# LEGUME INNOVATION LAB FOR COLLABORATIVE RESEARCH ON GRAIN LEGUMES

# FY 2015 WORKPLAN

## Project Code and Title: S01.A4

Development and implementation of robust molecular markers and genetic improvement of common and tepary beans to increase grain legume production in Central America and Haiti.

### Lead U.S. and Host Country Principal Investigators, Institutions and Countries:

James Beaver and Consuelo Estevez de Jensen - University of Puerto Rico, Mayagüez, PR, USA Timothy Porch - USDA/ARS/TARS, Mayagüez, PR, USA Phil Miklas - USDA/ARS, Prosser, WA, USA Juan Osorno and Phil McClean – North Dakota State University (NDSU), Fargo, ND, USA Juan Carlos Rosas - Escuela Agrícola Panamericana (Zamorano), Honduras Julio Cesar Villatoro - Instituto de Ciencia y Tecnología Agrícola (ICTA), Guatemala Emmanuel Prophete - National Seed Service, Ministry of Agriculture, Haiti

### I. Project Problem Statement and Justification:

During the past 30 years, most of the growth in bean production in Central America was due to an increase in the area of production in the lowlands (< 1000 m). Greater heat tolerance combined with resistance to *Bean Golden Yellow Mosaic Virus* (BGYMV), for example, permitted increased bean production in El Salvador. Bean production in both Guatemala and Nicaragua has expanded into more humid lowland regions whereas a significant portion of the beans in Haiti continues to be produced in the lowlands. Bean production in Africa could be expanded if lines with better lowland adaptation were developed. This Legume Innovation Laboratory project will address several of the biotic and abiotic constraints often encountered by bean producers in the tropical lowlands.

Andean bean breeding lines developed by Dr. Paul Kusolwa at Sokoine University of Agriculture have a unique combination of traits that confer a high level of resistance to bruchids (*Acanthoscelides obtectus*). These breeding lines include the arcelin 2 seed protein from common beans, the null phaseolin trait from *P. coccineus* and the APA locus derived from *P. acutifolius*. The bruchid resistant breeding lines have been used as progenitors at the University of Puerto Rico to introgress this resistance into black, small red and white beans that have resistance to *Bean Common Mosaic* Virus (BCMV), *Bean Common Mosaic Necrosis Virus* (BCMNV) and BGYMV. Regional performance trials will be conducted in Central America and the Caribbean to measure the durability of the resistance when exposed to different genera and ecotypes of bruchids.

The recent arrival of BCMNV in the Caribbean made the selection for resistance to this virus a priority breeding objective in Haiti, the Dominican Republic and Puerto Rico. BCMNV is also a serious disease in lowland bean production regions of southeastern Mexico. Collaborative research supported by the Bean/Cowpea and Pulse CRSP resulted in the development and release of black bean lines such as DPC-40, XRAV-40-4 and MEN-2201-64ML that combine

resistance to BCMNV and BGYMV. Small red bean breeding lines with the same combination of resistances have been developed at Zamorano. These BGYMV and BCMNV resistant black and small red bean lines will be available in the event that BCMNV emerges as a threat to bean production in Central America.

Increased resistance to common bacterial blight and web blight is needed for beans produced in warm and humid lowland regions such as the Petén and southern Guatemala. This combination of resistances may also permit increased production of beans in Central America during the first growing season when rainfall is more abundant and reliable.

The previous Dry Grain Pulse CRSP project (UPR-1) developed Middle American and Andean bean breeding lines having adaptation to the lowland tropics and different combinations of resistance to diseases (common bacterial blight, rust, angular leaf spot, web blight and root rot) and tolerance to edaphic constraints (low N soils, high temperature). During the next five years, the Legume Innovation Lab project will use these elite breeding lines as the base for the continued improvement of beans for our target countries.

Several improved black and small red bean germplasm lines and cultivars are expected to be released in Central America and the Caribbean during the next five years. This Legume Innovation Laboratory will continue, in collaboration with CIAT, to support bean research network activities in Central America and the Caribbean. Collaborative activities such as the regional performance nurseries will help to extend the impact of this project through the release of improved cultivars throughout the region.

During the next five years, the project plans to release in Haiti red mottled, yellow and white bean cultivars with enhanced levels of disease resistance including BGYMV and BCMNV. These seed types are produced in regions in Haiti where the CRSP projects had less impact. This effort is consistent with the FTF 2011-2015 multi-year strategy in Haiti to increase the production of staples such as beans to increase food security.

The project will continue to screen germplasm to identify additional sources of resistance to diseases that limit bean production in Central America, the Caribbean and Eastern Africa. For example, more resistance to ashy stem blight, caused by *Macrophomina phaseolina,* is needed to improve adaptation to hot and dry environments whereas greater resistance to web blight, caused by *Rhizoctonia solani,* is required to increase yield and seed quality of beans produced in more humid environments. Project personnel have the expertise and experience needed to reliably phenotype the Andean and Middle American Diversity Panels for traits of economic importance. This should contribute to the identification of new sources of resistance and molecular markers for these traits.

