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

FY 2014–2015 Annual Project Technical Progress Report
(April 1, 2014 – September 30, 2015)

Project Code and Title: SO1.A1- Genetic Improvement of Middle-American Climbing Beans for Guatemala.

Lead U.S. Principal Investigator and University: Juan M. Osorno, Dept. of Plant Sciences, North Dakota State University. Fargo-ND 58108.

Collaborating Host Country and U.S. PIs and Institutions:
Phil McClean, Dept. of Plant Sciences, North Dakota State University. Fargo-ND
Julio C. Villatoro, ICTA-Guatemala
Fernando Aldana, ICTA-Guatemala
Edgardo Carrillo, ICTA-Guatemala
Angela Miranda, ICTA-Guatemala
Jessica Moscoso, ICTA Guatemala – New team member.
Gustavo Mejia, ICTA-Guatemala – New team member.
Karla Ponciano, ICTA-Guatemala – Resigned February 2015.
Julio Martinez, ICTA-Guatemala – Retired January 2015.

I. Abstract of Research and Capacity Strengthening Achievements

The project continues to make progress towards the testing and release of improved climbing beans for the highlands if Guatemala. A total of 10 lines have been tested across more than 15 locations at farmer's fields in order to obtain information about their agronomic performance as well as grower's feedback. An additional year of testing will be needed before making final decisions regarding release of varieties. Three lines are showing the best combination of seed yield and reduced aggressiveness that would allow high productivity in the maize under the Milpa system. On-farm testing of Bolonillo Texel continues in order to ensure adaptation and acceptability by growers. Phenotypic variation within this line has been noticed and we are making efforts to ensure genetic purity of the line, even though this is not a big issue for growers since they are used to grow heterogeneous material in their fields. In addition, seed cannot be separated once harvested. The 600 accessions of the climbing bean collection were finally received at NDSU and are under DNA extraction at the time of this report. The baseline study with the growers was successfully completed (~500 growers) and tabulated and is currently under statistical analysis. In addition, seed samples from most growers surveyed was obtained and is currently being increased at the ICTA greenhouses. This is a great opportunity to assess the current genetic diversity being used by growers as well as to compare with the original climbing

bean germplasm collection collected 30 years ago. Last but not least, 2 female students started their M.S. training in plant breeding and genomics at NDSU. This will ensure the next generation of bean scientists for Guatemala. In addition, new collaborations have been established with project SO4-1 and MASFRIJOL to augment the success of the breeding efforts of this project.

II. Project Problem Statement and Justification

With approximately 11 million habitants, Guatemala is mostly a rural country, with 60% of the population living in farms and 50% of the population being indigenous. Maize and beans are the main staple food in most households with a per capita bean consumption of 9.4 kg per year. Since few other sources of protein are available, this amount is not enough to ensure an acceptable nutritional quality, especially within poor households. As expected, the lack of protein intake has reduced the nutritional quality in many households, significantly affecting children. Chronic malnutrition is frequent among children under 5 years old in the western highlands, with 67% of children affected, making Guatemala the country with the highest malnutrition level in the western hemisphere. One out of every three children from ages six to 59 months in the western highlands shows some degree of anemia. Approximately 18% of reproductive-age women exhibit anemia, with 29% prevalence among pregnant women and 23% prevalence among breastfeeding women.

Beans are grown on 31% of the agricultural land and mostly in the low to mid-altitude regions (0-1500 masl) in a monoculture system. Contrastingly, intercropping (locally known as Milpa) is the main production system in the highlands, where maize-bean is the most common crop association. Unfortunately, on-farm productivity of these climbing beans is approximately one third of their genetic yield potential mostly due to the lack of improved cultivars that are able to withstand biotic and abiotic stresses. Fungal and bacterial diseases as well as pests are the main cause for yield reductions. In addition, production is made with almost no inputs of fertilizers and/or other chemicals. Historically, climbing beans worldwide have received less attention and breeding efforts in comparison with the bush-type beans commonly grown in the lowlands, as shown by the significant yield gap between regions. In addition, there are genetic and environmental interactions among species (maize, bean, squash, etc.) not well understood within the intercropping system that may affect crop performance and hence, seed yield. The legume Innovation Lab has been involved in collaborative bean breeding research targeting lowland agro-ecologies in Central America, but research for the highland bean production systems is still lacking.

