Feed the Future Innovation Lab for Collaborative Research on Grain Legumes

LEGUME INNOVATION LAB

2015 ANNUAL TECHNICAL PROGRESS REPORT
(October 1, 2014 – September 30, 2015)

Project Code and Title: SO2.1 - Farmer Decision Making Strategies for Improved Soil Fertility Management in Maize-Bean Production Systems

Lead U.S. Principal Investigator and University: Robert Mazur - Iowa State University

Collaborating Host Country and U.S. PIs and Institutions:
Moses Tenywa - Makerere University, Uganda
Richard Miiro - Makerere University, Uganda
Onesimus Semalulu - Soils & Agro-meteorology, National Agricultural Research Lab, Uganda
Ricardo Maria - Institute of Agriculture Research of Mozambique
Venâncio Salegua - Institute of Agriculture Research of Mozambique
Eric Abbott - Iowa State University
Andrew Lenssen - Iowa State University
Ebby Luvaga - Iowa State University
Russell Yost - University of Hawaii at Manoa
Julia Bello-Bravo - University of Illinois at Urbana- Champaign
Barry Pittendrigh - University of Illinois at Urbana-Champaign

I. Abstract of Research Achievements and Impacts

The team analyzed physical and chemical properties of black, red and stony soil samples from farmers' fields in study communities in key bean production districts in Uganda (Masaka and Rakai) and Mozambique (Gurué). Results guided nutrient omission studies which revealed effects of N, P, K, Mg, Ca, S, and micronutrients on bean plant growth and development; this was complemented with lime requirement studies. Researcher-managed field trials conducted during two seasons used farmer-preferred and researcher-selected bean varieties. Treatments included seeding density, weeding frequency, P, Ca, Mg, Rhizobia, organic fertilizer, and seed and foliar fungicides. Analyses of farmers' resource endowments and social capital guide how we facilitate learning through on-farm experiments and farmer-selected field trials and demonstrations. We are compiling and analyzing data on weekly market prices and marketing patterns. We developed an animated video useful to farmers and for our research in Mozambique comparing the efficacy of three training methods. We assist two emerging multistakeholder bean value chain innovation platforms in Masaka and Rakai districts which share interests, concerns and strategies to address bean productivity and marketing constraints. They participate in project research and training, and will be important in development, testing, disseminating and using our diagnostic and decision support aids.

II. Project Problem Statement and Justification

Poor soil fertility is a major factor in low bean yields in Uganda and Mozambique, important Feed the Future countries. Both countries have weak extension systems, limiting widespread access to information and materials that enable smallholder bean farmers to improve crop management practices, technologies and yields. This research project is based on two premises: (1) sustainable intensification of agriculture production requires improved soil fertility management in which legumes are an integral part of cropping systems and (2) effectively addressing soil-related constraints involves enhancing smallholder farmers' capabilities in diagnosing and finding solutions to yield constraints, as well as helping to remove barriers to increased access to various types of soil amendments.

Analyses of soil physical and chemical properties, combined with field trials, are revealing soil-specific effects of macro- and micronutrients on bean plant growth and development. Our documentation and analysis of farmers' cropping systems, practices and technologies – and their resource endowments, is essential for identification of strategies likely to be used to address key constraints.

Working with farmer groups and members of multistakeholder bean value chain innovation platforms enables us to engage producers in field experiments that test and demonstrate the impact of the most promising management practices and technologies for improved bean production, and helps researchers learn about critical social, economic, and cultural factors that impact crop management decisions. Our research approach is generating practical results; strengthening social cohesion; collectively transforming farmers' knowledge, beliefs and actions; and stimulating interest among other farmers in learning from trials and demonstrations.

The project team is developing appropriate aids (methods and procedures) that will enable smallholder farmers with varying levels of education to better diagnose soil-related production constraints, and to make improved site-specific crop system management decisions which contribute to higher productivity of beans and associated crops and, over time, to improved soil fertility. We are assessing the effectiveness of innovative communication approaches and technologies to engage farmers with diverse characteristics and other key stakeholders in widespread dissemination and adoption of diagnostic and decision support aids.

III. Technical Research Progress

Objective 1: Characterize Farmers' Practices, Problem Diagnoses and Solutions

Farming system parameters in Uganda and Mozambique have some features in common, but also some significant differences. It will be important to incorporate an understanding of this in our models of decision making. In Uganda, median farm size is 3 acres, with 0.5 acres in beans in both growing seasons. *Food security* crops are cassava (85%), beans (81%), maize (69%), sweet potatoes (53%), and bananas (41%). *Income crops* are beans (72%), maize (64%), coffee (42%), cassava (26%), and groundnuts (22%). In Mozambique, median farm size is much larger – 8.5 acres (3.5 hectares), with 1.7 acres (0.7 ha) in beans during the rainy season and 1.25 acres (0.5 ha) in the dry season. *Food security* crops are maize (100%), cassava (74%), beans (71%), sorghum (25%), and rice (18%). *Income crops* are beans (94%), maize (55%), cassava (35%), soybean (31%), and pigeon pea (22%).

In both countries, most (90%) farmers practice crop rotation in fields where beans are grown. Soil erosion problems are recognized by 70% of farmers in Uganda and 62% in Mozambique. Bean production constraints reflect different emphases in Uganda and Mozambique during the baseline survey in 2014. In Uganda, the major constraints – in descending order, are: heavy rains, pests, low soil fertility, insufficient labor, diseases, and lack of improved seed. In Mozambique, the most pressing problems are lack of improved seed, pests, insufficient labor, diseases and low soil fertility. Hiring labor is much more common in Uganda (45%) than in Mozambique (21%). Livestock are more common in Uganda (93%) compared to Mozambique (58%); in Uganda, the most common are chickens (83%), pigs (62%), goats (42%), and cattle (33%), while in Mozambique only chickens (56%) are common. In terms of well-being, food security is a more pervasive problem in Mozambique, with 32% of households having experienced times without enough food to eat during the four weeks preceding the survey, compared to 13% in Uganda.

Following our initial scientist-managed field experiments on farmers' fields with the most common soil types for bean production, our research team in Uganda has been actively engaging the wider community involved in all aspects of bean production and marketing. Multistakeholder bean Innovation Platforms (IPs) – comprised of farmers, input dealers, traders, credit institutions, and former extension agents – are developing in Masaka and Rakai. Goals for IPs include enhancing farmers' interaction, learning, information access and decision making. Through them, our research team is sharing information, experiences and ideas on how to improve the bean value chain, engaging members in the project's on-farm research trials and demonstrations that foster collaborative learning, providing training, and improving bean marketing practices. IP processes involve joint planning and activity coordination with other stakeholders in the districts.

This project-facilitated initiative is essential in Uganda, where district agricultural outreach is characterized by a shortage of personnel, training materials, and transportation, resulting in infrequent interaction with farmers. Technical support for farmers from government extension services is even more limited in Mozambique. The recent restructuring of Uganda's National Agriculture Advisory Services has further exacerbated the problem; all sub-county extension agents have been laid off. The new government program 'Operation Wealth Creation' involves the military in distributing seeds to farmers for priority crops, with no advanced training or advisory services. Externally funded projects and NGOs have central roles in providing extension services to farmers at the district level, but their funding, scope and lifespans are limited. Thus, initiating and strengthening local community members and organizations that comprise IPs are essential for meaningful and sustainable improvement in bean production and marketing. Many farmers use income from bean production to pay for their children's education and to invest in agriculture. Project training activities have covered IP management, leadership, governance - including team and partnership dynamics, and leveraging of common resources while meeting each other's interests in the IP. Social capital, in the form of membership in a farmer or development group, is much more common in Uganda (50%) compared to Mozambique (4%) based on the baseline survey in 2014.

Through the IPs, eight field trials approximately one acre in size have been established in Masaka (n=3) and Rakai districts (n=5). Farmers, extension workers, students and scientists have been involved in site selection and sampling of soils for the field trials by soil type, cropping and fertilizer use history and accessibility. Farmers freely provided the land and have been involved in setting up trials using an improved bean variety (NABE 17) with organic and inorganic fertilizers, management (weeding, spraying) and evaluation (field observations) of crop development at different stages. Men, women and youths were involved in setting up field experimentation trials. These trials serve as learning sites for approximately 30 neighboring farmers at each site. Inputs for each learning site including bean seed, poultry manure, inorganic fertilizers and extension support have been collectively financed and supported by members of the IP, including three non-profit organizations and the research project team. Development of IPs and their members' interactions with research team members have significantly increased farmers' interest in project research. Preliminary results from initial on-farm trials on the various soil types and tentative implications for improved soil management were shared with farmers during IP meetings in both districts. In Masaka district, farmers requested that another set of trials be run before recommendations can be fully considered and scaled out to other farmers.

The past year in Mozambique has deepened the research team's appreciation of soil-related dynamics. As reported last year, farmers locally considered to be 'innovative' in Mepuaguía identify three types of soils based on their color and by the crop typically planted on that soil that is likely to succeed: (1) Ekotchokwa is red soil, the dominant one at the summit of the terrain which is also found on the back slope; (2) Epupu is black soil, found in small patches at the summit; and (3) N'tchokwa is black soil in the basin. Red soils do not typically exist in the toe slope position; in field observations in June 2015 indicated there was significant evidence of red soil near toe slopes, almost certainly due to major erosive events that transported substantial amounts of soil from the back slope and possibly summit topographic positions with the extreme rains of early 2015 (major supply roads were cut due to bridge washouts). Farmers reported that on the red soils of the summit there is almost no crop grain yield when beans (*Phaseolus vulgaris* L.) are planted. Consequently, on such soils, cassava (*Manihot esculenta)* is planted and more recently pigeon pea (*Cajanus cajan*). This represents an opportunity for the project to illustrate that with appropriate crop and soil management beans can be grown on such positions. In the majority of our recent cropping experiments in Gurué, there is a near ubiquitous response of beans to the addition of nitrogenous fertilizers.

Pulses are usually grown on summit positions of the landscape. Farmers appear to be aware of the problems of erosion and tend not to plant food crops on backslope positions. The backslope may be sandy; if so, it is often planted with pineapple (*Ananus comosus*). The backslope may be comprised of the Ekotchokwa and Epupu soils. In the basin position (typically the N'tchokwa soils), rice is planted during the rainy season, November to February, in rotation with beans during the dry season. During the dry season the summit position soils may be in a relay cropping of maize and climbing bean (locally called 'antenna' bean) during the cold months of June and July. Rice straw is often burned prior to planting beans on N'tchokwa soils.

