of pigeon pea that offered competition to the maize as observed during field monitoring and harvesting.

Total dry matter yield as influenced by type of residues incorporated and fertilizer N rates

There were no significant differences ($p<0.09$) in total maize dry matter yield of sole, doubled-up and maize plus 92 kg N ha^{-1} inorganic fertilizer regardless of the rate of fertilizer supplements to the systems. This indicates that the inorganic fertilizer did not have large effect. It could be noted that the lowest total dry matter yield of 2371 kg was obtained in the maize plus zero N system and was significantly lower than in any of the systems. Maize plus zero N system with a supplement of 23 kg N ha^{-1} was significantly lower than the sole and doubled-up legume systems with the same supplement of 23 kg N ha^{-1}. This could be due to the type of preceding crop residues. The maize tissue nitrogen % in these systems was lower than that of legumes and maize with 92 kg N ha^{-1} (see Table 4). Nandwa et. al., (1995) reported that crop residues of low quality that is less than 2% nitrogen result in poor growth of the succeeding cereal since N requirements of

the crop is not in synchrony with N mineralization. Higher total dry matter yields were obtained from maize plus 92 kg N ha^{-1}, maize plus 46 kg N ha^{-1}, groundnut residues plus 46 kg N ha^{-1}, groundnut residues plus 23 kg N ha^{-1}, inoculated soybean residues plus 23kg N ha^{-1} and inoculated soybean residues plus 46 kg N ha^{-1} that produced 5364 kg ha^{-1}, 5537 kg ha^{-1}, 5131 kg ha^{-1}, 5386 kg ha^{-1} and 5315 kg ha^{-1} respectively.

Implications of the research findings

- Farmer characterization formed a basis for socio-economic studies where labour and policy issues are being addressed by a sister project
- Quantity of inorganic fertilizers required per unit area reduced by 50%
- Technologies for scaling up to new agro-ecologies such as Ntcheu identified
- Legume based cropping systems should be promoted to optimize grain and calorie production under the low yielding environments faced by a majority of smallholder farmers.
- Cropping systems for wider adoption should provide multiple ecosystem services rather than yield only.
- Modeling effects of climate change on performance of diversified legume based cropping systems.
- The government and non-governmental organizations should look into strategies to increase access to legume seed and inorganic phosphate fertilizers by the small holder farmers. This can increase N fixation by legumes and associated positive effects on soil fertility and maize yield.
- Legume based cropping systems should be promoted among smallholder farmers for sustainable cropping systems

Participatory On farm trials by the Soils, Food and Healthy Communities project, Ekwendeni Mission Hospital, Ekwendeni Northern Malawi

Objective 1: Determine sets of characteristics of Best Bet, legumes and legume combinations which address nutritional and soil requirements

Activity 1.1.1: Field trials on legume based cropping systems

There were 26 baby trials and 22 mother trials. The baby trials were managed by farmers themselves, Some farmers planted the legumes on sole plots while others intercropped. Each farmer had different designs and different plot size because they had different objectives . This means they also had different planting patterns .

Some of the differences among the farmers baby trials plots were:

a) Planting more seeds (3-5 seeds / planting station: These seeds were planted like that because farmers thought that they can harvest more within a small plot if they can plant more seeds. Planting stations were also irregular within the plots

Results: Where farmers planted more seeds of legumes they only managed get the biomass and not yield as expected when compared with the 10cm spacing / planting station.

*Intercropping***:** Some intercropped with other crops like maize, ground nuts.

It was seen that soya bean grew well in terms of the leaf size and colour but farmers did not harvest as expected.

Lessons learnt from the baby trials

- Trials managed by farmers also need some input from extension staff because the way farmers managed their plots was not adequate, because the trials were taken as normal, they did not priotize because management was poor.
- Despite the poor management farmers have learnt that they can have high yields and quality seed with good spacing than congesting the plants.

- From the mother trial farmers have learnt a lot than in baby trials because on the mother trials there was a long period of time for them to observe the results, and the farmers have seen soil fertility improvement on their plots where mother trials were planted

Objective 2: Promote Best Bet Legumes in Diet to Improve Household Food Security and Nutrition, SFHC project, Ekwendeni Mission Hospital

Activity 2.2.3 Demonstrations of legume use to families
Eight recipe days were demonstrated in this reporting period in 5 areas (32 villages within the catchment. The areas are; Engcongolweni, Enyezini, Kaluhoro, Chisangano and Edundu (new project area).In both areas the demonstrations involved preparation of the following; soya meat, soya milk, beans meat, pumpkin flower meat, green soya snack, soya cake, fresh banana/ cassava futali, soya coffee (just to mention a few)

These recipe demonstrations were done during the pre-harvest and post harvest period thus within the months of February, and in August and September 2010.
The aim of the recipe demonstrations was to train farmers on how to process and utilize different locally available foods, and how to make them nutritious using local resources, and how they can diversify them in their day to day diets.
Different recipes were also demonstrated during the field days that were conducted.

