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

FY 2017 Annual Project Technical Progress Report
(October 1, 2016 – September 29, 2017)

Project Code and Title:
SO4.1 Impact Assessment of Dry Grain Pulses CRSP investments in research, institutional capacity building and technology dissemination for improved program effectiveness

Lead U.S. Principal Investigator and University:
Mywish Maredia, Professor, International Development, Agricultural, Food and Resource Economics (AFRE), Michigan State University

Collaborating Host Country and U.S. PIs and Institutions:
Eric Crawford (Co-PI), Robert Shupp, David Ortega, Nicole Mason, Nathalie MeNsope and David DeYoung (Collaborators), Agricultural, Food and Resource Economics, Michigan State University; Byron Reyes (Collaborator), CIAT; Fulgence Mishili and Paul Kusolwa (Collaborators), SUA; Francis Kusi (Collaborator), SARI; Dieudonne Ilboudo (Collaborator), INERA; James Beaver (Collaborator), UPR; Timothy Porch (Collaborator), USDA-ARS; Emmanuel Prophete (Collaborator), NSS, Haiti; Barry Pittendrigh (Collaborator), MSU.

I. Abstract of Research and Capacity Strengthening Achievements

In this final year of the Legume Innovation Lab, several assessments and case studies focused on outputs, outcomes and impact of legume research were completed by this project in Burkina Faso, Uganda, Guatemala, Haiti, and Nicaragua. Results of these assessments have important implications for impact oriented legume research in developing countries. The baseline assessment in Guatemala confirmed that men and women farmers have slightly different preferences for varietal traits, but the ranking of different types of traits was the same. Overall, size and color of the bean, and productivity traits were the top two most important traits preferred by both men and women. The study in Uganda based on a nationally representative survey of households suggests consistent positive effects of legume rotation, intercropping, and other legume technologies on calorie and protein production per capita. This evidence points to the need to promote these practice where it is feasible for farmers to do so. Research studies on the theme of sustainable seed system were extended to two more countries this year--Burkina Faso and Nicaragua. The results of the willingness to pay experiments conducted in these two countries are consistent with the previous studies conducted in Tanzania and Ghana. Together this cohort of four studies indicate that quality seeds do perform better and farmers are able to perceive this performance difference and willing to pay a premium for quality seed. However, across all the countries studied, for a significant proportion of legume growing farmers the willingness to pay a premium for quality seed is much lower than the existing certified seed to grain price ratio. Current efforts to promote private sector led production and supply of certified seeds can potentially meet the seed needs of at most 30-35% of farmers. More research and discussion needs to happen to address the seed needs

of a majority of farmers (two-thirds or more) whose WTP for quality seed is below the price at which certified seeds are sold in the market. The results of the farmer survey in Haiti point to the challenge of sustaining the use of improved varieties once they are disseminated to farmers through a systematic seed dissemination efforts such as the BTD project. This is due to the fact that most farmers sell their harvest and don't save seeds for the next planting. Secondly, the bean varieties have no name recognition, which makes it difficult to track improved varieties disseminated through formal channels. In this circumstances, DNA fingerprinting offers the best approach for varietal identification and estimating varietal adoption.

II. Project Problem Statement and Justification

Impact assessment is essential for evaluating publicly-funded research programs and planning future research. Organizations that implement these programs should be accountable for showing results, demonstrating impacts, and assessing the cost-effectiveness of their implementation strategies. It is therefore essential to document outputs, outcomes and impacts of public investments in research for development (R4D) activities. Anecdotal data and qualitative information are important in communicating impact to policymakers and the public, but must be augmented with empirical data, and sound and rigorous analysis.

The proposed research contributes towards evidence-based rigorous ex ante and ex post assessments of outputs, outcomes and impacts with the goal of assisting the Legume Innovation Lab program and its Management Office (MO) to achieve two important goals--accountability and learning. Greater accountability (and strategic validation) is a prerequisite for continued financial support from USAID and better learning is crucial for improving the effectiveness of development projects and ensuring that the lessons from experience – both positive and negative – are heeded. Integrating this culture of 'impact assessment' in publicly funded programs such as the Legume Innovation Lab and generating knowledge outputs will ultimately help increase the overall impact of such investments.

III. Technical Research Progress

Objective 1. Provide technical leadership in the design, collection and analysis of data for strategic input and impact evaluation

1a. Analysis of baseline study in Guatemala

A baseline survey of more than 500 farm households from the five departments (Quiche, Huehuetenango, San Marcos, Chimaltenango and Quetzaltenango) of the *Altiplano* region of Guatemala was conducted in 2015 jointly with the SO1.A1 project team under their objective '*Genetic improvement of climbing black beans for the highlands of Central America*.' The main objective of this survey was to study the constraints and opportunities for research to contribute to increased productivity of climbing beans in Guatemala. In FY 17, the data analysis was completed and a working paper has been developed for wider dissemination.

Main Results: This study is one of the first representative farm surveys of climbing bean growers in the *altiplano* region of Guatemala. The analysis of this data has helped gain a better understanding of farmer characteristics, bean production practices in the *milpa* system, varietal trait preferences, and the role of beans in household food consumption. The analysis contributes towards establishing priorities for the climbing bean breeding program targeted for increasing the productivity of the *milpa* system. It confirms the importance of beans in both the production and dietary systems of the indigenous people living in this region. More than 90% of farmers surveyed consider beans among the top two most important crops they produce in terms of area planted (on average a farmer planted 0.4 ha for bean production). Beans, planted as part of the traditional intercropped system called *milpa*, are most commonly planted simultaneously (or directly) with corn, although the relay (*milpa relevo)* system is also practiced by one out of every five farmers in this region.

Beans play an important role in the diets of the local population in this region and people perceive it to be a nutritious food relative to other commonly consumed food items. Beans are consumed throughout the year, but own production is not sufficient to meet the bean consumption needs for most farmers in this region; they rely on purchased beans to fill this deficit. Thus increasing productivity of bean crop can increase bean security, and potentially enhance nutritional outcomes by increasing the quantity and frequency of bean consumption.

To guide future bean breeding efforts targeted for this region by the SO1.A1 team, farmers were also asked to rank different varietal trait preferences they would like to see in new bean seed. The results for men and women respondents grouped into five varietal traits are presented in Figure 1. These include: 1) Visual traits: size and color; 2) Productivity (yield, disease resistance and resistance to insects); 3) Storage and Culinary traits (cooking time, taste of green beans, taste of dry beans and resistant to storage pests); 4) Agronomic traits (early maturity and anti-lodging); and 5) Marketability (easy to sell). Overall, the top trait indicated by farmers was either visual traits or productivity traits (60%) as seed in Figure 1.

Top preferences for size and color, storage and culinary quality traits, and marketability did not differ between men and women respondents. However, women farmers preferred as the top characteristic productivity traits on average more than men farmers at $p<0.05$; while men preferred agronomic traits (early maturity and anti-lodging properties) as the top characteristic more than women at $p<0.05$ (See Figure 1). If a variety with the preferred traits was made available, farmers were willing to pay on average 6.06 Quetzales/lb of bean seed of that improved variety. Women farmers were willing to pay about 0.16 Quetzales per lb. more than men counterparts for seeds of improved variety with preferred traits. However, this difference is not statistically significant (Table 1).

We estimated the determinants of farmers' willingness to pay for bean seed of preferred variety using regression analysis, and found that farmers' willingness to pay (WTP) for improved quality bean seed of preferred variety was highly correlated with farmers' poverty score, area planted to bean production, and gender. For example, all else equal an increase of 1 point in the poverty score (i.e., decreased probability of being poor) was associated with a 0.6% increase in WTP. All else equal, an additional *manzana* (0.7 ha) of bean production area (i.e., farmers growing more beans) increased WTP by 5.1%. All else equal women farmers were willing to pay 7.3% more than men farmers for bean varieties of their preferred traits.

The regression results confirm that men and women farmers have slightly different preferences for varietal traits. On characteristics traditionally considered to be more important for women than men (i.e., cooking quality, size and color), there was no significant difference in their ranking by men and women. The analysis did not find specific characteristics of bean varieties for which farmers were willing to pay a price premium. The average WTP for bean seed was 6.06 Quetzales/lbs (about $0.80), which reflects about 10% premium over the grain price. This indicates that even for improved bean varieties with preferred traits, most farmers in this region cannot afford to pay a premium price for bean seed that can cover the cost of making quality seed available to them.

The results of this study on varietal preferences have important implications for bean breeding research and seed dissemination efforts. Overall, size and color of the bean, and productivity traits (i.e., yield potential and resistance to stresses) were the first and second most important traits preferred by both men and women. **The study confirms that men and women farmers have slightly different preferences for varietal traits, but the ranking of different types of traits was the same.** On characteristics traditionally considered to be more important for women than men (i.e., cooking quality, size and color), there was no significant difference in their ranking by men and women.

The study did not find specific characteristics of bean varieties for which farmers were willing to pay a price premium. The average WTP for bean seed was 6 Quetzales/lbs (about $0.80), which reflects about 10% premium over grain price. This indicates that **even for improved bean varieties with preferred traits, most farmers in this region cannot afford to pay premium price for bean seed that can cover the cost of making certified seed available to them.** Thus, any efforts to make quality bean seed of improved varieties accessible to these communities will have to rely on subsidy based approaches or innovative profit-based models that can lower the cost of locally producing quality seed (albeit not certified per legal definition) and making them available to farmers in this remote areas of Guatemala at affordable prices.

Progress report on publication outputs: A report summarizing the descriptive results of the farmer survey is forthcoming as AFRE Department Staff Paper 2017- 08. Cleaning and organizing of survey dataset is ongoing, and will be registered and made available on USAID's DDL website by the end of November 2017.

1b. Analysis of existing data for strategic insights to guide impactful research on legume based farming systems

Legumes impart several agronomic, environmental, and economic benefits to smallholder farm households. As natural nitrogen fixers, legumes reduce the need for inorganic fertilizer and enhance long-term soil fertility and productivity. Due to their high protein, mineral, and fiber content, legumes also carry nutritional benefits. Legumes therefore likely play a positive role in ensuring a household's food security through two pathways:

- The income pathway (i.e. increasing the productivity and income-generating capacity of the production system), and
- The consumption pathway (i.e. increasing the diversity of nutrient-rich food for self-consumption).

Following up on the work conducted in Zambia in the previous year, in FY 17, the project team undertook a similar research activity in Uganda using existing data to build an evidence base by exploring pathways through which legumes potentially enhance agriculture-food security linkages. Specifically, we examine the links between the various ways in which households incorporate legumes into their cropping activities (namely, rotations with cereal or other crops, inter-cropping with cereal or other crops, or mono-cropping) and several indicators of household food security and welfare along the agricultural production and income pathways (Figure 2). The legumes commonly grown in Uganda and included in the study are Beans, Field peas, Pigeon peas, Chick peas, Groundnuts, Soybeans. We give a brief overview of the methodology, emerging results, and need for further research.