Low soil fertility, in particular low N and P, is a major constraint to bean production in Central America and Haiti. Breeding beans with enhanced biological nitrogen fixation can reduce the effects of low soil N. Previous research has identified a large amount of genetic variation in common beans for biological nitrogen fixation. The BTD project demonstrated that *Rhizobium* inoculants was well accepted by farmers in Central America and Haiti. After two cycles of recurrent selection elite lines that combine good nodulation with disease resistance and commercially acceptable seed type have been developed.

There are regions and/or growing seasons in Central America and Haiti that are too hot and/or dry to produce common beans. The tepary bean (*P. acutifolius*) is a potential alternative grain legume for these stressful environments. In fact, farmers on the Pacific coast of Central America

and some countries of Africa already produce tepary beans on a limited scale. In addition to heat and drought tolerance, tepary bean lines with high levels of resistance to common bacterial blight, bruchids and other important traits have been identified. Resistance to BCMV, BGYMV, larger seed size and improved agronomic traits, would increase the potential adoption of tepary beans. Interspecific crosses with common beans could be used to introgress these traits into tepary beans. This effort represents the first systematic attempt to genetically improve tepary beans. The S01.A4 project will collaborate with the USDA/ARS FTF project to select *Bradyrhizobium* efficient strains and to study the inheritance of interespecific tepary bean x common bean populations for specificity to establish symbiosis with *Rhizobium* and/or *Bradyrhizobium* using *nod*C, *rec*A y *atp*D genes.

Bean breeders were early adopters of marker-assisted selection to identify lines with desired combinations of traits. This has resulted in increased efficiency in the development of improved breeding lines. There are, however, molecular markers available for a limited number of traits. Others, such as the SAP-6 SCAR marker, are only effective in a specific gene pool. Therefore, there is a need to develop new or more robust markers, particularly for traits of economic importance to bean breeding programs in the tropics. Recent advances by the BeanCAP project, led by North Dakota State University, in sequencing the bean genome and the development of a SNP array will facilitate the mapping and development of molecular markers for traits of economic importance, while breeder-friendly indel markers are a broadly applicable technology. The availability of phenotypic data in appropriate populations is a major factor limiting the development of these markers. This Legume Innovation Lab will assist this effort through the development of the populations and information needed to identify improved markers for traits such as the *Ur-11* gene for rust resistance.

A better understanding of clusters of disease resistance genes is needed to achieve the goal of developing coupling phase linkage blocks to enhance the capacity to combat multiple pathogens. For example, genes for resistance to rust, anthracnose, ALS, powdery mildew, halo blight and other diseases co-locate on chromosomes Pv01, Pv04, and Pv11. These resistance genes may be in repulsion whereby selection of a specific gene for resistance may cause the displacement of a resistance gene in the recurrent parent that is effective against a different pathogen. Dr. Phil McClean at NDSU and Dr. Phil Miklas, USDA-ARS-Prosser will lead the collaborative effort to develop improved molecular markers.

II. Planned Project Activities for the Workplan Period (October 1, 2015 – September 30, 2016)

Objective 1: Genetic improvement of common beans for Central America and Haiti.

# **Collaborators:**

James Beaver and Consuelo Estevez de Jensen – University of Puerto Rico, Mayaguez, PR, USA Timothy Porch – USDA/ARS/TARS, Mayaguez, PR, USA Phil Miklas – USDA/ARS, Prosser, WA, USA Juan Osorno and Phil McClean – North Dakota State University (NDSU) Juan Carlos Rosas – Escuela Agrícola Panamericana (Zamorano), Honduras Julio Cesar Villatoro - Instituto de Ciencia y Tecnología Agrícola (ICTA), Guatemala Emmanuel Prophete– National Seed Service, Ministry of Agriculture, Haiti

# Approaches and Methods:

Conventional plant breeding techniques and marker-assisted selection will be used by Legume Innovation Lab scientists to develop common bean cultivars and breeding lines with enhanced levels of disease resistance and greater tolerance to abiotic stresses. Plant breeders will focus on the most important biotic and abiotic constraints in lowland (< 1000 m) bean production regions in Central America and Haiti.

Bruchid resistant bean breeding lines developed by Dr. Kusolwa at Sokoine University of Agriculture have been used to introgress resistance to this pest into commercial seed types (black, small red, red mottled, light red kidney and yellow) produced in the target countries. A laboratory screening technique developed at the University of Puerto Rico has been used to evaluate the resistance of bean breeding lines. Molecular markers (arcelin 2 and APA locus) developed by Dr. Kusolwa will be evaluated to determine their effectiveness in identifying lines with high levels of resistance to bruchids. An additional breeding objective is to combine bruchid and virus (BCMV, BCMNV and BGYMV) resistance. Bruchid resistant Andean bean lines with BCMV and BCMNV ( $I + bc - 1^2$ ) resistance have already been developed. Considerable progress has also been made toward the development of black beans that combine bruchid and virus resistance. During FY15, a small group of lines selected in Puerto Rico for bruchid resistance will be tested in Central America and Haiti to evaluate the durability of resistance when exposed to different ecotypes of *Acanthoscelides obtectus* and other genera (*Zabrotes subfasciatus*) of bruchids.