Objective 2: Develop and Refine Models of Smallholder Bean Farmers' Decision Making

Farmers are aware of the different types of soils, their physical properties and their productivity/suitability for different uses. They also know the rainfall patterns in their locations, but are less precisely aware of soil nutrients and pest and disease control regimes. They learn from fellow farmers, extension workers and researchers. Once a given practice is viewed as beneficial and affordable, an innovation's adoption or adaptation depends on its compatibility with their landscape and farming system, its relative advantage (local availability, benefit-cost analysis, multifunctionality), their ability to experiment with the practice, and their household resource endowment. Farmers generally understand the advantages of using good agronomic practices such as timely planting, line planting, fertilizer application, and pest and disease control regimes, and they are concerned with the costs and labor involved in using a given practice.

Upon completion of current on-farm trials and the participatory learning that is an integral part of our research, farmers will be able to decide which soil amendment inputs and practices to adopt or adapt for continued use according to soil type, farming system parameters, resource endowments, and their goals and priorities. Our ongoing analyses regarding farmers' assets (land, livestock, labor, tools, finance, etc.) will be instrumental in identifying differentiated strategies; our baseline household surveys covered 302 households in Uganda and 305 households in Mozambique. In-depth qualitative research in Uganda has revealed that farmers have adopted and adapted strategies to enhance productivity that are appropriate to their socioeconomic circumstances. Farmers constrained in terms of labor and credit access have adapted reciprocal labor sharing approaches as well as saving and borrowing money through village associations and 'merry-go-round' groups, respectively. Interventions targeted to such farmer adaptions will be important in promoting soil and water conservation practices such as timely weeding, planting, application of animal manure and complementing with inorganic fertilizers (Bwambale 2015).

Continued development and effective functioning of Innovation Platforms will be especially important as farmers improve their bean production and soil fertility management. Farmers in Uganda and Mozambique are interested in producing more beans for the market as an important source of income, but nearly all in Uganda (92%) and Mozambique (82%) cite low prices - usually at farm gate - as a major constraint; faulty weighing scales are also a serious problem. Nearly all households sell beans as individuals, with one-half selling at the farm gate. Households in Uganda obtain bean market price information primarily from traders (75%), though some contact fellow farmers (19%) or listen to the radio (14%). In Mozambique, the emphasis is somewhat different: traders (48%), fellow farmers (12%), and the radio (24%).

Arrangements for collective bean marketing linked to markets will be introduced to farmers via the IPs. Several IP members are preparing to train farmers about new market opportunities and how to access them. Arrangements are underway for IPs to formally register as cooperatives. Some IP members are preparing to conduct additional field trials with other bean seed varieties and farm inputs at their own cost, with participation of IP member farmers. IP members in Rakai have accessed improved bean seed from CEDO (Community Enterprises Development Organisation), paying back after harvest. CEDO has offered IP member farmers the opportunity to grow bean seed on a contract arrangement to expand the local supply of quality seed.

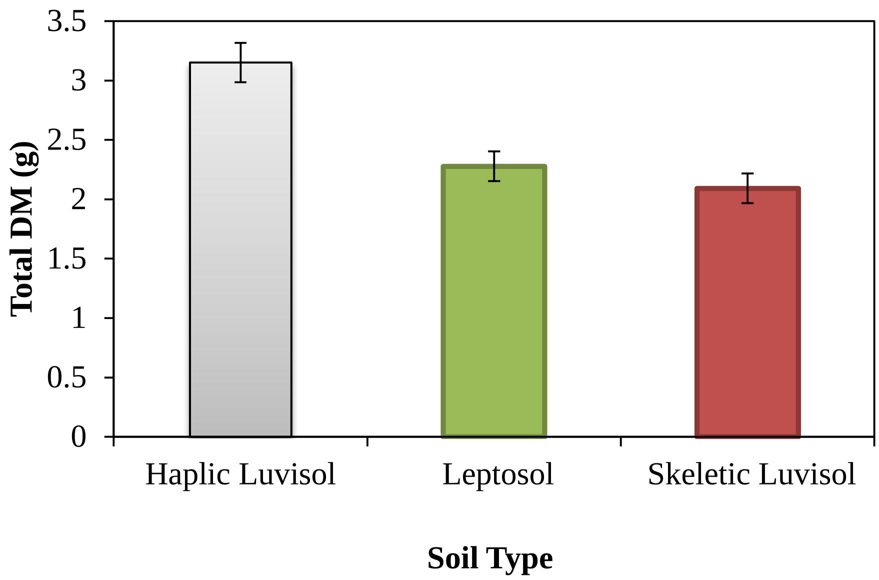
In Uganda and Mozambique, the project team is tracking bean prices in local and regional markets on a weekly basis. In Uganda, there are few resources to assist farmers in their marketing pursuits; the District Commercial Officers (DCOs) in Rakai and Masaka each have two staff responsible for 6 and 21 parishes, respectively, to oversee and provide training and support for marketing. DCOs lead weekly one hour radio programs on Radio BUDDU to provide information to farmers about a variety of relevant topics (agricultural management practices, expiration dates of agricultural chemicals, etc.). They also collect weekly commodity market prices which are posted on bulletin boards at sub-county level. We are analyzing baseline household survey data to understand the demographics, production assets and practices, marketing practices, etc. of farmers who received the highest prices for their marketed beans; we expect that this will help us identify strategies that other farmers might adopt or develop. Most farmers lack reliable storage capability and therefore sell their beans soon after harvest. Farmers greatly appreciated the training provided by project researchers in mid-2015 on anaerobic storage (triple bagging and jerry cans) which can allow them to safely store their beans as seed, grain for consumption, and marketing with minimal damage from pests.

District Agricultural officers and traders cited major challenges and constraints for farmers in production, quality control and marketing of beans. Farmers will benefit from training in seed quality and the importance of single variety beans, as well as in record keeping (production costs and sales). Increasing integration of capital-intensive inputs such as fertilizers, foliar spays, pesticides and fungicides into farmers cropping systems will require tracking the various costs and determining returns to investment. Such an approach will help us in developing recommendations that cater for heterogeneity in smallholders' resource endowments, particularly land size, livestock ownership and income. Further, in the absence of a vibrant extension service system, men do not consistently share information with women who are thus at risk of being 'left behind' in efforts to improve agricultural practices. Women are involved in most agricultural activities but with variable access and control of household resources and decision making. Women who attend agricultural training sessions are active, with some in leadership positions.

Objective 3: Develop and Validate Appropriate Diagnostic and Decision Support Aids

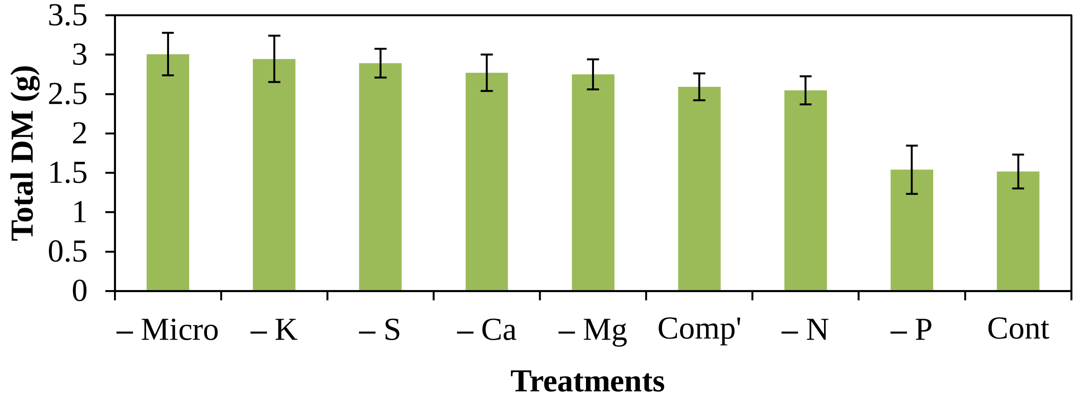
Uganda - The Nutrient Omission study conducted in Uganda found the main effects of soil and nutrient omission treatment were significant for aboveground biomass accumulation of common beans, but the interaction of soil × nutrient omission was not significant (throughout this section, 'significant' differences connote $p \leq 0.05$). Plants growing in Haplic Luvisol (*Liddugavu*) accumulated significantly higher biomass than plants grown in other soil types (Figure 1). Plants grown in Haplic Luvisol accumulated 27.7 % and 33.6 % greater aboveground biomass than those grown in Leptosol (*Luyinjayinja*) and Skeletic Luvisol (*Limufumyufu*) respectively. Although plants growing in Leptosol accumulated 8.2 % higher above ground biomass than plants growing in Skeletic Luvisol, the difference was not statistically significant (Figure 1).

