PII-UPR-1 WORKPLAN
Development, Testing and Dissemination of Genetically Improved Bean Cultivars for Central America, the Caribbean and Angola

Lead U.S. Principle Investigator
James Beaver, UPR, U.S.

Collaborating Scientists
Juan Carlos Rosas, EAP, Honduras
Timothy Porch, USDA-ARS, U.S.
António Chicapa Dovala, IIA, Angola
Emmanuel Prophete, CRDA, Haiti
Consuelo Estevez de Jensen, UPR, U.S.

Project Problem Statement and Justification
Common bean (*Phaseolus vulgaris* L.) is an important source of protein for low income families in Central America, the Caribbean and Angola. Increased or more stable bean yield can improve the diet and provide a reliable source of income for small-scale farm families in these countries. An increased supply of beans should also benefit urban consumers of beans.

The development of improved bean varieties has proven to be an effective strategy to address biotic and abiotic factors that limit bean production in Central America and the Caribbean. During the past 10 years, however, only a limited number of black bean cultivars have been released in Latin America and the Caribbean. This is the result of a lower level of investment in black bean breeding and less emphasis in Central America on the testing and on-farm evaluation of advanced black bean breeding lines by national programs. As a consequence, black bean cultivars tend to have lower seed yield potential and less disease resistance than the most recently released small red bean cultivars. The most promising small red bean cultivars developed at Zamorano can be readily used to improve black beans. In fact, the lowland bean breeding project of the Bean/Cowpea CRSP initiated the development of black bean breeding lines and a sizeable number of breeding lines have already been distributed to bean research network members in Guatemala and Haiti. The bean research network supported by the Bean/Cowpea CRSP was a key element in the success of the cultivar development program in Central America. The Dry Grain Pulse CRSP project will emphasize field-testing of black bean breeding lines in Central American and Caribbean countries. The project will also complete the evaluation, release and dissemination of Andean (red mottled and light red kidney) bean lines that have resistance to BGYM, BCNM and rust.

The research project is in the position to make significant impacts in Central America, the Caribbean, and Angola. Many small red and black bean breeding lines with enhanced disease resistance and tolerance to abiotic stress are already in an advanced stage of development. There is an established network of bean researchers in Central America with a proven capability of testing, releasing and disseminating improved bean cultivars. The Dry Grain Pulse CRSP project will complement ongoing collaborative bean research in Central America. In addition, the project includes partners from Haiti that will extend the potential impact of the collaborative research. The project will provide formal and informal training to Instituto de Investigacão Agronómica (IIA) researchers based on the critical experiences and successes in Central America and the Caribbean. The project also
plans to improve Instituto de Investigación Agronómica facilities and develop populations and bean breeding lines that will permit the Legume Program to develop improved bean cultivars for Angola.

Improved bean breeding lines developed by the Dry Grain Pulse CRSP bean breeding program in Central America and the Caribbean may be useful in some bean production regions of Africa, given the similarity in agro ecological zones and production constraints. Results from the exchange of breeding lines during Phase I of the project identified a few red mottled beans from the Caribbean that were well adapted to Rwanda. Some small red bean cultivars and breeding lines developed in Central America have resistance to diseases (BCNM, rust, angular leaf spot, and anthracnose) and tolerance to abiotic stresses (low soil fertility, drought and high temperature) that are important constraints to bean production in Africa. Although black beans are estimated to account for < 5% of bean production in Africa, this seed type is often a component of mixtures grown in low fertility soils. The lowland bean breeding team has developed Andean (red mottled and light red kidney) bean breeding lines with resistance to BCNMV (bc3) and rust (Ur-11) that may be useful in Southern Africa.

**Planned Project Activities**

**Objective 1:** Development, release and dissemination of improved bean cultivars for Central America, the Caribbean and Angola.

**Collaborators**

James Beaver, University of Puerto Rico  
Timothy Porch, USDA-ARS Tropical Agriculture Research Station, Mayaguez  
Consuelo Estevez de Jensen, University of Puerto Rico  
Juan Carlos Rosas, Escuela Agrícola Panamericana-Zamorano (EAP), Honduras  
Emmanuel Prophete, National Seed Program, Ministry of Agriculture, Haiti  
António Chicapa Dovala and António Francisco Castame, Instituto de Investigación Agronómica (IIA), Angola

**Approaches and Methods:** Plant breeders will focus on the combination of disease (BGYMV, BCMNV, rust, common bacterial blight, anthracnose, Ascochyta blight and angular leaf spot) resistance with enhanced resistance to pests (bruchid, leafhopper) and greater tolerance to abiotic stress (drought, low soil fertility, high temperature). Elite bean breeding lines with multiple disease resistance have already been crossed with sources of resistance to pests or tolerance to abiotic stress. Bean lines will be screened for the selected traits each generation in environments that are most likely to provide the desired abiotic or biotic stress. This can be most easily achieved through collaboration among Dry Grain Pulse CRSP scientists and the regional bean research network in Central America and the Caribbean. Regional performance trials for black, small red, red mottled and light red kidney bean lines will be conducted in collaboration with national bean research programs in Latin America and the Caribbean.