Legume Innovation Lab plant breeders will assist bean research programs in Guatemala and Haiti to develop the capacity to produce populations and test breeding lines that will lead to the release of improved bean cultivars. This should contribute to the long-term sustainability of bean breeding activities in the region.

Dr. Juan Carlos Rosas will coordinate the regional testing of small red and black bean breeding lines. These trials will be conducted in collaboration with national bean research programs and CIAT. Promising lines will be tested throughout Central America and the Caribbean, including countries that are not participating in this Legume Innovation Lab project. Testing lines in different countries provides more information concerning the potential performance of the lines and expands the potential impact of the research supported by the Legume Innovation Lab. In addition to yield trials, field trials will be conducted to screen bean lines for resistance to different diseases such as angular leaf spot and web blight. Testing sites will be chosen that are expected to produce the most reliable results for screening for specific traits.

The Middle American and Andean Diversity panels will be screened in Central America and the Caribbean for specific traits. For example, the Andean Diversity Panel will be screened in Haiti for reaction to powdery mildew and in Honduras for angular leaf spot. Performance of the Middle American Diversity Panel will be evaluated in low N environments in Central America and the Caribbean. The Middle American Diversity Panel will be screened in Puerto Rico for resistance to ashy stem blight.

Although disease resistance is the primary focus of this Legume Innovation Lab project, the performance of bean breeding lines will be evaluated in low fertility soils. Honduras has an ideal site for the evaluation of lines for adaptation to low P soils whereas Puerto Rico has good locations for screening beans for performance in a low N soil and root rot resistance. These sites will be inoculated with efficient *Rhizobium* strains to allow indirect selection for enhanced biological nitrogen fixation. We have screened Andean Diversity Panel for biological nitrogen fixation with *R. tropici* and *R. etli* and selected genotypes efficient for BNF under screenhouse

and field conditions. The project plans to screen the Middle American Diversity Panel to identify lines with superior BNF characteristics.

Specific research activities for objective 1 during FY15:

## Central America

- Develop and test on research stations and farms black and small red bean breeding lines that combine disease and pest resistance with greater tolerance to abiotic stress, including drought and low soil fertility.
- Multiply and maintain breeder and foundation seed stocks of recently-released small red and black bean cultivars.
- Coordinate the regional testing of small red and black bean breeding lines in the lowlands of Central America and Haiti.
- Utilize recurrent selection to develop bean populations for better adaptation to low N soils and greater resistance to web blight.
- Characterize pathogen variability of *Phaeoisariosis griseola* isolates from Guatemala and Honduras.
- Evaluate the ADP for resistance to angular leaf spot in Honduras.
- Test the performance of improved tepary bean lines.
- Test the performance of bruchid resistant lines when exposed to natural infestation.
- Support the development of bean breeding populations in Guatemala with the goal of releasing locally-developed cultivars by the end of the current period of funding.
- Develop a population that will be used to identify a molecular marker for the *Bgp* gene that permits normal pod development in the presence of BGYMV.

### <u>Haiti</u>

- Test on research stations and farms black and Andean bean breeding lines that combine disease and pest resistance with greater tolerance to abiotic stress.
- Test the performance of improved tepary bean lines.
- Study the potential benefit of thicker pod walls in common bean to prevent seed germination during periods of wet weather during the harvest.
- Support the development of bean breeding populations in Haiti with the goal of releasing a locally-produced cultivar by the end of the five-year extension period.
- Strengthen collaboration between the NSS and NGOs in Haiti for on-farm testing of improved bean breeding lines (black, white, yellow and red mottled)
- Screen the Andean Diversity Panel (ADP) in Haiti for resistance to powdery mildew to identify new sources of resistance and to use association mapping to identify molecular markers for resistance.
- Conduct field trials to test the performance of elite lines selected from the second cycle of recurrent selection for enhanced biological nitrogen fixation.
- Conduct field trials to test the performance of elite lines selected from the second cycle of recurrent selection for web blight resistance.
- Test the performance of bruchid resistant lines when exposed to natural infestation.

### Puerto Rico (UPR and USDA/ARS/TARS)

- Develop and test Andean and Middle American bean breeding lines that combine disease and pest resistance with greater tolerance to abiotic stress.
- Screen the Middle American Diversity Panel for resistance to ashy stem blight and performance in low N soils.
- Screen bean lines from recurrent selection for enhanced biological nitrogen fixation for root rot resistance and adaptation to low N soil.
- Coordinate the Andean bean line performance trials for the Caribbean.
- Test the performance of bruchid resistant lines when exposed to natural infestation.