There is an existing collection of approximately 600 accessions of climbing beans collected across all bean production regions in Guatemala. This collection is kept by ICTA and has been characterized morphologically, agronomically, and with few molecular markers (6 SSR primers). Initial results suggest that ½ of the collection consist of duplicates. In addition, some initial crosses among climbing

beans and selections have been made by the ICTA group. These lines will be used intensively in this project.

III. Technical Research Progress

Objective 1: Development of germplasm with improved disease resistance and agronomic performance.

Collaborators:
NDSU: Juan M. Osorno and Phil McClean.
ICTA: Julio Cesar Villatoro, Fernando Aldana, Jessica Moscoso.

1.1: Field testing of 10 selected lines (ICTA): A total of 10 climbing bean breeding lines that are at advanced breeding stages were selected to be part of field trials:

1. Bolonillo Altense
2. Bolonillo Hunapu
3. Bolonillo Texel
4. Bolonillo Anita
5. Bolonillo Labor Ovalle
6. Bolonillo San Martin
7. Bolonillo ICTA Santa Lucia
8. Voluble GUATE 1120
9. Voluble GUATE 1026
10. Local check from the grower (different among farms).

Most of these breeding lines are the product of initial crosses made 5-6 years ago and subsequent composite mass-selection and testing made by Dr. Fernando Aldana at the ICTA-Quetzaltenango station. Any superior line or lines could be released as varieties in the near future while a breeding pipeline is established. The trials were planted around May and grown both at the ICTA-Quetzaltenango station and at farmer's fields in 17 locations (Table 1).

Table 1. List of climbing bean trials (location and department) made during the 2015 growing season in the Guatemalan highlands.

	LOCALIDAD	DEPARTAMENTO
1.	PAXTOCA	TOTONICAPÁN
2.	CHUISUC	TOTONICAPÁN
3.	SAN ANTONIO SIJA	TOTONICAPÁN
4.	XESENA	TOTONICAPÁN
5.	PATACHAJ	TOTONICAPÁN
6.	CHOQUI ALTO	QUETZALTENANGO
7.	OLINTEPEQUE	QUETZALTENANGO
8.	SJ OSTUNCALCO	QUETZALTENANGO
9.	SP SACATEPEQUEZ	SN MARCOS
10.	CHIANTLA	HUEHUETENANGO
11.	SN SEBASTIAN	HUEHUETENANGO
12.	SANTA POLONIA	CHIMALTENANGO
13.	COMALAPA	CHIMALTENANGO
14.	TECPAN	CHIMALTENANGO
15.	EL TEJAR	CHIMALTENANGO
16.	ZARAGOZA	CHIMALTENANGO
17.	LABOR OVALLE	QUETZALTENANGO

Most locations were tested under the common intercropping system (Milpa). Depending on space and resources at each location, the 10-entry trials were planted using a Randomized Complete Block Design (RCBD) with 2 or 3 replications. Farmer's trials included also the local varieties/landraces used by the farmer as the local check in order to be able to make side-by-side comparisons for these growers. Harvest of these field trials is still underway at some locations at the time this report is being written and should be finished by early December 2015. All this extensive testing is coordinated by the field validation unit at ICTA (Julio Franco is the coordinator), which is the final step before official variety release under ICTA standards. Results from the previous year (FY2014) are available as Appendix 1.

Across locations, Bolonillo San Martin had the highest seed yield, followed by Bolonillo Hunapu and Bolonillo Altense. Unfortunately, the general trend is that these genotypes are extremely aggressive in their growth in order to obtain the high yields reported and therefore, there is significant damage to the maize (mostly due to lodging). This is the main reason why growers have stopped growing beans in association with maize because culturally, the latter is the most important crop for them. This is more accentuated above 1500 masl because direct planting (instead of relay) cause more competition between maize and bean. Consequently, the best combination of high seed yield and minimum damage to maize is offered by Bolonillo Santa Lucia, Bolonillo Texel, GUATE 1026, and Bolonillo Labor Ovalle (Appendix 1). In addition, Bolonillo Anita was the most stable genotype across locations. ICTA validation unit needs a minimum of 3 years of multi-location testing before making decisions about which genotypes to be released, but we will keep directly involved in this process. Main production problem during the last 2 years are the Mexican weevil (*Apion* spp.) as well as rust, anthracnose, ascochyta, and angular leaf spot.