Figure 1 *Mean aboveground biomass (g plant^{-1}) for common bean grown on three soils*



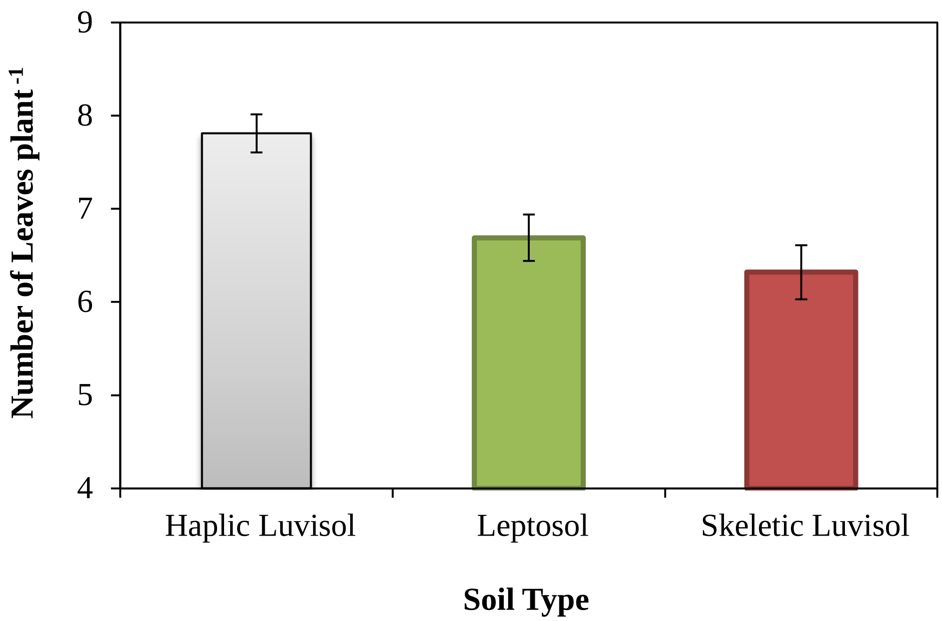
Across soil types, the 'all nutrients supplied' treatment had greater aboveground biomass than the 'phosphorus omission' and the unamended control (Figure 2). However, the 'all nutrients supplied' treatment was not different from all other omission treatments, indicating that phosphorus availability is a primary factor limiting common bean growth in predominant soils in Masaka. Beans grown in 'phosphorus omission' treatment accumulated 39.6% lower above ground biomass than those in the complete treatment. Beans grown in the control treatment accumulated 41.5% less aboveground biomass than the 'all nutrients supplied' treatment.

***Figure* 2** Mean aboveground biomass for nine fertility treatments in a nutrient omission study



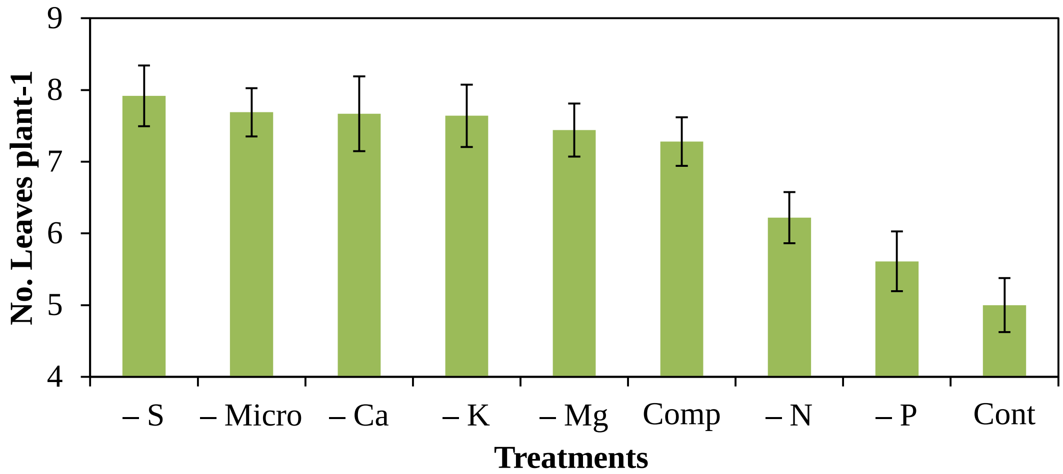
The Nutrient Omission study conducted in Uganda found that the main effects of soil and nutrient omission were significant for mean number of leaves per plant but the interaction of soil × nutrient omission treatment was not significant. Bean plants growing in Haplic Luvisol had more fully expanded leaves than plants grown in Skeletic Luvisol or Leptosol (Figure 3). Bean plants grown in Leptosol had a similar number of leaves to those grown in Skeletic Luvisol.

Figure 3 Mean number of fully expanded leaves per bean plant grown in three soil types



Bean plants grown in the 'all nutrients supplied' treatment had more fully expanded leaves than beans grown in the -P and -N treatment. Plants grown in the control (no nutrients added) treatment had the fewest number of fully expanded leaves, significantly fewer than the 'all nutrients supplied' plants (Figure 4). The number of fully expanded leaves in the 'all nutrients supplied' treatment was similar to that for the nutrient omission treatments for K, Ca, Mg, micronutrients, and S (Figure 4).

Figure 4 *Mean number of leaves per bean plant for nine nutrient treatments over three soils*



Our results demonstrate that the Haplic Luvisol has inherently greater fertility than the other two soils. Additionally, improved P and N availability likely will increase bean growth, development, and yield in the predominant soils in Masaka, Uganda.

We conducted a field study in Masaka District to determine whether an improved bean management system could significantly increase bean yield and profitability. The experimental design was a randomized complete block in a split-plot configuration. The main plot factor was three management systems; subplot factor was four bean varieties. Management systems (farmer management system, low-input, and high-input) differed for seed treatment (no vs. yes), seeding density (10 vs. 20 seed m^{-2}), plant configuration (broadcast vs. rows), liming (no vs. yes), fertilizer applications (P, K, Ca, Mg, Zn, and S), rhizobium inoculation (no vs. yes), pesticide applications (no vs. yes), and frequency and timing of weeding. Subplots were four popular varieties, the older varieties K132 (red mottled color and large seed size) and NABE 4 (red mottled color and medium seed size), and two newer varieties with improved resistance to common diseases, NABE 14 (red kidney color and large seed size) and NABE 15 (tan color and medium seed size). The study was conducted on two soil types. The black Liddugavu soil type was described as a Phaeozem using the FAO-UNESCO Soil Legend and as a Mollisols using USDA Soil Taxonomy. The red Limyufumyufu soil type was described as a Ferrosol using the FAO-UNESCO Soil Legend and as a Eutrudox using USDA Soil Taxonomy. Both soils had sandy clay loam texture. Specific fertilizer rates differed between sites due to fertility differences between soils. Farmers avoid planting bean on red soil if black soil is available due to the differences in fertility (Table 1).

Table 1 Post-harvest soil pH, available P, K, and Ca, organic matter, and base saturation from three common bean (*Phaseolus vulgaris* L.) management systems in two soils. Masaka District, Uganda, 2014

Property	FMS	Low-input	High-input
	Black Liddugavu		
pH	6.6	6.5	6.5
P ($mg\ kg^{-1}$)	27	32	27
K ($mg\ kg^{-1}$)	89	124	101
Ca ($mg\ kg^{-1}$)	1898	2058	1910
OM ($g\ kg^{-1}$)	39	34	36
Base Saturation	89	88	88
	Red Limyufumyufu		
pH	5.2^{b}	7.0^{a}	7.1^{a}
P ($mg\ kg^{-1}$)	4^{b}	15^{a}	19^{a}
K ($mg\ kg^{-1}$)	49^{b}	79^{a}	87^{a}
Ca ($mg\ kg^{-1}$)	785^{b}	3138^{a}	3603^{a}
OM ($g\ kg^{-1}$)	38	37	39
Base Saturation	54^{b}	94^{a}	95^{a}

Means within property and soil type followed by different letters are significantly different by protected LSD ($P<0.05$).

In 2014, management system and the management system × variety interaction were significant for bean yield on both black (Table 2) and red soil (Figure 5). On black soil in the low-input management system, NABE 4 (1475 kg ha^{-1}) produced greater yield than did NABE15 (1175 kg ha^{-1}) and K132 (1000 kg ha^{-1}) (Figure 6). Additionally, NABE 14 (1351 kg ha^{-1}) produced significantly greater yield than K132, the lowest yielding variety. Varieties did not differ for yield in the high-input management system on black soil. Averaged across varieties, beans grown on black soil under the high-input management system had seed yield of 1808 kg ha^{-1}, 98% greater than the farmer management system (FMS) which had yield of 912 kg ha^{-1}. The low-input and high-input management systems did not significantly differ in yield on black soil, producing 1238 kg ha^{-1} and 1808 kg ha^{-1}, respectively.

Table 2 Yield, yield components, and pod harvest index (PHI) for bean in three management systems and four varieties for two rainy seasons on Black Soil.[a]

Treatment	Plant stand R9 (# m^{-2})	Height (cm)	Pods (# m^{-2})	Seed (# pod^{-1})	Seed (mg $seed^{-1}$)	Biomass (g $plant^{-1}$)	Grain (kg ha^{-1})	PHI
Management System [b]								
CFS	8 b	29	40 b	2.9	425	21	593 b	76
IFS	17 a	31	67 ab	2.8	387	16	818 b	77
HIS	17 a	34	92 a	2.9	437	18	1275 a	75
Variety								
NABE 14	15 a	36 a	90 a	3.2	417 ab	22 a	1212 a	73 b
NABE 15	13 b	23 c	52 b	2.6	378 a	18 ab	668 c	81 a
K132	14 a	34 ab	62 b	2.8	431 b	17 b	803 bc	74 ab
NABE 4	14 a	32 b	63 b	2.9	439 b	16 b	899 b	76 a
Rainy season [c]								
2014L	13 b	38 a	91 a	3.3	445 a	27 a	1318 a	76
2015S	15 a	25 b	42 b	2.5	388 b	9 b	473 b	76
Significance				P > F				
System (S)	***	NS	*	NS	NS	NS	*	NS
Variety (V)	***	***	***	***	*	*	***	*
S × V	**	NS	NS	NS	NS	NS	NS	NS
Rainy season (R)	***	***	***	***	***	***	***	NS
S × R	NS	**	*	NS	NS	**	**	NS
V × R	**	**	***	***	NS	***	***	NS
S × V × R	NS	NS	*	NS	NS	NS	*	NS

[a] Means within treatment and column followed by the same letter , or no letter, are not different at P=0.05.
[b] CFS, Conventional Farmer System; IFS, Improved Farmer System; HIS, High Input System
[c] Rainy season: 2014L, long rainy season; 2015S, short rainy season.

