Feed the Future Innovation Lab for Collaborative Research on Grain Legumes
LEGUME INNOVATION LAB

2016 ANNUAL TECHNICAL PROGRESS REPORT
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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

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I. Abstract of research achievements and impacts

An assessment of the current status of the climbing bean/maize intercropping production system was completed in the highlands of Guatemala in close collaboration with SO1.A1 team. A research activity was initiated using existing data to build an evidence base by exploring pathways through which legumes can potentially enhance agriculture-food security linkages. Analysis using nationally representative data from Zambia suggest consistent positive effects of cereal-legume rotation and other legume technologies on net crop income, calorie and protein production, and months of adequate household food provisioning. Several research studies on the theme of sustainable seed system were initiated or completed in FY 16. This includes two studies on 'willingness to pay' for different types of seeds--one in northern Tanzania (for beans) and the other in northern Ghana (for cowpea). A case study focused on a farmer association in Burkina Faso was completed. The case of ASK provides a good example of how a farmer based local seed entrepreneurship model can be combined with a non-governmental oversight of quality control to produce QDS. But this case study also points to the challenges of small-holder farmers' ability to grow seeds that meet quality standards despite technical training and supervision from ASK. It points to the need for lowering the price of QDS that is still attractive to a seed producer to remain in the seed business but is within the 30-40% range of grain price to remain within the average range of farmers' willingness to pay for seed. The case study and the willingness to pay experiments indicate that increasing the

yield of cowpea seed that meets quality standards is key to lowering the price of seed and still make it profitable for seed producers to produce them.

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.

This project is designed to contribute 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 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:

Rationale: The indigenous population of mostly Mayan descent living in the western highlands of Guatemala are among the most undernourished in the world. Beans, which are one of the best sources of nutrients, are commonly grown in this region as part of the *Milpa* system, which is a traditional system of intercropping maize and beans (or other crops). The crops are either planted simultaneously, or maize first, and beans a few weeks later. Research indicates that to tackle the problem of undernourishment, household energy consumption from own-produced beans can be significantly enhanced by increasing bean yields. Genetic improvement of climbing beans for the highlands of Central America is thus one of the research activities of the Legume Innovation Lab project (SO1.A1) led by NDSU and ICTA.

To better understand the current status of the climbing bean/maize intercropping production system, and to establish a baseline about production of climbing beans in the highlands of Guatemala, a study was designed by this project team jointly with the SO1.A1 project team (Juan Osorno (NDSU) and Julio Martinez (ICTA) under their objective '*Genetic improvement of climbing black beans for the highlands of Central America*.' Byron Reyes, who joined CIAT in November 2014 is also a collaborator in this study.

Method: A survey of more than 500 farm households from five FTF Departments in Guatemala representing the highland bean growing regions was conducted in 2015, and data cleaning and analysis was completed in FY 16. The survey was designed to get a representative picture of the bean growers in the highlands of the five FTF departments of Guatemala defined as areas above 1500 meters above sea level. Data were collected from an average of 6 randomly selected farm households from 87 villages across the Departments of Chimaltenango, Quiché, Huehuetenango, San Marcos and Quetzaltenango.

Results: The results indicate the importance of beans in the diets of the indigenous population and confirm the need for increasing productivity to increase 'bean security' in the region. Major findings are summarized below.

Bean Consumption:

- Majority of farmers (80%) do not sell beans; only 6% sold more than 50% of their harvest
- Own production covered less than half of annual bean consumption for 23% of farmers; For another 33% of farmers, own production covered between 50-75% of annual consumption. Once own produced beans were consumed, 50% of farmers purchased beans at least weekly.
- On average, a household cooked beans 2.5 times and consumed a total of 5 cups of (uncooked) beans in the week prior to the survey.
- Households with children (under 14) on average served beans to the children 3 days in the week preceding the interview. On days that children ate beans, more households served beans at breakfast (75%) and dinner (79%) than at lunch (53%)
- Beans are consumed throughout the year; it is highest at or after the harvest – from November to March, and lowest in July and August (Figure 1)

Dietary diversity, culinary preferences and farmers' perceived nutritional value of beans

- On average a household consumed 6 out of 12 diverse food groups in the day prior to the survey; More than 85% reported consuming beans the previous day.
- Frijol negro', 'vulgaris' and 'bolonillo' were among the most preferred bean variety/type for consumption named by farmers (Figure 2)
- Respondents indicated that flavor (76%) was what they like most about a bean variety followed by thickness of bean broth (32%), cooking time (3.2%), expansion of size (1.5%) and color retention during cooking (0.7%).
- On a scale of 0-10, farmers rated beans 8.9 in terms of nutritional value, which was just below the score for maize (9.4), but higher than the perceived nutritional value of rice (8.1), potatoes (7.8), meat (6.9), chayote (5.9) and Coca Cola (1.4).

Bean Productivity and Production Practices:

- An average household owns 0.73 ha (median=0.27 ha) and devotes 1.3 parcels of land on the simultaneous planting of Milpa (direct planting) system, with an average plot size of 0.29 ha (median=0.18 ha). The average bean yield on the simultaneous planting milpa plots is 318 kg/ha (median=208 kg/ha)
- Farmers use the Milpa intercropping system with low crop rotation. The majority of farmers' plots were planted with maize in the year of the survey (94%) and also in the previous year (92%). Climbing beans were also planted on the same plot in the previous year (91%).
- Simultaneous Milpa (direct planting) was a more common practice (73%) than waiting several weeks to plant beans (relay) (21%); only 2.3% of plots surveyed had beans planted alone in rows or intercropped with other crops (2.0%).
- Most plots were planted with one bean variety (74%) while 18% had two varieties, and 6% had three varieties.
- Desired characteristics of a bean variety as cited by percentage of farmers are yield (49%), seed size (36%), seed color (32%), fast cooking time (32%), taste (31%), resistance to field pests (27%), resistance to lodging/weighing down maize (23%), early maturity (21%), and resistance to diseases (21%).
- Farmers are willing to pay on average 6.6 Guatemalan Quetzales per pound (US$ 0.80) for improved variety seeds that have the characteristics they desire and indicated that they would initially purchase on average 6.8 pounds of seed.