1.2: Breeding pipeline and genetic purification of selected material (ICTA/NDSU): As explained in the Technical Project Description, phenotypic variation has been detected not only within accessions but also within the improved lines selected by Dr. Fernando Aldana at ICTA-Quetzaltenango. The main reason for this is that Dr. Aldana kept these lines as bulked lines during multiple generations and therefore, no individual plant selections have been done during the breeding process. Therefore, individual plant selections were made within the breeding lines during the 2013 growing season and planted again as plant-rows at ICTA-Quetzaltenango.

A total of 43 individual plant selections within each one of the 10 lines mentioned in objective 1A were made based on potential yield and quality, absence of disease symptoms, pod distribution and color, and other agronomic traits. These individual selections were sent to the ICTA-San Jeronimo station for winter increase and each selection was planted as individual rows for further evaluation/selection. This allowed for detection of additional genetic heterogeneity within lines while increasing seed. Since phenotypic heterogeneity

was still detected, more individual plants and some bulked rows were selected and sent to ICTA-Quetzaltenango for evaluations during the 2015 growing season. A total of 130 individual plant selections were planted as rows and harvest of this material is almost complete at the time of this report. A final round of phenotypic evaluation will be made during FY2016 in order to ensure a homogeneous source of breeder seed to start the seed increase process.

Additional studies were focused in evaluating population dynamics and densities of Mexican bean weevil (*Apion godmani*) in the 4 most promising breeding lines mentioned in Objective 1.1. This study is actually part of the thesis project for a local Agronomy B.S. student in Quetzaltenango (Karen Agreda), and also an agro-economic study of alternative intercropping systems besides the common Milpa to see if maize-bean productivity could be increased by having different arrangements. Finally, several rust mobile nurseries were deployed in different growing areas in order to assess the race structure of the pathogen across the region. At least 9 rust races could be identified based on the disease reaction observed in the differentials. Please refer to Appendix 2 to find specific details and results about these complementary studies.

1.3: Field evaluation of Bolonillo-TEXEL (ICTA): One of the improved lines selected by Dr. Fernando Aldana at advanced breeding stages (known as Bolonillo-Texel) was also tested at grower's fields. Side-by-side Milpa on-farm strip trials of the local's farmer variety/landrace and Bolonillo-Texel were grown (using the same maize material and agronomic practices) in 5-6 of the locations mentioned in Table 1 as on-farm strip trials. Bolonillo-Texel is one of the most promising breeding lines based on preliminary data previously collected by Dr. Fernando Aldana, ICTA-Quetzaltenango. Since these trials are mostly managed by growers, data collection is mostly focused on seed yield, agronomic performance, and personal feedback from each grower. Technical assistance from ICTA agronomists (special tanks to Elmer Estrada) and crop extension personnel from the Ministry of Agriculture have been crucial for finding these growers and locations.

Differences in pod color have been noticed in these trials, which confirm the genetic heterogeneity still present in Bolonillo Texel, even though this is not a big issue for local growers since they already grow heterogeneous material in their farms. However, it is a concern for this breeding project and we are doing all necessary activities (see objective 1.2) that will allow obtaining a uniform variety at the end of this project. The MASFRIJOL project is highly interested in obtaining a new climbing bean variety for his disseminations program, so efforts are in coordination with them in order to speed up this process as much as possible.

1.4: First crossing block: With the results obtained from the field testing and the evaluation of the germplasm collection during the 2014 growing season (objective 2.3), a first set of 23 potential parents were selected by Osorno,

Villatoro, McClean, and Aldana, and planted in the greenhouse at the ICTA station in Chimaltenango during the 2015 growing season. Parental accessions were selected mainly based on uniform pod distribution, potential yield, and disease resistance.

Unfortunately, the first generation of single crosses during FY15 has encountered some difficulties in regards to flowering synchronicity in spite of planting the material at staggered planting dates. Anecdotal results suggest that this germplasm is highly sensitive to daylenght (photoperiod), so the long days during the summer would not trigger flowering in these materials. Therefore, some crosses planned initially won't be accomplished and will have to be attempted again during FY16. Since the collection was planted again in the trellis system available at ICTA-Chimaltenango, we took advantage of this opportunity and attempted to do crosses in the field rather than in the greenhouse. Results were relatively successful so far and F1 seed is being harvested at the time of this report. Therefore, complementary crosses will be attempted again during the 2016 growing season in order to have a continuous breeding pipeline for the future (see objective 1.2).