**Objective 2**: Improve agronomic traits and disease resistance of climate resilient tepary bean.

#### **Collaborators:**

Timothy Porch - USDA/ARS/TARS, Mayaguez, PR, USA James Beaver and Consuelo Estevez de Jensen - University of Puerto Rico, Mayaguez, PR, USA Phil McClean- North Dakota State University, Fargo, ND USA Juan Carlos Rosas - Escuela Agrícola Panamericana (Zamorano), Honduras Julio Cesar Villatoro - Instituto de Ciencia y Tecnología Agrícolas (ICTA), Guatemala Emmanuel Prophete - National Seed Service, Ministry of Agriculture, Haiti Kirstin Bett- U. of Saskatchewan, Saskatoon, Canada Mark Brick- Colorado State University, Ft. Collins, Colorado, USA

### Approaches and Methods:

Although tepary bean has high levels of abiotic stress tolerance, it is susceptible to viruses such as BGYMV, BCMV, and BCMNV. In order to expand the potential use of tepary bean in abiotic stress prone regions, a primary focus of this project will be to initiate the introgression of virus resistance from common bean into tepary bean. By project end (FY17) we expect to have tepary breeding lines with improved virus resistance that will be available for pyramiding of virus resistance loci in future efforts.

A tepary breeding program was initiated at USDA-ARS-TARS in 2008. Advanced breeding lines developed from these previous breeding efforts will be increased and shared with the collaborators for testing in Tepary Adaptation Trials (TAT).

New tepary  $F_4$  lines will be generated from crosses between promising large and round seeded genotypes from the CIAT collection and breeding lines selected for disease and abiotic stress tolerance. Using leveraged funds, these materials will be initially tested through a shuttle breeding program with M. Brick at Colorado State University. This effort will focus on seed size/shape, drought and heat tolerance, and CBB and bruchid resistance in PR; and on photoperiod insensitivity, broad adaptation, rust resistance, and yield in Colorado. Superior lines will then be tested in the host countries for potential future release.

In order to speed the breeding progress with tepary and to advance genetic analysis, common bean Indel markers will be tested in tepary to evaluate their potential use. Research in BNF will evaluate *Bradyrhizobium* strains USDA 110, USDA 122, USDA 123, USDA 73, USDA 3 (*B. japonicum*), USDA 94, USDA 3254, USDA 76 (*B. elkanii*), and EAP-1001 (*Bradyrhizobium* sp.) with 20 tepary genotypes from the CIAT germplasm bank.

Efficient strains will be selected for BNF in crosses between lines from the CIAT tepary collection and promising breeding lines. In addition, the inheritance of interespecific (tepary

bean x common bean) populations to establish symbiosis with *Rhizobium* and/or *Bradyrhizobium* using *nod*C, *rec*A y *atp*D genes will be studied.

Additional sources of disease resistance will be evaluated using the CIAT tepary bean collection (about 250 accessions). These accessions will be evaluated for CBB and BCMV.

Breeding and introgression of BGYMV res., I and bc3 into tepary/common bean hybrids.

- Based on previous Pa x Pv crossing efforts, effective Pv and Pa parents (e.g. Pv 'Beniquez' with all 4 virus genes) will be selected for hybridization during FY13-14.
- F<sub>1</sub> Pv x Pa hybrids will be completed during FY14 from crosses between selected parents above at ARS-TARS.
- Embryo rescue will be initiated from the BC<sub>1</sub>F<sub>1</sub> generation material in FY15 through collaboration with the U. of Saskatchewan.

Determine potential use of P. vulgaris Indels for tepary genetic analysis and mapping.

- A small subset representing tepary genetic diversity will be assembled at USDA-ARS-TARS in FY13 and sent to NDSU.
- NDSU will evaluate a subset of the 3,000 Pv indels on the Pa germplasm to evaluate potential use.

Characterize the CIAT tepary bean germplasm collection for BCMV and CBB resistance.

- The CIAT tepary bean germplasm collection (~250 lines) will be evaluated for CBB (FY13), adaptation (FY14) at USDA-ARS-TARS using leveraged ARS-FTF funds.
- The CIAT tepary bean germplasm collection (~250 lines) will be evaluated for response to NL3 at the UPR (FY15) using leveraged ARS-FTF funds.
- The CIAT tepary bean germplasm collection will be evaluated for BGYMV in Honduras
- Multi-location testing of improved tepary bean breeding lines
- Collaborators in Central America and Haiti will initiate testing of breeding lines in Tepary Adaptation Trials (TAT) to test wide adaptation as well as specific adaptation of lines to specific potential growing areas.