Progress report on publication outputs: A paper summarizing the main results of the survey was presented as a poster paper at the Pan African Legume conference in Zambia early this year, and is planned to be published as an MSU Ag Econ Staff Paper by the end of this year.

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

Rationale: 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).

In FY 16, this project team undertook a research activity using existing data to build an evidence base by exploring pathways through which legumes can 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, cereal-legume rotations, cereal-legume intercropping, and other means such as legume monocropping or intercropping legumes with non-cereal crops) and several indicators of household food security and welfare along the agricultural production and income pathways. The legumes commonly grown in Zambia and included in the study are groundnuts, soybeans, mixed beans, cowpeas, velvet beans, and bambara nuts. The cereals considered for cereal-legume rotation and intercropping are maize, sorghum, and millet.

Data: The data for this study are from the Rural Agricultural Livelihoods Survey (RALS), a two-wave, nationally representative panel survey of Zambian smallholder farm households conducted in June-July 2012 and 2015 by the Indaba Agricultural Policy Research Institute.[1] The RALS data include detailed information on household demographics, crop production (e.g., input use, area planted, and quantities harvested by plot and crop, as well as plot-level information on the use of intercropping and the main crop that was planted on the plot in the previous agricultural year), crop sales, asset holdings, and access and distances to agricultural extension, *inter alia*. From these data, we compute net crop income, defined here as the gross value of crop production minus fertilizer costs. (Insufficient data are available to net out other input costs; however, fertilizer is the major cash input cost incurred by Zambian smallholder farmers.) Both RALS survey waves also capture households' months of adequate household food provisions (MAHFP; Bilinsky and Swindale, 2010), and the 2015 wave included a household dietary diversity score (HDDS) module (Swindale and Bilinsky 2006). These data allow us to analyze the effects of legume technologies on five household-level welfare indicators: net crop income, calories produced/capita/day, protein produced/capita/day (in grams), MAHFP and HDDS.

Because we are interested in how incorporating legumes into their cropping activities affects cereal- (i.e., maize-, sorghum-, or millet-) growing households, our analytical sample consisted of all panel households that grew a cereal crop in both the 2010/2011 and 2013/2014 agricultural seasons (N=6,226).

Empirical strategy: In this study, we relied on observational data on the adoption of legume technologies and household welfare, and thus employed quasi-experimental techniques to identify the welfare effects of cereal-legume intercropping and rotation and other legume combinations. More specifically, we used panel data methods (e.g., the fixed effects estimator and the correlated random effects approach) or two-stage least squares to control/correct for different sources of endogeneity. For the purpose of comparison, we also report OLS estimates for all outcome variables.

For all outcome variables except for HDDS, which is only observed in the 2015 RALS, we estimate household fixed effects (FE) models of the welfare indicators regressed on measures of the household's adoption of the various legume technologies (cereal-legume intercropping, cereal-legume rotation, and other legume technologies), and a vector of control variables. Adoption of the various legume

[1] In Zambia, smallholder households are defined as those cultivating less than 20 ha of land. For details on the RALS sample design, see IAPRI (2012, 2015).

technologies is measured as either: (i) a binary ‘treatment’ variable equal to one if the household practiced the legume technology on at least one plot, and equal to zero otherwise; or (ii) a continuous ‘treatment’ variable equal to the household’s total hectares under the legume technology.

Given the count-variable nature of the MAHFP and HDDS, we also attempted to estimate correlated random effects negative binomial (CRE-NB) models for these outcome variables. But unfortunately, the CRE-NB model did not converge for MAHFP. For HDDS we estimate linear CRE and CRE-NB models in which the RALS 2015 HDDS is regressed on the RALS 2015 levels of the covariates as well as the RALS 2012 and 2015 household time averages of the covariates.

Finally, for all outcome variables, we estimate two-stage least squares (2SLS) regressions in which we instrument for the three main explanatory variables of interest, which we suspect may be endogenous to household welfare: adoption of cereal-legume intercropping, of cereal-legume rotation, and of other legume technologies.

Results: Legume cultivation is fairly common among cereal-growing smallholder households in Zambia. Approximately 64% of such households grow legumes in some way (Figure 3). Among legume crops, groundnuts are the most popular (53% of cereal-growing households grew groundnuts in the 2013/14 agricultural year), followed by mixed beans (about 17% of households), soybeans (8% of households), and Bambara nuts and cowpeas (3% of households each); just 0.1% of households grew velvet beans. The most common way that Zambian smallholders incorporate legumes into their farms is via rotation with cereals – approximately 40-43% of households do this each year (Figure 4). In contrast, cereal-legume intercropping is practiced by less than 5% of households each year. Approximately 22-23% of households grow legumes via other means (e.g., legume monocropping).

The econometric analysis results are summarized in Table 1 and indicate that cereal-legume intercropping exhibits few statistically significant ($p<0.10$) effects on the outcome variables examined in this study. Only for HDDS do we find statistically significant effects that are retained across multiple non-OLS estimators. The results suggest positive and statistically significant cereal-legume intercropping effects on HDDS in three of eight models.

In contrast to cereal-legume intercropping, cereal-legume rotation has more statistically significant, and generally positive, effects on household welfare (Table 1). The results are not robust to the choice of estimator for HDDS (although they are positive where statistically significant), but for MAHFP, calorie production, and protein production, the majority of the estimates suggest that cereal-legume rotation positively affects these outcome variables. The fixed effects results, for example, suggest that MAHFP increases by an average of 0.05 units with the use of cereal-legume rotation, and by an average of an additional 0.05 units given a one-hectare increase in cereal-legume rotations, ceteris paribus.

The positive effects of cereal-legume rotation on MAHFP appear to be coming mainly through the food production pathway, as cereal-legume rotation significantly increases both household calorie and protein production but has mixed effects on household crop income (Table 1). In terms of the magnitudes of the effects, the FE results, for example, suggest that each additional hectare of cereal-legume rotated land increases calorie production by an average of 1,088 calories/capita/day and protein production by an average of 38 grams/capita/day, holding other factors constant. These are substantial increases vis-à-vis the sample means of 5,913 calories/capita/day and 158 grams of protein/capita/day.