Attendance was as follows:

Area	**Men**	**women**	**Children**	**Totals**
Encongolweni	24	33	0	57
Encongolweni	18	27	7	52
Kaluhoro	76	90	63	229
Edundu	107	114	59	280
Totals	450	528	129	1107
			Totals	**1725**

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Activity 2.2.2:
Conduct Field days
Two field days were conducted in Ekwendeni in the month of March, 2010. The areas where these field days took place were; Enyezini farmers visited legume best fields to see the impact of doubled up legumes in the soils, Kaluholo and Luhomero
The objective of the field days was to show farmers how they can improve their soils using doubled up legume and how they can also improve their diets using different legumes , because farmers also displayed different meals prepared from different legumes, and farmers were also taken to different fields in Kaluholo where they saw sorghum, cassava and cowpea fields as a way of adapting to climate change.

Attendance during field days

Area	Men	Women	Children	Totals

Kaluholo	76	90	63	229
Enyezini	107	114	59	280
Luhomero	204	196	122	522

b. Recipe training materials

1500 leaflets for recipes have been developed, in three languages (Tumbuka, English and Chichewa) have been produced which explains procedures on how to prepare different meals and snacks from local food crops grown in most parts of Malawi., the major focus is on Soya bean processing because it's the one that has really performed wonders in improving child nutrition . The leaflet s will be kept updated all the time new things come in.

The aim of the leaflets is to extend the knowledge of how to process and utilize soya bean to other farmers who haven't been exposed to such trainings in order to improve nutrition and food security at household level by using local resources available.

The leaflet was designed and produced by Soils, Food and Healthy communities project (SFHC) staff and project participating farmers (The Nutrition Research Team [NRT] and Farmers Research Team [FRT) of Ekwendeni in collaboration with Bunda College of Agriculture, with the support from Mc Knight Foundation CCRP.

c. FIELD DAYS

Two field days were conducted in Ekwendeni in the month of March, 2010. The areas which hosted the field day were Kaluhoro and Edundu. The dates were 23rd March and 25th respectively.

The objective of this year's field days was to show how farmers can adapt climate change through drought tolerant crops like legumes (Cowpea, gnuts, soybeans, common beans) and others like sorghum, cassava sweet potatoes, some early maturing maize varieties and other cereals. The occasion was spiced with recipe preparations and aroused much interest to the people so that other neighboring communities are demanding the project to extend to their areas.

Attendance

AREA	MEN	WOMEN	CHILDREN	TOTAL
Kaluhoro	76	90	63	229
Edundu	107	114	59	280
TOTALS	183	204	122	509

d. Activity 2.2.: Farmer Exchange Visits

About 10 people participating in McKnight best bet trials went to the central region (Kasungu and Lilongwe) to see and learn what their fellow farmers are doing.

The farmers started by viewing field crops at Bunda research station. Farmers learnt that research at Bunda aims at answering the farmers question pertaining to farmers need

especially on improving production of legumes and cereals, and issues of soil infertility. Different treatments were shown to farmers so that they can choose what to do at household level. Livestock like cattle, goats, pigs are some of the animals kept at Bunda and their different breeds. Aquaculture was not left out. Fish breeds, feeds, dams and nets of different types were among the information shared.

Farmers were also taken to SAFI (School of Agriculture for family independence) farmers here wanted to learn more but there was limited time. Farmers learnt that it is good to train both the husband and wife at household level because each one of them is aware of the different technologies and the can easily make some developments at household level. At SAFI farmers are trained to live independently on farming. During training farmers are given a house to live with family and classes are attended by husband and wife in the same way. This is so to equip the family with equal knowledge in case one dies, the other shouldn't suffer. Trainees are also provided with land and farm inputs. After two years they graduate and go back home.

At Simulemba, different innovations are practiced to improve soil fertility through legumes and composting. Amounts of fertilizer applied were also treated differently to demonstrate reduction of fertilizer costs through use of legumes. Each farmer held more than ten plots. Some had maize applied with composite manure, sole legumes, pigeon pea intercropped with either groundnuts or soya beans, maize applied with top dressing fertilizers only etc. Maize plots were treated with ½ or ¼ dose of chemical fertilizer where legumes were planted the previous year or manure applied.