Objective 3: Develop and implement robust molecular markers for disease resistance genes

### **Collaborators:**

Phil McClean and Juan Osorno, North Dakota State University, Fargo, ND, USA Karla Ponciano and Julio Cesar Villatoro, ICTA, Guatemala City, Guatemala Phil Miklas, USDA/ARS, Prosser, WA, USA

# Approaches and Methods:

This project will leverage the results from the USDA Common Bean Agricultural Project and the USDA/DOE/JGI common bean sequencing project. The BeanCAP project developed a suite of ~3000 indel markers distributed across all common bean chromosomes. These markers are codominant and designed to be functional with a single experimental condition (PCR protocol). The power of these markers is that they are simple to implement and thus completely portable in all laboratories and are amenable to multiplexing with suites of markers. Multiplexing reduces

the cost of genotyping an individual line. The release of the common bean whole genome assembled sequence allows for precise localization of each of these markers. The final key element that facilitates this project is the development, over the last fifteen years, of markers that are linked, from 0-5 cM, to important target disease genes. While useful, there has been some difficulty in the portability of these markers from one laboratory to another. They all have unique experimental conditions that preclude multiplexing, and 5% recombination reduces effectiveness due to recombination between marker and target gene.

Dr. Phil McClean and Dr. Miklas will coordinate phenotyping, marker development, and the use of markers to facilitate the breeding of disease resistance beans. Molecular markers for critical gene or gene clusters will be improved and employed in breeding multiple disease resistant bean lines. Major genes for resistance to ALS, anthracnose, BCMV, BGMV, common blight, halo blight, rust and other diseases od economic importance to breeders will be targeted for marker-assisted selection in small and large-seeded market classes, and for specific production regions. Dr. Miklas' research will integrate McClean's genomic work with the needs of Legume Innovation Lab bean breeders. The critical *I* gene for BCMV, the *Ur-11* gene for rust, *Phg-1* gene for angular leaf spot, the *Co-4*<sup>2</sup> for anthracnose, and the new Xa11.4 QTL for CBB resistance will be targeted for more reliable and efficient marker-assisted selection.

### Identify genetic materials for marker evaluation

Potential targets for improved marker development include:

- Improved markers for bean rust resistance genes (Ur-4, Ur-5, Ur-11).
- Populations will be developed for subsequent development of improved markers for BGYMV resistance genes and QTL (*Bgp*, SW12, and *bgm*).
- Investigate efficacy of currently available markers for bruchid resistance genes.
- Establish background information for marker development for ashy stem blight resistance by conducting association mapping analysis.
- Evaluate the genetics of web blight resistance through association mapping analysis.
- The ADP will be evaluated in Haiti for reaction to powdery mildew.
- Resistance genes will be surveyed in the *P. vulgaris* genome.

For each of these targets, we will adopt the same procedure. First, we will search the published literature and communicate personally with breeders, geneticists, and pathologists in both Legume innovation Lab projects to identify genetic materials with contrasting phenotypes (resistance, susceptibility) for the specific disease. These could be genetic populations or a collection of lines with known phenotype that can then be used for the identification of closely linked indel markers.

# Development of Indel markers

- DNA will be isolated from genetic populations or collections of lines with known phenotypes.
- The physical locations of target genes or markers will be identified using sequence information and the common bean genome sequence. If the sequence information is poor or unavailable, the specific marker will be cloned and sequenced.
- <u>Indel marker selection</u>: Once the location of the marker is determined, it will then be compared to the indel database to discover 30 indel markers that straddle the physical

location of the marker. Those indel markers will be used in PCR amplification to determine which one acts as a definitive marker that is unambiguous in its predictive power. If several markers have equal predictive power, then the one that will best work as a multiplexing marker will be selected. Legume Innovation Lab bean breeding programs in Guatemala, Honduras, Ecuador and Uganda have the facilities and technical expertise needed to immediately adopt the use of indels for marker-assisted selection.

**Objective 4**: Institutional capacity building

# **Collaborators:**

James Beaver and Consuelo Estevez de Jensen - University of Puerto Rico, Mayaguez, PR, USA Timothy Porch - USDA/ARS/TARS, Mayaguez, PR, USA Phil Miklas - USDA/ARS, Prosser, WA, USA Juan Osorno and Phil McClean – North Dakota State University (NDSU), Fargo, ND, USA Juan Carlos Rosas – Escuela Agrícola Panamericana (Zamorano), Honduras Julio Cesar Villatoro - Instituto de Ciencia y Tecnología Agrícolas (ICTA), Guatemala Emmanuel Prophete– National Seed Service, Ministry of Agriculture, Haiti

# Approaches and Methods:

Formal and informal training activities will be conducted to enhance the capacity of host country bean research programs to develop and release superior-performing bean cultivars that will increase production or reduce losses in the target countries. At the end of this project, these bean research programs should have the capacity to utilize the newly-developed suite of indel markers for marker-assisted selection. The Ph.D. and M.S. degree students will be provided a broad range of training in conventional and molecular plant breeding techniques so that they can assume roles of leadership in bean research programs in the target countries. Informal training of technicians should improve the reliability and quality of bean research conducted in host countries.