In summary, cereal-legume rotation appears to have generally positive effects on household food access (especially MAHFP) and on per capita calorie and protein production. These effects appear to come through both the crop income pathway and the agricultural production pathway. From a policy perspective, the empirical evidence that cereal-legume rotations can improve food production and food access among Zambian smallholder cereal growers, points to the need to promote this practice where it is feasible for farmers to do so. Researchers at the Zambian Agriculture Research Institute together with social scientists could investigate the specific types and lengths of cereal-legume rotations that are the most welfare-enhancing for Zambian 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 preliminary results of the survey were as a poster paper at the Pan African Legume conference in Zambia in February and as an oral presentation at the AAEA meetings in August. In the coming months we plan to publish this paper as an IAPRI working paper. We also plan to submit a manuscript for consideration in the *Journal of Development Studies*.

Objective 2: Conduct ex ante and ex post impact assessments

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

Motivation: One of the important factors that determine the sustainability of a seed system is the 'effective demand' for seed (i.e., planting material) of improved varieties as reflected in the volume and frequency of purchase of fresh seed by farmers. Even where farmers have adopted improved varieties, the low volume and low frequency of seed demand has been often cited as a major reason for the lack of private sector involvement in the seed system or the development of alternative models of a sustainable seed system. This is especially the case for self-pollinated crops like beans (*Phaseolus vulgaris*), because bean 'seed' of the same variety / type / market class is highly competitive with bean 'grain' as planting material.

Since producing and marketing beans as ‘seed’ involves taking specific and extra measures during seed production and post-harvest processing to ensure quality, it is more costly to produce than bean grain. Also, complying with the country’s seed regulatory requirements to be able to sell the seeds labeled and packaged as ‘certified seed’ or ‘quality declared seed’ (QDS) increases the cost.

Keeping the genetics constant (i.e., for the same improved variety), the viability of a seed market will depend on the co-existence of the following demand and supply side conditions. On the demand side, it will depend on: 1) whether farmers are able to perceive the ‘seed’ product as a quality planting material, and 2) given the perceived quality difference, whether they are willing to pay a premium price for seed compared to grain price. On the supply side, it will depend on: 3) whether the price farmers are willing to pay is high enough to recover the cost of producing quality seed; and 3) whether the quantity and frequency of seed demanded at that price is large enough to attract suppliers to produce and sell quality seed. There are no rigorous studies that have examined these demand and supply side dynamics in a systematic manner. The following two activities (2a-i: assessment of the willingness of small holder farmers to pay for quality seed, and 2a-ii: case study on community based seed system) undertaken by this project are attempts to address these demand and supply-side research questions in the context of dry grain legumes—beans and cowpeas.

i. *Willingness of small holder farmers to pay for quality seed*

This study is conducted in Tanzania for beans in collaboration with SUA and CIAT, and in Ghana for cowpeas in collaboration with SARI. In Ghana all the field work and data collection is completed and data entry and analysis is still ongoing. In Tanzania the study was concluded in FY 16 and we present the main results of this study in this Report.

Rationale: In Tanzania, four types of seed products are potential options available to farmers as planting materials—certified seeds produced from foundation seed (certified 1), certified seed produced from certified 1 seed (certified 2), quality declared seeds (QDS) and recycled seeds saved from farmers’ own harvested grain. These four types of seeds or planting materials differ in seed input (i.e., which generation of seed is used to produce them), the regulatory supervision they receive or not receive, and technical conditions under which they are produced, and thus vary in cost. However, 1) whether the cost differential across these types of seeds makes them qualitatively different products as reflected in their perceived or actual performance of the plant, and 2) whether that translates into differential price that farmers are willing to pay for these seeds are empirical questions addressed by this study.

Method: A two-step approach was used to address the two research quesitons. First, double-blind field experiments were established in 12 hamlets across two districts in Kilimanjaro region, northern Tanzania. The FE (also called demonstration plots) were used to demonstrate the value of planting certified 1 vs. certified 2 vs. QDS vs. recycled seed of the bean variety, Jesca, so farmers can see first-hand the difference in agronomic performance of the plants, the amount (that could be) harvested and the quality of the beans. Through these experiments farmers were able to learn first-hand how different types/grades of seeds of the same improved variety perform in a location that is close to their farm. The reason for doing the FE as a double blind experiment is to reduce any systematic bias on the part of the technical staff or the farmer managing the plot towards or against any pre-conceived higher and lower quality seed type (this is called the Hawthorne effect in the economics literature). Second, once farmers observed how different types of seeds of a particular variety perform, bidding experimental auctions were carried out to extract information about how much they are willing to pay for these seeds based on the perceived / observed differences in their performance.

The FEs were planted on approximately 100 sq. m. (10m x 10m) sub-plot with a total plot of 400 sq m of land. The amount of seed required for this area was 1 kg (at a planting rate of 40 kg/acre) or 4 kg of seed in total (i.e., 1 kg of each grade). The seeds of different grades were obtained from appropriate seed source prior to the planting. The field experiments were planted in a farmer's field. Farmers hosting the FE were in charge of planting and managing the FE following their own management practices (i.e., these were not managed as 'experimental trials'). During the production cycle, two field days were carried out in the two best performing fields in each village. All farmers living in the village were invited to these field days to see the bean plots and learn about their performance, first-hand. The first field day was conducted around the flowering stage (or soon after), and the second field day occurred just before or after harvest. Attendees in the first Field Day were given a sheet where they ranked the sub-plots according to a set of criteria agreed upon by the farmers as a group. During the second field day, the same attendees were asked to rank the best and the worst sub-plots and the reason for their ranking.

The Bidding Experimental Auctions (BEA) were conducted to determine how much farmers are willing to pay for the different types of seeds (i.e., planting materials, not food grain). These took place during the second field day in October 2015. We followed the Becker-DeGroot-Marschak (BDM, 1964) method, where participants did not bid against other people, but only against themselves. Prior to the seed BDM auction, a 'practice BDM' was conducted with a bar of soap to make sure farmers understood the auction mechanism.