Figure 5 The interaction of management system × variety × rainy season for (a) pod density and (b) grain yield of bean. Management systems include conventional farmer system (CFS), improved farmer system (IFS), and high input system (HIS) on Limyufumyufu (RED) soil

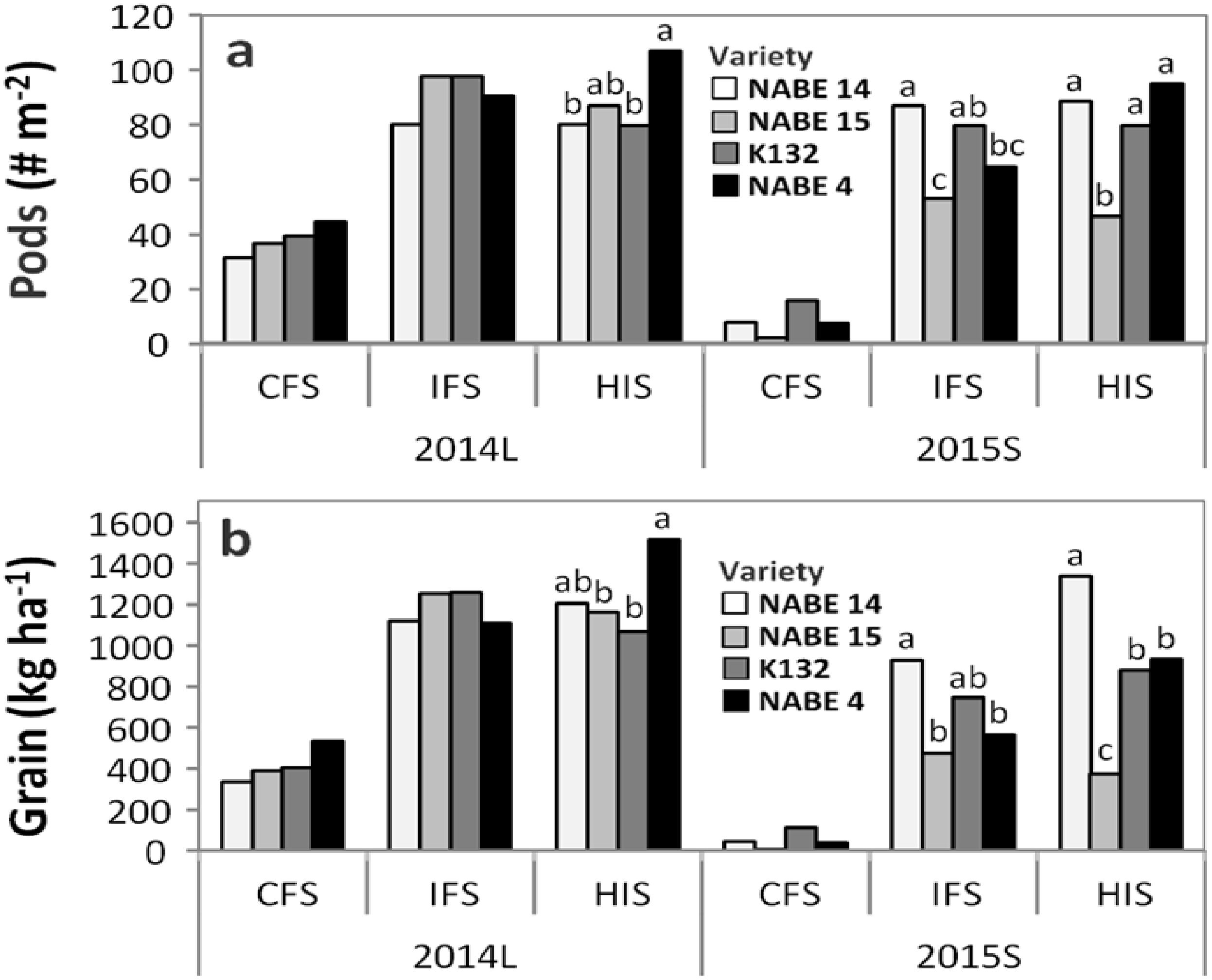
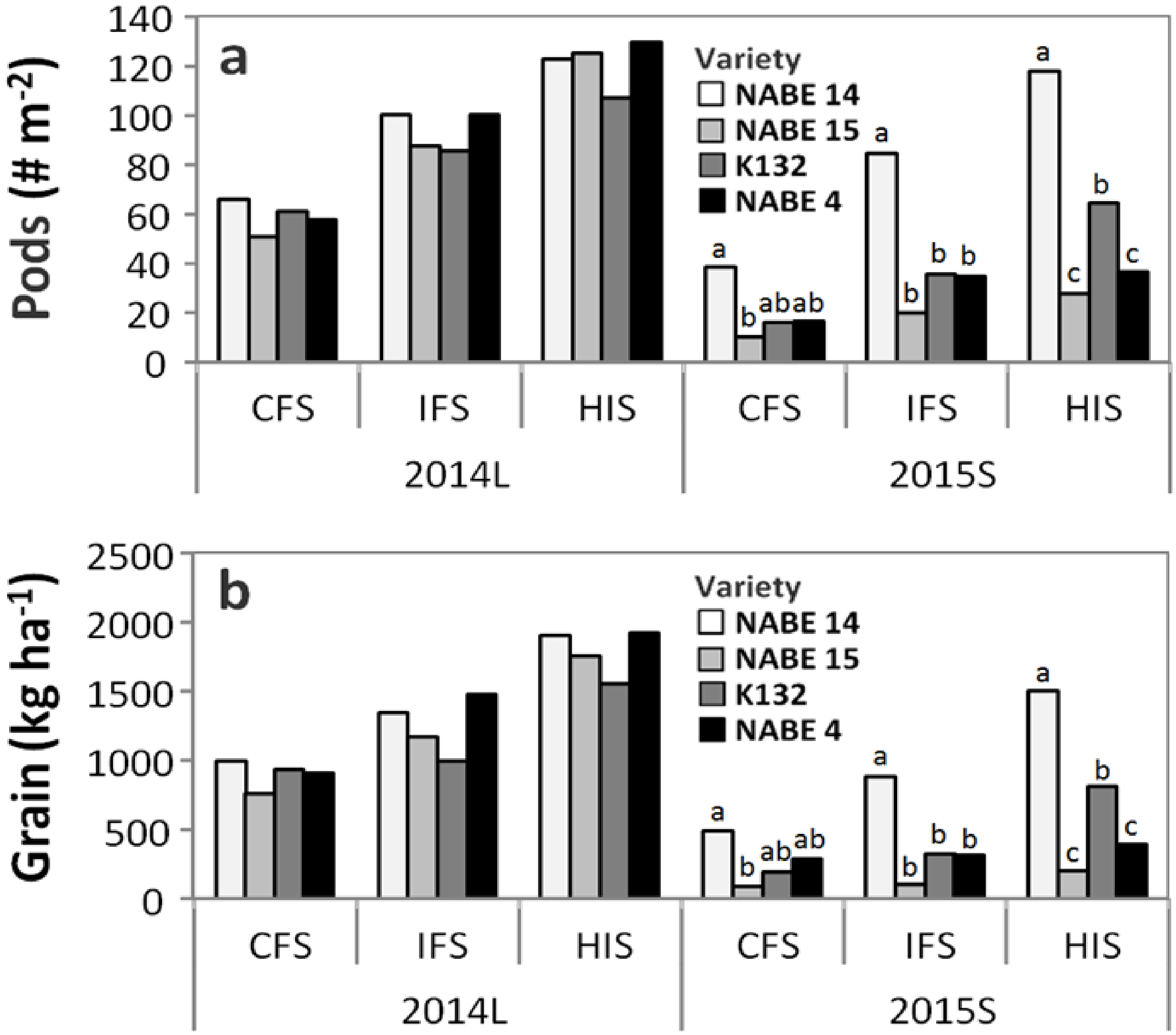


Figure 6 Interaction of management system × variety × rainy season for (a) pod density and (b) grain yield of bean. Management systems include conventional farmer system (CFS), improved farmer system (IFS), and high input system (HIS) on Liddugavu (BLACK) soil



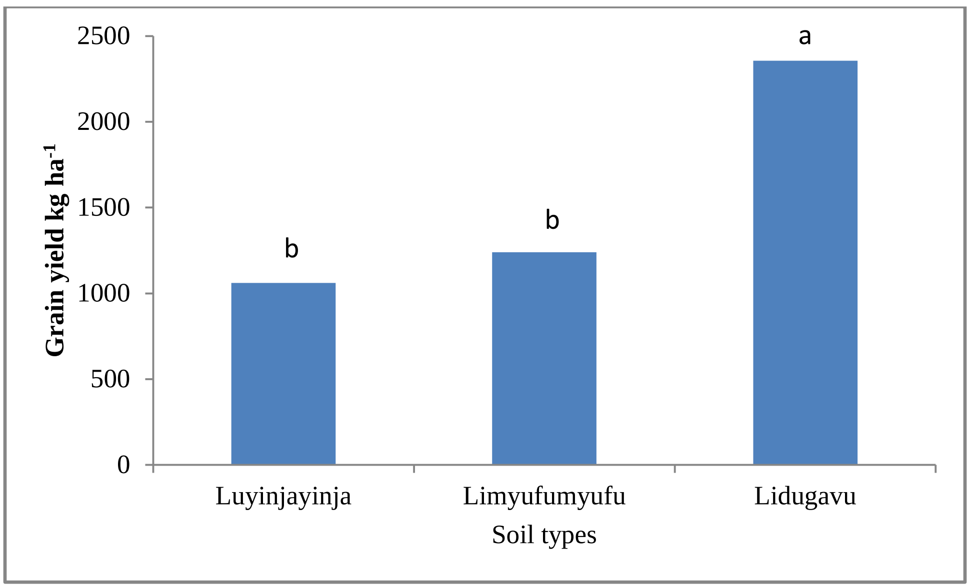
Conversely, on red soil, varieties did not differ for yield in the low-input management system. Averaged across varieties, beans grown on red soil under this system had seed yield of 1188 kg ha^{-1}, 184% greater than the FMS which had yield of 418 kg ha^{-1}. Bean varieties differed for yield in the high-input management system on red soil where NABE 4 (1516 kg ha^{-1}) produced significantly greater yields than NABE 15 (1163 kg ha^{-1}) and K132 (1068 kg ha^{-1}). Averaged across varieties, beans grown on red soil under the high-input management system had seed yield of 1238 kg ha^{-1}, 196% greater than the FMS which had yield of 418 kg ha^{-1}.

NABE 4 frequently produced significantly greater yields than the other bean varieties under the improved management systems. The high-input management system produced significantly greater yields than the FMS on black soil. Beans grown on red soil under either of the two improved management systems produced significantly greater yields than the FMS. After one rainy season of production, beans grown on black soil obtained the greatest profits by utilizing either of the two improved bean management systems compared to the FMS (results not presented). Conversely, beans grown on the red soils obtained the greatest profits under the FMS. On the red soil, beans grown on the improved management systems registered a net loss due to the need for greater amounts of expensive agricultural inputs to improve productivity.