# Informal training

- In-service training will be provided at NDSU for two Legume Innovation Laboratory scientists to review recent advances in sequencing the bean genome and the utilization of SNP arrays to develop indel markers for traits of economic importance.
- A workshop will be held in Honduras in December 2014 to train technical personnel concerning bean research techniques with the goal of improving the quality of field research. Topics will include the development and management of field trials, breeding and selection methods, field evaluation techniques, the use of molecular markers, research with *Rhizobium*, participatory plant breeding and agro-ecological techniques.
- A significant amount of information concerning bean research techniques is already available on the BIC web site <u>http://bic.css.msu.edu/ResearchTechniques.cfm</u>. This Legume Innovation Lab project will collaborate with the BIC in developing modules for the BIC web site that will describe research techniques for additional traits such as bruchid resistance.

# Formal training

- Undergraduate students at Zamorano will be provided opportunities to participate in bean research activities related to Legume Innovation Lab project objectives.
- Ph.D. degree training at NDSU of two bean researchers from Central America or the Caribbean. Both students will be trained in the use of conventional and molecular techniques.

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

- Seed production of improved bean varieties developed with support from the Legume Innovation Lab can provide an indirect estimate of the number of hectares planted in target countries (performance indicator 4.5.2 (2).
- Ph.D., M.S. and B.S. degree training in the U.S. and Host Countries will contribute to performance indicator 4.5.2(6).
- In-service training and workshops will contribute to performance indicator 4.5.2(7).
- The development of indel markers can be documented as a Phase I performance indicator 4.5.2(39).
- Performance of breeding lines in regional trials and other field trials can be recorded as a Phase II performance indicator 4.5.2(39).
- Release of improved bean cultivars can be recorded as a Phase III performance indicator 4.5.2(39).

# **IV. Outputs:**

- Release and dissemination in the lowlands of Central America and the Caribbean of black and small red bean cultivars with BGYMV & BCMV resistance and greater tolerance to low soil fertility.
- Release and dissemination in the lowlands of Central America and the Caribbean black, white and red mottled bean breeding lines with resistance to bruchids, BGYMV, BCMV and BCMNV.
- Release and dissemination of lowland black and white bean breeding lines with resistance to BGYMV, BCMV, BCMNV, web blight and rust.
- Testing and possible release in Haiti of yellow and red mottled bean lines with resistance to BGYMV, BCMNV and BCMV.
- New bioinformatic-based approach to enabling marker development.
- Indel markers for traits of economic importance that will facilitate the selection of bean lines with the desired combination of traits.
- Technical personnel in Central America and the Caribbean with greater capacity to conduct field trials and to produce reliable and repeatable results.
- Graduate degree training of students from Central America, the Caribbean and Eastern Africa.

# V. Engagement of USAID Field Mission(s)

Host country scientists will be responsible of informing local USAID Missions about progress of the Legume Innovation Laboratory project toward research and training objectives. Opportunities will be sought to obtain USAID Mission support to expand activities in host countries. Local USAID Missions will be contacted when U.S. scientists visit host countries.

# VI. Partnering and Networking Activities:

Dr. Phil Miklas serves as the President of the Bean Improvement Cooperative. Many Grain Legume Innovation Lab scientists publish research achievements in the Annual Report and make presentations or present posters at the biennial meeting.

Several Legume Innovation Laboratory scientists participate in Regional Hatch Project W-2150 which is a multi-disciplinary network of U.S. bean researchers.

Researchers in Central America and the Caribbean often make scientific presentations at the annual meeting of the PCCMCA. The meeting provides an opportunity for the Central American/Caribbean research network which includes national programs, CIAT and the Legume Innovation Laboratory scientists to meet to exchange results from research and plan activities for the upcoming year

Dr. Miklas and Dr. Porch receive USDA-ARS FTF funds which complement Legume Innovation Laboratory research and training activities. Dr. Miklas, Dr. Porch, Dr. Rosas, Dr. Beebe and Dr. Beaver participate in the Penn State University FTF project led by Dr. Jonathan Lynch dealing with abiotic stress. Legume Innovation Lab project personnel will strive to coordinate activities so that regional field trials and travel plans complement the goals of both projects.

#### VII. Leveraging of Legume Innovation Laboratory Resources:

Project scientists will continue close collaboration with other Legume Innovation Laboratory and FTF projects focused on genetic improvement of beans. Promising breeding lines are frequently exchanged among U.S. and Host Country scientists. For example, we recently provided collaborators in Ecuador with a source of bruchid resistance. The exchange of breeding lines developed by the Legume Innovation Lab can also benefit U.S. bean breeding programs. Interspecific lines originally developed for web blight resistance were found to have the high levels of resistance to white mold (McCoy et al. 2012. BIC 55:153-154).