Objective 2: Characterization of the genetic diversity of this unique set of germplasm.

Collaborators:
NDSU: Juan M. Osorno and Phil McClean.
ICTA: Julio Cesar Villatoro, Fernando Aldana, Jessica Moscoso, Angela Miranda.

2.1: Evaluation of core collection with the 6k SNP chip (NDSU): As explained in the milestones, this activity had to be postponed because the seed available from the germplasm collection stored at ICTA-Chimaltenango was in bad condition and would not pass phytosanitary inspection in order to be shipped to NDSU. Seed was severely affected by bruchids (mostly *Acanthoscelides* spp.). ICTA doesn't have adequate long-term seed storage infrastructure and it is something that needs to be addressed in the future. Another option would be to have a backup set of this collection with USDA-GRIN. It also appears that CIAT has most of the accessions from this climbing bean collection but this is something that needs to be revised.

In order to solve this issue with seed quality, it was decided to do a new field increase of all the germplasm collection at the ICTA-Chimaltenango station during FY14 in order to produce fresh seed to be shipped to NDSU for DNA analysis. Delays in getting a phytosanitary certificate from the Ministry of Agriculture in Guatemala caused that seed was not shipped to NDSU until August 2015. However, the timing was actually perfect since it did coincide with the arrival of the three new students (trainees) that will work with these accessions (Objective 4.1). One of the students (Gabriela Tobar) will have the molecular characterization of the collection as her main research topic for her

M.S. degree.

Seed from each accession of the climbing bean collection is currently being processed for DNA extraction and SNP genotyping. First objective is to confirm the previous reports about half of the collection being duplicates. For this, a set of ~70 InDel markers will be used and then decisions will be made about what will be genotyped with SNP markers. We expect to present the first results of this molecular characterization at the Pan-African Grain Legume and World Cowpea Conference at Zambia in March 2016.

2.2: Assessment of the intra-accession variability (NDSU): Because of the reasons exposed in the previous section, this activity had to be postponed as well. A genetic assessment of variation within the 10 selected lines used in objective 1.1 will be made in order to account for the heterogeneity not only among but within accessions and possibly, extrapolate that information to the rest of accessions. Preliminary phenotypic observations in the field suggest that there is a high amount of genetic heterogeneity (heterozygocity) within accessions. Therefore, 20 plants from each of the 10 selected accessions will be planted in the greenhouse at NDSU and DNA will be extracted, for a total of 200 DNA samples/individuals. These genotypes will be also screened with a subset of InDel markers developed in the NDSU bean molecular genetics lab (Moghaddam et al., 2014). The InDel markers were developed from polymorphic SNPs, but their advantage is that they can be easily reproduced by PCR and visualized in an agarose gel. Since the main goal is to assess intra-accession variability, this will be easily detected by looking at the band polymorphisms in the gels. Polymorphic Information Content (PIC) and other genetic parameters will be estimated. This information will allow a better understanding of the organization of the genetic diversity within this core collection for future use and research.

Because this collection will form the basis of future breeding efforts by ICTA, it is necessary to understand the diversity among the lines in the collection. At the same time, the project is interested in ensuring that a line is pure. All lines were visually screened at ICTA, and any line that contained multiple seed coat color or patterns were discarded. Those lines were delivered to NDSU in September 2015. In addition, at NDSU, any line with a single seed coat color and pattern, but which the seeds varied for seed size, was also discarded. This left ~400 lines. Two seeds for each line were planted in the NDSU greenhouse and leaf tissue was from each plant were collected and pooled. DNA was isolated from the leaf sample for each line.

2.3 Field evaluation of the ICTA collection of climbing beans (ICTA-NDSU): The entire collection of climbing beans from ICTA has been planted in FY2014 at the ICTA station in Chimaltenango to allow a re-evaluation of the material and

also the production of a newer batch of seed. Each accession has been planted in short rows (~2 m) mostly for phenotypic observation. A first set of 23 potential parents were selected by Osorno, Villatoro, McClean, and Aldana, and planted in the greenhouse at the ICTA station in Chimaltenango during the 2014 growing season for initial crosses (Objective 1.4). A list of selected accessions can be found in Appendix 2. Parental accessions were selected mainly based on uniform pod distribution, potential yield, and disease resistance. Since the entire collection was planted again during FY2015, it gave us an opportunity to re-evaluate the 23 accessions selected the year before. The research group felt very confident that the 23 selected accessions represent the best of the collection in terms of agronomic performance. Some of these activities will overlap with FY2016. These selected accessions were used for the first set of crosses described in objective 1.4.

