Feed the Future Innovation Lab for Collaborative Research on Grain Legumes
(Legume Innovation Lab)

FY 2017 WORKPLAN

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 (PI) and affiliated Lead U.S. University:
Robert E. Mazur - Iowa State University

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

I. Project Problem Statement and Justification

This research project is based on two premises: (1) sustainable intensification of agricultural production requires improved soil fertility management in which legumes are an integral part of cropping systems; and (2) effectively addressing soil-related constraints is based on enhancing smallholder farmers' capabilities to diagnose and find solutions to important yield constraints.

Project research activities focus on key common bean production regions – in Masaka and Rakai districts in south-central Uganda and in Gurúè district in northern Mozambique, important Feed the Future focus countries. To understand potentially limiting soil nutrients, the team analyzed physical and chemical properties of the three predominant soil types used to grow beans in these regions in each country. The nutrient omission study laboratory experiment for Masaka and Rakai showed that low P availability limits bean growth across all three soil types - black, stony and red. Effects of N, K, Mg and Ca on number of leaves and biomass varied with soil type, particularly affecting stony and red soils. Some negative interactions between macro and micronutrients were observed for the complete treatment. Nutrient addition study field experiments in Gurúè during the 2016 rainy season have recently been harvested, with data analysis and determination of implications pending. Lime requirement studies addressed low pH, Ca and Mg availability, and Al toxicity. In Uganda, this showed that black soil is not significantly affected by pH related limitations, excessive Al or low P availability. However, red soils (pH 5.02, CEC 12.3) require more lime [$Ca(OH)_2$] (11.3T/ha) than stony soils (8.0T/ha) to raise pH to 6.5. In Mozambique, liming material had an additive effect with inorganic fertilizer and increased bean yield.

Researcher-managed field experiments in Masaka and Rakai produced specific recommendations of N, P and chicken manure for black, stony, and red soils. Researcher managed field experiments in Gurúè during the 2015 dry season in lowland fields indicated that N, P and K are the most limiting nutrients for beans in paddy rice fields. In Gurúè, field experiments from the 2016 rainy season have recently been harvested, with data analysis and determination of implications pending. These results will guide treatment design of field experiments in Gurúè during the 2017 rainy season and 2017 dry season.

Two multistakeholder innovation platforms (IPs) have been established in Masaka and Rakai districts with project assistance. Members across the value chain share interests, concerns and strategies to address bean productivity and marketing constraints. In season 2016A, IP members in Masaka hosted 18 field trials to demonstrate improved management practices and technologies (MPTs) for bean production. These trials are currently being harvested, with data analysis and determination of implications pending. Additional field trials will be conducted in Masaka and Rakai during 2016B. In Gurúè, field experiments in early 2017 will serve as the basis for farmer field days to stimulate widespread interest through direct observation and comparison of site-specific MPT. These activities will engage producers and other stakeholders in social learning, stimulate interest among community members in the demonstrations and trials, and stimulate widespread use of MPT that are proven successful in local conditions.

This project team is developing aids (methods and procedures) that will enable smallholder producers with varying levels of education to better diagnose soil and other production constraints, and make improved site-specific crop system management decisions that contribute to higher bean productivity and improvements in soil fertility. These improved crop management systems cover soil characteristics and associated nutrient deficiencies, field preparation and measurement, seed selection, plant spacing, application of organic and inorganic fertilizers, weeding, post-harvest handling, and farm business economic analysis. We have field tested video animations, in both Uganda and Mozambique, delivered via smartphones as one innovative communication approach. We are developing a dissemination strategy that integrates the use of radio, animations and print materials delivered through networks of partner organizations supplemented by field demonstrations and other participatory activities. These will engage farmers with diverse backgrounds, characteristics, and other key stakeholders in widespread dissemination and adoption of appropriate diagnostic and decision support aids.

II. Project Activities for the Workplan Period (October 1, 2016 – September 29, 2017)

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

Approaches and Methods

In Masaka and Rakai districts in Uganda, beans are planted in both rainy seasons. In Mozambique's Gurúè district, beans are planted in the single rainy season and, in communities with paddy rice fields, in the subsequent dry season. Our interviews and interactions with smallholder farmers in Uganda and Mozambique have revealed a variety of management practices and technologies (MPTs) used to maintain or increase bean productivity. There is significant variation by location regarding type and extent of use - reflecting awareness, availability, access and affordability. Our baseline farming system and socioeconomic surveys have provided detailed profiles of farmers' acreage and number of fields, practices of field selection and preparation, crop and variety selection, procurement of seeds, planting methods and spacing, use of various types of inputs (manure, inorganic fertilizers, foliar sprays, pesticides, herbicides), intercropping and rotation patterns, weeding, burning or incorporating crop

residues in soil, mounding ridges, mulching, and fallow. Understanding methods and criteria of problem identification and management practices currently utilized by farmers is important to our study. These findings have guided the research team in its observations and learning how farmers use existing knowledge to help determine crop system needs and to improve farming conditions.

Our project's field experiments and community-based field trials being conducted in Masaka and Rakai and Gurúè have demonstrated the key management practices and amendments specific to soil type that can improve soil fertility and help farmers significantly increase their bean crop yield. Assessment of access to required inputs and labor, combined with detailed analysis of costs and profits, will provide farmers with the basis for determining which improved management practices and technologies are appropriate for their farming system and goals. While individual and household resource endowments significantly shape farmers' decisions, the context in which alternative farming practices are learned and evaluated is fundamentally social in nature. Learning and decision making are influenced by discussion with group members, peers and other key stakeholders. Social learning will be especially important in horizontal (farmer-to-farmer) dissemination of information about new management practices and technologies (MPTs), both within a community that is participating in project activities and potentially have spillover effects to neighboring communities. Our approach involves engaging farmers' in design, implementation and assessment of on-farm trials in Uganda and in farmer field days in both Mozambique and Uganda (described under Objective 2 below). We will monitor involvement and obtain feedback from participants regarding their learning experience to guide our overall dissemination strategy.