The willingness to pay (WTP) elicitation mechanism was performed using a full bidding method (e.g., Lusk and Shogren 2007, and Alfnes 2009). In this method, farmers were first endowed with TS 4000 (equivalent to about US$2) to make their decisions more realistic (and not be constrained by available cash) and then asked to participate in four auctions by "bidding" their maximum willingness to pay (WTP) for a one kg of seed for each seed type A, B, C and D. Farmers were told that one of the four auctions will be chosen randomly and the bid for that seed would then be compared to a randomly drawn number from a given revealed price range of TS 0 to 3950. If the bid is greater than or equal to the randomly drawn price, then the farmer buys that seed at the randomly drawn price (not his/her bid price). The difference in the bids between the four auctions reveals the premium (or discount) due to the different seed type attributes (QDS vs. certified 1 vs. certified 2 vs. recycled). In this method, the farmer is likely to pay less than his/her bid (unless the bid and random price are equal) and thus the auctions are theoretically incentive compatible with regards to eliciting true farmer WTP.

A total of 245 farmers participated in the BEA across the 12 villages. Survey data were collected from each farmer that participated in the auction experiment to capture their socio-economic household characteristics, and experience with producing beans, varietal use and prior use of different types of seed.

Results: This study on farmers' willingness to pay for quality seed has generated three interesting results that have implications on designing seed systems for legume crops. First, seed quality matters (not just the genetics)--on average certified seed 1 (Type A) consistently outperformed certified seed 2 (Type B) and quality declared seeds (QDS) (Type D) and QDS outperformed farmer recycled seeds (Type C) of the same variety in field experiments conducted on farmers' fields and farmers perception of these quality difference was highly correlated with the yield performance as reflected in their ratings of different plots during the flowering and harvest stages (Figure 5).

Second, all else equal, farmers are willing to pay premium for quality seeds--the relative difference in Farmers' WTP for different seed types is correlated with the relative difference in their perceived quality differences (Figure 6). Third, results confirm the downward sloping demand curve for quality seed—the number of farmers willing to pay a premium price for quality seed declines as price of seed increases (Figure 7).

The overall implication of these findings is that there is no one-size-fits-all strategy to meet the seed needs of all the farmers. The strategy should be built on multi-pronged approaches based on subsidies to meet the needs of farmers on the lower end of the WTP spectrum, private sector based approaches to meet the needs of farmers on the higher end of the WTP spectrum, and alternative models based on in-kind subsidy and not for profit seed production models (e.g., community based models) for farmers in the middle ranges.

Progress report on publication outputs: A paper summarizing preliminary results of the survey was presented at the Pan African Legume conference in Zambia in February. In the coming months we plan to submit a manuscript for consideration in a development journal.

2a-ii. Case study on community based seed system: The problem of lack of farmer access to legume seed has left millions of smallholder farmers relying on their own or other farmers' harvested 'grain' (accessed from the local market) as the main source for seed. The advantages of this decentralized informal seed system is that it is able to meet diverse needs of farmers at lower cost (i.e., at grain price). However, on the disadvantage side, the informal system is not directly linked with the research system, and thus not able to quickly channel new improved varieties, and produces lower quality 'seed,' which negatively impacts the productivity of food production. In view of these challenges, this project undertook a case study of a farmer association in Burkina Faso called *Association-Song-Koaadba* (ASK), which is involved in training its members to produce quality declared seeds (QDS) of cowpea for sale to other farmers. The goal of this case study was to investigate whether and how the ASK model builds on the cost advantages of community based seed production, and minimizes the disadvantages of potentially lower seed quality of an informal seed system. This study was conducted in close collaboration with INERA socio-economist (Dieudonne Ilboudo) and host country PIs of other Legume Lab projects (Issa Drabo and Clementine Dabire).

Method: The case study uses a combination of qualitative and quantitative methods comprised of: a) Key informant interviews (KII) conducted in 2015 and 2016 with the staff members of the ASK management team, INERA, the National Seed Service (SNS), the Union Nationale des Production Semenciers (UNPS) and other farmer organizations that purchased seeds from ASK; and b) Survey conducted in 2015 of 225 cowpea farmers across 25 villages where ASK is active, including ASK member seed producers (53), non-seed producers (99) and non-members (73).

Results: The *Association Song Koaadba* (ASK) was established more than 20 years ago with the goal of promoting food self-sufficiency and food security in rural farming communities. It currently has about 7500 members spread over 58 villages in the provinces of Oubritenga, Kourweogo, Kouritenga, Ganzourgou, Sanmatenga, Passore and Sissili. Table 2 presents the business model used by ASK based on the key informant interviews and farmer survey in terms of operating costs, types of services offered by ASK, scale of seed production, seed distribution, marketing, cost of seed production, and the requirement vs. reality of seed production system used by ASK. According to the ASK management team, in 2014, a total of about 80 ha of land was devoted to cowpea seed production by about 125 members. ASK members involved in seed production mostly produce QDS seeds of cowpea for sale to other ASK members and non-member farmers in their communities. Over the past 20 years, ASK has had strong ties with INERA and has received continuous guidance and technical support from them in strengthening their cowpea seed production activities. In turn, ASK has served as an effective organization for INERA to channel new and improved cowpea varieties generated by its cowpea breeding program.

In terms of the evidence of use of purchased seed, 70% of members and 30% of non-members in the village surveyed had purchased seed from ASK in the past. However, the last time a farmer purchased seed was on average 3 years ago. In terms of the seed source for the 2014 planting season, according to the farmer survey, 77% of cowpea plots had planted seeds from previous harvest, 14% had accessed it from ASK, 6%

had purchased as grain and 2% had purchased or received as seed; 35% of cowpea plots surveyed was planted to an improved variety (IV). Thus, despite the presence of ASK, own saved seed remains the major source of planting material. Only 35% of cowpea plots surveyed were reported as planted to an improved variety (IV).

The case of ASK provides a good example of how a farmer based local seed entrepreneurship model can be combined with a non-governmental oversight of quality control to produce QDS. The broad based services provided by ASK to its members is highly valued and is the reason for its long-term operation. But despite their operation, access to new varieties and affordable quality seeds of cowpea in ASK member communities remains a constraint as evidenced by:

- Low adoption of improved varieties: 30-40% of plots planted to IV
- Low cowpea grain and seed yields: average 300 kg/ha
- High rejection rate: 30% seed is rejected (according to farmer survey)
- High price of seed set by ASK: More than double the grain price
- Reliance on the subsidized seed distribution channel: More than 1/3 of seed produced by ASK members ends up being sold outside the ASK network, which ends up being distributed as free or highly subsidized QDS (To put this in broader context--95% of certified seed ends up in this channel). The high percentage of seed in the subsidized seed distribution channel undermines the overall sustainability of the model.