Method: Three rounds of the Living Standard Measurement Survey (LSMS) data for Uganda, representing years 2009, 2011 and 2013 were used for this analysis. A subsample of households who grew legume crops at least in one plot in any of these three years was included in the analysis. The analytical sample consists of 3,390 Households comprised of 1,130 HHs from each wave. Data were analyzed at the household level using panel data methods (i.e., pooled OLS and household fixed effects). The aim of these analyses is to assess the impact of the adoption of legume intercropping, legume rotation and legume mono-cropping practices on crop income, calorie and protein production, and indicators of household food security and diet diversity.

Main Results: Figure 3 shows the extent to which legume-based cropping practices are adopted by farmers in Uganda. Note that these are not all mutually exclusive practices. A household may be using multiple practices on different plots in a given year. On average the adoption rate of different technologies in each of the waves is around 50 %. For some reason, the percentage of households practicing these different technologies was smaller in 2013 compared with 2011 and 2009 (fig 3). Mean comparisons (using t-test) of outcome indicators between users and non-users of these practices indicated positive correlation between the legume based cropping practices (i.e., intercropping and rotation) and the outcomes, which is encouraging.

Preliminary regression results using the pooled OLS and household fixed effects methodology showed **significant effects** of legume based technologies on food production (i.e., calories) and nutrient production (i.e., protein). However, the effects of individual technologies on other indicators down the impact pathway are mixed (Table 2).

The positive correlation between legume based cropping practices and some of the production, income, consumption and dietary diversity outcomes pointed out by this study is encouraging. However, rigorous analysis that control for selection bias and the issue of endogeneity is needed to assess any causal link between these different agricultural practices and nutritional outcomes, and to assess which pathways are contributing to those impacts (if impacts can be attributed to legume technology).

In summary, the two case studies conducted over the last two years using nationally representative data from Zambia and Uganda suggest that incorporating legume crops in cropping system either as rotation crop or inter-crop have positive effects on some indicators of household income, production, food security and dietary diversity. **The most robust effects are on the production of calorie and protein per capita.** From a policy perspective, the empirical evidence that legume rotations and inter-cropping can improve food production and food access among smallholder farmers, points to the need to promote these practice where it is feasible for farmers to do so. Researchers from NARS together with social scientists in these countries should investigate the specific types and lengths of cereal-legume rotations that are the most welfare-enhancing for Zambian and Ugandan smallholders.

Further research is also needed to understand the low adoption rates of cereal-legume intercropping among Zambian smallholders, and to identify and promote specific cereal-legume intercrops that meet farmers' needs.

Progress report on publication outputs: A paper summarizing the results of the Zambia study has been published as an MSU International Development Working Paper, and revisions are underway for publication as an IAPRI working paper. The Uganda analysis and preliminary results were presented as a poster paper at the Legume Innovation Lab conference in Burkina Faso in August and as an oral presentation at the Mastercard Foundation Scholars event on campus in October. The graduate student funded by Mastercard Foundation plans to extend and further refine the analysis for Uganda as part of her thesis research. Eventually, we plan to submit two manuscripts (one for each country) for consideration in a peer reviewed Ag Econ journal.

Objective 2. Conduct ex ante and ex post impact assessments

2a. Sustainability of legume seed system constraints and opportunities to guide policies and programs

Two studies were initiated/completed in FY 15 (Tanzania) and FY 16 (Ghana) under this broad theme. This line of research was further extended in FY 17 to include the following three country-specific studies.

i. ***Willingness of small holder farmers to pay for quality seed—Study in Nicaragua:***

Benefits from plant breeding research that generates new varieties with improved agronomic and nutritional traits (i.e., biofortification) can only be transferred to farmers if those varieties are officially released, and good quality seeds of such improved varieties are available to and planted by farmers. To date the plant breeding program of the Nicaraguan Research System (INTA) in collaboration with HarvestPlus and CIAT has released two iron biofortified bean varieties. However, the delivery of improved seed to farmers is happening at a small scale. Farmers can potentially use three types of seeds of these improved and biofortified bean varieties—certified seed, quality-declared seed (referred locally as Apta Seed) or recycled grain as planting material. This study was carried out in collaboration with CIAT/HarvestPlus in Nicaragua to address the following three objectives:

1. Analyze the agronomic performance of these three types of planting materials: certified seed, apta seed, and recycled grain.
2. Quantify the premium farmers are willing to pay (WTP) for these alternatives, using two methods—bidding auction experiments (BDM) and real choice experiments (RCE).
3. Test the impact of information treatment about the high iron content (and nutritional benefits) of the variety on farmers' WTP for quality seed.

Method: To address these objectives, double-blind farmer-run demonstrative field experiments were established in the first season of the year (May-August 2017) in 12 villages in Nicaragua, distributed across four departments and six municipalities. However, later in the season two of the villages were excluded from the study because one was planted too late (and could not carry out the field days on time) and another was completely lost by pest damage.

Specifically, to address objectives 1 and 2, a two-step approach was used. First, the double-blind demonstrative fields allowed experts to track the management given by the farmer, and to estimate yields, in addition to allowing farmers to learn first-hand how the different types of seeds of the same improved variety performed in a location that is close to their farm and under farmer management. Second, once farmers learned how the different types of seeds performed, a bidding experimental mechanism and a real choice experiment were carried out to extract information about how much they were willing to pay for these seeds based on their perceived or observed differences in performance. To address objective 3, information about the high iron content of the improved variety, and the benefits of consuming these beans was provided to farmers using a poster as a visual aide. This information treatment was given to farmers in half of the villages prior to implementing the bidding/choice experiments.

In each field, three plots with different qualities of bean seed of an iron-rich biofortified variety named INTA Ferroso were planted: Certified Seed (which was purchased from the government seed vendor in 2017 at a price of $1.15/lb), Apta or quality-declared seed (obtained at a price of $0.60/lb) and recycled grain (purchased at price $0/48/lb). The Apta and recycled grain were both produced by farmer-run community seed banks. It should be noted that since INTA Ferroso is a relatively new variety and not yet widely disseminated to farmers, the recycled seed used in these experiments was simply one generation advanced seed produced by the seed bank (i.e., it represents recycled grain by CSB, not the farmer).

To maintain the blindness of the experiment, the demonstration plots were marked using symbols: a circle for certified seed, a square for apta seed and a triangle for recycled grain. Neither the field technicians, nor the farmers managing the fields knew which symbol corresponded to which seed type; hence the experiments are considered double-blind. Two field days were organized in each village where all farmers in the village were invited to participate. The first field day was done soon after flowering, and farmers evaluated the plots and ranked them, and a census of participants was done. The second field day was done near maturing, and farmers evaluated the fields a second time, ranked them, and both the bidding mechanisms (i.e., the Becker-DeGroot-Marschak method and the real choice experiments) were carried out in each village in that order. Although all farmers who participated in the first field day were invited to the second field day, some did not attend. Further, some farmers participated in the second field day, but not the first one.

Results: Yields, standardized to 14% moisture, varied across locations (**Error! Reference source not found.**3). Analysis of agronomic data suggest that the low yields observed in villages El Porcal and Ojo de Agua were due to a poor crop management and the low soil quality. The villages with the highest grain yield (average of the three seed types) were B3 (Las Mesas Sur), A5 (Moropoto) and A1 (Santa Rosa), followed by all other villages. On average, apta seed yielded more, followed by recycled grain and certified seed. This probably was due to, in addition to crop management, the quality of the planting materials, as determined by its germination rates: 91% for apta seed, 86% for recycled grain and 78% for certified seed.

To statistically test the mean yield difference across treatments, an analysis of variance (ANOVA) was carried out (**Error! Reference source not found.**3). As can be seen, on average seed obtained from the community seed bank (i.e., apta seed) yielded statistically significantly more than certified seed obtained from a government vendor. This suggest that high-quality, low-cost seed can be made available to farmers using a community based approach. Furthermore, there were no statistically significant differences in yields between recycled grain (obtained from the same community seed bank as the apta seed) and either apta or certified seed.

Results from the second field day evaluation showed that 78% of farmers selected the square symbol plots planted with apta seed as the best plot (Table 3), far more than percentage of farmers ranking circle and triangle plots as the best plots (11% and 10%, respectively). Although farmers did not know the identity of the seed type, nor the actual yields, their ranking of plots during field day 2 (based only on visual characteristics of plant growth) are consistent with the yield results (Table 3).

Results from both the BDM and RCE exercises show that most farmers were willing to pay a premium for high quality seed, as perceived by them during the second field day evaluation of the plots. Results for the BDM are presented in Table 4. On average, farmers were willing to pay more than double the price of reported grain price for the highest ranked quality seed (which was plot square) and about 65-70% over the reported grain price for the lower ranked quality seed (i.e., plot circle and triangle). Finally, bivariate statistical test suggest that providing information about the high iron content of the variety did not have any statistically significant effect at the 10% level in farmers' WTP for any of the seed types (Table 4). The average price premium farmers are WTP for highest rated seed type (which turned out to be apta seed in this case) over lowest rated seed type (which turned out be recycled grain) is about 33%, which is similar to premium price we had estimated for beans in Tanzania, but lower than estimated for cowpea in Ghana (73%).

ii. ***Willingness of small holder farmers to pay for quality seed—Study in Burkina Faso:***

Similar to the study in Nicaragua, Ghana, and Tanzania, the goal of this research conducted in Burkina Faso this year was to understand cowpea farmers' willingness to pay (WTP) for certified, quality declared and own-saved or recycled cowpea seeds. Specific research questions addressed include:

a. Do farmers perceive any difference in quality (performance) between the 3 types of seed or planting materials?
b. How does the perceived differential performance of different types of seeds translate into farmers' WTP for these seeds?
c. What factors determine the WTP for each type of "seed" product?

Method: The Becker-DeGroot-Marschak experimental method was used to elicit information on how much cowpea farmers are willing to pay for certified, QDS and recycled seeds based on their perceived/observed differences in their performance. The experiment was conducted with individual farmers. Each farmer received an initial endowment of 1500 FCFA to purchase one kilogram of cowpea seed of an improved variety that varied in ‘quality.’ The study in Burkina Faso was different from other past studies in two ways. First, instead of conducting double blind field experiments and allowing farmers to observe the performance of plants in actual fields, farmer was presented with pictures of two farmer plots planted to each of the three types of seed products, one picture at the flowering stage and the other at the harvest stage. The plots were simply labeled as plot G, L or M. The identity of the seed quality type planted on these plots was not revealed either to the enumerator of the farmer. In this sense, these were double-blind exercises. The farmers were given some time to visually perceive the performance characteristics or key quality attributes of each seed plot based on the high quality color pictures printed on legal size papers, after which he/she was asked to reveal the willingness to pay for each seed product (type G, L or M). Secondly, in this study we also included a non-blind experimental component. In the non-blind experiment, each farmer were shown three one kg sample of cowpea seeds of the same variety—certified, QDS, and recycled. Farmer expressed their bid for each of these three seed types knowing which of the three seed types they were bidding for. This was done before the picture based exercise. Once the farmer had expressed his/her bid for the three seed types based on labeled seed samples (non-blind), and the three seed types based on plot pictures labeled as plot G, L and M (blind), one of these bids was randomly selected, and a random price was determined to decide whether the farmer purchased that seed at the random price or kept the endowment money.