Obj. 1a. Engage farmers in design, implementation and assessment of on-farm trials and through farmer field days (lead researchers: M. Tenywa, O. Semalulu, R. Miiro, R. Maria)

1a.1. Assist, monitor and assess on-farm trials with farmers' groups and field experiments (also: A. Lenssen, R. Yost)

1a.2. Document methods of learning and sharing information among farmers participating in on-farm trials and with other farmers, and participants in farmer field days (also: R. Mazur, E. Abbott)

Milestones

Oct. 2016 – Mar. 2017 and *Apr. 2017 – Sept. 2017*

1.1 - Reports on community learning through on-farm trials in Masaka & Rakai

1.2 - Reports on community learning through farmer field days in Gurúè

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

Collaborators:

Josephine Nampijja, GIS specialist, Makerere University, Uganda

Venâncio Salegua - Institute of Agriculture Research of Mozambique

Approaches and Methods

Information obtained during participatory rural appraisals, household interviews, student research projects, and interactions with farmers during on-farm trials and farmer field days has provided insights about key social, cultural, and economic factors which shape farmers' decision making about bean crop and soil fertility management. These include: information sources and credibility; assets, flows and constraints of key resources (land, labor, finance, etc.); gender roles; food security; market sales; and risk management strategies. Contextual factors of relevance include availability, accessibility and affordability of key resources; value chain development (input and output markets); group and network

size and strength; and collective action experience. Together, these help explain current knowledge, attitudes, practices; provide insight into which households are more able and likely to make fundamental changes and why; and inform our approaches to information dissemination, training, and support to stimulate and sustain widespread change.

Farmer groups and social networks play key roles in experimentation and adoption of new MPTs, involving changes in beliefs, knowledge, and behavior. Farmers observe, ask questions and seek answers, and make sense of each other's experiences and knowledge alongside scientific knowledge. This process of *sensemaking* enables people to collectively: devolve new 'mental maps;' set their own goals and outcomes; experiment, evaluate, collectively frame and legitimize the 'way forward;' develop a sense of identity, efficacy and pride; and encourage each other and persuade others to take similar actions.

Key dimensions of the institutional context play significant roles in farmers' interest in and ability to make investments for improved crop production and soil fertility. Uganda and Mozambique have weak and uneven extension systems and rural social and economic institutions, which limit widespread access to improved crop management information, quality inputs, and credit; Mozambique is particularly problematic in this regard. The existence and strength of farmers' groups and associations, typically the principal mechanisms to access training and other support, vary significantly. However, in the research focal regions in both countries, the situation is dynamic and indicators of improvement have been identified and are being followed up by the project team.

In Uganda, the development of two multistakeholder Innovation Platforms (IPs) in Masaka and Rakai districts indicates strong interest in coordination across the value chain from inputs to markets. The project research institutions are collaborating with private sector businesses (trade, microfinance, input supply, etc.) and an agricultural NGO which supports development of certified seeds (Community Enterprises Development Organization - CEDO). The IPs have established 18 farmer hosted field trials which exhibit 'best bet' management practices and technologies (MPTs) identified through project research as IPs transition toward collective market linkage development. Availability of markets for beans is creating demand for the recommended MPTs in order to meet market quality and quantity targets. Good platform leadership and commitment by all actors underpins the significant progress achieved to date. The IPs currently have more than 400 active members.

Farmer groups in the IPs in Masaka and Rakai participate in on-farm trials that test and demonstrate the impact of variations in recommended improved management practices and technologies (MPTs) for bean production. These on-farm trials enable us to confirm nutrient limitations on farmers' fields and improved systems that address the most critical limiting soil nutrients and management practices. These activities engage farmers in social learning, stimulate interest among other community members in the trials and demonstrations, and are already contributing to adoption of proven MPTs.

In Mozambique, an array of cash crops have been introduced or efforts intensified in the past decade by private sector foreign investors, NGOs and international research organizations which provide training, seed and other inputs, and marketing (including exports) – for soybean, pigeon pea, sunflower, pineapple, cotton, and tobacco. This 'support system' has significant implications for farmers' decisions to prioritize cultivation of specific crops for income. In contrast, common bean production and sales have been primarily driven by domestic market actors. Initiatives by Maputo-based 'market women' during the past five years have helped increase market prices for common beans. Efforts to promote development along the value chain for several key crops valued for food security and income, including common beans, have been recently initiated in Mozambique through several development projects and programs.

- IITA (with CIAT, ICRISAT and IIAM) operates the SEMEAR program (Improved Seeds for Better Agriculture, 2015-2019) that uses a public-private partnership approach to disseminate improved legume seeds and complementary crop management practices already developed in Mozambique through the PARTI (Platform for Agriculture Research and Technology Innovation). The goals are to: (1) increase the production and supply of breeder, pre-basic, basic, and certified seeds; (2) increase adoption of improved technologies, income, and food security of 100,000+ smallholder farm households in Zambézia, Nampula, Manica and Tete provinces; and (3) enhance national policy dialog on seed and fertilizer supply.
- CLUSA (NCBA CLUSA) operates a project on 'Conservation Agriculture and Climate Change Resilience Farming Techniques and Technology for Food Security' in and around Gurúè.
- FAO's Millennium Development Goals program is working in Gurúè district, including our research areas of Tetete and Mepuagíua, on seed production, farmer field schools, demonstration plots, home gardening and nutrition, poultry vaccination against Newcastle, and improved granaries.
- TechnoServe is providing assistance to the COPAZA (Production and Commercialization of Soy) project in Gurúè to improve the quantity and quality of soybean seed.