Field studies to determine optimum combinations of organic and inorganic fertilizers for beans grown on three contrasting soils - black, red and gravelly - have been ongoing in Masaka since August 2014. Results to date over two seasons indicate a significant grain yield improvement following combined application of organic and inorganic fertilizers compared to either organic or inorganic application alone. These preliminary results will be compared with those during the 2015B season (Sept. - Dec.).

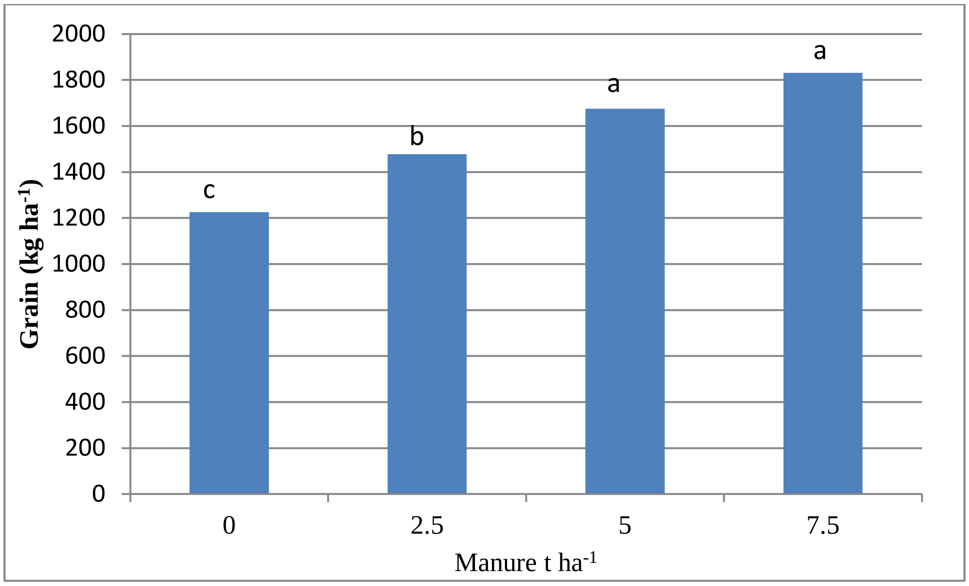
Bean (K131) grain yield for the 2014B rainy season varied for the main effects of soil type and manure rate; however, the interaction of soil type × manure rate was non-significant. Bean grain yield was greatest on Liddugavu soil (Figure 7). Yield of beans from Luyinjayinja and Limyufumyufu soils was similar.

Figure 7 Bean grain yields as affected by differences in soil types, 2014B season



Across the three soil types, bean yield was greatest for the 7.5 and 5.0 t ha^{-1} manure application rates (Figure 8) which averaged nearly 1800 kg ha^{-1}. The 2.5 t ha^{-1} manure application rate resulted in bean yield that was greater than the control where manure was not applied.

Figure 8 Effect of manure application on bean grain yields, 2014B season



For 2015A, main effects of soil type, manure, the two-way interaction of soil × manure, and four-way interaction of soil type × manure rate × N rate × P rate were significant for bean yield.

On the gravelly soil, application of 2.5 t manure ha^{-1} (with no N or P applied) increased bean grain yield but not significantly; increasing manure rate to 5 t ha^{-1} increased grain yield significantly over the control (Table 3). Application of 5 t manure ha^{-1} in presence of 15 kg N ha^{-1} and 15 kg P ha^{-1} resulted in a significant increase in beans grain yield over the control.

Table 3 Effect of N, P and manure application on the bean grain yield over three contrasting soils, 2015A season

Soil type	N (kgha^{-1})	P (kgha^{-1})	Manure (t ha^{-1}) 0	2.5	5
			Grain yield (kgha^{-1})		
Luyinjayinja (stony) soil (SkeleticLixicMollicUmbrisol)	0	0	2097	2851	3209
	0	7.5	2836	2426	2317
	0	15	2325	2488	2551
	7.5	0	2590	2664	2571
	7.5	7.5	2432	2577	2591
	7.5	15	2424	3100	2566
	15	0	3052	2676	2609
	15	7.5	2503	2535	2720
	15	15	2210	2086	3077
Lidugavu (black) soil (Cambic LuvicPhaeosem)	0	0	1920	2662	2306
	0	7.5	1605	2114	2590
	0	15	2273	2674	3251
	7.5	0	2271	2623	3136
	7.5	7.5	1715	3338	2708
	7.5	15	1947	2789	3121
	15	0	1943	3019	2516
	15	7.5	1914	3041	3019
	15	15	2005	3188	2582
Limyufumyufu (reddish) soil (EutricSideralicCambisol)	0	0	2080	2287	2307
	0	7.5	1488	2424	2091
	0	15	1739	1954	2296
	7.5	0	2191	2283	2072
	7.5	7.5	1921	1848	2159
	7.5	15	1580	1870	1974
	15	0	1926	2212	2568
	15	7.5	1736	1468	1914
	15	15	1903	2775	2020
LSD				**782.8**	
CV				**20.3**	

Bean yield from black soil responded to manure addition. Where manure was added at 5 t manure ha^{-1} but no N, application of 7.5 kg P ha^{-1} increased beans grain yield but not significantly; increasing the P rate to 15 kg ha^{-1} significantly increased bean grain yield over the control (Table 3). Application of 5 t manure ha^{-1} in presence of 7.5 kg N ha^{-1} but 0 P added, resulted in a significant grain yield increment over the control. Application of 2.5 t manure ha^{-1} in presence of 7.5 kg N ha^{-1} and 15 kg P ha^{-1} resulted in a significant increase in bean grain yield;

increasing the rate to 5 t manure ha^{-1} increased bean grain yield further, although not significantly from the 2.5 t manure ha^{-1} rate. At 15 kg N ha^{-1} and no P applied, grain yields increased significantly on addition of 2.5 t manure ha^{-1}. Similarly, at 15 kg N ha^{-1} and 7.5 kg P ha^{-1}, application of 2.5 t manure ha^{-1} on the black soil increased beans grain yield significantly over the control. A similar response to manure was observed on treatments with 15 kg N ha^{-1} and 15 kg P ha^{-1} on the black soil. On red soil, the combined application of 15 kg N ha^{-1} and 15 kg P ha^{-1} and 2.5 t manure ha^{-1} significantly increased bean grain yield over the 0 control treatment (Table 3).

Results from the field experiments show that combined application of organic and inorganic fertilizers is more beneficial than either of organic or inorganic fertilizer applied separately. The fertilizer must be applied at planting. Timely planting is crucial. In addition regular monitoring of pests on weekly basis is essential. Timely management activities such as weed control are needed for the recommended fertilizers rates to be effective.

Through the bean Innovation Platforms, farmers are validating the preliminary fertilizer recommendations on selected fields of their choice. A total of nine trial/demonstration plots, three in Masaka and six in Rakai, were set up starting 2015B season. The rest of the management practices such as spacing were based on the scientific recommendations. The demonstrations are managed by farmers themselves, with extension workers and researchers offering requested or necessary technical advice.

Mozambique – Soil acidity is a key limiting factor for crop production in highly weathered Oxisols of Gurué. Increasing crop yield with fertilizer use require soil amelioration and neutralization of potential acidity and hence improving nutrient availability. Soil samples were collected from paddy-rice production areas where beans are grown during the dry season following the rice harvest. Samples were analyzed for pH and color in the laboratory of IMAPEG (Instituto Medio Agropecúario de Gurué) in Gurué. The pH ranged from acidic (5.6-6.5) to very strongly acidic (4.5-5.5). Soil color, an indicator of soil quality, was measured with Munsell Soil-color charts (2009) in wet and dry samples. The color of wet samples color ranged from Dark Reddish Brown (5YR2, 5/2) to Black (5YR2, 5/1-5/2). When dry, the dominant colors are Brown (5YR4/4), Dark Brown (10YR 3/3) and Dark Yellow Brown (10 YR3/4-3/6). Further chemical and physical characterization will be conducted at IIAM’s soil and plant tissue lab in Maputo.

Based on preliminary soil analyses, an experiment was conducted to assess the effect of limestone in combination with fertilizer and inoculant on common bean yield using a randomized complete block design in a strip-plot treatment structure with fertilizer, lime or a combination in the main plot and inoculated versus uninoculated seed in strip-plots. Agronomic and phenological data were collected and are being analyzed. Pictures were taken using HD digital camera at vegetative stage, flowering, and harvest for developing visual diagnostic and decision aids.