2.6 Objective 3: Quantify the effect of legumes on soil P, N organic matter and yield of subsequent crops

Summary of research trials conducted in 2008/9, to test soil nutrient enrichment in addition to on-farm demonstrations.

Ekwendeni Research Trials – 20 trials sited on low and high fertility soils (10 of each)

1. Maize sole cropped

2. Maize intercropped with Pigeonpea
3. Maize sole cropped after doubled up legume technologies

Nitrogen fixation by natural abundance method (maize as reference plant) tissue is being ground, analyzed, and nutrient budgets are underway.

Kasungu Trials – 10 `mother` trials;

1. Maize sole cropped
2. Maize intercropped with Pigeonpea (Cajanus cajan)
3. Pigeonpea sole cropped

Kasungu - 50 `baby` trials:

1. Maize only
2. Maize + N fertilizer
3. Legume intercrop (Farmers choose Maize intercropped with Pigeon pea or Pigeonpea intercropped with Groundnut)
4. Maize + compost manure*

* Compost to be included in Baby trials where available on-farm (10+ farmers)
'Mother' trials have the complete set of treatments.
'Baby trials': Farmers have 10m x 10m plots with up to 4 treatments.
All systems were planted to maize in year 2 of the trial
Maize planting stations 0.9 m planting station, 3 plants per station

Soil samples were collected from baseline survey transects, and from farmers' fields in the on-farm trials underway in Ekwendeni and Kasungu. Soil analyses are underway as part of Keston Njira's MS thesis research, and for Wezi Mhango's dissertation. Initial results are shown in the appendix.

Composite soil samples from 0-15cm and 15-30 cm depths were collected for analysis of soil properties. Soils are being analyzed in the laboratory for N, P, K, Fe, Organic Carbon, Mg, Ca and pH. In the field 'soil test kit' information was conducted with farmers to provide a rapid assessment and immediate feedback, which will be followed up by the laboratory results. Initial assessment included soil pH using Hellige TRUOG pH tester and texture using the feel method were done insitu in a participatory manner with farmers. Verification will include using lab tests at Bunda College.

2.7 Objective 4: Strengthen farmer, Research, Extension and NGO capacity in Legume production and Utilization including Gender Issues

Capacity building/training

In addition to the research trials described above, 40 baby trials were carried out in Ekwendeni and 100 baby trials in Kasungu, included farmer research group designed experimentation primarily with different combinations of soybean and pigeonpea with maize. These will be surveyed, farmer assessment and knowledge gained documented in 2009/2010.

2.7.1 Field day and farmer exchange visits and demonstrations on legume soil fertility technologies and crop residue incorporation training. The FRT members and SFHC staff carried out this activity in each to promote crop residue incorporation. Farmers met in a central location and FRT members demonstrated how to bury crop residues and its role in soil fertility.

2.7.2 MSc and PhD students at Bunda College and MSU

Austin Phiri successfully defended his MSc thesis on Friday, June 26, 2009 and graduated from the University of Malawi on 10 September, 2009. He is now working as a research scientist in agro-forestry at Chtedze Research Station in the Ministry of Agriculture and food Security. Wezi Mhango (PhD candidate at MSU) defended her dissertation and is currently finalizing formatting requirements before submission of dissertation to the Graduate School Keston Njira has submitted his thesis to major supervisor is after Austin Phiri, studying at Bunda College, University of Malawi. All students have shown rapid progress in their academic studies.

2.8 Key Outcomes of the Best bet project over three years

1. Legume technologies identified for scaling up and out, and knowledge on these legumes disseminated through extension materials, farmer-to-farmer and training of extension and NGO staff.
2. The doubled up legume technology (pigeonpea intercropped with soybean or groundnut, then rotated with maize) has shown itself superior in terms of multiple crops produced per land and labor invested, and in terms of improving fertilizer efficiency by 30 kg of N per ha (equivalent to an additional bag of fertilizer).

3. Improved capacity of farmers to adopt, manage and use legume and compost technologies. Over 9000 farm families have been reached in Ekwendeni, and over a thousand in Kasungu. The project has strengthened the capacity of farmer leaders to carry out research including designing their own experiments.
4. Enhanced incorporation of legumes in local diets in Ekwendeni and Kasungu, including understanding of nutrition benefits among farm families
5. Effect of legumes and intercrop combinations determined on soil OM fractions and biological nitrogen fixation
6. Three students trained to PhD and MS level, strengthening Univ of Malawi and Ministry of Agriculture, Chitedze Research Station (in progress)
7. Publications on preferred legume traits; N fixation of legume-legume vs legume-cereal intercrops; maize response to legume cropping systems (1 journal article and two chapters published, three papers presented, one thesis completed, and two additional journal papers in progress)
8. Integrated soil fertilizer management technologies identified, including quantifying on-farm the N equivalency of legume systems and increase in fertilizer efficiency, information presented to Malawi policymakers and subsidy program expanding legume access due to fertilizer efficiency implications. Policy briefing papers are in preparation.