In summary, this case study results indicate the challenges of small-holder farmers' ability to grow seeds that meet quality standards despite technical training and supervision from ASK. It points to the need for lowering the price of QDS that is still attractive to a seed producer to remain in the seed business but is within the 30-50% range of grain price. Increasing the yield of cowpea seed that meets quality standards is key to lowering the price of seed and still make it profitable for small-scale community based seed producers.

Progress report on publication outputs: A paper summarizing preliminary results of the survey was presented as a poster paper at the Pan African Legume conference in Zambia in February. In the coming months we plan to publish this study as an MSU International Development Working Paper.

2b. Adoption study in Haiti:

During the past 20 years, with support from USAID, the National Seed Service of the Ministry of Agriculture in Haiti has conducted bean research in collaboration with the University of Puerto Rico, the USDA-ARS and Zamorano. This collaboration resulted in the development and release of bean cultivars such as DPC-40, XRAV-40-4, MEN 2201-64ML and Aifi Wuriti that have greater disease resistance, improved agronomic traits and higher seed yield potential than local landrace varieties of beans. In recent years, the Bean Technology Dissemination (BTD) project in Haiti received funding from USAID to produce and distribute 69 MT of seed of these improved bean cultivars to > 25,000 farmers. Some of the NGO's such as Zanmi Agrikol and Helping Hands that participated in the production of bean seed continue to produce seed of the improved bean cultivars after the BTD project ended.

Despite these recent and long-term investments in bean research and dissemination of improved variety seeds, there is no study conducted by NSS, the Ministry of Agriculture or the National Agricultural Statistics Service in Haiti to assess the adoption of these technologies and its impact. A major reason for this is the lack of capacity within the national system in Haiti to conduct rigorous adoption and impact studies based on farm household surveys. Hence, last year the SO1-A4 team expressed a strong interest in conducting an impact study in Haiti through technical assistance from this project team. As a result, this activity was included in the FY15-16 workplan of this project and supplemental funding was secured in 2015 under the *Strengthening Host Country Institutional Capacity* call for proposals.

In collaboration with the SO1.A4 team and based on the feedback received from the Management Office and the USAID, the study design was finalized in May this year and shared with the MO and USAID/Haiti. Specific objectives of this study are:

1. 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.
2. 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
3. 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.'
4. 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.

The plan was to do the field research in summer 2016. However, due to personnel changes in NSS, which delayed the release of funds and hurricane Mathew, field data collection was postponed. Thus, no activities were undertaken to report in FY 16. The plan is to implement the survey in November-December in 8 Departments not affected by the hurricane and in March-April in the 2 Departments affected by the hurricane. Field activities for the impact study will be led by the National Agricultural Statistics Service with technical support and guidance from MSU. All other activities will be a joint collaboration between SO4.1 and the host country partners.

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 15:

a. Research studies conducted in Guatemala, Burkina Faso, Ghana and Tanzania under objectives 1 and 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).

IV. Major Achievements

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

- Research conducted in Zambia suggest consistent positive effects of cereal-legume rotation and other legume technologies on net crop income, calorie and protein production, and months of adequate household food provisioning. However, effects of cereal-legume intercropping are mixed for these indicators, and effects of the integration of legume crops in cereal based farming systems on household dietary diversity were inconclusive.

- All else equal, farmers are willing to pay a premium for quality seed; but the average willingness to pay for highest rated quality seed over the lowest rated quality seed was only 30%. This is less than the price premium charged for certified seeds over the grain price in most developing countries. Secondly, the number of farmers willing to pay a premium price for quality seed declines as price of seed increases (i.e., evidence of a downward sloping demand curve). The implications of these findings are that there is no one-size-fits-all strategy (or business model) to meet the seed needs of all the farmers. Secondly, The importance of private sector, public sector and not-for profit sector in the seed system will depend on at what price the suppliers can produce and sell seeds that are perceived by the farmers to be of better quality than the grain. There is a need for:
  - Lowering the cost of quality seed production by increasing seed yield (i.e., reducing the rejection of seeds that don't meet quality standards)
  - Adopting a flexible seed price system where price of different quality grade seeds are determined by cost of production and not by the government or a seed regulatory agency

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 Development

1. **Short-term Training**
   Survey design and implementation training in Haiti (classroom and field testing)
   Status: Not completed in FY 2016

2. **Degree Training**

   First and Other Given Names: Christine
   Last Name: Sauer
   Citizenship: USA
   Gender: Female
   Training Institution: Michigan State University
   Supervising CRSP PI: Mywish Maredia
   Degree Program for training: M.S..
   Program Areas or Discipline: Agricultural Economics
   If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? No
   Host Country Institution to Benefit from Training: None
   Thesis Title/Research Area: the student assisted in panel data analysis of existing datasets from Zambia
   Start Date: Fall 2015
   Projected Completion Date: Fall 2017
   Training status (Active, completed, pending, discontinued or delayed): Active
   Type of CRSP Support (full, partial or indirect) for training activity: Partial (student hourly job; the student had ¼ time assistantship from the Department)

   First and Other Given Names: Edward
   Last Name: Opoku
   Citizenship: Ghana
   Gender: Male
   Training Institution: Michigan State University
   Supervising CRSP PI: Mywish Maredia
   Degree Program for training: M.S..
   Program Areas or Discipline: Agricultural Economics
   If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? No
   Host Country Institution to Benefit from Training: None
   Thesis Title/Research Area: the student assisted in the Ghana study on farmers' willingness to pay for cowpea seed
   Start Date: Fall 2015

Projected Completion Date: Fall 2017
Training status (Active, completed, pending, discontinued or delayed): Active
Type of CRSP Support (full, partial or indirect) for training activity: Indirect (the student has funding from the Mastercard Foundation Scholarship program)

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.

VIII. Achievement and Progress Along the Impact Pathway

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 2016 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: Four technical reports, one thesis, and three manuscripts for peer reviewed venue have been completed.