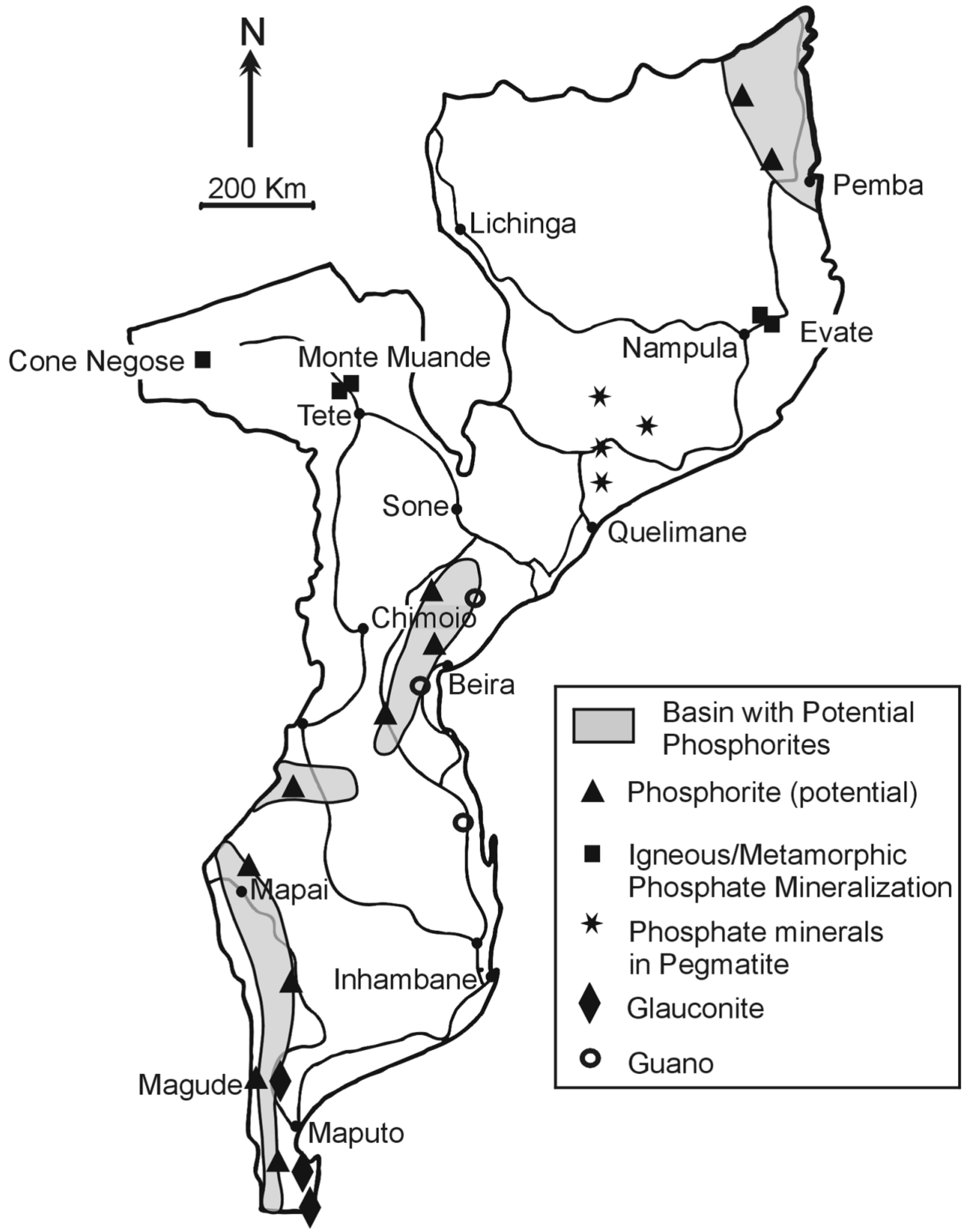
Soil fertility is a limiting factor for bean yield in Gurué exacerbated by a cyclic burning of rice straw after tilling the soil. It is generally known that P and K are the most limiting nutrients for bean production. To diagnose other limiting plant nutrients, an additional experiment was conducted on-farm in a paddy rice production system. A randomized complete block design with three replications was used in a split plot treatment structure. In one experiment, fertilizer applications were assigned to the main plot and two promising improved bean varieties were assigned to a sub-plot. An additional experiment with a local preferred bean variety was used with same experimental design. Tested plant nutrients were: control (no fertilizer added), PK, NK, NP, NPK, NPKS, NPKS+Zn + ZnB, and 7NPKS+ ZnB. Nutrients used were Urea, Diammonium Phosphate (DAP), SOP, triple superphosphate (TSP), Muriate of Potash (MOP), Zinc oxide and Borax at 30 kg N ha^{-1}, 34.5 kg P_2O_5 ha^{-1}, 24.0 kg K_2O ha^{-1}, 2.5 kg ZnO ha^{-1}, 0.5 kg B ha^{-1}. Agronomic and phenological data were collected and are being analyzed for diagnosing limiting plant nutrients and performing comparisons among treatments.

Pictures were taken in each treatment during vegetative growth, flowering and harvesting. For developing a decision aid and documenting differences in crop performance among treatments, photos were taken from horizontal, vertical positions and leaf at plot level for a single replicate. Vertical pictures will allow us to measure an index of canopy cover and leaf pictures will allow us to measure the greenness and leaf size for each given fertilizer use. A comprehensive database is being developed using MS Access as a project information management system for easy retrieval and future reference.

Soil fertility is declining due to continuous cultivation without nutrient replenishment through fertilization. Building more resilient production systems requires better understanding of farmers' constraints and opportunities for improving crop productivity. To understand farmers' perceptions about differences in crop performance for experiments and treatments, a two-day field day was organized in Mepuagíua. The aims of the field day were to: create awareness among farmers about soil fertility problems through differences in crop performance; compare and contrast crop responses in different soils; exchange ideas and views among farmers, researchers, agricultural college faculty members and students, and local community leaders; and identify research issues for future study. Approximately 60 participants attended the field day which was followed by a meeting with the community to review field observations and identify how to improve implementation of project activities. During the field day, it was evident that there is a lack of understanding among farmers about basic aspects of agro-ecosystem of bean production, including implications of plant density for pest management and crop productivity and cause and effect of different treatments on crop performance. Farmers considered the event a learning opportunity and recommended this kind of interaction in future project activities.

There are extensive deposits of high quality rock phosphate and limestone in Mozambique, both of which are typical major inputs leading to sustainable increases in crop productivity. There are several extensive phosphate deposits of sedimentary, metamorphic and igneous origin which could be used for small-scale agromineral development. The very extensive phosphate deposit of Evate (with more than 155 million tons of phosphate-bearing ore) (van Straaten 2002) and other deposits are suitable for large-scale phosphate extraction, and perhaps small- to medium-scale development (Figure 9). With Gurué District's acid soils, the potential direct application of rock phosphate should be researched. The extensive glauconite-bearing Eocene Cheringoma Formation with fossil fish and teeth beds is another naturally occurring deposit that certainly merits further characterization (van Straaten 2002) and may provide an excellent source of potassium which also is deficient in many farmed soils in Mozambique.

Figure 9



Recent studies suggest that the Evate rock phosphate contains up to 19% phosphorus (Momade 2012). Samples of the Evate rock phosphate have been exported to Hawai‘i and will be used for laboratory incubation studies to determine efficacy as P source for bean (Figures 10 and 11).

Figure 10

Figure 11

Limestone/dolomite resources are also abundant throughout the country (Figure 12). Given the extensive acid soils, as characterized by analysis of our data (Table 4) and reports from others, the limestone resources should be characterized for quality and quantity. Preliminary IIAM experiments indicate that extensive agricultural areas of the country are affected by low soil pH and inadequate levels of nutrients, especially phosphorus. The presence of limestone and dolomite, along with its potential provision of magnesium, present additional excellent potential benefits from wisely used local resources for local agriculture.

Figure 12

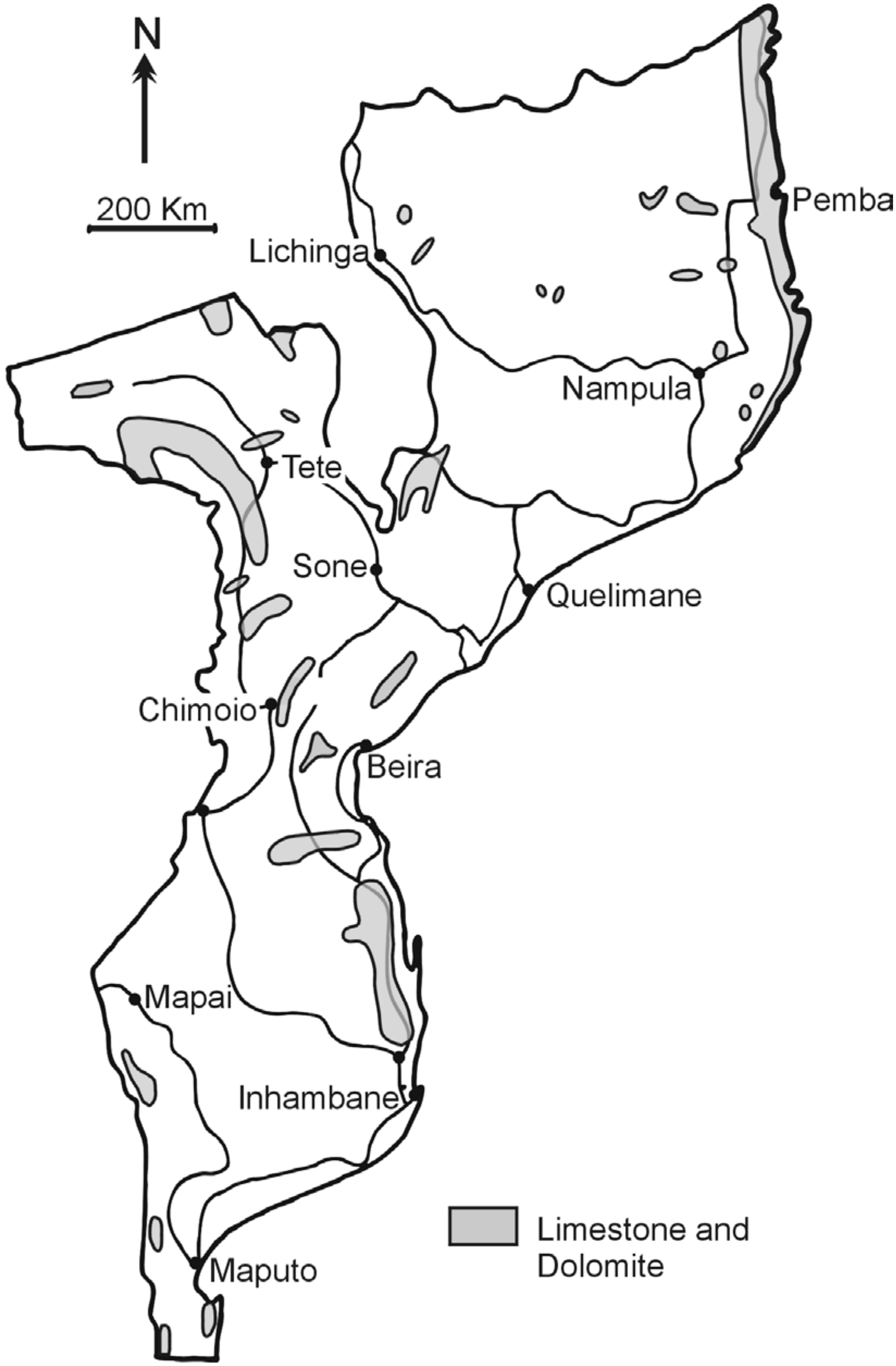

N
200 Km
Lichinga
Pemba
Nampula
Tete
Sone
Quelimane
Chimoio
Beira
Mapai
Inhambane
Maputo
Limestone and
Dolomite