2.9 Implications for future development activities

Promising best bet legume technologies have been identified, notably the doubled up grain legumes, that show potential for candidates for scaling up to other smallholder farmers especially in areas of similar agro ecologies. The Farmers Union of Malawi, which is collaborating in this project, and technical advice to the government subsidy program are expected to play crucial roles in scaling up the “best bet” technologies by promoting farmer access to pigeonpeas, soybean and groundnuts around the country. The project is working closely with the Ministry of Agriculture and Food Security (MoAFS) to ensure commitment and sustainability. MoAFS has indicated interest in piloting the FROT approach for selected technologies including soil fertility and nutrition, for

example in each Extension Planning Area (EPA) in Kasungu Agricultural Development Division (ADD).

- A number of extension materials have been produced by project staff on legume best bet agronomy by Bunda College, by MALEZA on composting, and by SFHC on legume recipes. These were produced in several local languages to be understood by farmers and researchers, and were reviewed with a wide range of partners – including NGOs and farmer research groups - and the information revised based on comments and incorporating research findings, then disseminated widely.
- It is envisaged that those best bets that show potential for adoption will be candidates for scaling up to other smallholder farmers especially in those areas of similar agro ecologies. SFHC and MALEZA, which are collaborating in this project, are expected to play a crucial role in scaling up the "best bet" technologies in their mandated areas of Ekwendeni (Northern Region) and Kalulma, Kasungu (Central Region).

2.10 Implications for policy

- Research findings on farmer preferences for the 'doubled-up' pigeon pea/groundnut legume technology and the maize/pigeonpea intercrop by farmers indicate the importance of legumes in people's livelihoods. A supportive policy environment is needed to promote the technologies and improve availability and access to seed inputs. A policy workshop is one way we will start the process of engaging with policymakers in Malawi in 2008-09 regarding best bet legume technologies, where we will invite collegues in Extension, Ministry of Agriculture, NASFAM, Farmers Union and others.
- **Legume seeds have now been included in the 'flexible voucher' distributed to up to 1 million farmers to purchase seed.** The best bets project team will continue efforts to engage in dialogue and provide technical input working with the Ministry of Agriculture, Ministry of Finance and seed companies through the Input Task Force on varieties, location and the seed subsidy.
- Inorganic fertilizer landed in Malawi is currently priced at $1200 per tonne– this is now prohibitively expensive for the majority of smallholder farmers, unless in receipt

of a subsidy voucher. At the same time the Government is increasingly looking for options to reduced dependency on fertilizer as the subsidy scheme is becoming increasingly expensive to operate. Composting and legume residue management is being actively promoted by the Ministry of Agriculture in a number of districts including Kasungu, as well as by NGOs, as a means of improving soil structure and reducing requirements for inorganic fertiliser, as well as returns from small doses of fertilizer. Research by the project in the coming season on long-term impacts of technologies, including building soils to enhance fertilizer efficiency is **important in providing science-based information to inform policy on fertilizer alternatives, and on improving fertilizer efficiency** (which can make it more affordable).

3. TEAM REPORT

3.1 Team Activities

3.1.1 Stakeholders review meetings and field day activities

3.1.1.1 ISFM POLICY WORKSHOP : A policy workshop on integrated soil fertility management and seed systems in Malawi was organized. A report produced and distributed to stakeholders.

3.1.1.2 FIELD DAYS, FARMER EXCHANGE VISITS AND VISITS TO BUNDA COLLEGE OF AGRICULTURE AND DOWA SCHOOL OF AGRICULTURE FOR FAMILY INDEPENCE (SAFI) 11th -13th APRIL 2010

Background: Field days were conducted at Ndaya village, Mkanakhothi Extension Planning Area in Kasungu District, Central Malawi to disseminate sole and double-up legume techologies. A group of 10 representative farmers from Ekwendeni, Northern Malawi working with the Ekwendeni Soils Food and Healthy Communities (SFHC) project were invited to participate in preparation of various legume recipes. A group of 20 representative participating farmers, 10 from each of the Ekwendeni and Mkananakhothi sites were taken for a field visit at Bunda College of Agriculture to observe and learn more of growing of different legumes on a large scale. They had also a chance to interact with agricultural experts of different fields including agronomy, horticulture, nutrition, animal science and aquaculture and fisheries. On their way from Bunda College farmers had a chance to visit the School of Agriculture for Family Independence (SAFI) in Dowa district. At SAFI farmers learnt on how they can use agriculture to improve their livelihoods.