The study was conducted in 20 villages cutting across 4 provinces in Burkina Faso (Bazega, Boulgou, Gansourgou and Zoundweogo). From each of these villages, 16 households were selected. This resulted in a total sample size of 320 cowpea farmers.

Main Results: The results of the blind experiment suggest that farmers perceived quality attributes associated with different seed types based on plant performance at the flowering and harvest stages. Approximately 86% of the farmers surveyed rated plots planted with certified seeds (plot G) as the best plot, while 13% rated the plot planted with quality declared seeds (plot L) as the best seed plot. Farmers’ perception of the performance of each seed type was also reflected in their bids—average bidding price per kilogram was 1226 CFA for seed type G (i.e., certified seeds), 1058 CFA for seed type L (i.e., QDS), and 653 CFA for seed type M (i.e., recycled or own-saved seeds). These prices were also higher than the average price of cowpea grain sold in the market (396 CFA/kg) as reported by the farmers (Figure 4).

Farmers are willing to pay a premium for quality seeds if quality seeds are available. There is a demand for quality cowpea seeds. However, access to these seeds remain an important challenge for cowpea farmers in Burkina Faso. Farmers who did not win the 1 kg of seeds that was randomly offered for sale were very disappointed. As observed by these farmers, quality seeds are difficult to find even when they have money to buy the seeds. These findings suggests the need for investments in cowpea seed value chain to increase the availability of quality seeds—for example, seed multiplication and further production, seed quality assurance system, and seed distribution.

The number of farmers willing to pay a premium price for quality seed declined as the price of seed increased. This finding, which is similar to other studies conducted under this sub-objective, also suggest the need for interventions to reduce the cost of seed production, thereby reducing the price of quality seeds, and consequently making the quality seed affordable to more number of farmers.

Summary of key findings and implications from research on farmer willingness to pay for quality seeds: We would like to summarize the main findings and implications emerging from the four studies conducted so far under this sub-objective in different countries and for two legume crops (beans and cowpea).

Finding # 1: Quality seeds do perform better in terms of important characteristics (i.e., germination rate, yield, etc.) relative to recycled grain of legume crops.

Implications:

- To increase productivity, it is not sufficient to promote only the adoption of improved varieties, but also quality seed
- Need more experimental evidence on productivity differences in seed types across legume crops and countries to confirm or challenge the notion that self-pollinated crops such as beans and cowpeas do not suffer from yield loss (from seed quality deterioration) due to recycling seeds for up to five or more generations.

Finding # 2: Farmers are able to perceive quality differences in planting material and are willing to pay a premium for QUALITY seed

Implications:

- Further research is needed to assess the quantity of seed farmers would be willing to buy at a premium price and the frequency. This information will help gauge the size of the demand for quality seed.

Finding # 3: Although the bidding experiments reveal that about 30-35% of farmers' WTP for quality seed was above the price of certified seed, in practice farmers' use of purchased certified seeds or QDS is much lower than reflected in the percentage of farmers WTP a premium for quality seed.

Implications:

- Further research is needed to investigate whether the low (actual) demand for quality seed products is a trust issue (i.e., counterfeit or inferior seed) or availability issue (i.e., supply side constraint)?

Finding # 4: Number of farmers willing to pay a premium price for quality seed declines as price of seed increases (i.e., results are consistent with the downward sloping demand curve). Across all the countries studied, we find that there are a significant proportion of legume growing farmers whose willingness to pay a premium for quality seed is much lower than the existing certified seed to grain price ratio.

Implications:

- Need multi-pronged approaches to meet the seed needs of all the farmers across this spectrum of WTP. Current efforts to promote private sector to produce and supply certified seeds can potentially meet the seed needs of at most 30-35% of farmers (if the quality of those seeds is substantially superior to recycled grain).

- More research and discussion needs to happen to address the seed needs of a majority of farmers (two-thirds or more) whose WTP for quality seed is below the price at which certified seeds are sold in the market. Research is needed on how to lower the cost of quality seed production so that per unit cost can be brought closer to grain price, without lowering the profit margins for seed producers to stay in business. For example, training and capacity building of seed producers, supporting the development of new innovative technologies for seed production, and quality assurance monitoring system, that can both lower the cost of quality assurance system and reduce the rejection of seeds that don't meet quality standards, can increase the 'seed' yield, and thus lower the cost per unit of 'seed' produced.

iii. ***Case study on community based seed system in Nicaragua***

One of the innovative approaches to produce and disseminate low cost quality bean seed to farmers in Nicaragua that was used by the BTD project was the Community Seed Banks (CSB), a model promoted by the Government of Nicaragua as a mechanism to promote quality seed availability at the community level. Between 2011 and 2013, the BTD project supported or helped create a network of 234 CSBs across the country and an estimated 16,065 farmers obtained seed from these project supported CSBs, which represented 23% of farmers cultivating beans on 10 MZ (7 hectares) or less. The seed produced by the CSBs was from Registered Seed but called *Apta* seed because it was not certified. It was not Quality Declared Seed because no such category of seed exists in the Nicaraguan seed law. The CSB leadership determined various pricing mechanisms (mostly in-kind exchange of seed with grain), often depending on their relationships with the clients.

A study of the cohort of CSBs established in the first year of the BTD project found that many seed banks had failed (or ceased operation) after 1, 2, or 3 years, and only some were still functioning in 2014 when the BTD project had ended. The analysis of the data collected in 2012 using survival analysis technique, reinforced the importance of seed marketing training, production of quality seed, inclusive transparent operations, and experienced leadership as factors contributing to the longevity, and thus sustainability, of CSBs. While these results were important, the study was limited to a time period in which the CSBs received external financial and technical support.

To further understand the factors contributing to sustainability of CSBs, and specifically, after external financial support in the form of the BTD project ended, a follow up study in collaboration with CIAT was conducted this year. The study was designed to sought to explain why some CSBs discontinued operations and if the model is scalable both in Nicaragua and in other countries. The methodology and main results emerging from this study are reported here.

Method: While the baseline study was limited to CSBs that began operation in 2011, this follow up study included a sub-sample of CSBs surveyed in 2012, and new CSBs initiated between 2011 and 2014. A total of 81 CSBs were surveyed from 13 departments and 47 municipalities by trained enumerators. The survey took place between 7-22 June 2017.

Main Results: By combining the baseline data with data collected in the follow up study, we are able to increase the number of observations from 154 to 180 CSBs. The data from the follow up study also increased the years of survival (the dependent variable in our duration analysis) from three years in the baseline study to six years. Table 5 provides descriptive statistics of the variables included in the duration analysis.

The results of the duration analysis technique identify several CSB characteristics as associated with longer operation as well as lower risk of failure. As would be expected, yield was positively associated with survival (an increase in yield by 100 lbs per mz increased survival by 3%). Likewise, cost recovery measured by client repayment for purchase of seeds was positively associated with survival (survival increased by 3.5% as cost recovery increased by 10%). Access to productive assets, such as a silo, increased survival for CSBs. Holding all else constant, CSBs with seed marketing training survived 87% longer than CSBs without such training, and helped the survival of CSBs with low yield potential.

CSBs with high levels of clients (beneficiaries) per manzana of seed production (i.e., higher intensity of operation) had higher risk of failure. Seed quality data reveal that CSBs are widely distributed across quality standards as measured by acceptable humidity level (maximum of 15%), seed germination rate (minimum 80%), and purity (minimum 97.5%). Only 23% of CSBs met all three quality standards. An acceptable humidity level was the most difficult standard to achieve (See graphs in Figure 5).

Missing from the 2012 study were the reasons for CSB failure. Of the 81 CSBs in the follow up study, two thirds had ceased operations and an additional 9% of CSBs' operations had been interrupted for at least one year since their inception. Table 6 presents the reasons given for discontinuing or interrupting seed production. Each CSB could give up to three reasons. Surprisingly, the most common reason given for ending the CSB was the impacts of weather that damaged crops[1]. While bean seed and grain production was impacted by weather during the years of study in Nicaragua, these conditions also create an opportunity for NARS to promote drought resistant varieties developed through research. For seed producers this also creates a potential market for their product (i.e., seed) as most farmers would have also suffered weather related loss in grain production and would be looking towards the market for seed to plant in following season.

Several of the reasons for ending the CSBs could be linked together under financial constraints. Namely, the end of INTA financial support at the end of the BTD project (33% of CSBs cited this reason), high seed production costs (reported by 23% of CSBs) and low cost recovery (reported by 11% for CSBs). No availability of registered seeds of preferred varieties from INTA was reported by 26% of CSBs as a reason for ending CSB operations. This is a supply side constraint that needs further investigation to understand why INTA was not able to meet the demand for registered seeds of preferred varieties.

[1] Specifically, CSBs listed "poor rainy season, "drought," "two consecutive years of drought," "climate change (drought)," "unfavorable climatic conductions" among others

Community based seed production models such as the CSBs have often been criticized as not being sustainable because there is no ‘profit’ motive to serve as a driver of sustainability. In the case of CSBs, despite their name suggests, banks do operate on the principle of profit-sharing among the membership. This profit that a CSB realizes from its operation can come from two sources of revenues (less cost of seed producing). One is the repayment of grain they receive from farmers. To encourage a culture of valuing quality bean seed, the BTD project suggested farmers pay back 2 pounds of grain for every pound of *Apta* bean seed received. In reality, however, grain repayment was well below the anticipated level. On average, CSBs received 6.61 qq of grain in the form of repayment for every 6.5 qq of *Apta* bean seed distributed to farmers. The value of this average quantity of grain repayment received by CSB is estimated to be about $ 407 per CSB.

A second source of potential economic incentive for CSB membership to get involved in joint seed production is the value of apta seed produced but not distributed to community farmers (i.e., surplus seed production that is potentially available to CSB members to either sell or keep for themselves). Using the survey data and some back-of-the-envelope calculations, we estimate that on average, CSBs produced 1376 lbs of *Apta* bean seed in its first year of production but only distributed 650 lbs to farmers. The remaining 726 lbs represent surplus seed valued at $560 per CSB. It is unknown what portion of this surplus was divided among CSB members, saved for future or used for other purposes. However, this surplus seed plus the value of grain repayments represent potential economic incentives for CSB members, and can contribute to its sustainability. More analysis to examine the underlying economic (or other) incentives that motivate the survival of CSBs is planned for future.