Project team members have recently held initial discussions with IITA, CLUSA and FAO in Mozambique to explore possible bases for collaboration through sharing results of research, dissemination of information about recommended management practices and technologies, etc.

Obj. 2a. Characterize resources and actions required for increasing bean crop productivity and marketing, and improving soil fertility (lead researchers: R. Miiro, V. Salegua, S. Mocumbe, R. Mazur, E. Abbott, E. Luvaga)

2a.1. Identify and quantify resources and actions required for increasing productivity and marketing, and improving soil fertility

2a.2. Document farmers actions to invest in and adopt (or intentions to do so) new management practices and technologies

Milestones

Oct. 2016 - Mar. 2017 and *Apr. 2017 – Sept. 2017*

2.1 – Reports on activities of members of multistakeholder innovation platforms and successes in promoting improved bean crop management practices, investments and marketing

2.2 – Reports on farmers' investments in and adoption of management practices and technologies to increase bean crop productivity and marketing, and improve soil fertility

Obj. 2b. Refine models of farmer decision making and identify recommendations for training and support to increase bean crop productivity and marketing, and to improve soil fertility (lead researchers: R. Mazur, R. Miiro, V. Salegua, E. Luvaga, E. Abbott)

2b.1. Analyze data from farmer interviews to model farmers' decision making

2b.2. Identify specific information and knowledge gaps to be addressed through training

Milestones

Apr. 2017 – Sept. 2017

2.3 – Updated models of farmer decision making vis. mgmt. practices, investments and marketing

2.4 – Recommendations for training and support for bean production and soil fertility management

Objective 3: Develop and Validate Diagnostic and Decision Support Aids

Collaborators:
Charles Kizza Luswata, soils lab senior technician, Makerere University, Uganda
Josephine Nampijja, GIS specialist, Makerere University, Uganda
Stanley Nkalubo, bean breeder, NaCRRI, Uganda

Approaches and Methods

To improve bean crop and soil management decision making, diagnostic and decision support aids (DDSAs) are being developed with and for farmers who have varying levels of education. These aids are based upon field-observable soil classification characteristics in diverse agroecologies in Masaka and Rakai districts in Uganda and Gurúè district in Mozambique. We are utilizing farmer experience, local and indigenous knowledge and soil classification systems, and input from soil scientists and crop systems agronomists, drawing from results obtained from field experiments and trials in our project. We also access the global knowledge base of appropriate practices and technologies, soil and cropping system management strategies and options appropriate for various smallholder farm systems. DDSAs enable farmers to compare stages and outcomes, using readily observable characteristics, based on conventional and improved management practices and technologies. The method of their introduction and context of their use will provide farmers with the basis for assessing benefits and costs, and weighing 'trade-offs' among alternatives. The development of DDSAs is being done using photographs from the nutrient omission and addition studies, scientist-managed field experiments, and productive innovative farmer fields that document differences in bean plant growth and development, bean leaf health, and subsequent bean yields.

In Uganda, shortened or more typically non-existent fallow periods, lack of fertilizer inputs, reduced soil organic matter concentration, and erosion from water have resulted in stagnant or decreased bean yields. The soil survey conducted in Masaka and Rakai districts in January 2014 and replicated field research conducted in Masaka in 2014-2016 documented that Liddugavu (black) soils generally had adequate levels of nutrients, and rooting depth generally was not constrained by excessively low pH or Al^{+3} concentrations. Results from our soil survey documented that the Limyufumyufu (red) soils were strongly acidic in the 15-30 cm depth, while available P, K, Ca, Mg, S, and Zn likely were limiting bean growth, and this was confirmed with scientist-managed field research in Masaka over three rainy seasons. Additionally, Al^{+3} levels were often significant in red soil, further constraining potential root growth for water and nutrient extraction; improved systems that included the addition of limestone proved highly effective, doubling bean yields. Research studies documented that addition of fertilizer P, K, Ca, Mg, S, and Zn improved bean yield on black soil similarly to addition of chicken manure with synthetic N and P fertilizers.

Farmer-assisted on-farm field trials were hosted at 18 sites in Masaka in the 2016A rainy season. The four treatments included N and P fertilizer, chicken manure, N and P fertilizer with chicken manure, and an untreated control. The sites used included four black, four red, and four stony (Luyinjayinja) soils. Soils and chicken manure were sampled for nutrient availabilities prior to treatment initiation. All beans were planted in rows 50cm apart with two seeds at 10cm within-row spacing. Bean varieties were chosen by farmers and included NABE 14 and NABE 17. Visual assessments by farmers and scientists indicated that the combination of N and P fertilizer with chicken manure provided superior bean growth and vigor compared to the other three treatments on 11 of 12 farms for which complete data are being collected. On one farm only, beans in the manure only treatment were not different from the N and P plus chicken manure treatment. At harvest, pod harvest index, pod density, seed per pod, individual seed weight, and total seed yield will be determined. Economic analyses will be conducted on the trial plots using costs obtained from farmers for seed, fertilizers and chicken manure, pest management, and

labor. Farmers consistently mentioned that planting in rows initially required more time per unit area compared to the time required to scatter plant. Some acknowledged that with experience the time differential is reduced or eliminated, especially since row planting reduces weeding time. All farmers reported that row planting allows for superior weed, pest and disease management with far less time and effort required.