3.1.1.2.1 FIELD DAY AT MKANAKHOTHI, KASUNGU, CENTRAL MALAWI 12th -13th APRIL 2010

A field day was conducted on 13th April 2010 at Mkanakhothi EPA. A group of 10 farmers (4 women and 6 men) from Ekwendeni attended the field day. Farmers from the following villages: Chisazima, Tchezo, Kaunda, Chaguma and Ndaya in the Mkanakhothi EPA, Kasungu in attendance. The meeting was also attended by government officials from agricultural sector (Kasungu ADD), non-governmental organization representative, chiefs and other traditional leaders (Table 13)

3.1.1.2.2 On farm trials on sole and double legume technologies and maize response to legume cropping technologies

Fields of two farmers from Ndaya village were visited. Farmers and all other invited guests were accompanied by Prof. G. Y. Kanyama-Phiri and Keston Njira (MSc Student). The sole and doubled-up legume technologies included legumes that are sole cropped and pigeon pea grown in intercrops with soybean and groundnuts. Maize response to legume residual effects was one of the MSc student's research objectives for the second season. At the field each responsible farmer took lead in explaining all the cultural practices (Fig. 1 & 2) and all the benefits he/she is getting.

Comments and questions—Field days

a) Farmers noted that groundnuts/maize rotation is better than compost making mainly due to labour reasons.

b) Participants noted that inoculated soybean produced better residual effects on subsequent maize yields than un-inoculated soybean

c) Participants noted that residual benefits on maize from sole and double-up legumes produced better stands than maize from continuous maize monoculture system

d) Participants noted that there were no observable differences between maize crop stands with legume residues plus a top dressing of 23 kg N/ha and legume residues plus to dressing of 46 kg N/ha

e) Some farmers wanted to know the recommended plant population for soybeans

f) Officials from Ministry of Agriculture recommend that next time assessment of legume residual effect trials should include different plant patterns of maize especially the one being promoted popularly known as SASAKAWA (i.e. 1seed x 25cm x 75cm).

g)Farmers asked how can they access inoculants (Answer: through Research Stations, ADD but distance is a problem).

h) Farmers complained about termites damage on both maize and legumes and beetles damage on pigeon pea.

3.1.1.2.3 RECIPE HOUR

Farmers from both Ekwendeni and Kasungu participated in legume and other food stuffs recipe preparation and during the recipe hour where recipes were observed and tasted by participants. This was an opportunity for Kasungu farmers to show the skills they learnt from Ekwendeni farmers in the previous field days by demonstrating the products. Recipes prepared included soya milk, soya meat, soy coffee, ground nuts and soybean flour for seasoning cassava and bananas, green soybeans cooked for relish and groundnut flour for seasoning vegetables (Fig. 3).

3.1.1.2.4 VISIT TO BUNDA COLLEGE OF AGRICULTURE, 12th APRIL 2010

Groups of 20 farmers, 10 each from the Ekwendeni and Mkanakhothi sites were take to Bunda College of Agriculture to learn more about growing legumes on a large scale. At Bunda they were addressed by the Principal of the college, who thanked The PI of Legume Best Bets project, the organizer of field day for bringing farmers to an agricultural institution where they can gain knowledge of different agricultural fields including agronomy, horticulture, animal science, nutrition and aquaculture and fisheries (Fig. 4). The Principal emphasized that Bunda is a college for farmers. Farmers were then taken to research farms for various departments starting with that of the crop science (Fig.5).

Comments and questions

a)How many tones/ha of grain and biomass are produced from both monocrops and intercrops?

b) How much nitrogen is fixed by soybean and pigeon pea?

c) Farmers asked about the planting pattern especially for spaces left between pigeon pea and soybean (Answer: reduce competition resources between different crops).

3.1.1.2..5 Lessons learnt

a) Pigeon pea and soybean intercrop increases plant biomass for soil organic matter.

b) Pigeon pea establishes itself more after harvesting the other component crop.

c) Legumes can be an economic opportunity, although marketing remains a challenge and marketing outlets sporadic

d) Need to diversify farming activities for example they may consider a wider range of crops, aquaculture and mushroom production within their farming systems.