In conclusion, the results of this study reinforce the importance of training, ability to produce quality seed, and access to productive assets in reducing the risk of failure. These features should be taken into consideration when promoting community based seed production / distribution model to increase the probability of its long-term operation and sustainability. This study has also shown that producing bean seed that meets all the quality standards remains one of the challenges of the community based seed system. There is a need to find cost-effective ways for community based seed models to produce seeds that meet the minimum quality standards.

Surprisingly, the most common reason given for ending the CSB was the impacts of weather (mostly drought). While bean seed and grain production was impacted by weather during the years of study in Nicaragua, these conditions also create opportunities for bean seed producers and INTA to promote drought resistant varieties during a period of anticipated high bean seed demand. Future support of models based on local bean seed production should take into consideration the demoralizing impacts of crop failure on new seed producers. A conditional support mechanism, like crop insurance, that supplies periodic infusions of registered seed or financial support triggered by weather conditions or other indicators might increase sustainability of such group based efforts, while avoiding dependence on external funding. In drought prone areas, irrigation might be necessity for seed production and should be included in a viability study before supporting new community based seed production enterprises.

While it would be ideal for CSBs to be able to operate with internal funds, after a few years of external support, it is also anticipated that new business ventures will not be profitable in the first two to four years of operations. The 20 CSBs that listed an end of INTA support as one of the main reasons for failure represent 25% of CSBs interviewed in the follow up study and can be considered as a benchmark for anticipated rate of failure without external financial support.

Integrating community based bean seed production enterprises with the national agricultural research systems such as INTA present an opportunity to increase seed security in local communities. CSBs are one such model that has presented positive short term results as measured in number of small holder farmers receiving improved varieties of bean seed. The results of this study highlight some of the challenges that CSBs face and encourage future iterations of models similar to the CSB model in Nicaragua to consider these lessons learned.

2b. Adoption study in Haiti

In collaboration with the SO1.A4 team, this proposed study was initiated in FY 16 and data collection was completed in FY 17. The study is designed to generate systematic and rigorous evidence on the use of improved bean varieties by farmers in Haiti. Specific objectives of this study are:

a. To conduct a survey of bean farmers in Haiti and collect information on farm characteristics, bean area, varieties planted, sources of seed, criteria farmers use in making seed use decisions (type, quantity, source, etc.), varietal trait preferences, and perceptions on seed quality, price, availability, and constraints.
b. To conduct an assessment of the bean seed supply chain to understand the seed system characteristics, supply and demand side constraints, institutional players involved in different nodes of the supply chain (i.e., producers/multipliers of different generation of seeds, distributors, traders, sellers, and buyers), and strategies/approaches used by the seed suppliers and users to meet the country's need for quantity and quality seed
c. To collect bean seed samples throughout the seed supply chain (i.e., seed producers, distributors, traders, seed and grain vendors, agro-dealers, and farmers) and conduct DNA fingerprinting analysis to identify the genetic identity of bean varieties planted by farmers and available in the 'seed system.'
d. To estimate the extent to which bean seeds of improved varieties are used by farmers and are in circulation in the seed system, and identify major constraints and opportunities for increasing the adoption of quality of bean seeds by farmers in Haiti.

Method: For the household surveys, two sampling frames were used to select two different groups of farmers. The first was a sample targeting 700 farmers drawn from a nationally representative list of bean growers from the 2014 agricultural production survey provided by the Agricultural Statistics and Informatics Unit (USAI) of the Haitian Ministry of Agriculture. The second sample targeted 300 farmers drawn from beneficiaries of the BTD project. Enumerators interviewed farmers from both groups using the same standardized questionnaire.

Data collection occurred in late November and early December 2016, in all departments except Sud and Grand'Anse departments. Due to the effects of Hurricane Matthew, data collection in these two departments occurred in April 2017. Table 1 summaries the number of farmers interviewed (both as representative farmers from the USAI Ag. Production Survey and beneficiary farmers of the BTD project) and the number of seed samples collected for DNA fingerprinting.

Towards objective 2, key informant interviews using a structured questionnaire were conducted with agro-dealers, international and national NGOs, IICA, FAO, and donor funded programs across the country in June-July 2017. A consultant was hired to assist with this task. A sample of 50 seed distributors and 50 seed producers were selected based on a comprehensive list compiled by this consultant. During the interviews, a total of 54 seed samples from these producers and distributors were also collected for DNA fingerprinting.

Also towards objective 2, we piggybacked on the existing infrastructure managed by NASS (i.e., Systeme D'information Sur Les Marches Argricoles (SIMA) and collected bean seed samples and information from 9 bean vendors in 25 markets across the country at three time periods over a period of 12 months--Nov-Dec 2016; Mar-Apr 2017; and Aug-Sept 2017. Since a large number of farmers in Haiti source their bean seeds from vendors in the market, this sample of seeds collected from 25 markets at three time periods capture the temporal and spatial diversity of beans potentially available as planting material for farmers. A total of 2660 bean seed samples were collected from bean vendors in SIMA markets.

Protocols for collecting seed samples, labeling, handling, shipping and storage of seeds from the point of collection to NSS facilities in Haiti, and then shipping these seeds to Puerto Rico were developed with SO1.A4 team. Seed germination and DNA extraction, and GBS library construction was done in Puerto Rico at USDA's facilities. DNA fingerprinting is being conducted at Cornell University. Given the fact that the last seed sample were collected in September and the significant delays caused by hurricane Irma, this component of this study remains incomplete at this point. To date, DNA analysis of farmer samples collected in survey round 1 (from 8 Depts) has been completed, and analysis of market samples collected in round 1 is ongoing. DNA analysis of farmer samples from round 2 (2 Depts); market samples from Round 2 and 3; samples from seed producers and distributors, and reference library accessions is still pending. The plan is to continue these tasks beyond November 30 using other resources.

Main Results: The results of the farmer survey confirmed that farmers were not able to identify varieties by name. Bean seed/variety types planted by farmers were referred mostly by market class (e.g., black bean, red beans, etc.). Farmers reported growing 9 market classes; black bean was the most common bean type planted in Haiti (Table 8). When asked for the names of the varieties planted, 63 percent of farmers gave black bean (Pwa Nwa or Pois Noir) as the variety name, 10% reported cream (Pwa Be) as the variety name, 8% listed white (Pwa Blan) as the name and 7% reported red (Pwa Wouj). Improved varieties Aifi Wuriti (given as Arifi), DPC40 and Icta Ligero were only mentioned once each. Variety Arroyo Loro Negro (given as Awoyo) was mentioned 4 times. Farmer inability to recognize variety names further emphasizes the importance of DNA fingerprinting of seed samples collected from farmers to identify the use of improved varieties. Relying only on the varietal names given by farmers would give unreliable estimates of varietal adoption.

The Seed System Security Assessment conducted in Haiti post-earthquake (Sperling et al. 2010) determined that about 80% of bean seed was acquired from local grain markets. The importance of the local grain market as the source of seed is confirmed in our study as the majority (84%) of farmer reported purchasing seed from a grain vendor when they first acquired the bean seed they were currently using. Farmer reported only 5% of first seed source of varieties they were currently planting came from institutions and organizations (NGOs, seed aid, government and FAO), 3% from the private sector (input dealer and seed grower), and 3% from local sources (e.g., Madam Sara, Farmer groups, cooperatives and other farmers or family).

In the most recent season, farmers still purchased the majority (72%) of the bean seeds from grain vendors. Farmers across both sample frames (i.e., USAI production survey and BTD beneficiaries) reported saved seed from previous harvest (13%) as the second important source of seed. The fact that 13% is the same figure of seed from own stocks found in 2010 by Sperling could point to a long term trend in farmer seed sourcing practices or indicate that the acute challenges of 2015 and 2016 (such as Hurricane Matthew) had resulted in conditions of seed availability similar to those in 2010 following the earthquake.
Farmers were also asked about any free or subsidized seed they had received in the past five years. Surprisingly, only 148 BTD farmers (51%) provided information about receiving free or subsidized seed. Among the varieties reported by BTD farmers, only 3% were the names of improved varieties while 92% reported the variety as "black bean." The study found no evidence that farmers successfully save seed stocks of their own production for future planting after receiving free or subsidized seed. The main reason given by BTD farmers for no longer using a variety they would have obtained from seed distribution programs is that they sell most of their beans harvested and there is no seed available (87%) after that program ends. The varieties that farmers continue to use depend on the seed availability from outside sources. Only 14% of the varieties received by BTD farmers and 38% of the varieties received by non-BTD farmers that are still used are saved from the farmers saved seed stocks of their own production.

In summary, the results of the farmer survey in Haiti point to the challenge of sustaining the use of improved varieties once they are disseminated to farmers through a systematic seed dissemination efforts such as the BTD project. This is due to the fact that most farmers sell their harvest and don't save seeds for the next planting. Secondly, the bean varieties have no name recognition, which makes it difficult to track improved varieties disseminated through formal channels. In this circumstances, DNA fingerprinting offers the best approach for varietal identification and estimating varietal adoption. DNA analysis of the first round of farmer samples indicate that approximately 1/3 of these samples were older generation improved varieties such as Arroyo Loro Negro which has BCMV resistant gene. The SR2 marker present in new generation of bean varieties was found in samples in proximity to Mirebalais, Jacmel and SE Haiti (Savane Zombi)--areas where the Legume Innovation Lab and previous Bean/Cowpea CRSP projects have worked and release germplasm. But in a broader picture, the levels of current use of these varieties may be low. These are still tentative conclusions, as 20% of farmer samples and 100% of seed samples collected from seed value chain, include the bean markets still remain to be analyzed.

2c. Follow-up survey in Burkina Faso for impact assessment of biocontrol IPM research

Cowpea (*Vigna unguiculata*) is an important staple in Burkina Faso as well as many other countries in West Africa. Among the major cowpea pests affecting the crop are the legume pod borer (*Maruca vitrata*), flower thrips (*Megalurothrips sjostedti*), bruchids (*Callosobruchus maculatus*), and pod-sucking bugs, for which conventional plant breeding has not been effective and the use of pesticides has economic, health and environmental limitations. Through support from the predecessor CRSP and the current Legume Innovation Lab, the SO1.B1 project team has developed alternative strategies to control these insect pests and reduce the levels of pesticide used on the crop. One of these strategies includes implementing a comprehensive bio-control program. As part of this strategy, the SO1.B1 team had planned to release bio-control agents in selected locations in Burkina Faso where baseline data were collected by this project in 2012. The baseline sample covered a total of 560 households distributed across 56 villages and 10 provinces. In FY 17, the plan was to conduct a follow-up survey (in collaboration with INERA) of the same farmers in 56 communities to be able to evaluate the impacts of bio-control research using difference-in-difference methodology. However, due to several factors beyond the control of this project team (i.e., required approvals for releasing biocontrol agents by the SO1.B1 project, building capacity of INERA for mass rearing parasitoids as biocontrol agents, etc.), the first release of these bio-control agents did not occur until mid-2016 in few locations. Given the long time that had elapsed between the baseline survey and the intervention, and the short time since the release of the biocontrol agents and the planned end line survey, the focus of the survey was changed from assessing the impact of biocontrol strategy of pest control to assessing farmers' preferences for chemical versus biological pest control methods. We describe the objectives, methodology and main results of this study.