In the coming seasons, on-farm trials and demonstrations will continue in Masaka. Six farms will include comparisons of banded vs. broadcast N-P-chicken manure. An additional six farmer groups in Masaka and 12 farmer groups in Rakai will compare the four treatments used in 2016, N and P fertilizer, chicken manure, and N and P fertilizer with chicken manure, and an untreated control. Data collection will include yield components (pods/m^2, seed/pod, seed weight, pod harvest index); analysis of variance, regression techniques, and economic analyses will be used to compare soil management techniques.

Yet to be determined is exactly how much lime is required to moderate the effects of low pH on red soil and the profitability of lime addition. The application of P, K and 295 kg/ha limestone more than doubled bean yield in the scientist-managed field research compared to the management system used by farmers in Masaka. Addition of N and P with chicken manure also improved bean yield on red soil. However, in the long term, chicken manure will likely increase soil acidification. At current prices, a large addition of limestone to red soil in Uganda is not profitable. In the U.S., federal farm programs subsidized limestone additions to soil for several decades. Perhaps this will be necessary in Uganda and elsewhere in sub-Saharan Africa for long term sustainability of crop production on red soils.

In Gurúè, visual observations of the nutrient omission experiment and the measured results indicate that rainy season bean growth on upland soils is responding to both N and P. These are the most costly of the nutrients when added as purchased fertilizer. Therefore, means to provide both N and P to local farmers for the extensive upland soils using low cost systems they can manage are being explored. The inclusion and expansion of the local practice of a pigeon pea rotation in bean production systems may be one way to add biological nitrogen fixation inputs of N into otherwise N limited bean production. This study was initiated in 2016 with pigeon pea preceding bean to provide increased N input.

In the Tetete and Mepuagíua administrative posts in Gurúè, replicated studies were conducted with two bean varieties comparing N, P, K, Ca, Mg, S, and Zn. Harvests are being completed in June 2016. Analysis of soil samples obtained from farmers in Gurúè will yield similarly useful results and provide insights regarding nutrient limitations in bean productivity and yield enhancement by fertilizer additions, resulting in management practices and technologies (MPTs) for improved bean production. Red soils in Gurúè are highly acidic. Farmers currently do not plant beans on them because beans do not grow well using conventional farmer production practices. The incubation study established that 2.3T/ha of locally available limestone is needed to ameliorate soil pH from initial level of 4.6 to an adequate level for bean production. In the 2017 rainy season, experiments will be conducted with beans on these soils comparing the effects of limestone, rock P, and fertilizer additions. In another study, the rate of limestone, with and without fertilizer blend addition, will be tested on a red soil site. In Tetete, bean production with blended fertilizer addition rates will be tested.

In Uganda, our field experiments and on-farm trials have been demonstrating improved management practices and technologies (MPTs) that have tangible benefits in terms of increased bean production. They are also feasible in terms of adoption by farmers. These MPTs that together more than double bean yield are: use of certified seed; planting in rows appropriately spaced apart and spacing within rows to achieve optimal stand density; addition of fertilizer (organic and inorganic) to provide key limiting nutrients; banded vs. broadcast nutrient application; and timely weeding. Recommended fertilizer amounts differ according to soil type. We have also determined that farmers will benefit from developing relatively accurate estimates of field size (area) where beans will be planted in order to

correctly calculate the amount of quality seed needed and to apply fertilizers at the optimal rate; relatively simple methods of estimating area are being devised. These MPTs serve as the bases for initial DDSAs. Farmers will be interviewed after each cropping cycle to determine the impact of using the DDSAs.

Obj. 3a. Determine Solutions to Soil Fertility and Other Bean Production Constraints

(lead researchers: M. Tenywa, O. Semalulu, R. Maria, R. Yost, A. Lenssen)

3a.1. Conduct on-farm trials of bean crop management systems

3a.2. Analyze results and recommended solutions

Milestones

Oct. 2016 – Mar. 2017 and *Apr. 2017 – Sept. 2017*

3.1 – Updated reports for on-farm trials of bean crop management systems

3.2 – Updated analyses and recommendations for bean crop management systems

Obj. 3b. Develop Diagnostic Methods and Aids

(lead researchers: M. Tenywa, O. Semalulu, R. Maria, R. Yost, A. Lenssen)

3b.1. Engage farmers in a participatory assessment of all diagnostic and decision support aids

3b.2. Finalize all diagnostic and decision support aids

Milestones

Oct. 2016 - Mar. 2017 and *Apr. 2017 – Sept. 2017*

3.3 - Participatory assessment of all diagnostic and decision support aids

Apr. 2017 – Sept. 2017

3.4 – Refined and finalized diagnostic and decision support aids

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

Collaborators:

Freddie Kabango, Masaka District Agricultural Officer, Uganda
Charles Katabalwa – Community Enterprises Development Organization (CEDO), Rakai, Uganda
José Eufrates - Gurúè District Agricultural Extension Officer, Mozambique
Venâncio Salegua - Institute of Agriculture Research of Mozambique

Approaches and Methods

To realize our goals, the team is working with existing institutions and organizations to identify and develop messages to provide farmers with appropriate and reliable information to make critical decisions about beans and soil fertility, and pathways that can provide relevant information in an effective, efficient, and sustainable manner. In Uganda, groups and Innovation Platforms (IPs) are especially important sources of valued information, along with fellow farmers and extension. Local and national radio programs also are used by some farmers. In Mozambique, fellow farmers are a major source of information, and there is much less access through groups, contact with extension agents, or radio. Development projects led by organizations such as IITA, TechnoServe and CLUSA offer information and advice through farmer groups, demonstration plots and on-farm trials. In addition, our project team is working through the recently established Center for Interdisciplinary Studies and Development (CEID) in Gurúè to coordinate and facilitate information gathering and dissemination activities.