IX. Explanation for Changes

The following activities targeted to be achieved by the end of FY 2016 have been delayed:

1. Haiti impact study and short-term training: As indicated before, due to personnel changes and the hurricane, the field work for this study was delayed and is now being conducted in FY 17.

X. Self-Evaluation and Lessons-Learned

- **Challenges:**
    - Our project is a collaborative project cutting across all the other projects funded by the Legume Innovation Lab. We depend on the support and collaboration of the lead US and HC PIs in implementing our workplan. In some cases, we have to rely on the existing contractual agreements between the US and HC institutions of other LIL projects to channel the funds for field research. As such delays in the contract amendments between these institutional partners (which is not in our control) impacts our workplan.
- **Failures:** Although, there are no 'failures' in doing research, we do consider the 'delays' in implementing the workplan or 'incomplete' activities reported in this Annual Report as a failure on our part to properly manage time and available resources to meet the outputs set for this project.
- **Successes/Strengths:** The support and collaboration we have received from other project teams in the implementation of research and capacity building activities is greatly appreciated. This spirit of cross-disciplinary collaboration evident in the activities reported in this project's annual report is a strength of this program.

XI. Scholarly Accomplishments

Publications and Manuscripts:

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. (under review *Information Technology for Development*)

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.

Thesis:

DeYoung, David. 2015. Determinants of sustainability of community seed banks in Nicaragua: A duration analysis approach. Thesis for partial fulfillment of MS degree in Agricultural, Food and Resource Economics, Michigan State University (submitted in December 2015).

Presentations

Posters:

DeYoung, D., B. Reyes, J. C. Villatoro, L. Montejo, J. Moscoso, J. M. Osorno and Mywish Maredia. 2016. The Role of Beans in *Milpa* Production and Dietary Systems of Guatemalan Highlands: Results of a Farm Household Survey. Poster paper presented at the Pan-African Grain legume Conference, Livingston, Zambia, February 28 – March 4, 2016.

DeYoung, D. and M. Maredia. 2016. Can Community Based Seed Growers Produce Quality Seeds and be Sustainable? Evidence from the Community Seed Bank models in Nicaragua. Poster paper presented at the Pan-African Grain legume Conference, Livingston, Zambia, February 28 – March 4, 2016.

Maredia, M., D. Ilboudo and R. Pitoro. 2016. The Economics of Community Based Seed Production: A Case Study of the *Association Song Koaadba* (ASK), Burkina Faso. Poster paper presented at the Pan-African Grain legume Conference, Livingston, Zambia, February 28 – March 4, 2016.

Maredia, M., B. Reyes and D. DeYoung. 2016. Farmers' Willingness to Pay for Quality Bean Seed: Evidence from Central America. Poster paper presented at the Pan-African Grain legume Conference, Livingston, Zambia, February 28 – March 4, 2016.

Sauer, C., M. Maredia and N. Mason. 2016. Legume Technology and Agricultural Productivity: Evidence from Zambia. Poster paper presented at the Pan-African Grain legume Conference, Livingston, Zambia, February 28 – March 4, 2016.

Oral presentation:

DeYoung, D. and M. Maredia. 2016. Determinants of Sustainability of Community Seed Banks in Nicaragua: A Duration Analysis Approach. Selected Paper prepared for presentation at the 2016 Agricultural & Applied Economics Association Annual Meeting, Boston, Massachusetts, July 31-August 2

Maredia, M., R. Shupp, F. Mishili, B. Reyes and P. Kusolwa. 2016. Farmer willingness to pay for quality bean seed: Experimental evidence from Tanzania**.** Paper presented at the Pan-African Grain legume Conference, Livingston, Zambia, February 28 – March 4, 2016.

Sauer, C., N. Mason, M. Maredia and R. Mofya-Mukaka. 2016. The role of legume technologies in the agriculture-nutrition-food security nexus: evidence from Zambia. Selected Paper prepared for presentation at the 2016 Agricultural & Applied Economics Association Annual Meeting, Boston, Massachusetts, July 31-August 2

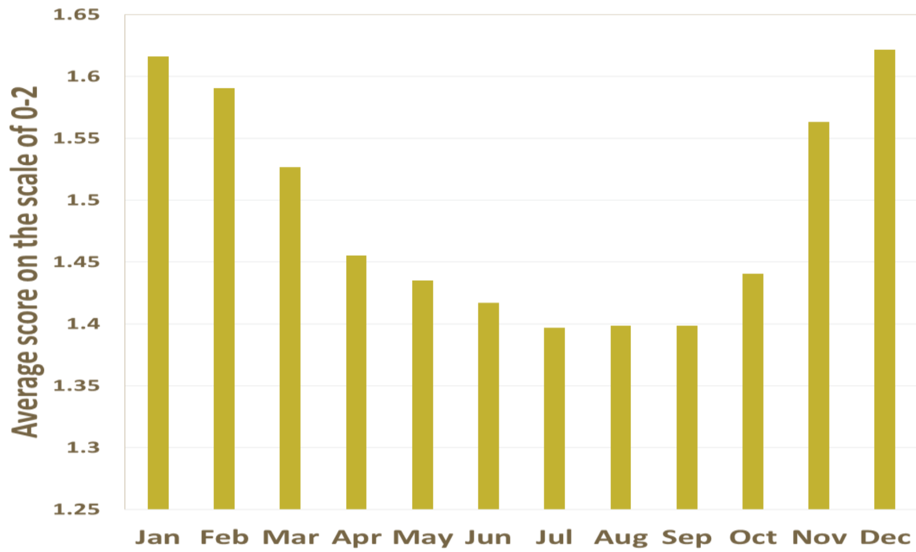
XII. Data Management

The following datasets were submitted to USAID's DDL site in this reporting period (FY2016).