Objectives: This study was designed to address three objectives: 1) to understand cowpea farmers' preference for pest control strategy (biological versus synthetic pesticides); 2) the factors that influence cowpea farmers' choice of a given pest control strategy, and 3) the effects of sharing information on the health and environmental consequences of synthetic/chemical versus biological pesticides on farmers' preference for a given pest control strategy. The study was designed in collaboration with INERA, Institut de l'Environnement et des Recherches Agricoles (INERA) in Burkina Faso.

Method: The study used a survey-based discrete choice experiment (CE) method to: elicit farmers' stated preferences for (or predict the adoption of) biological pest control strategy compared to existing pest control methods based on synthetic/chemical pesticides; and to understand the effect of sharing the information about the health and environmental impacts of alternative pest control method on farmers' preference for biological versus chemical pesticides. Thirty-three (33) villages from seven provinces were selected from the pool of villages surveyed in 2011. In each village 16 households were surveyed—10 farmers from the baseline sample and an additional six (6) farmers were selected from each village by the enumerators. The total sample size for the study was 528 households. The sample was randomly assigned to one of the three information treatment groups—those that received information on: a) the health effects, b) the environmental effects, and c) both health and environmental effects. All farmers were presented the same 12 scenarios of discrete choice sets (in random order) before (block 1) and after (block 2) the information treatment. An example of one of these choice sets is given in Figure 9. It presents a farmer three options to select from which had different attribute values associated with them. The attributes were presented for a 0.5 ha cowpea plot and included: the method of pest control (synthetic, biological or none), input cost, labor cost, and expected cowpea production.

Main Results: Survey results indicate that about 6% of the market value of harvested cowpea grains is allocated to purchasing chemicals for pest control. For cash-constrained farm households, this expenditure is nontrivial.

The descriptive results indicate that cowpea farmers' preference for synthetic pesticides decreases with the information treatment. Prior to receiving information on the harmful effects on health and environment of synthetic pesticides, 33% of the sample (N=528) revealed a preference for synthetic pesticides. However, after the information treatment, only 10% of the farmers in the sample would still choose synthetic pesticides. The percentage of farmers who would choose organic pesticides increased from 57% before the information treatment to 79% after the information treatment. 10 percent of the farmers chose neither organic nor synthetic pesticides before or after treatment.

Information on environmental and health effects of pest control methods was highly effective in increasing farmers' willingness to pay for organic pesticides relative to synthetic pesticides. Parameter estimates from the mixed logit model suggest a treatment effect of 4.5 times of the effect of environmental information on cowpea farmers' willingness to pay (WTP) for organic methods of pest control— the average WTP for organic method (biopesticides/biocontrol) relative to synthetic pesticides (CFA per 0.5 ha) increased from 12,940 CFA before environmental treatment to 58,320 FCFA after the treatment. Applying health information, the treatment effect was 4.0 – average WTP for organic method (biopesticides/biocontrol) relative to synthetic pesticides increased four times after health information was provided. The effect on average WTP when both treatments (health and environmental information) were administered as estimated at 2.6—bundling the both types of information increased average WTP to 56,480 CFA from an average WTP of 21,540 CFA before treatment.

The findings also suggests that cowpea farmers in Burkina Faso are aware of health hazards from chemical pesticides but continue to use them out of necessity since they lack awareness of safe alternative pest control methods (i.e., biocontrol, viruses), as well as knowledge on how to prepare/access biopesticides.

In general, farmers are willing to pay higher cost and lower production for more safer pest control method relative to synthetic pesticides. There appear to be a high potential for biocontrol strategy to be widely accepted

Overall, these findings suggest the need for the following interventions:

- Systematic campaigns to increase awareness and to provide technical knowhow on the preparation, use and availability of biopesticides, are needed to improve adoption of these alternative methods
- Incorporating the information on the environmental and health effects of alternate pest control methods in these campaigns can significantly improve

Objective 3: *Build institutional capacity and develop human resources in the area of impact assessment research*

This project addressed the objective of institutional capacity building and human resource development through the following activities implemented in FY 17:

a. Research studies conducted in Burkina Faso, Haiti, Ghana and Nicaragua under objective 2 (described above) involved host country PIs/collaborators/students in the planning and execution of field data collection. Host country collaborators from Legume Innovation Lab projects participated in the rapid appraisal visits, development of research design, and training enumerators and field staff in data collection, data entry and analysis.

b. Activities planned under this project involved graduate students in the planning and conduct of field research and write-up of research results. These students were recruited from within the Department of Agricultural, Food and Resource Economics at MSU (see the details on trainees in the Training section). Two of these students are Scholars funded by Master Card Foundation with the aim of empowering youth and building the capacity of the next generation of African leaders.

IV. Major Achievements

We would like to highlight the following emerging 'messages' based on the research results presented in this report.

- The results of the Guatemalan survey of farmers growing beans in the milpa system have important implications for bean breeding research and seed dissemination efforts. Overall, size and color of the bean, and productivity traits (i.e., yield potential and resistance to stresses) were the first and second most important traits preferred by both men and women. The study confirms that men and women farmers have slightly different preferences for varietal traits, but the ranking of different types of traits was the same. On characteristics traditionally considered to be more important for women than men (i.e., cooking quality, size and color), there was no significant difference in their ranking by men and women. The average WTP for bean seed of preferred variety was only 10% higher than the grain price. Thus, any efforts to make quality bean seed of improved varieties accessible to these communities will have to rely on subsidy based approaches or innovative profit-based models that can lower the cost of locally producing quality seed (albeit not certified per legal definition) and making them available to farmers in this remote areas of Guatemala at affordable prices.
- The two case studies conducted over the last two years using nationally representative data from Zambia and Uganda suggest that incorporating legume crops in cropping system either as rotation crop or inter-crop have positive effects on some indicators of household income, production, food security and dietary diversity. The most robust effects are on the production of calorie and protein per capita. From a policy perspective, this empirical evidence points to the need to promote these practices where it is feasible for farmers to do so.
- Quality seeds do perform better in terms of important characteristics (i.e., germination rate, yield, etc.) relative to recycled grain of legume crops. Thus, to increase productivity, it is not sufficient to promote only the adoption of improved varieties, but also quality seed.
- Farmers are able to perceive quality differences in planting material and are willing to pay a premium for QUALITY seed.
- Although, about 30-35% of farmers' WTP for quality seed was above the price of certified seed, in practice farmers' use of purchased certified seeds or QDS is much lower than reflected in the percentage of farmers WTP a premium for quality seed. Further research is needed to investigate whether the low (actual) demand for quality seed products is a trust issue (i.e., counterfeit or inferior seed) or availability issue (i.e., supply side constraint)?
- Across all the countries studied, we find that there are a significant proportion of

legume growing farmers whose willingness to pay a premium for quality seed is much lower than the existing certified seed to grain price ratio. Thus, need multi-pronged approaches to meet the seed needs of all the farmers across this spectrum of WTP. Current efforts to promote private sector to produce and supply certified seeds can potentially meet the seed needs of at most 30-35% of farmers (if the quality of those seeds is substantially superior to recycled grain). More research and discussion needs to happen to address the seed needs of a majority of farmers (two-thirds or more) whose WTP for quality seed is below the price at which certified seeds are sold in the market.

- Research indicates that cowpea farmers in Burkina Faso are aware of health hazards from chemical pesticides but continue to use them out of necessity since they lack awareness of safe alternative pest control methods (i.e., biocontrol, viruses), as well as knowledge on how to prepare/access biopesticides. In general, farmers are willing to pay higher cost and lower production for safer pest control method relative to synthetic pesticides. There appear to be a high potential for biocontrol strategy to be widely accepted

V. Research Capacity Strengthening

Unlike other Legume Innovation Lab projects, this project does not have a country-specific collaborating HC institution. We serve as the cross-cutting project that works towards building the institutional capacity and human resources in the area of impact assessment across all the projects of the Legume Innovation Lab.

VI. Human Resource and Institution Capacity Strengthening

1. **Short-Term Training**
   i. Purpose of Training: To collect bean seed samples and vendor information from selected markets across Haiti
   ii. Type of Training: Classroom and field testing
   iii. Country Benefiting: Haiti
   iv. Estimated USAID funding for activity:
      a. US$ for Instruction: $4,000
      b. US$ for Participants: $500
      c. US$ for Travel: $500
   v. Location and dates of training: 3 locations in Haiti between November 9-12, 2016
   vi. Number receiving training (by gender): 1 Female; 18 Male
   vii. Home institution(s): Ministry of Agriculture, Haiti
   viii. Institution providing training or mechanism: Michigan State University

2. **Degree Training in the US or elsewhere**
   Degree Training (1)
   i. Name of trainee (First and Last Name): Edward Opoku
   ii. Country of Citizenship: Ghana
   iii. Gender: Male
   iv. Host Country Institution Benefitting from Training: None
   v. Institution providing training: Michigan State University

vi. Supervising LIL PI: Mywish Maredia
vii. Degree Program: M.S.
viii. Field or Discipline: Agricultural, Food, and Resource Economics
ix. Research Project Title: Farmer willingness to pay for quality cowpea seeds
   a. US$ for Instruction: 0
   b. US$ for Participants: 0
   c. US$ for Travel: 0
x. Estimated funding from other sources for activity if not conducted in US (see footnote 1)
   a. Provider of Funds: Master Card Foundation
   b. US$ for Instruction: ~$11,729
   c. US$ for Participants ~$25,104
   d. US$ for Travel: ~$5000
xi. Start Date: August 2015
xii. Projected/Actual Completion Date: August 2017
xiii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiv. Training status (Active, Completed, Pending, Discontinued, or Delayed): Completed

Degree Training (2)

i. Name of trainee (First and Last Name): Sean Posey
ii. Country of Citizenship: USA
iii. Gender: Male
iv. Host Country Institution Benefitting from Training: None
v. Institution providing training: Michigan State University
vi. Supervising LIL PI: Mywish Maredia
vii. Degree Program: M.S.
viii. Field or Discipline: Agricultural, Food, and Resource Economics
ix. Research Project Title: Farmer willingness to pay for quality bean seeds in Nicaragua
   d. US$ for Instruction: $11,729
   e. US$ for Participants: $ 25,104
   f. US$ for Travel: $10,000
x. Estimated funding from other sources for activity if not conducted in US
   e. Provider of Funds: AFRE Department (50% value of Fall semester of Research Assistantship support)
   f. US$ for Instruction: ~$5,800
   g. US$ for Participants: ~$4,000
   h. US$ for Travel: 0
xi. Start Date: August 2016
xii. Projected/Actual Completion Date: August 2018
xiii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiv. Training status (Active, Completed, Pending, Discontinued, or Delayed): Active