The project is engaging producers and other stakeholders, women and men, in testing innovative communication approaches and technologies for learning and sharing information about new management practices and technologies for increasing bean yields and improving soil fertility. Given limited extension system resources in Uganda and Mozambique, methods that enhance the ability of extension services (public, NGOs, and private sector) to deliver messages as well as local peer-to-peer dissemination and learning (field days, exchange visits, local community based organizations, farmer associations) will be important. To ensure that those with low literacy skills can benefit, especially women, our communication approaches and technologies utilize visual aids (print materials and animated videos developed through collaboration with Scientific Animations Without Borders - SAWBO), and radio messages in local languages.

In 2015, to test the potential of video animations delivered through smartphones, we developed and field-tested an animation addressing a widespread problem (weevil damage) by utilizing training materials developed during the previous Pulses CRSP project in Uganda's Kamuli District regarding anaerobic bean grain and seed storage using jerry cans and the triple bag system. Sostino Mocumbe's field research with 314 farmers in Mozambique confirmed that farmers learn just as effectively from animated videos displayed on smartphones as they did from extension-led on demonstrations. Follow-up interviews at six months and one year later indicated that farmers still clearly remember the steps involved in the process. Additional video animations focusing on the project's primary research-based recommendations concerning bean production will be produced and field tested during 2016-2017. To test and disseminate the video animations and other materials, the project will partner with existing organizations that already are using tablets, smartphones, or other devices to reach farmers. CEDO in Uganda, for example, has provided smartphones to 62 of its village enterprise agents (VEAs). Our new animation video will be provided to each VEA so that, in turn, each will show the video to their member groups (up to 215 farmers each). Similar use of partner and group-based dissemination systems may be tested in projects in Mozambique led by organizations such as IITA, TechnoServe and CLUSA, with which preliminary discussions were initiated during June 2016.

Communication messages work best as part of a system that reinforces the messages and provides needed logistical support. For example, to grow beans effectively using the project's recommendations, farmers need access to certified seed and fertilizer. They also need to be assured that markets exist for their beans. By partnering with existing Innovation Platforms in Uganda and organizations leading development projects in Mozambique, farmers will have access to seed, fertilizer, credit and marketing services needed to take advantage of the communication messages. In addition to learning about recommendations through the animated videos, the Innovation Platforms and partner organizations also sponsor on-farm trials or demonstration plots where farmers can see and compare results of following the recommendations directly. Interviews suggest that the combination of awareness-raising by video animations, hand-on demonstrations in the field, and access to supporting services will be effective in persuading a number of farmers to adopt the recommendations. Video animations are most effective when the communication problem involves a process – showing specific steps to take. Printed materials to compare costs and benefits of using the recommendations, and to provide support for other crop system management diagnostic and decision support aids are being developed by project researchers working in a participatory manner with farmers and other stakeholders. In each case, prototype materials will be developed, pre-tested with farmers, revised as appropriate, and prepared for initial dissemination. Optimum levels of training and follow-up support will be determined to identify efficient use of resources (extension personnel, material, financial); this will enable development projects to utilize our research results for scaling up and achieving widespread impact. Emphasis in each country will be placed on utilizing communication approaches/technologies that maximize available resources in a sustainable manner.

Obj. 4a. Devise Evidence-Based Information Dissemination System

(lead researchers: E. Abbott, J. Bello-Bravo, B. Pittendrigh, R. Miiro, S. Mocumbe)

4a.1. Analyze results of field tests of new video animations for Uganda and Mozambique

4a.2. Develop new messages based on soil tests and research results and align with appropriate media

Milestones

Oct. 2016 - Mar. 2017 and *Apr. 2017 – Sept. 2017*

4.1 – Analysis of dissemination system and effectiveness of new video animations

4.2 – Message and media for dissemination of additional diagnostic and decision support aids

Obj. 4b. Refine Content and Information Dissemination System

(lead researchers: E. Abbott, J. Bello-Bravo, B. Pittendrigh, R. Miiro, S. Mocumbe)

4b.1. Engage farmers and other key stakeholders in a participatory process of assessing the messages and media for all diagnostic and decision support aids

4b.2. Develop strategy for effective dissemination of all diagnostic and decision support aids utilizing existing groups, organizations and communication systems

Milestones

Apr. 2017 – Sept. 2017

4.3 – Participatory assessment of messages and media for all diagnostic and decision support aids

4.4 – Strategy for dissemination of all diagnostic and decision support aids

Objective 5: Enhance Institutional Research Capacity Relative to Grain Legumes

Approaches and Methods

A key element in building institutional research capacity to increase effectiveness and sustainability of agricultural research institutions that serve the bean sector in Uganda and Mozambique is to provide graduate student training. Our project has supported training and research of graduate students in academic programs in U.S. institutions (three completed, two continuing) and in host countries (three nearing completion). Specific research foci and affiliations of current students follow:

- one Ph.D. student from Uganda is studying Sustainable Agriculture and Sociology at Iowa State University, will conduct research on farmers' perceptions, knowledge and socioeconomic factors influencing decision making for inmproved soil fertility management
- one M.S. student from Mozambique is studying soils/crops at the University of Hawaii and conducting research on alternative management practices for improving bean production

Three graduate students who have received training at Makerere University and are near completion in M.S. programs that contribute directly to project objectives:

- one student studied soils/crops and conducted research on limiting nutrients and lime requirements for bean production
- one student studied soils/crops at Makerere University and conducted research on evaluation of bean production under different soil fertility management options in Masaka, Uganda
- one student studied agricultural extension and innovation at Makerere University and is conducting research on gender dimensions of bean farmers' decision making for bean production and soil fertility management in Masaka and Rakai Districts, Uganda

Short term training is planned for 2016-2017, in which Makerere University staff, Ph.D. and M.S. students, and undergraduate students will learn how Innovation Platforms work. They will also participate in responding to farmers' technical questions using an ICT based response mobile phone operated system. In addition, a Ph.D. student supervised by Richard Miiro has joined the field research team, under private funding; he is studying 'The Effect of Smallholder Farmers' Engagement in Agricultural Innovation Platforms on Their Innovation Capacity.'

Three types of short-term training sessions are planned to enhance the understanding and skills of important bean production value chain stakeholders in Uganda: (1) equip agro-input dealers with skills for appropriate fertilizer application in quantity, quality and method of application; (2) empower frontline field extension workers with skills for appropriate soil fertility problem diagnosis; and (3) empower Innovation Platform leaders and farmer group leaders to use sound governance and leadership skills to keep a strong farmer base with capacity to absorb the technologies developed in the project. Details are provided in Appendix 1 below.

In Mozambique, IIAM is planning a workshop to share research findings with farming communities, agricultural development organizations and policy makers. This will cover information and analyses gained through the participatory rural appraisal, baseline household survey, and biophysical and agronomic studies. Details are provided in Appendix 1 below.

Milestones

Oct. 2016 - Mar. 2017 and *Apr. 2017 – Sept. 2017*

5.1 - Students continue/complete graduate study programs

5.2 - Short-term training of partners and communities

III. Contribution of Project to USAID Feed the Future Performance Indicators

(*Performance Indicators / Targets Spreadsheet for FY 2015, FY 2016, FY 2017* = attached)

IV. Outputs

Project activities are producing the following outputs:

- Characterization of smallholder bean farmers' agricultural motivations, current knowledge and practices, problem diagnoses, and livelihood and risk management strategies
- Models of farmer decision making strategies that reflect influences of social, cultural, economic, institutional and contextual factors are developed and refined
- Innovative diagnostic aids using observable characteristics that enable farmers to make site-specific management decisions are developed and validated
- Process for identifying alternative strategies and management practices for improving cropping system productivity and soil fertility is developed
- Materials to compare costs and benefits of using the recommendations, and to provide support for other crop system management diagnostic and decision support aids, are being developed
- Effective and efficient methods and media for information dissemination to intermediate and end users are developed and assessed
- Capacity strengthening through applied research-based training is conducted
- Research results published in peer-reviewed literature and at the Legume Innovation Lab website hosted by the Management Office at Michigan State University

The project's *Impact Pathway Worksheet* provides details of outputs, uses, and steps to achieving our vision of success.

V. Engagement of USAID Field Missions

We will continue to maintain and enhance communication with USAID Mission staff in Uganda and Mozambique. In 2016 in Mozambique, project PIs Russ Yost (University of Hawaii) and Ricardo Maria (IIAM) met with USAID staff members Paula Pimentel (Senior Agricultural Research & Technology Transfer Advisor), Karelyn Cruz (Agricultural Project Officer), and Surrendra Bhatta (Feed the Future Coordinator, Agriculture, Trade, and Business Office) in Maputo on February. PIs Rob Mazur, Andy Lenssen and Ricardo Maria – accompanied by Cynthia Donovan (Legume Innovation Lab Associate Director) met with Isabel Alves, Paula Pimentel and Ken Hasson (Agricultural Development Officer) on March 8. These meetings provided great opportunities to discuss project objectives and activities in the context of recent and current USAID programs in Mozambique, and identify appropriate organizations and individuals to contact to explore possible bases for collaboration.

In Uganda, on June 2, 2016, project researchers Rob Mazur, Eric Abbott, Andy Lenssen, Ebby Luvaga (all ISU), Moses Tenywa, Richard Miiro (both Makerere University), Onesmus Semalulu (NARL), and Sostino Mocumbe (IIAM) met with USAID's Andrew McCown (Agricultural Officer), Apell Oceng (Program Management Specialist for Policy) and Simon Byabagambi (Agronomist and Program Management Specialist) in Kampala. Ugandan Co-PIs maintain contact with Robert Anyang (Deputy Chief of Party of the USAID Uganda Feed the Future 'Commodity Production and Marketing' project) and William Luyinda (Program Manager) and Mary Arach of AKORION (ICT for Agriculture). Following our discussion in 2015 with Mark Tamale, General Manager of Buddu Broadcasting Services in Masaka, we met with Robert Kayabula (marketing) and Godfrey Dicxon (presenter) on May 25, 2016. These meetings established the basis for radio broadcasts in Masaka and Rakai concerning project research results and crop system recommendations.

We will be pleased to respond when the Missions express interest in an Associate Award that would enable us to provide technical assistance and access to grain legume technologies.