- Bean Technology Dissemination Project: Beneficiary Survey in Guatemala
- Bean Technology Dissemination Project: Beneficiary Survey in Honduras
- Bean Technology Dissemination Project: Beneficiary Survey in Nicaragua

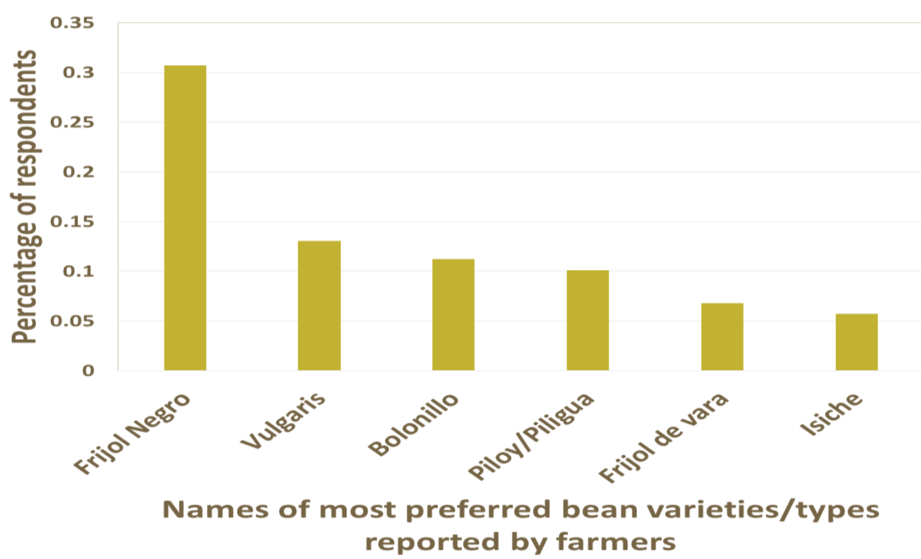
ANNEXES:

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



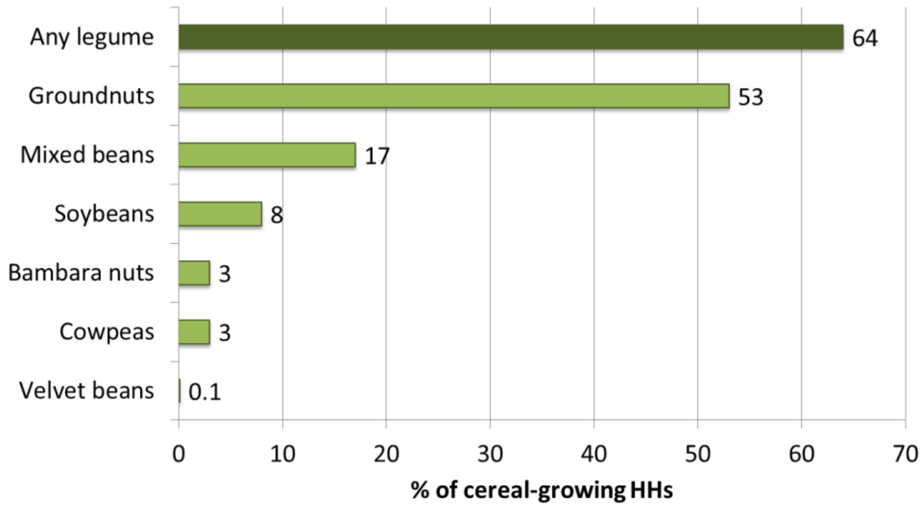
Source: Baseline survey of bean farmers in highlands of Guatemala (2015)

Fig 1. Mean bean consumption score over the past 12 months on a scale of 0 (no consumption) to 2 (relatively more consumption)



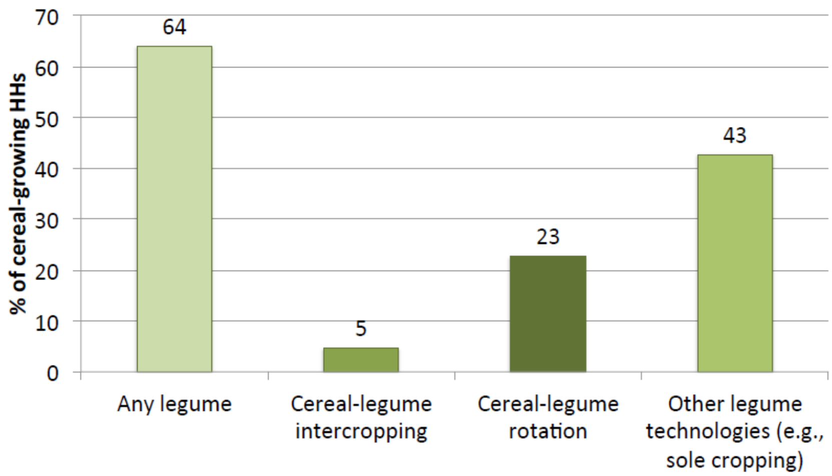
Source: Baseline survey of bean farmers in highlands of Guatemala (2015)

Fig 2. Most preferred bean varieties for consumption as named by farmers in Guatemalan highlands



Source: RALS (2015)

Figure 3. Percentage of cereal-growing HHs in Zambia producing legumes (2013/14 agricultural year)



Source: RALS (2015)

Figure 4. Prevalence of legume technologies among cereal-growing HHs in Zambia (2013/14 agricultural year)

Table 1. Effect of legume technologies on household income, calorie and protein production, Months of Adequate Household Food Provisioning, and Household Dietary Diversity Score: Key findings from Zambia

	Main explanatory variables of interest		
Outcome variables	Cereal-legume intercropping	Cereal-legume rotation	Other legume technologies
Net crop income	• Little evidence of stat. sig. effects once use 2SLS/FE	• Consistent (+) effects for continuous measure of adoption	
Calorie production			
Protein production			
MAHFP			
HDDS	• Some evidence of (+) effect (3/8 models)	• Some evidence of (+) effect (4/8 models)	• (+) in most (6/8) models