Dr. Porch has received funds from the USDA which are being used to support a graduate student from Nicaragua (Ana Vargas). He is coordinating collaboration between the USDA/ARS and Legume Innovation Lab in the evaluation of the Andean Bean Diversity Panel for powdery mildew and root rot resistance, low fertility response, and biological nitrogen fixation efficiency.

The McKnight Foundation supports work in Tanzania on the development of bruchid resistance in farmer-preferred varieties and the integration of botanical and physical methods to control bruchids. Bean lines developed from this project will be useful to the Legume Innovation Lab project for bean improvement in collaborating countries. Marker-assisted selection will be used to develop bean lines with bruchid resistant genes.

Dr. Rosas continues to collaborate with Dr. Lynch in the selection of bean lines having root traits that should improve performance in low P soils. Several scientists in this Legume Innovation Lab project will participate in a USAID-funded project led by Dr. Jonathan Lynch that seeks to use marker-assisted selection to develop bean lines with greater tolerance to drought and heat.

Legume Innovation Lab breeders and pathologists (Kelly, Steadman, Urrea, Osorno, Beaver, Estevez and Porch) have an opportunity to meet at least once a year in Puerto Rico. This facilitates communication between the Legume Innovation Lab bean breeding projects.

The Bean Technology Dissemination associate award led by Michigan State University allowed the Pulse CRSP and Legume Innovation Lab projects to produce and distribute seed of

improved black and small red bean cultivars and *Rhizobium* inoculants to thousands of farmers in Central America and the Caribbean.

### VIII. Timeline for Achievement of Milestones of Technical Progress:

Please refer to the document describing milestones

#### Training/Capacity Building Workplan for FY 2015

#### Long-term training:

First and Other Given Names: Giovanni Lorenzo Last Name: Vazquez Citizenship: U.S. Gender: M Training Institution: University of Puerto Rico Supervising CRSP PI: James Beaver Degree Program for training: M.S. Program Areas or Discipline: Plant breeding 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: TBD Start Date: Aug. 2014 Projected Completion Date: Aug. 2016 Training status (Active, completed, pending, discontinued or delayed): Active Type of CRSP Support (full, partial or indirect) for training activity: Partial First and Other Given Names: Angela Nadeshda Nicte Last Name: Miranda Mijangos Citizenship: Guatemala Gender: F Training Institution: University of Puerto Rico Supervising CRSP PI: James Beaver and Tim Porch Degree Program for training: M.S. 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: To be defined Start Date: Aug. 2014 Projected Completion Date: Aug. 2016 Training status (Active, completed, pending, discontinued or delayed): Pending Type of CRSP Support (full, partial or indirect) for training activity: Full

First and Other Given Names: M.J. Last Name: Cunguan Cundar Citizenship: Ecuador Gender: F Training Institution: Zamorano Supervising CRSP PI: Juan Carlos Rosas Degree Program for training: B.S. Program Areas or Discipline: Agronomy 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: Molecular analysis of the genetic diversity of common bean landraces from Honduras and El Salvador. Start Date: Jan. 2014 Projected Completion Date: Dec. 2014.. Training status (Active, completed, pending, discontinued or delayed): Active Type of CRSP Support (full, partial or indirect) for training activity: Partial First and Other Given Names: C. Last Name: Lopez Ramos Citizenship: Ecuador Gender: F Training Institution: Zamorano Supervising CRSP PI: Juan Carlos Rosas Degree Program for training: B.S. Program Areas or Discipline: Agronomy 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: Molecular analysis of the genetic diversity of common bean landraces from Honduras and El Salvador. Start Date: Jan. 2014 Projected Completion Date: Dec. 2014 Training status (Active, completed, pending, discontinued or delayed): Active Type of CRSP Support (full, partial or indirect) for training activity: Partial First and Other Given Names: L.A. Last Name: Avilés López Citizenship: El Salvador Gender: F Training Institution: Zamorano Supervising CRSP PI: Juan Carlos Rosas Degree Program for training: B.S. Program Areas or Discipline: Agronomy 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: Applications of the bc3 gen marker in selection for resistance to BCNMV. Start Date: Jan. 2014 Projected Completion Date: Dec. 2014.. Training status (Active, completed, pending, discontinued or delayed): Active Type of CRSP Support (full, partial or indirect) for training activity: Partial First and Other Given Names: S.D. Last Name: Escobar Flores Citizenship: El Salvador Gender: F Training Institution: Zamorano Supervising CRSP PI: Juan Carlos Rosas Degree Program for training: B.S. Program Areas or Discipline: Agronomy