Table 4 Preliminary results of soil analysis. Gurué District Mozambique

Location:	Soil pH	Clay %	ECEC, $cmol_c\ kg^{-1}$
Tetete	6.2	12.7	12.7
Lioma	6.0	12.9	11.4
Ruace	6.1	13.3	13.8
Mepuagiua	5.7	13.3	6.4

Location:	Soil P	- - $cmol_c\ kg^{-1}$ - -	
		K	Ca
Tetete	118	0.71	9.27
Lioma	65	0.49	8.05
Ruace	165	0.83	10.2
Mepuagiua	8	0.31	3.86

Location:	Mg, $cmol_c\ kg^{-1}$	OM $g\ kg^{-1}$	N, $g\ kg^{-1}$
Tetete	2.17	40.5	1.5
Lioma	2.12	37.9	1.6
Ruace	2.71	46.3	1.7
Mepuagiua	1.66	47.3	1.9

Current experimental plans include conducting an official total analysis of the Evate rock phosphate by the International Fertilizer Development Center. A detailed analysis of the Evate rock phosphate from Eastern Nampula Province, Mozambique is underway. These studies will be conducted in collaboration with Dr. Debbie Hellums senior scientist, IFDC as well as Dr. I. Momade, IIAM, Nampula. Apparently there has never been an analysis of the heavy metal content of the Evate rock phosphate. Such an analysis is in progress and will include determination of total quantities of the heavy metals of concern: Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, and Zn. Knowledge of heavy metal concentration is necessary because some phosphate deposits have high levels of toxic Cd and Co, which can be taken up by plants and concentrated in seed. Initial laboratory incubations are designed to test a range of rates of dissolution of the apatite in the Evate rock phosphate and measure its effects on plant availability of phosphate. The possibility of evaluating the effectiveness of the addition of microorganisms (*Thiobacillus thiooxidans*) to facilitate rock phosphate dissolution is under discussion with Dr. Sounder Rajan, New Zealand. These experiments and an anticipated field experiment during the next growing season constitute a key portion of the M.S. thesis research of project trainee António Rocha.

Objective 4: Develop and Assess Effectiveness of Innovative Approaches for Dissemination of Information and Decision Support Aids, Training, and Follow-up Technical Support

Farmers will benefit from having a variety of means to access information to learn about ways to improve bean production, storage and marketing. This suggests considering all available information platforms to address agricultural related issues at different stages of the agricultural cycle. Established means of communication are being considered - radio programs, demonstration plots and simple training materials in the form of posters and handouts in local languages; all of these can foster information dissemination and uptake. Our project is exploring the efficacy of video, particularly animated videos.

In advance of having content based on project field results that will serve as soil fertility diagnostic and decision support aids, it is important to begin to understand communication patterns and dynamics in the study communities in both countries. For this, we enhanced training materials for a technique that was promoted in a previous project – anaerobic storage using triple bags and sealed plastic jerry cans. Prototype messages and training approaches were developed for both Uganda and Mozambique. This included two main approaches: (1) expert extension hands-on presentations in which an agent demonstrated post-harvest bean storage (using triple bagging and jerry can storage in Uganda, and jerry can storage in Mozambique); and (2) video of each step of the post-harvest process, and animations showing the steps of the process. In all cases, farmers viewing the training were asked to actually carry out the tasks in a demonstration following the training.

Extension training, video shot locally in the local language, and an animation developed by SAWBO (Scientific Animations Without Borders) were tested. Animations were created, reviewed by experts, and translated into the local language. In Uganda, groups of key farmers from both Masaka and Rakai were brought together for the training. In Masaka, farmers received the extension training first, and then the video and animation training. They were then asked to demonstrate what they had learned. In Rakai, farmers received the video and animation training first, and then the extension training. In both cases, farmers were asked to evaluate all forms of training, and to indicate which they preferred. In Mozambique, a field experiment was conducted with 314 randomly selected farmers from ten communities out of two different Administrative Posts in Gurué (Tetete and Mepuagiua) to compare the effectiveness of the extension-only approach and an animation approach delivered via smartphones. The animation, translated into Lomwe (see https://www.youtube.com/watch?v=ACIyKKEkpgc to view the English language version), shows the jerry can post-harvest storage technique for preserving beans.

Farmers received one of three treatments: (1) extension only; (2) animation only; (3) both - the order was varied. Following all of the treatments, farmers were asked to carry out the task of filling the jerry cans with beans for storage. In both Uganda and Mozambique, beans were sealed in triple bags or jerry cans; the farmers will gather again in mid-November or December to open them and evaluate the results of the test. At that time, an assessment will be made of how many farmers have already adopted this storage technique, or plan to do so in the future. Already, some male and female Innovation Platform farmers in Uganda have run their own experiments, and have trained other farmers in airtight storage, particularly using the jerry can method. Those passing on the knowledge to others particularly in Rakai are mainly women. In Gurué, the Administrator of the district and the local Agriculture Director met and officially authorized the research team to proceed with testing the prototype, and shared their enthusiasm and willingness to see positive results being implemented beyond randomly selected communities. Additionally, the Kings (and local leaders) of both Tetete and Mepuagíua were instrumental in providing the list of bean growing farmers region from which the 314 participants were randomly selected.

The purpose of the training was to test the communication system for reaching farmers with information about how to improve their farming or post-harvest practices. In Uganda, the key farmers and innovation platform committee members attending the training will be used in future communication campaigns (via radio, smartphones, extension presentations and demonstrations) to multiply the messages. The baseline household survey documented the importance of these ‘fellow farmers’ in adoption of many soil fertility and bean practices in the country. Video and animations were both well-received by these farmers, so they can be included in future communication approaches. In Mozambique, early results show that the smartphone animated videos were at least as effective as the extension-only approach, and that farmers learned significantly about specific steps to follow by viewing either approach. Because of the lack of extension agents in Gurué, animations delivered by smartphones will be an important part of future communication efforts.

As other project team members identify priority messages for improvement of soil fertility and bean production in the coming six months, the communication team will create appropriate messages and message strategies building on the testing already conducted of the communication system. Although messages and approaches will depend on what is recommended and what channels are best for communicating these messages, it is expected that animations will play a role since they demonstrated their effectiveness during the trials. Communication campaigns will include multiple channels and approaches, and will be pre-tested with farmers and experts.

IV. Major Achievements

- Our experiments and analyses of soils and cropping system treatments are progressing well in both countries, with clear and actionable results expected by June 2016.
- We have broadened and deepened our understanding of farmers' resource endowments and social capital; this guides how we generate interest and cooperation, and facilitate learning through on-farm experiments and farmer-selected field trials and demonstrations, and will promote adoption and adaptation of improved management practices and technologies.
- We are compiling and analyzing data on weekly market prices, and analyzing marketing patterns. This will be incorporated in development of decision support aids and training.
- Multistakeholder Bean Innovation Platforms in Masaka and Rakai are rapidly developing in membership size, diversity, enthusiasm and capability and as formal organizations.
- Our training in anaerobic storage methods (triple bags and jerry cans), using extension personnel and a newly developed animated video, meets an important need identified by farmers. In Mozambique, our research is comparing the efficacy of three training methods.

V. Research Capacity Strengthening

The breadth of our team spans soil and crop sciences, sociology, economics, extension and communications, contributing significantly to conceptualizing our research objectives, methods, data collection, analysis and interpretation. In addition, members from various institutions and disciplines contribute significantly to mentoring and guiding the research of graduate students:

- Naboth Bwambale, M.S. student in Sustainable Agriculture and Sociology at Iowa State University, defended his thesis and will graduate in December. Title: "Farmers' Knowledge, Perceptions, and Socioeconomic Factors Influencing Decision Making for Integrated Soil Fertility Management Practices in Masaka and Rakai Districts, Central Uganda."
- Prossy Kyomuhendo, M.Sc. student in Soil Science at Makerere U. conducted research in limiting nutrients and lime requirements for bean production in Leptosols and Luvisols. She submitted her thesis for examination and she is working on the paper for publication.
- Lance Goettsch, M.S. student in Crop Production & Physiology at ISU, plans to graduate in May 2016. His thesis involves two manuscripts in preparation: (1) "Practical management systems to alleviate yield constraints of common bean on Liddugavu soil in Uganda" for *Field Crops Research* and (2) "Practical management systems to alleviate yield constraints of common bean on Limyufumyufu soil" for *Field Crops Research.*

- Stewart Kyebogola, M.Sc. student in Soil Science at Makerere U., is conducting research on the effect of integrating organic with inorganic fertilizers on bean yield on three contrasting soils in Masaka district.
- Sostino Mocumbe, M.S. student in Communications at ISU, is conducting research on "Use of Animated Videos through Mobile Phones to Enhance Agricultural Knowledge and Adoption among Bean Farmers in Gúruè District, Mozambique."
- António José Rocha, M.S. student in Soil Science at U. of Hawaii, is conducting research on Alternative Management Practices for Improving Bean Production in Gurue.
- Jafali Matege, M.Sc. student in Extension Education at Makerere U., is conducting research on Gender Dimensions of Bean Farmers' Decision Making for Soil Fertility Management.
- Chrysostom Muyanja, B.Sc. Agriculture student at Makerere University, is carrying out a survey on the use of foliar fertilizers.
- Abbas Isabirye, Ph.D. student in Agricultural and Rural Innovations at Makerere University, is examining the efficacy of the bean Innovation Platforms in Masaka and Rakai.