Degree Training (3)

i. Name of trainee (First and Last Name): Trhas Weldesghi
ii. Country of Citizenship: Eritrea
iii. Gender: Female

iv. Host Country Institution Benefitting from Training: None
v. Institution providing training: Michigan State University
vi. Supervising LIL PI: Mywish Maredia
vii. Degree Program: M.S.
viii. Field or Discipline: Agricultural, Food, and Resource Economics
ix. Research Project Title: Analysis of existing data for strategic insights to guide impactful research on legume based farming systems
  g. US$ for Instruction: 0
  h. US$ for Participants: 0
  i. US$ for Travel: 0
x. Estimated funding from other sources for activity if not conducted in US (see footnote 1)
  i. Provider of Funds: Master Card Foundation
  j. US$ for Instruction: ~$11,729
  k. US$ for Participants ~$25,104
  l. US$ for Travel: 0
xi. Start Date: August 2016
xii. Projected/Actual Completion Date: August 2018
xiii. Is trainee a USAID Participant Trainee and registered on TraiNet? No
xiv. Training status (Active, Completed, Pending, Discontinued, or Delayed): Active

VII. Achievement of Gender Equity Goals

This project is designed to assess how the technologies and knowledge generated by the Legume Innovation Lab (and its predecessor CRSP) benefits both men and women farmers, entrepreneurs and consumers. Thus, where applicable, 'gender equity' is used as one of the metrics in evaluating the impact of Legume Innovation Lab research. Survey instruments are designed to collect gender disaggregated data on beneficiaries. Where applicable, results of analysis based on primary data are reported by gender to assess the impact on women farmers and other potential beneficiaries of Legume research (see for example the gender disaggregated analysis of varietal preferences and willingness to pay for quality seed in Guatemala).

VIII. Implementation of Data Management Plan

#	Datasets	Year data collection completed	Status
1	Bean Technology Dissemination Project Beneficiary Survey in Nicaragua	2012	Registered and submitted to DDL (July 2016)
2	Bean Technology Dissemination Project Beneficiary Survey in Honduras	2013	Registered and submitted to DDL (July 2016)
3	Bean Technology Dissemination Project Beneficiary Survey in Guatemala	2013	Registered and submitted to DDL (July 2016)
4	Effectiveness and Impact of Mobile Phone based	2013	Registered and

#	Datasets	Year data collection completed	Status
	Extension Methods to Disseminate Solar Treatment and Triple Bag Technology for Cowpea in Burkina Faso		submitted to DDL (May 2017)
5	Survey of Nicaraguan Community Seed Banks	2012	To be registered by end of November; data to be submitted to DDL when requested by USAID
6	Farm household survey data on the Management of Field Insect Pests of Cowpea in Burkina Faso	2013	
7	Household Survey of Guatemalan Climbing Bean Farmers	2015	
8	The Economics of Community Based Seed Production based on the Association Song Koaadba (ASK) model: Farmer surveys in ASK villages	2015	
9	Farmer surveys in two districts in northern Tanzania to assess farmers' willingness to pay for quality bean seeds and farm yield gains	2016	
10	Farmer survey in northern Ghana to assess farmers' willingness to pay for quality cowpea seeds and farm yield gains.	2016	
11	Farm household survey to assess the Management of Field Insect Pests of Cowpea and Choice Experiments in Burkina Faso	2017	
12	Adoption of Improved Bean Seed Varietal Technology in Haiti: Farmer survey data	2017	
13	Adoption of Improved Bean Seed Varietal Technology in Haiti: Market vendor survey	2017	
14	Adoption of Improved Bean Seed Varietal Technology in Haiti: Seed producer and distributor survey	2017	
15	Survey of Nicaraguan Community Seed Banks: Follow up survey	2017	
16	Farmer survey in northern Ghana to assess farmers' willingness to pay for quality cowpea seeds and cost of seed production	2017	
17	Farmer survey in Nicaragua to assess farmers' willingness to pay for quality seeds of a biofortified bean variety	2017	
18	Farmer survey in Burkina Faso to assess farmers' willingness to pay for quality cowpea seeds	2017	

IX. Scholarly Accomplishments

<u>Publications and Manuscripts:</u>

Maredia, M, Shupp, R., Opoku, E., Mishili, F., Reyes, B., Kusolwa, P., Kusi, F., and Kudra, A. 2017. Do farmers economically value seeds of different quality differently? Evidence from willingness to pay studies in Tanzania and Ghana. MSU International Development Working Paper. East Lansing: Michigan State University (*forthcoming*)

DeYoung, David, Byron Reyes, Juan Osorno, Julio Cesar Villatoro and Mywish Maredia. 2017. An Overview of Bean Production Practices, Varietal Preferences, and Consumption Patterns in the *Milpa* System of the Guatemalan Highlands: Results of a Farm Household Survey. *Staff Paper 2017-08.* Michigan State University Department of Agricultural, Food and Resource Economics Staff Paper Series. (*forthcoming*)

Maredia, M. K., Reyes, B. A., Ba, M., C. Dabire, Pittendrigh, B., & Bello-Bravo, J. Effectiveness of animation videos in inducing technology adoption: A field experiment in Burkina Faso. 2017. *Information Technology for Development (April 19, 2017)* DOI https://doi.org/10.1080/02681102.2017.1312245

Sauer, C., Mason, N. M., Maredia, M. K., & Mofya-Mukuka, R. 2016. Impacts of legume technologies on food security: Evidence from Zambia. *FSP Research Paper No. 36*. East Lansing, MI: Feed the Future Innovation Lab for Food Security Policy. *(December 2016)*

Reyes, Byron A., Mywish K. Maredia, Richard H. Bernsten, and Juan Carlos Rosas. 2016. Opportunities Seized, Opportunities Missed: Differences in the Economic Impact of Bean Research in Five Latin American Countries. MSU International Development Working Paper 151. East Lansing: Michigan State University. *(November 2016)*

Thesis:

Opoku, Edward. 2017. Willingness to pay for quality cowpea seeds: experimental evidence from northern Ghana. Thesis for partial fulfillment of MS degree in Agricultural, Food and Resource Economics, Michigan State University (submitted, October 2017).

Presentations

Oral presentation:

Maredia, M, Shupp, R., Opoku, E., Mishili, F., Reyes, B., Kusolwa, P., Kusi, F., and Kudra, A. Do farmers economically value seeds of different quality differently? Evidence from willingness to pay studies in Tanzania and Ghana. Selected Paper presentation at the 2017 Agricultural & Applied Economics Association Annual Meeting, Chicago, Illinois, August 1, 2017.

Maredia, M K., D DeYoung, E. Prophete, C.D. Joseph, J. Beaver, and T. Porch. "Adoption of Improved Bean Seed Varietal Technology in Haiti: An Assessment Using Farm Surveys, Bean Seed Supply Chain Analysis, and DNA Fingerprinting." Grain Legume Research Conference. Burkina Faso. August 16, 2017.

DeYoung, David and Mywish K. Maredia. "Farmers' Willingness to Pay for Quality Seeds of Bean Varieties with Preferred Traits: Evidence from two Central American Countries." Grain Legume Research Conference. Burkina Faso. August 16, 2017.

Maredia, M., MeNsope, N., Ilboudo, D., and Ortega, D. 2017. Farmers' preferences for chemical versus biological pest control methods: Evidence from choice experiments conducted in Burkina Faso. Grain Legume Research Conference. Burkina Faso. August 15, 2017.

Shupp, R., Maredia, M., Reyes, B., Posey, S., Rodríguez, C., and Urbina, R. Towards Improving Access to High Quality Bean Seed in Nicaragua: How Much are Farmers Willing to Pay? Grain Legume Research Conference. Burkina Faso. August 16, 2017.

Me-Nsope, N., Maredia, M,, Shupp, R., and Ilboudo, D. Factors Influencing Cowpea Farmers' Willingness to Pay for Quality Seeds in Burkina Faso. Grain Legume Research Conference. Burkina Faso. August 16, 2017.

Ilboudo, I., Balima, M., and Maredia, M. A local success story on cowpea production and distribution compromised by a national project. Grain Legume Research Conference. Burkina Faso. August 16, 2017.

DeYoung, David and Mywish K. Maredia. "An Assessment of the Local Bean Seed Production and Marketing Model: The Case of Community Seed Banks in Nicaragua." New Models for Legume Seed Business: Resilience, Nutrition and Reaching Farmers at the Last Mile Conference. Washington, DC. March 2, 2017.

Maredia, M. and Ilboudo, D. The economics of local seed entrepreneurship: A case study of the Association Song Koaadba (ASK), Burkina Faso. New Models for Legume Seed Business: Resilience, Nutrition and Reaching Farmers at the Last Mile Conference. Washington, DC. March 2, 2017.

Maredia, M. and R. Shupp. 2016. Farmer willingness to pay for quality bean seed: Experimental evidence from Tanzania**.** AFRE Departmental Seminar, November 22, 2016.

Posters:

DeYoung, David, Byron Reyes, Mywish K Maredia and Lorena Gomez. "An Assessment of the Local Bean Seed Production and Marketing Model: The Case of the Community Seed Banks in Nicaragua." Grain Legume Research Conference. Burkina Faso. August 13-18, 2017.

DeYoung, David, Byron Reyes, Gustavo Mejia, Manuela Tucux, Mizael Vasquez, Juan Josue Santos, Julio Cesar Vilatoro, Luz de Maria Montejo, Jessica Moscoso, Juan Osorno and Mywish K. Maredia. "Gender Differences in Varietal Preference and Willingness to Pay for Quality Bean Seeds: Evidence from the Guatemalan Highlands." Grain Legume Research Conference. Burkina Faso. August 13-18, 2017.

Opoku, E., Maredia, M., Shupp, R., Kusi, F. Willingness to pay for quality cowpea seeds: Experimental evidence from Northern Ghana. Grain Legume Research Conference. Burkina Faso. August 13-18, 2017.

Ray, M., Weldezghi, T., and Maredia, M. Legume Technologies and agriculture-nutrition linkages: Exploratory Evidence from Uganda. Grain Legume Research Conference. Burkina Faso. August 13-18, 2017.

Reyes, B., Maredia, M., Shupp, R., González, C., Rodríguez, C., Urbina, R. Posey, S. Quantifying farmers' willingness to pay for biofortified characteristics in three qualities of planting materials: The case of bean producers in Nicaragua. Grain Legume Research Conference. Burkina Faso. August 13-18, 2017.