Objective 3: A better understanding of the current socio-economic status and needs of bean production within the context of intercropping systems in the region.

Collaborators:
NDSU: Juan M. Osorno.
ICTA: Gustavo Mejia, Julio Cesar Villatoro, Fernando Aldana.
MSU: Mywish Maredia, David DeYoung, and Byron Reyes from project SO4-1.

As described in the technical project description and FY15 work plan, a grower survey was deployed during March 2015 in the main regions where climbing beans are produced. The survey activity was very successful thanks to a great collaboration established with the project lead by Mywish Maredia (SO4.1). They have far more experience with surveys than any person in our team, so we appreciate their willingness to help. Originally, Julio Martinez from ICTA was the social economist in charge of this. However, he decided to retire in January 2015 and ICTA quickly assigned Gustavo Mejia, another social economist at ICTA-Quetzaltenango to be in charge of this activity. His involvement and passion in this activity was crucial for the success of the survey. Considerable time was devoted to designing the survey instrument, with skype calls every week until completed. Survey instrument (Word or PDF format) is available as Appendix 3.

We focused on the following departments based on some stratified analysis: Quiche, Huehuetenango, San Marcos, Totonicapán, and Quetzaltenango which represent most of the climbing bean production areas. Once approval for the survey was obtained from the Institutional Research Board (IRB) at NDSU, a group of ~15 surveyors was selected and trained by David DeYoung and Byron Reyes. Approximately 500 growers across 5 departments were surveyed during the 3-4 week period during March 2015.

Collected data has been entered into a digital format (Excel) by ICTA personnel and is currently under revision and filtering of errors at MSU. Therefore, during FY16, data will be analyzed using the proper statistical tools and results will be summarized. Results of this survey will be shared not only within the project but with other projects currently working in Guatemala (e.g. Masfrijol) and government agencies interested. First results will be shared at the Pan-African Grain Legume and World Cowpea Conference at Zambia in March 2016.

An interesting activity performed during the survey was the collection of a seed sample (~10 seeds) that was requested to each grower surveyed. Seed samples were donated voluntarily and ~85% of the growers surveyed accepted to give us a sample of the seed they use in their farms. Therefore, now we have a newer set of 540 climbing bean germplasm accessions that virtually represents what growers are using in their farms currently. Since seed amounts were limited, 4 seeds per sample were planted in the greenhouse for increase and future evaluation during FY2016. Future activities with this set of germplasm include a comparison of the original germplasm collection from ICTA with this new collection and see what changes in genetic diversity could be detected. This will provide an opportunity to do a phenotypic evaluation of the germplasm collected during the survey and possibly to identify genetic material of interest for the breeding pipeline (Objective 1.2). In addition, the specific location from where each seed sample was obtained is available and therefore, some geographical diversity analyses are possible in the near future. Even more, the new germplasm collected during the survey could be compared with the original germplasm collection via SNP analysis (Objective 2.1) and try to establish some genetic similarities and hence, some possible geographical origin for the original germplasm collection since all the passport data was lost several years ago. We foresee this study as a good research topic for one of the students coming to do their M.S. training at NDSU (Objective 4).

Objective 4: Capacity building: training the next generation of plant breeders for Guatemala and establishing a long-term breeding plan to increase the productivity of climbing bean in the region.

Recruiting efforts during FY2014 and FY2015 at ICTA have allowed the identification of three candidates for M.S. at NDSU. Gabriela Tobar Piñon and Carlos Maldonado are ICTA employees initially identified through the CAPA project, which is an early career program at ICTA to identify outstanding individuals for future employment and ICTA. The third candidate is Luz de Maria Montejo who is a graduate from the Escuela Agricola Panamericana Zamorano and was working with the Guatemalan Ministry of Agriculture. Luz was highly recommended by Juan Carlos Rosas and Jim Steadman and therefore, she was transferred to ICTA. The 3 students started their M.S. programs at NDSU in the fall of 2015. Given our inexperience with TraiNet and the process, we

experienced multiple difficulties during the process, which caused the delay in having our first M.S. student (Gabriela) starting in January 2015. The process was reinitiated for this student plus the two new candidates so they all successfully started their M.S. degrees in fall 2015. The three students are currently living in Fargo, ND taking classes and doing research at NDSU.