VI. Partnering and Networking Activities

In Masaka and Rakai, multistakeholder Innovation Platforms (IPs) are consortia of partners - private sector, researchers, extension workers, district local government staff, and NGOs. The Bean Program of the National Crops Resources Research Institute (NaCRRI), through its Pre-cooked Beans Project with CIAT, has joined the bean Innovation Platform. The African Forum for Agricultural Advisory Services (AFAAS), and the Ugandan equivalent (UFAAS) have also joined the platform. They will contribute resources for promoting relevant technologies as our project team addresses soil improvement issues and market opportunities. They will also be part of the collective learning process, informing how to scale up the use of IPs as farmer learning centers alongside value chain actors. Project activities in Uganda, particularly through the IPs, have stimulated efforts to involve pathologists to address potential bean seed and soil borne diseases. Discussions are underway with the leadership of the National Agricultural Research Organization in Uganda to become more involved in the platforms and offer more technical and resource support. The AFAAS and UFAAS network will facilitate sub-regional connections and information sharing.

The IPs and the forms of technology dissemination such as using animated videos - are attracting other partners, such as the m-Omulimisa meaning 'mobile extensionist.' The m-Omulimisa proprietor

has demonstrated the use of mobile phones to access agricultural information. Discussions are underway with the International Institute of Tropical Agriculture (IITA) to scale up the use of IPs as a form of technology dissemination, extension advice and innovative marketing. The project IPs in Uganda will serve as one of the learning centers. Under this collaboration, several disciplines in the College of Agricultural and Environmental Sciences, Makerere University will be involved. They will contribute their expertise to solving farmers' bean production problems through the mobile extension system, while their understanding of IP functionality will also be enhanced. This is expected to contribute to University curriculum changes including understanding the practical relevance of IPs during student training and research.

Co-PI Ricardo Maria and Sostino Mocumbe (IIAM) are following up initial meetings held by research team members with: (1) IITA (Dr. Steve Boahen - Regional Coordinator; Carlos Malita - SEMEAR project manager; and Ana Covinhas - Communications officer); (2) NCBA CLUSA (Dr. Carlos Sanchez - Regional Director); and (3) FAO (Mr. Omar - representative in Gurúè). Communication with Rowland Chirwa (CIAT/PABRA) focuses on research objectives and activities, and identification of potential bases for collaboration vis. seed varieties. We continue to learn about relevant existing and emerging conservation agriculture approaches and technologies (e.g., how upland farming practices can be improved for reducing erosion and quality of lowlands where rice and bean are grown). We will continue to network with PABRA, the AGRA Soil Health Program and CABI (Ricardo Maria is involved with both programs), McKnight Foundation which has programs with an integrated multi-functional intensification emphasis, Africa RISING which focuses on maize-legume based systems in the Eastern Highland of Africa, the Bill and Melinda Gates Foundation, and IFDC.

Project researchers will continue to build collaborative relationships with two African based networks under PABRA (the Pan-African Bean Research Alliance): the Eastern and Central Africa Bean Research Network (ECABREN) and the Southern Africa Bean Research Network (SABREN). The project team, particularly collaborating research institutions in Uganda and Mozambique, will identify partnering and networking activities to ensure that appropriate public and private sector institutions can engage in follow-up adaptive research and field validation, in addition to technology transfer, in FTF countries and regions so that research outputs are disseminated on a wide scale for quantifiable developmental impact.

VII. Leveraged Resources

The project team is exploring opportunities to collaborate and coordinate research efforts with CGIAR scientists (IITA, CIAT and ICRISAT in the USAID-funded SEMEAR project in Mozambique), the AGRA Soil Health Program, McKnight Foundation, Africa RISING, the Bill and Melinda Gates Foundation, and IFDC. We are identifying how such opportunities will complement and coordinate with planned activities described in the Workplan of this Legume Innovation Lab project.

VIII. Timeline for Achievement of Milestones of Technical Progress

(*Milestones of Progress* = attached)

Appendix 1: Workplan for Training/Capacity Strengthening - FY 2017

Degree Training

Trainee #1

First and Other Given Names: Naboth
Last Name: Bwambale
Citizenship: Uganda
Gender: Male
Training Institution: Iowa State University
Supervising Legume Innovation Lab PI: Robert Mazur
Degree Program for training: Ph.D.
Program Areas or Discipline: Graduate Program in Sustainable Agriculture *and* Sociology
If enrolled at a US university, will Trainee be a 'Participant Trainee' as defined by USAID? No
Host Country Institution to Benefit from Training: Makerere University
Thesis Title/Research Area: Farmers' Perceptions, Knowledge and Socioeconomic Factors Influencing Decision Making for Integrated Soil Fertility Management
Start Date: August 2016
Projected Completion Date: May 2019
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect) for training activity: Partial

Trainee #2
First and Other Given Names: Prossy
Last Name: 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 at a US university, will Trainee be a 'Participant Trainee' as defined by USAID?
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: January 2017
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect) for training activity: Partial

Trainee #3
First and Other Given Names: Stewart
Last Name: 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 at a US university, will Trainee be a 'Participant Trainee' as defined by USAID?
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: January 2017
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect): Partial

Trainee #4
First and Other Given Names: Jafali
Last Name: 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 at a US university, will Trainee be a 'Participant Trainee' as defined by USAID?
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 2017
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect): Partial

Trainee #5
First and Other Given Names: António José
Last Name: 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 at a US university, will Trainee be a 'Participant Trainee' as defined by USAID? Yes
Host Country Institution to Benefit from Training: 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: August 2017
Training status: (active, completed, pending, discontinued or delayed): Active
Type of USG Support (full, partial or indirect) for training activity: Full

Short-term Training:
Name of training program: Agro-Input Dealer Training
Type of training: Fertilizer application
Description of training activity: Equip agro-input dealers with skills for appropriate fertilizer application in quantity, quality and method of application
Location: Kampala
Duration: 3 days
When will it occur? Jan 2017
Participants/Beneficiaries of Training Activity: 30