Short-Term Training of Technical Staff - The project team benefitted from four Institutional Capacity Strengthening grants. The first involved close collaboration among Makerere University, Uganda's National Agricultural Research Laboratories, and the University of Hawaii. It focused on combining indigenous and scientific knowledge of soils. The second enabled the Institute of Agriculture Research of Mozambique to record, analyze and interpret GIS associated data with biophysical, economic, and social data. Work with the funds from these supplemental grants began early in 2015. The third involved training workshop for IIAM, Instituto Medio Agropecúario de Gurué (IMAPEG), UniZambeze (University of Zambézia) researchers in survey techniques to learn how farmers identify local indigenous soil types and use that information in their selection of cropping systems and crop and soil management. It also involved training on spatial data management. The fourth supported training of scientists, technicians, students and district staff in GIS and geo-spatial skills for distinguishing toposequencing, chronosequencing and lithosequncing of soil catena in Uganda in September 2015. Through this field and lab-based activities, trainees acquired practical skills and detailed understanding of soil variability along selected landscapes of the Buganda catena using characteristics identified locally by farmers and related it to modern scientific approaches (GIS, geo-statistics and the FAO World Reference systems). Trainees also developed practical skills to enhance farmer decision making for soil fertility management through combined use of indigenous and modern scientific soil classification. Two project scientists from IIAM participated in this training. This activity is anticipated to assist in the understanding and documentation of the high importance of geomorphology and topography of soils and its importance in the farmers' classification or grouping of soils of the project villages. Knowledge gained in Uganda will enhance the training workshop for mapping indigenous soil classification in project interventions in Mozambique.

In addition, during June - August 2015, Mr. Rocha, provided supervision and training on a variety of research tasks in Gurué, Mozambique, including soil sampling and crop harvesting techniques. Eng. Ricardo Maria conducted several field demonstrations of a portable soil pH test kit to EMAPEG students. Three project graduate students at Makerere (Prossy Kyomuhendo, Stewart Kyebogola, and Jafali Matege) benefitted from training in designing and carrying out gender sensitive research under a project on Gender Responsive Researchers for Agricultural Transformation (GREAT). Dr. Richard Miiro participated in Legume Innovation Lab sponsored training in Lusaka, Zambia on impact assessment of projects.

VI. Human Resource and Institution Capacity Development

1. Short-Term Training

A. GIS and Geo-Spatial Skills

i. Purpose of Training – GIS and geo-spatial skills
ii. Type of Training – computer lab and field observations
iii. Country Benefiting - Uganda
iv. Location and dates of training – Kampala, Masaka and Rakai; Sept. 2015
v. Number receiving training (by gender) – 10 female, 24 male
vi. Home institution(s) – Makerere University and National Agric. Research Lab.
vii. Institution providing training – Iowa State University and Makerere University

B. Spatial Data Management

i. Purpose of Training – indigenous soil types and spatial data management
ii. Type of Training – computer lab and field observations
iii. Country Benefiting - Mozambique
iv. Location and dates of training – Mocuba; June 2015
v. Number receiving training (by gender) – 6 female, 26 male
vi. Home institution(s) – Institute of Agricultural Research of Mozambique
vii. Institution providing training – U. of Hawaii & Instit. Ag. Research of Mozambique

C. Innovation Platform

i. Purpose of Training – innovation platform strengthening
ii. Type of Training – participatory methods
iii. Country Benefiting - Uganda
iv. Location and dates of training – Masaka and Rakai; ongoing
v. Number receiving training (by gender) – 58 female, 79 male
vi. Home institution(s) – Makerere University and National Agric. Research Lab
vii. Institution providing training or mechanism – Makerere University, National Agricultural Research Laboratories, Iowa State University & University of Illinois

2. Degree Training

Trainee #1

Name: Naboth Bwambale
Citizenship: Uganda
Gender: Male
Training Institution: Iowa State University
Supervising Legume Innovation Lab PI: Robert Mazur
Degree Program for training: M.S.
Program Areas or Discipline: Graduate Program in Sustainable Agriculture *and* Sociology
If enrolled in the US, is Trainee a USAID ‘Participant Trainee’ and registered in TraiNet? Yes
Host Country Institution to Benefit from Training: Makerere University
Thesis Title/Research Area: Farmers’ Knowledge, Perceptions, and Socioeconomic Factors Influencing Decision Making for Integrated Soil Fertility Management Practices in Uganda
Start Date: August 2013
Projected Completion Date: December 2015
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect) for training activity: Full

Trainee #2
Name: Lance Goettsch
Citizenship: United States
Gender: Male
Training institution: Iowa State University
Supervising Legume Innovation Lab PI: Andrew Lenssen
Degree Program for training: M.S.
Program Areas or Discipline: Agronomy
If enrolled in the US, is Trainee a USAID ‘Participant Trainee’ and registered in TraiNet? No
Host Country Institution to Benefit from Training: Makerere University
Thesis Title/Research Area: Practical Methods to Alleviate Constraints Limiting Common Bean Production in Masaka, Uganda
Start Date: August 2013
Projected Completion Date: May 2016
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect): Partial

Trainee #3
Name: Prossy Kyomuhendo
Citizenship: Uganda
Gender: Female
Training institution: Makerere University
Supervising Legume Innovation Lab PI: Moses Tenywa
Degree Program for training: M.S.
Program Areas or Discipline: Soil Science and Crop Production
If enrolled in the US, is Trainee a USAID ‘Participant Trainee’ and registered in TraiNet? N/A
Host Country Institution to Benefit from Training: Makerere University
Thesis Title/Research Area: Limiting Nutrients and Lime Requirements for Bean Production
Start Date: January 2014
Projected Completion Date: August 2016
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect) for training activity: Partial

Trainee #4
Name: Sostino Mocumbe
Citizenship: Mozambique
Gender: Male
Training institution: Iowa State University
Supervising Legume Innovation Lab PI: Eric Abbott
Degree Program for training: M.S.
Program Areas or Discipline: Communications
If enrolled in the US, is Trainee a USAID ‘Participant Trainee’ and registered in TraiNet? Yes
Host Country Institution to Benefit: Institute of Agricultural Research of Mozambique (IIAM)
Thesis Title/Research Area: Socio-technical Approaches for Dissemination of Information and Decision Support Aids
Start Date: July 2014
Projected Completion Date: August 2016
Training status: (active, completed, pending, discontinued or delayed): Active

Type of USG Support (full, partial or indirect): Full

Trainee #5
Name: Jafali Matege
Citizenship: Uganda
Gender: Male
University to provide training: Makerere University
Supervising Legume Innovation Lab PI: Richard Miiro
Degree Program for training: M.S.
Program Areas or Discipline: Agricultural Extension Education
If enrolled in the US, is Trainee a USAID 'Participant Trainee' and registered in TraiNet? N/A
Host Country Institution to Benefit from Training: Makerere University
Thesis Title/Research Area: Gender Dimensions of Bean Farmers' Decision Making for Soil Fertility Management in Masaka and Rakai Districts, Uganda
Start Date: July 2014
Projected Completion Date: August 2016
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect): Partial

Trainee #6
Name: Stewart Kyebogola
Citizenship: Uganda
Gender: Male
Training institution: Makerere University
Supervising Legume Innovation Lab PI: Onesimus Semalulu
Degree Program for training: M.S.
Program Areas or Discipline: Soil Science and Crop Production
If enrolled in the US, is Trainee a USAID 'Participant Trainee' and registered in TraiNet? N/A
Host Country Institution to Benefit from Training: National Agricultural Research Laboratories
Thesis Title/Research Area: Effect of integrating organic with inorganic fertilizers on bean yield on three contrasting soils of Masaka district
Start Date: July 2014
Projected Completion Date: August 2016
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect): Partial

Trainee #7
Name: António José Rocha
Citizenship: Mozambique
Gender: Male
Training institution: University of Hawaii - Manoa
Supervising Legume Innovation Lab PI: Russell Yost
Degree Program for training: M.S.
Program Areas or Discipline: Agronomy and Tropical Soils
If enrolled in the US, is Trainee a USAID 'Participant Trainee' and registered in TraiNet? Yes
Host Country Institution to Benefit: Institute of Agricultural Research of Mozambique (IIAM)
Thesis Title/Research Area: Alternative Management Practices for Improving Bean Production
Start Date: January 2015

Projected Completion Date: September 2017
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect) for training activity: Full

VII. Achievement of Gender Equity Goals

The project team has actively promoted participation of women farmers during research activities and trainings in Uganda and Mozambique. In our short-term training, 64 women have benefited (out of 172) and one woman is benefitting from long-term training. Extension research in Mozambique involved 140 women (and 174 men).

VIII. Achievement and Progress Along the Impact Pathway

The project team is making excellent progress in implementing the action plan: (1) project research activities are on track to determine soil and crop system improvements that should be recommended, and to develop and refine appropriate models of farmer decision making strategies; (2) we are compiling materials that will be useful for development of diagnostic and decision support aids using observable characteristics that enable farmers to make site-specific management decisions; and (3) we have started to assess the appropriateness of existing methods and media for information dissemination to intermediate and end users.

IX. Explanation for Changes

We significantly exceeded the planned number of short-term training participants/beneficiaries.

X. Self-Evaluation and Lessons-Learned

Our collegial multidisciplinary multi-country team is responsive in multi-way communications and collaborates well in planning and implementing all project activities in Uganda and Mozambique. Researchers from all institutions are actively involved in mentoring all of our graduate students in their research. This generates high quality scientific data, engages diverse teams in analysis and making critical decisions, and following through. We continue to build on our diverse experiences and expertise to make wise decisions with our resources and achieve meaningful outputs and impacts. We have adapted to weather-related challenges in our field experiments, and are responding to the partnership opportunity provided by Bean Innovation Platforms in Uganda to advance our work and its long term impact.

XI. Scholarly Accomplishments

- Goettsch, L. & A. Lenssen. 2014-2015. U.S. Borlaug Fellows in Global Food Security graduate research grant. 'Practical methods to alleviate constraints to common bean (*Phaseolus vulgaris* L.) production in Masaka, Uganda.'
- Goettsch, L. 2013-2016. Louis Thompson Endowment Graduate Fellowship. Agronomy Department (its premium assistantship). Iowa State University.
- Mazur, R., N.Bwambale & V. Salegua. 2015. "Land Rights and Integrated Soil Fertility Management in Uganda & Mozambique." Paper presented at LANDac Conference 2015 - Land Governance for Equitable and Sustainable Development. Utrecht, Netherlands.
- Bwambale, N. 2015. "Farmers' Knowledge, Perceptions, and Socioeconomic Factors Influencing Decision Making for Integrated Soil Fertility Management Practices in Uganda." (M.S. thesis successfully defended; manuscripts in preparation for publication)

XII. Data Management

All databases will be archived and publicly accessible at Iowa State University's Digital Repository, and some will also be available through the Soil Health Consortium Database of the Institute of Agriculture Research of Mozambique.