Research topics will be directly related to the research objectives described above. We foresee research projects focused on the analyses of genetic diversity, genetic resistance to diseases, and production systems, among others. The graduate students will be provided a broad range of training in conventional and molecular plant breeding techniques so that they can assume leadership roles in bean research programs in the target countries.

IV. Major Achievements

1- **On farm field testing and validation across 17 locations of 9 breeding lines with potential to be released in the near future.**

2- **On-farm testing and validation of Bolonillo-Texel across 6 locations.**

3- **Establishment of a breeding pipeline and first set of crosses.**

4- **Initial molecular characterization (DNA extraction) of climbing bean collection.**

5- **Completion of grower survey and data tabulation of ~500 questionnaires.**

6- **Collection of seed samples from surveyed growers and seed increases in the greenhouses.**

7- **Recruitment of 2 female students for formal training (M.S. in Plant Sciences) at NDSU.**

8- **New collaborations established with project SO4-1 and MASFRIJOL will augment the success of the breeding efforts of this project.**

V. Research Capacity Strengthening

During FY2015, our project successfully obtained one of the capacity strengthening awards for host countries. We used the funds to support activities related to the PCCMCA annual meetings (Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales). This is the most important scientific meeting in Central America and the Caribbean about crop and animal production research. It is an annual regional forum hosted since 1954 on a rotating basis by the National Institutes of Agricultural Research (INIA) in Central America and the Caribbean. Scientists from universities, private companies, NGOs, international organizations involved in agricultural research in

the region and other countries meet to discuss and analyze current issues and perspectives of research, technology, and innovation in agriculture and to exchange experiences and promote cooperative activities. The meeting was hosted by ICTA in Guatemala City May 4-7, 2015. The meeting attracted approximately 300 participants from the region. There was a 2.5 hour plenary session that showcased all the activities that we are currently doing in the region, so it was a great opportunity to show the model of the Legume Innovation Lab and its regional impact.

VI. Human Resource and Institution Capacity Development

1. Short-Term Training

i. Training to surveyors for grower baseline study survey:

a. Purpose of Training: To train a group of 17 surveyors for the baseline study deployed in March 2015.
b. Type of Training: 3-day workshop.
c. Country Benefiting: Guatemala.
d. Location and dates of training: ICTA Quetzaltenango, March 5-7 2015.
e. Number receiving training (by gender)
f. Home institution(s) ICTA-Guatemala
g. Institution providing training or mechanism: Training was provided by David DeYoung from Michigan State Univ (SO4.1) and Byron Reyes (CIAT).

2. Degree Training:

First and Other Given Names: Maria Gabriela
Last Name: Tobar Piñon
Citizenship: Guatemalan
Gender: Female
Training Institution: NDSU
Supervising CRSP PI: Phil McClean
Degree Program for training: M.S. in Plant Sciences
Program Areas or Discipline: Plant breeding/genomics
If enrolled at a US university, will Trainee be a “Participant Trainee” as defined by USAID? Yes
Host Country Institution to Benefit from Training: ICTA
Thesis Title/Research Area: Molecular characterization of germplasm collection of Guatemalan climbing beans.
Start Date: August 2015
Projected Completion Date: December 2017
Training status (Active, completed, pending, discontinued or delayed): Active
Type of CRSP Support (full, partial or indirect) g for training activity: Full

First and Other Given Names: Luz de Maria
Last Name: Montejo
Citizenship: Guatemalan
Gender: Female
Training Institution: NDSU
Supervising CRSP PI: Juan M. Osorno
Degree Program for training: M.S. in Plant Sciences
Program Areas or Discipline: Plant breeding
If enrolled at a US university, will Trainee be a “Participant Trainee” as defined by USAID? Yes
Host Country Institution to Benefit from Training: ICTA
Thesis Title/Research Area: Disease resistance in Guatemalan climbing bean germplasm collection.
Start Date: August 2015
Projected Completion Date: December 2017
Training status (Active, completed, pending, discontinued or delayed): Active
Type of CRSP Support (full, partial or indirect) g for training activity: Full

VII. Achievement of Gender Equity Goals

The ICTA bean breeding program includes two women in their team (Angela Miranda and Jessica Moscoso) and they are in charge of the activities at San Jeronimo and Quetzaltenango. In addition, 2 women who are ICTA employees (Gabriela Tobar and Luz Montejo) have been recruited for formal training (M.S. in Plant Sciences) at NDSU.