Anticipated numbers of Beneficiaries (male and female): 15 M and 15F
PI/Collaborator responsible for this training activity: Dr. O. Semalulu
Approximate budget allocation from USAID funds for training: US$ 6000
List other funding sources that will be sought (if any): Private sector
Training justification: Meets project goal

Name of training program: Field Extension Workers Training
Type of training: Soil fertility problem diagnosis
Description of training activity: Empower frontline field extension workers with skills for appropriate soil fertility problem diagnosis
Location: Masaka
Duration: 3 days
When will it occur? Jan 2017
Participants/Beneficiaries of Training Activity: 30
Anticipated numbers of Beneficiaries (male and female): 15 M and 15F
PI/Collaborator responsible for this training activity: Dr. O. Semalulu
Approximate budget allocation from USAID funds for training: US$ 5000
List other funding sources that will be sought (if any): n.a.
Training justification: Meets project goal

Name of training program: Innovation Platform Leadership and Group Management
Type of training: Training of farmer innovation platform leaders in leadership and group management skills in order to facilitate uptake of project practices and technologies
Description of training activity: Empower Innovation Platform leaders at the Apex and the farmer group leaders to use sound governance and leadership skills to keep a strong farmer base with capacity to absorb the technologies developed in the project
Location: Masaka & Rakai
Duration: 6 days, split into 3 offerings
When will it occur? March 2017
Participants/Beneficiaries of Training Activity: 45
Anticipated numbers of Beneficiaries (male and female): 25 M and 20 F
PI/Collaborator responsible for this training activity: Dr. R. Miiro
Approximate budget allocation from USAID funds for training: US$ 8000
List other funding sources that will be sought (if any): n.a
Training justification: Meets project goal

Name of training program: Workshop for sharing research findings with communities, agriculture development organizations, and District Agricultural Department
Type of training: Soil research and participatory action research findings
Description of training activity: increase awareness of soil fertility problems, responses for integrated soil fertility management and challenges and opportunities for improving bean productivity in Gurúè
Location: Gurúè
Duration: 2 days
When will it occur? September 2017
Participants/Beneficiaries of Training Activity: 25
Anticipated numbers of Beneficiaries (male and female): 15 M and 10F
PI/Collaborator responsible for this training activity: Ricardo Maria and District Agricultural Department
Approximate budget allocation from USAID funds for training: US$ 4000

List other funding sources that will be sought (if any): Optimizing Fertilizer Recommendation in Africa (OFRA).
Training justification: Meets project goal

Name of training program: Developing Soil Quality indicators and Decision Guides corresponding to soils and bean crop requirements
Type of training: Use innovative farmers to support clustering soils and developing decision guides
Description of training activity: Empower innovative farmers, field extension and researchers in identifying soil quality indicators and matching with crop requirements. The training will draw on generalized scientific soil classification and sharpen the focus to match local soil groupings.
Location: Gurúè
Duration: 6 days, including field and office activities
When will it occur? July 2017
Participants/Beneficiaries of Training Activity: 59
Anticipated numbers of Beneficiaries (male and female): 45 M and 14 F
PI/Collaborator responsible for this training activity: Ricardo Maria
Approximate budget allocation from USAID funds for training: US$ 9000
List other funding sources that will be sought (if any): n.a.
Training justification: Meets project goal

Equipment (costing >$5,000)**:**
Specific Type of Equipment to be purchased:
Justification for equipment to achieve Workplan objectives:
Institution to benefit from equipment:
Institution to purchase equipment:
Amount budgeted for equipment item:

Appendix 2: **Budget Narrative (SO2.1)**

a. Personnel Cost

Salaries – ($97,460) this includes: Graduate Research Assistant stipend and tuition at ISU, Hawaii, and Makerere; a software specialist at Hawaii; and technicians at NARL and IIAM.

Fringe Benefit – ($13,709) institutional rates are applied at ISU and Hawaii; these vary according to personnel type.

b. Travel – ($101,957) this includes: travel to Lead PI and U.S.-based Co-PIs to Uganda and Mozambique for field research and meetings; travel to the U.S. by Africa-based Co-PIs to collaborate on analyses and writing; and travel by the GRAs to Uganda and Mozambique for field research.

c. Equipment ($5000 Plus) – N/A

d. Supplies – ($51,044) this includes: research materials to conduct interviews and for communication and extension activities (ISU); research materials and analyses of soil and plant samples (Hawaii); field experiment inputs and supplies, soil analyses, farmer workshops and trainings, and use of communication media (Makerere, NARL, and IIAM); and fuel and maintenance for vehicle (IIAM).

e. Training

Degree – ($7,303) this includes: tuition for the GRAs at ISU and Makerere (tuition at Hawaii is not charged to the grant, but covered by the institution).

Non-Degree – these costs are incorporated in the supplies budget for Makerere, NARL and IIAM.

f. Other – ($9,349) this includes: phone calls and DHL (all institutions); dissemination workshop (Makerere)

g. Total Direct Cost – ($280,822)

h. Indirect Cost - ($50,201) institutional rates on applicable categories of expenditure are applied (26% at ISU, 24% at Hawaii, and 10% at Makerere, NARL and IIAM).

i. Indirect Cost on Subcontracts (First $25000) – N/A

j. Total Indirect Cost – ($50,201)

Total – ($331,023)

Grand Total - $331,023

Notes:

- The split in total direct costs is U.S. (16.05%) and HC institutions (83.95%)
- Breakdown in cost share contributions (in-kind & cash) by the U.S. (100% - $25,245 by ISU and $8,5889 by Hawaii) and Host Country institutions
- Total budgetary attribution to institutional capacity building (29.78%)