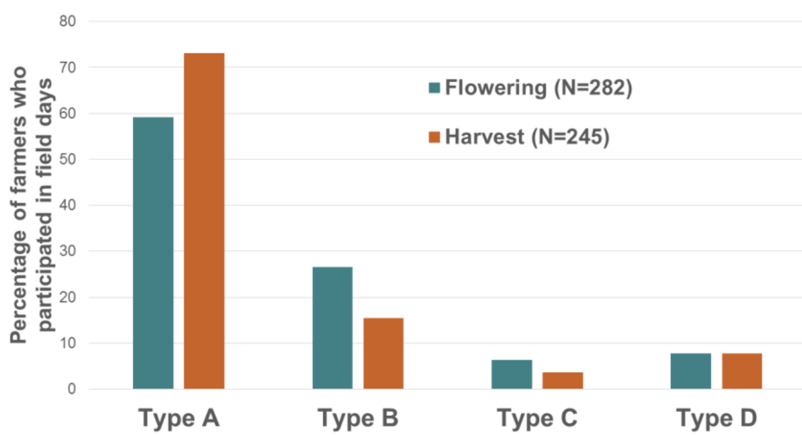
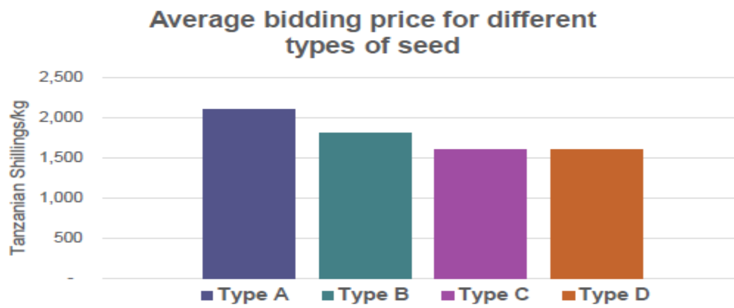


Figure 5. Farmer's rating of the best plot at two stages: Results from Tanzania



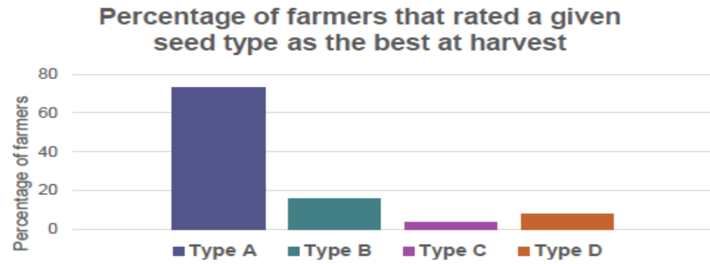


Figure 6. Comparison of farmers willingness to pay with their perceived quality differences (N=247)

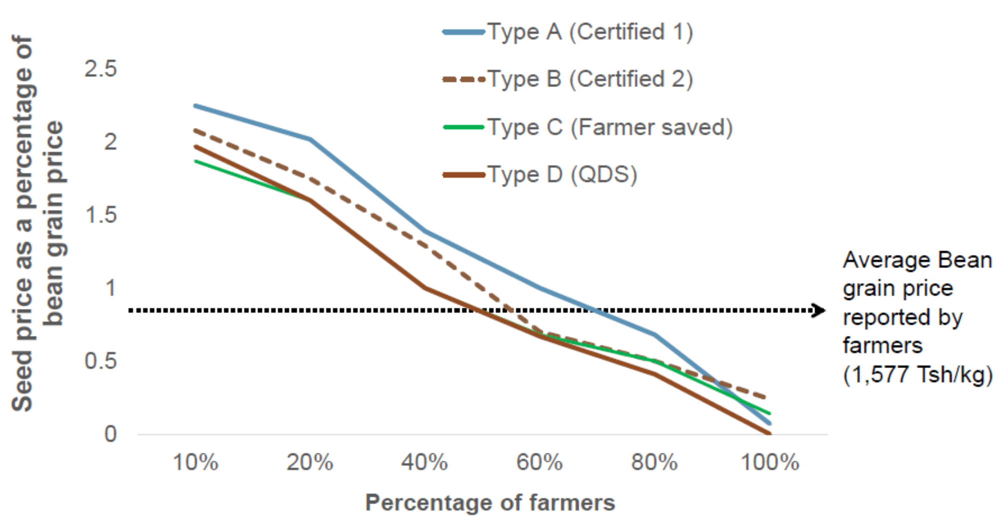


Figure 7. Farmer willingness to pay for seed of different perceived quality as a percentage of bean grain price: Results from Tanzania

Table 2. Business Model of ASK based on key informant interviews and farmers' survey

According to ASK key informant interviews	
Operation cost	30% of operating budget comes from sales of cowpea seeds (20%) membership fees (5%) and renting equipment (5%); The other 70% comes from donor support (NGOs).
Product/ services offered (all free to members)	a) Test, adapt and promote technologies; b) Capacity building (train farmers, trainers, farmer field schools); c) Technical monitoring, inspection and 'certification' of quality declared seeds produced by ASK members; d) Facilitate the purchase and sale of excess seeds produced by members
Scale of cowpea seed production	On average ASK members together produce ~40 tons of cowpea seed per year. In 2014, seed producing members devoted total 80 ha for cowpea seed production and produced 54 t of QDS cowpea seeds (compared to total 300 t of certified seeds produced in the country that year)
Seed distribution	In 2014 (According to ASK): 60%: sold by seed producer members directly to other farmers; 30%: sold through assistance from ASK; 10% sold or saved as grain by farmers
According to Producer Survey	
Requirement vs. Reality	Must devote 1-3 ha of land for seed production (compared with min 3 ha for certified seed); In practice: Only 30% of farmers devoted 1 or more ha for seed production. Must follow technical guidelines: Only 2/3 seed producers received monitoring visits from ASK during seed production. Can sell the harvest as 'seed' only if it meets the quality standards set by ASK; Rejected seed can be sold/consumed as grain: On average 31% of harvest is rejected as seed due to quality issues
Cost of seed production	Major costs: Foundation seed (procured by ASK from INERA)--2,500 CFA/kg applied at a rate of 12 kg/ha; labor; purchased inputs (e.g., fertilizer, chemicals); post-harvest handling (drying, sorting, conditioning). On average cowpea QDS seed production costs are ~50% more than cost of grain production *(Source: farmer survey)*
Quantity	On average a seed producer harvested 200 kg of approved seed
Marketing	36% of seed is sold to others; 34% to ASK and 30% retained; Price of QDS seed is set by ASK--700 CFA/kg for members, 800 CFA/kg for non-members (compare to price of grain-300 CFA/kg, certified seed-850 CFA/kg. A seed producer on avg. sold seed to 13 farmers.