X. Achievement of Impact Pathway Action Plan

For this project we have identified two project outputs to be achieved over the life of the project that will contribute towards developing an impact oriented research program that features: 1) Greater awareness among researchers of the importance of achieving developmental outcomes; and 2) Better design of research programs that incorporate strategies and partnerships to transfer research outputs into outcomes and impacts; and 3) Continued and increased support for investments in agricultural research in general, and on legume crops in particular. Towards the impact pathway of achieving this 'vision of success', the following was achieved (cumulatively) as of the end of FY 2017 for each output:

1. Output 1: development of impact pathway analytical tools and guidelines:
    a. Transfer of analytical tools to project PIs and research teams: Completed as planned (in FY 14)
    b. Input and feedback to research teams on their impact pathway: Completed as planned (in FY 14)
    c. Monitor the progress towards projected outputs and strategies to achieving the vision of success as laid down in the impact pathways: Ongoing
2. Output 2: Evidence based assessments of potential and realized impacts of investments in agricultural research:
    a. Publication of results of the assessments in technical reports and peer reviewed venues: Six technical reports, two thesis, one peer reviewed journal article, and two manuscripts for peer reviewed venue have been completed.

ANNEXES

Annex 1. Tables, Figures, and Photos Cited in the Report

Figure 1. Top Varietal Trait Preferences by Gender of Respondents: Results of a Representative Bean Farmer Survey in Western Highlands of Guatemala, 2015

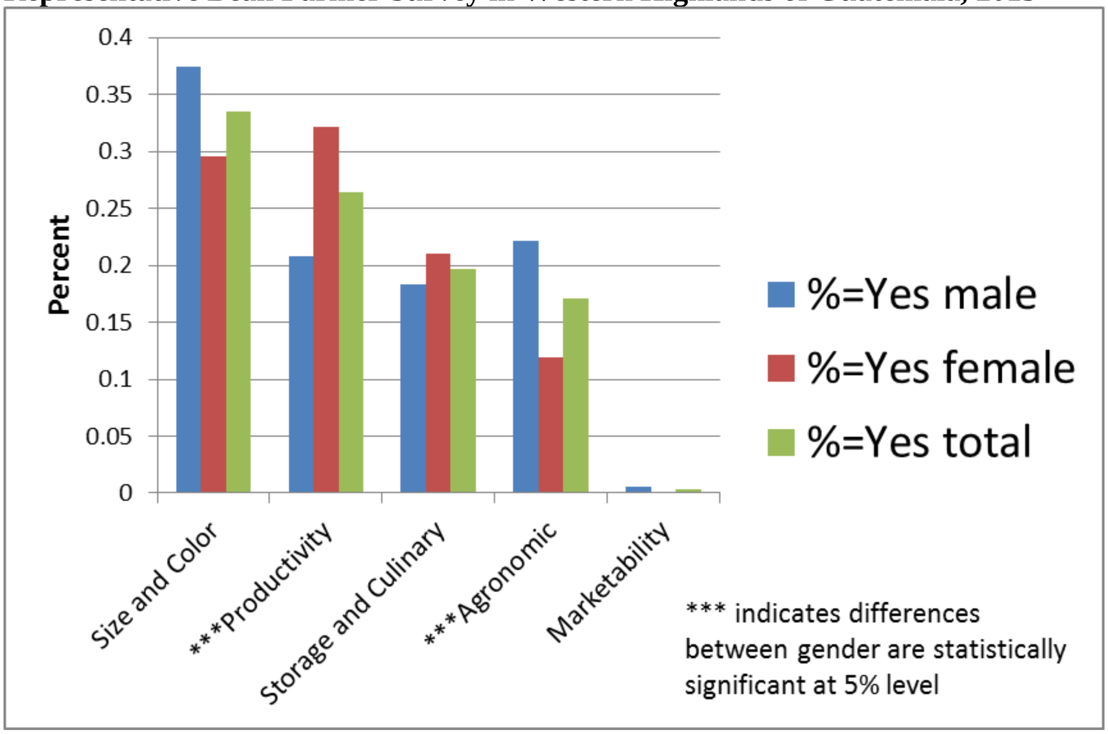
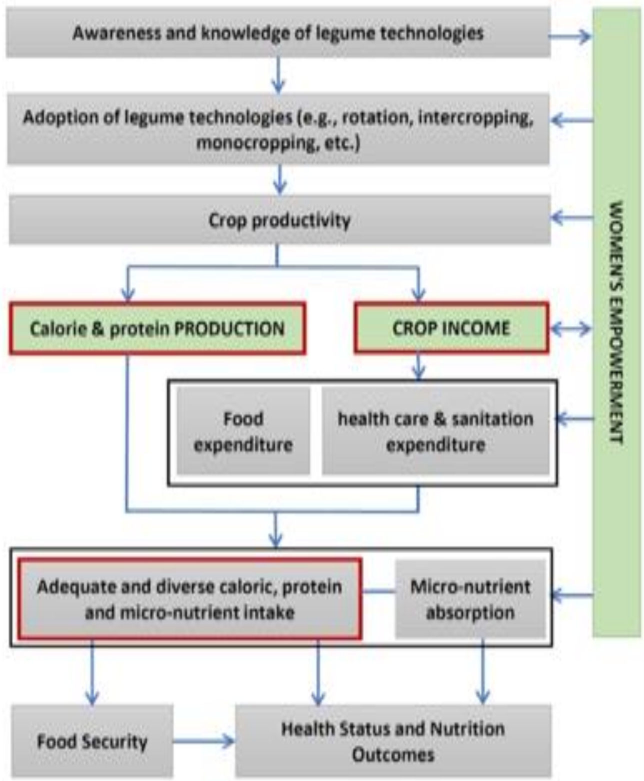
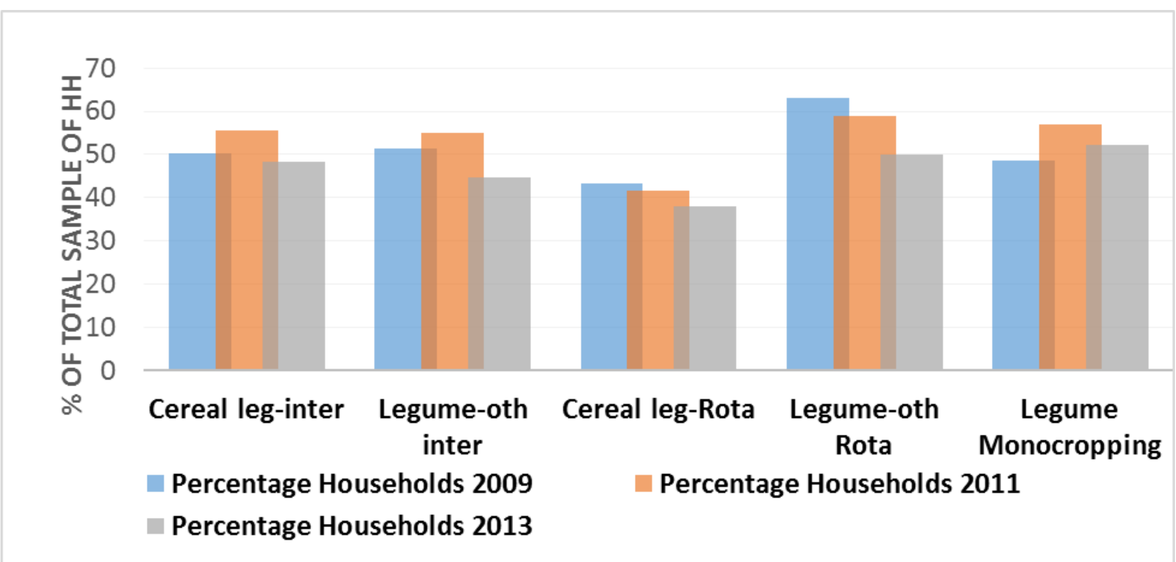


Figure 2: Theory of change: Conceptualized pathways of effects of legumes technology adoption on household food security and nutritional outcomes



Source: Sauer et al. (2016)

Figure 3. Percentage of households practicing different legume-based technologies in the three rounds of LSMS dataset for Uganda



Source: Authors analysis using Uganda LSMS dataset (2009, 2011 and 2013)

Figure 4. Average bidding price (CFA/kg) for different seed types: Results of the blind experiment based on pictures in Burkina Faso (N=320)

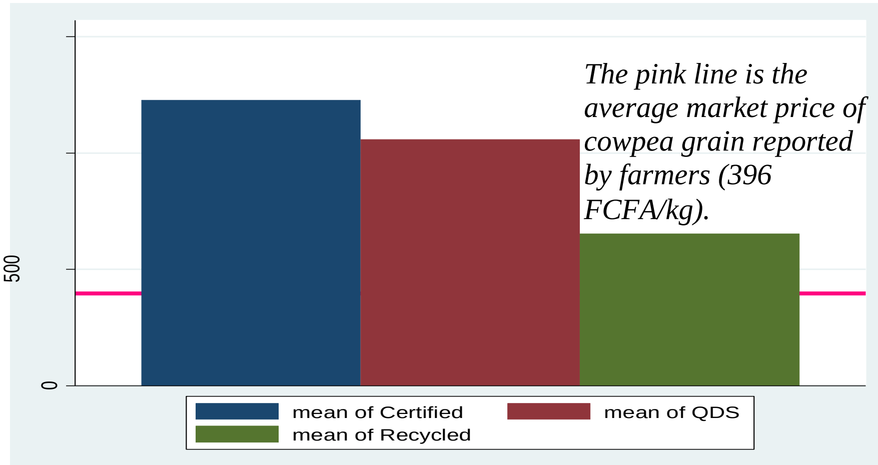


Figure 5: Graphs of Quality Standards Met by CSBs (red line represents minimum standard of quality