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: Applications of the bc3 gen marker in selection for resistance to BCNMV. Start Date: Jan. 2014 Projected Completion Date: Dec. 2014.. Training status (Active, completed, pending, discontinued or delayed): Active Type of CRSP Support (full, partial or indirect) for training activity: Partial First and Other Given Names: M.D. Last Name: Govzueta Altamirano Citizenship: Bolivia Gender: M Training Institution: Zamorano Supervising CRSP PI: Juan Carlos Rosas Degree Program for training: B.S. Program Areas or Discipline: Agronomy 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: Selection of small red bean lines with multiple resistance to BCMV, **BCNMV and BGYMV** Start Date: Jan. 2014 Projected Completion Date: Dec. 2014.. Training status (Active, completed, pending, discontinued or delayed): Active Type of CRSP Support (full, partial or indirect) for training activity: Partial First and Other Given Names: S.D. Last Name: Chicas Marguez Citizenship: El Salvador Gender: F Training Institution: Zamorano Supervising CRSP PI: Juan Carlos Rosas Degree Program for training: B.S. Program Areas or Discipline: Agronomy 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: Selection of small red bean lines with multiple resistance to BCMV, BCNMV and BGYMV. Start Date: Jan. 2014 Projected Completion Date: Dec. 2014.. Training status (Active, completed, pending, discontinued or delayed): Active Type of CRSP Support (full, partial or indirect) for training activity: Partial First and Other Given Names: E.D. Last Name: Gutierrez Benitez Citizenship: Honduras Gender: M

Training Institution: Zamorano

Supervising CRSP PI: Juan Carlos Rosas

Degree Program for training: B.S.

Program Areas or Discipline: Agronomy

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: Selection of disease resistant bean lines with better adaptation to climate change and greater mineral content. Start Date: Jan. 2014 Projected Completion Date: Dec. 2014. Training status (Active, completed, pending, discontinued or delayed): Active Type of CRSP Support (full, partial or indirect) for training activity: Partial First and Other Given Names: M.G. Last Name: Cruz Cerrato Citizenship: Honduras Gender: F Training Institution: Zamorano Supervising CRSP PI: Juan Carlos Rosas Degree Program for training: B.S. Program Areas or Discipline: Agronomy 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: Characterization of bean differentials lines inoculated with Rhizobium species. Start Date: Jan. 2014 Projected Completion Date: Dec. 2014. Training status (Active, completed, pending, discontinued or delayed): Active Type of CRSP Support (full, partial or indirect) for training activity: Partial First and Other Given Names: To be determined (TBD) Last Name: TBD Citizenship: TBD Gender: TBD Training Institution: North Dakota State University Supervising CRSP PI: Phil McClean and Juan Osorno Degree Program for training: Ph.D. Program Areas or Discipline: Plant breeding and genetics If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? - Yes Host Country Institution to Benefit from Training: TBD Thesis Title/Research Area: TBD Start Date: TBD Projected Completion Date: TBD Training status (Active, completed, pending, discontinued or delayed): Pending Type of CRSP Support (full, partial or indirect) for training activity: Full First and Other Given Names: To be determined (TBD) Last Name: TBD Citizenship: TBD Gender: TBD Training Institution: North Dakota State University Supervising CRSP PI: Juan Osorno and Phil McClean Degree Program for training: Ph.D.

Program Areas or Discipline: Plant breeding and genetics

If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? - Yes Host Country Institution to Benefit from Training: TBD Thesis Title/Research Area: TBD Start Date: TBD Projected Completion Date: TBD Training status (Active, completed, pending, discontinued or delayed): Pending Type of CRSP Support (full, partial or indirect) for training activity: Full

# Short-term Training:

Type of training: In-service training

Description of training activity: In-service training will be provided at NDSU for Legume Innovation Lab scientists to review recent advances in sequencing the bean genome and the utilization of a SNP arrays to develop indel markers for traits of economic importance. Location: NDSU

Duration: Two weeks

When will it occur? - 2015

Participants/Beneficiaries of Training Activity: 2

Anticipated numbers of Beneficiaries (male and female): 1M, 1F

PI/Collaborator responsible for this training activity: Phil McClean

List other funding sources that will be sought (if any): None

Training justification: This training is needed to permit host country scientists to take advantage of the recent advances in the development and use of molecular markers for bean breeding programs.

Type of training: Workshops

Description of training activity: A workshop will be held in Honduras to train technical personnel concerning bean research techniques with the goal of improving the quality of field research. Topics will include the conduct of field trials, breeding and selection methods, field evaluation techniques, research with *Rhizobium*, participatory plant breeding and agro-ecological techniques.

Location: Honduras

Duration: One week

When will it occur? - December 2014

Participants/Beneficiaries of Training Activity: Technicians working for bean research programs in Central America and Haiti.

Anticipated numbers of Beneficiaries (male and female): 30

PI/Collaborator responsible for this training activity: Juan Carlos Rosas and Consuelo Estevez List other funding sources that will be sought (if any): None

Training justification: Trainees will improve their skills in conducting field and laboratory research. This should improve the quality and reliability of research conducted in host countries.

### Equipment (costing >\$5,000):

None during FY-14