VIII. Explanation for Changes

Objective 2 – Delays in seed production and acquisition of phytosanitary certificates caused the molecular characterization to be delayed. This will be completed in early FY2016 and activities should be back in track.

IX. Self-Evaluation and Lessons-Learned

After 2 years working in this partnership between NDSU and ICTA-Guatemala, the project has been able to make a lot of progress. The genetic material previously developed by Dr. Aldana at ICTA-Quetzaltenango allowed having breeding material ready to be tested in farmer’s fields. This will ensure this program has significant impact in the short-medium term while a new breeding pipeline is established (long term). So far we are impressed with the capabilities and passion that ICTA personnel put into this project. ICTA has proven success with the long term program supported by the Legume Innovation lab for bush type beans for the lowlands along with the University of Puerto Rico. Since we are halfway in the project’s timeline, we have been devoting a lot of time discussing what needs to be done in the next 2 years in order to ensure successful accomplishment of all objectives. The pod color segregation observed

in the advanced material is a new concern for the breeding program, but not so much for the growers since they already deal with phenotypic variation in their fields. Seeds cannot be visually separated once harvested. Nonetheless, we are working towards the genetic purification of these lines in order to ensure the genetic stability of any variety that ICTA decides to release.

After many difficulties, we were able to recruit 2 M.S. students to work in this project at NDSU. The climbing bean collection is used as part of their research requirements for completion of their degree. The training of this human resource will ensure the next generation of plant breeders for Guatemala.

X. Scholarly Accomplishments (Project member in bold)

Song Q., Jia G., Hyten D.L., Jenkins J. , Hwang E.Y., Schroeder S.G., **Osorno J.M.**, Schmutz J., Jackson S.A., **McClean P.E.**, and Cregan P.B. 2015. SNP Assay Development for Linkage Map Construction, Anchoring Whole Genome Sequence and Other Genetic and Genomic Applications in Common Bean. G3: Genes | Genomes| Genetics g3-115.

Osorno J.M. 2015. Avances en las secuencias genomicas de cultivos. Annual Meetings PCCMCA. Guatemala City, Guatemala. May 1-5. Oral presentation.

Tobar-Piñon M.G., Illescas O.V., and **Villatoro J.C.** 2015 Evaluación sensorial y de aceptación de productos alimenticios a partir de variedades de frijol (*Phaseolus vulgaris*) biofortificado. Annual Meetings PCCMCA. Guatemala City, Guatemala. May 1-5. Oral presentation.

Montejo, L.M., **Villatoro, J.C.**, and Dardon, D. 2015. Identification of physiological races of common bean rust (*Uromyces appendiculatus*). Annual Meetings PCCMCA. Guatemala City, Guatemala. May 1-5. Poster presentation.

Maldonado-Mota C., Villatoro J.C., Miranda A., Moscoso-Alfaro J., Aldana L.F. 2015. Fitomejoramiento de frijoles (*Phaseolus vulgaris*) biofortificados para Guatemala. Annual Meetings PCCMCA. Guatemala City, Guatemala. May 1-5. Poster presentation.

Khankhum S., Valverde R., Pastor-Corrales M., **Osorno J.M.,** and Sabanadzovic S. 2014. Two endornaviruses show differential infection patterns between gene pools of *Phaseolus vulgaris*. Arch. Virol. 160:1131-1137.

XI. Progress in Implementing Impact Pathway Action Plan

After two years of this new project, we are confident that our activities have been in accordance with our impact pathway plan, with the exception of the molecular characterization of the germplasm collection. Specific plans are in place for FY2016 to ensure we meet the established pathways by the end of next funding cycle. Please refer to the Impact Pathway Plan document for more details.

ANNEXES

Appendix 1: Study of stability and yield of 10 genotypes of climbing beans across 17 locations from the western highlands in Guatemala. (Estudio de estabilidad y rendimiento de diez genotipos de frijol voluble en 17 localidades del altiplano occidental de Guatemala).

Appendix 2: ICTA bean program annual report of activities for climbing beans (Informe de Proyecto de frijol voluble).

Appendix 3: Grower survey instrument (Guatemala encuesta de frijol voluble).