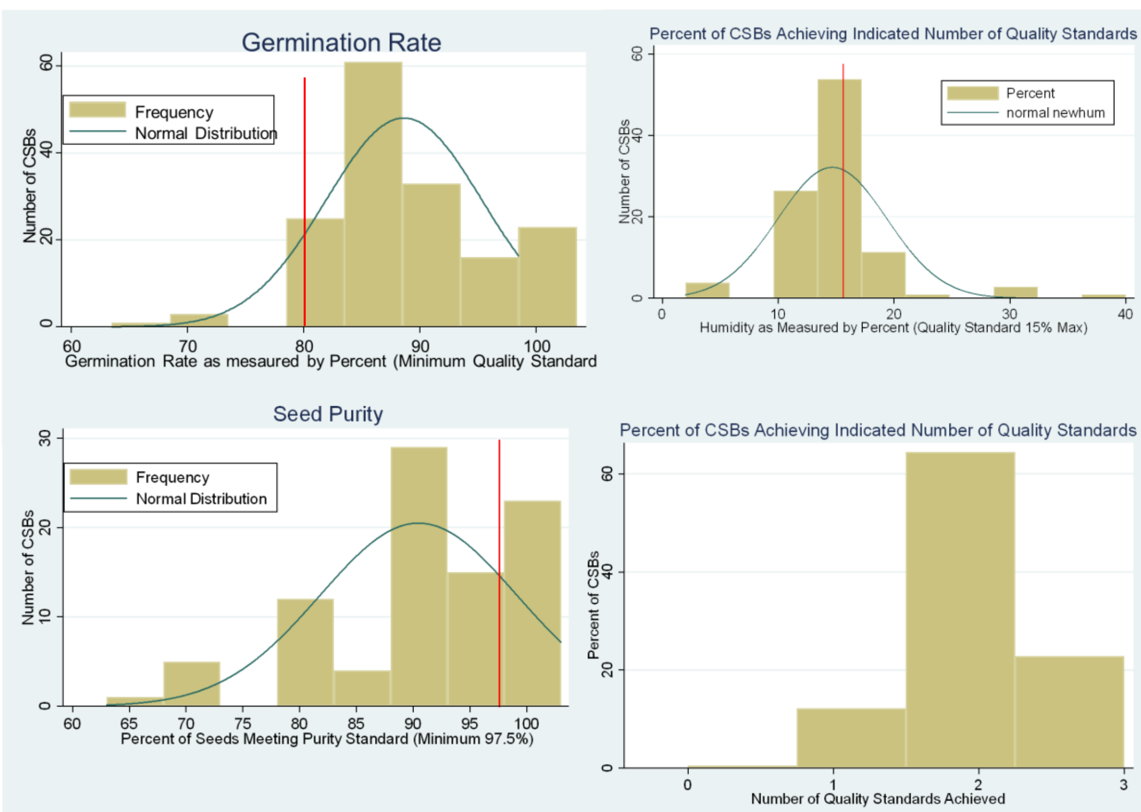


Figure 6. Example of a choice set used in the choice experiment, Burkina Faso

Scénario 2: Bloc 1

Les trois OPTIONS suivantes sont à votre disposition pour lutter contre les ravageurs sur un terrain de 0,5 ha cultivé en niébé

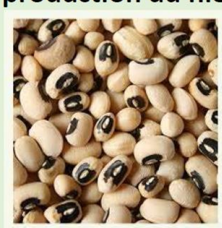
	Option A	Option B	Option C
Type de méthode de lutte contre les ravageurs	**Pesticides Organiques (Bio-pesticide/Bio-contrôle)** 	**Pesticide chimique** 	**Je n'utiliserai aucune méthodes de lutte les ravageurs**
Coût	**1000 CFA** 	**5000 CFA** 	0
La main d'œuvre 	**3000 CFA** 	**3000 CFA** 	0
la production du niébé 	**100 KG** 	**200 KG** 	**100 KG** 
Z1. Quelle option choisiriez-vous? *Noter la réponse dans la questionnaire*	○	○	○

Table 1. Men and women farmers' willingness to pay for quality seed of bean varieties with preferred traits: Results of the farmer survey in western highlands of Guatemala, 2015

		Men	**Women**	**All**
Number of farmers		*313*	*236*	*549*
Willingness to pay for quality seed of bean varieties with preferred traits indicated in Figure 1 (Quetzales/lb)	*mean*	5.98	6.14	6.06
	(sd)\a	(2.94)	(2.37)	(2.68)

\a Standard deviation are reported in the parenthesis

Table 2: Impact of legume technologies on crop production, income and household food security/dietary diversity indicators: Preliminary results using nationally representative sample of legume growing households in Uganda

Pathways	Outcome Variables	Main explanatory Variables				
		Cereal leg-inter	Legume-oth inter	Cereal leg-Rota	Legume-oth Rota	Legume-mono
Pooled OLS Model						
Crop Income	Net crop Income	(+) sig	(+) sig	nonsig	(+) sig	nonsig
Crop production	Calories produced/capita/day	(+) sig	(+) sig	(+) sig	(+) sig	nonsig
	Protein Produced/capita/day	(+) sig	(+) sig	(+) sig	(+) sig	nonsig
Food Security & Nutrition Indicators \a	MAHFP	nonsig	nonsig	nonsig	nonsig	nonsig
	FCS	nonsig	(+) sig	nonsig	nonsig	(-) sig
	Dietary Diversity	(+) sig	(+) sig	nonsig	(+) sig	(-) sig
Fixed effects Model						
Crop Income	Net crop Income	nonsig	(+) sig	(+) sig	nonsig	(+) sig
Crop production	Calories produced/capita/day	(+) sig	(+) sig	(+) sig	(+) sig	nonsig
	Protein Produced/capita/day	(+) sig	(+) sig	(+) sig	(+) sig	(+) sig
Food Security & Nutrition Indicators \a	MAHFP					nonsig
	FCS	nonsig				nonsig
	Dietary Diversity					(-) sig

Source: Authors analysis using Uganda LSMS dataset (2009, 2011 and 2013)

\a Definitions of indicators used: **MAHFP** (Months of Adequate Household Food Provisioning) measures the number of months a household had adequate level of food consumption**; FCS** (Food Consumption Score) score represents dietary diversity, food frequency, and relative nutritional importance of different food groups; **Dietary Diversity score** measures number of food groups (out of 12) consumed by the household over the past 7 days (this is similar to HDDS, but the reference period is past 7 days as data for past 24 hours were not captured in the LSMS dataset).

Table 3. Bean yield (kg/ha) from double blind demonstrative field experiments managed by farmers and farmer ranking of plots during harvest stage, Nicaragua

Village ID	Village	Yield (kg/ha, standardized at 14% moisture)			
		Certified seed (Plot circle)	Apta seed (Plot square)	Recycled (Plot triangle)	Average
A1	Santa Rosa	1,821	2,047	1,472	1,780
A2	El Bramadero	1,377	1,696	1,245	1,439
A3	El Horno	1,004	1,419	1,215	1,213
A4	Matapalo	495	570	675	580
A5	Moropoto	2,236	1,895	2,079	2,070
A6	El Porcal	358	655	456	490
B2	Susuli	944	1,543	1,693	1,393
B3	Las Mesas Sur	2,457	2,512	2,615	2,528
B4	Ojo de Agua	312	410	335	352
B6	La Chichigüa	728	1,029	844	867
Average yield\a		**1,173.2 b**	**1,377.6 a**	**1,262.9 ab**	
Percentage of farmers giving the BEST plot rating to plots planted with a given seed (average across all villages)		**11%**	**78%**	**10%**	

Source: Farmer managed field experimental data (Nicaragua willingness to pay study, 2017)
\a Mean with a different letter imply they are statistically significantly different at the 10% level

Table 4. Farmers' BDM WTP (Córdobas/lb) by seed type and biofortification information

Details	Biofortification Information NO	Biofortification Information YES	p-value	Total
Average WTP (C$/lb) for:				
Apta Seed	23.39	20.58	0.175	22.0
Certified Seed	17.03	17.37	0.886	17.2
Recycled Grain	17.69	16.01	0.541	16.8
Average Premium (%) for:				
Apta Seed	226.23	212.17	0.498	218.8
Certified Seed	165.81	180.78	0.531	173.8
Recycled Grain	169.79	169.54	0.992	169.7
Number of observations	**112**	**119**		**231**

Table 5. Descriptive Statistics of CSBs in Nicaragua (N=180)

	Mean	Std. dev.
Years of Survival (Years)*	2.36	1.50
Yield Potential (qq/mz)	15.77	8.85
Repayment Rate (%)	0.43	0.39
Received Seed Marketing Training (% Yes)	0.33	0.47
Beneficiaries per Manzana (farmers)	26.38	21.54
Number of Silos owned	2.19	1.97
President over 31 years (% Yes)	0.91	0.29
President is male (% Yes)	0.88	0.32
Type of CSB (% Yes)		
Classic	0.45	
Parceled	0.36	
Individual	0.19	
Travel time to market (Minutes)	28.04	23.74
Meeting Minuets Recorded (% Yes)	0.51	0.50
Access to Backpack Sprayer (% Yes)	0.52	0.50
Received CSB Formation and Operations training (% Yes)	0.76	0.43
Seed plots belong to CSB member (% Yes)	0.63	0.48
CSB members that are immediate family of each other (%)	0.28	0.31
Access to draught animal to pull, plough or cart (% Yes)	0.68	0.47
Region (% Yes)		
Centro Norte	0.24	
Centro Sur	0.25	
Las Segovias	0.20	
Pacifico Norte	0.18	
Pacifico Sur	0.13	

Source: Survey of CSBs in Nicaragua, baseline (2012) and follow-up survey (2017)
\a Survival means CSBs that are still functioning

Table 6: Top three reasons for ending the CSB as reported by CSBs surveyed in Nicaragua, 2017

N=61	Mean	Std. deviation
Reason for Ending CSB (% Yes)		
Impacts of weather (damaged crops)	0.41	0.50
INTA no longer supported the CSB	0.33	0.47
Internal member disagreements on CSB decisions	0.30	0.46
No more registered seed of preferred varieties	0.26	0.44
High cost of producing APTA seed	0.23	0.42
Change of INTA extension agent	0.11	0.32
Low cost recovery (low seed loan repayment)	0.11	0.32
Lack of equipment or land	0.10	0.30
No demand for APTA seed in village	0.08	0.28
Poor seed or not adapted to local conditions	0.08	0.28
No working capital	0.07	0.25
CSB focused on other activities	0.05	0.22
Low quality seed produced	0.05	0.22
Not enough training	0.05	0.22
Issues with INTA extension agent	0.03	0.18
Lack of experience	0.02	0.13

Source: Survey of CSBs in Nicaragua, follow-up survey (2017)
Note: Each CSB could give up to three reason, thus percentages don't add to 100%.

Table 7: Summary of farmer interviews conducted and seed samples collected in Haiti by Department

	Interviews			Seed Samples	
Departments	**Nationally representative sample (selected from USAI farmer list)**	**BTD Farmers**	**TOTAL Farmers Interviewed**	**Number of Farmers Providing Seed Samples**	**Total Seed Samples**
Ouest	132	0	132	65	79
Sud'Est	62	0	62	39	44
Nord	56	62	118	43	46
Nord'Est	39	117	156	36	48
Artibonite	128	109	237	57	77
Centre	74	0	74	69	93
Sud*	66	0	66	30	33
Grand'Anse*	73	0	73	26	26
Nord'Ouest	26	0	26	8	16
Nippes	31	0	31	16	17
Total	687	288	975	389	479

Table 8: Type of Bean Varieties Planted by farmer in Haiti, by type of farmer sample, 2016-17

			BTD Beneficiaries		Nationally representative sample	
Bean Color	**All**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Black	921	0.719	290	0.713	631	0.722
White	114	0.089	58	0.143	56	0.064
Red	80	0.062	17	0.042	63	0.072
Other	166	0.130	42	0.103	124	0.142
Total	1281		407		874	

Source: Haiti bean farmer survey, 2016-17