Basic seed stocks of bean varieties developed and released by the project will be multiplied and small lots of seed will be distributed to farmers in Latin America and the Caribbean for testing in on-farm trials. Performance of the varieties in the on-farm trials also provides bean breeders with valuable feedback concerning the direction of their
research. The project will also produce basic seed stocks of the most promising bean breeding lines and make seed available to the national bean research programs and NGO’s involved in the multiplication and dissemination of improved seed.

The project will strengthen collaborative research with the Legume Program of the Instituto de Investigacãao Agronómica (IIA) in Angola. Bean breeding lines from Central America, the Caribbean and the U.S. that have performed well in preliminary trials conducted in Angola have been used as parents in crosses with Angolan bean landrace varieties. The focus of the research in Angola will be development and evaluation of bean breeding lines. Project personnel will visit Angola twice each year to meet with Antonio Chicapa Dovala, António Francisco Castame, and other members of the IIA Legume Program. The goal is to develop the capacity to develop, select, release, multiply and disseminate seed of at least one improved bean cultivar before the end of the current period of funding.

**Objective 2:** Selection of beans for adaptation to low N soils.

**Collaborators**
James Beaver, University of Puerto Rico
Consuelo Estevez de Jensen, University of Puerto Rico
Timothy Porch, USDA-ARS Tropical Agriculture Research Station, Mayaguez
Juan Carlos Rosas, Escuela Agrícola Panamericana-Zamorano (EAP), Honduras
Emmanuel Prophete, National Seed Program, Ministry of Agriculture, Haiti
António Chicapa Dovala and António Francisco Castame, Instituto de Investigacãao Agronómica (IIA), Angola

**Approaches and Methods:** Inadequate soil nitrogen is a frequent yield constraint for common beans in the Tropics. The use of nitrogen fertilizers increase production costs and, in some intensive bean production systems, can contribute to groundwater contamination. Researchers have pointed out the need to develop integrated soil nutrient management practices for beans that would combine biological nitrogen fixation with limited use of fertilizers, sustainable crop management practices, and the development of crop varieties better adapted to low fertility soils. Bean varieties with greater efficiency in the utilization of nitrogen should have enhanced biological nitrogen fixation capacity, root traits such as greater root hair density that contribute to tolerance to low soil P, and healthy root systems that can take advantage of available soil nitrogen and other nutrients.

Recurrent selection (RS) has proven to be useful in the selection of quantitatively inherited traits such as web blight resistance and tolerance to low soil P. We propose to conduct an additional cycle of recurrent selection to develop Mesoamerican and Andean breeding lines with greater adaptation to low soil N. Preliminary screening conducted in Honduras and Puerto Rico has identified disease resistant bean breeding lines that can be used to form the base population for the next cycle of recurrent selection. A few elite small red bean breeding lines from Zamorano were found to have good biological nitrogen fixation when evaluated in field trials in Minnesota. The root rot resistant black bean line PR0443-151 and the small red line PR0340-3-3-1 from Puerto Rico and CIAT bean breeding lines A 774 and VAX 3 have performed well in a low N soil field site in...
Puerto Rico. During the past five years, the Zamorano bean breeding program and Dr. Jonathan Lynch have collaborated in the development of small red and black bean breeding lines with greater tolerance to low P soils and drought. Some of these lines also have better yield under low N soils due to increased nodulation by resident rhizobia. Zamorano has experience conducting strain selection and inoculation studies, maintains a collection of bean rhizobia and has the expertise needed to conduct the multifaceted research related to biological nitrogen fixation. Black bean lines \( (F_5) \) developed at the University of Puerto Rico with enhanced levels of root rot resistance and adaptation to low N soils will be evaluated in replicated yield trials and will be screened using molecular markers for disease resistance and traits associated with tolerance to low P soils. The most promising breeding lines from each cycle of recurrent selection will be included as entries in regional performance trials in Central America and the Caribbean. Less progress has been made in the selection of Andean bean lines for adaptation to low N soils. The performance of Andean bean landrace varieties from Haiti and the Dominican Republic will be evaluated in a low N soil in Puerto Rico to attempt to identify germplasm with greater tolerance to this edaphic constraint. During the two-year extension period, the project plans to develop the capacity to produce inoculum in Haiti and Angola.

**Objective 3:** Develop and test molecular markers for disease and pest resistance.

**Collaborators**

James Beaver, University of Puerto Rico  
Timothy Porch, USDA-ARS Tropical Agriculture Research Station, Mayaguez  
Juan Carlos Rosas, Escuela Agrícola Panamericana-Zamorano (EAP), Honduras

**Approaches and Methods:** Marker-assisted selection has proven to be a very useful tool for bean breeders. Unfortunately, molecular markers are not available for some important genes and the use of other molecular markers is often limited to either the Andean or Middle American gene pools. The development of new molecular markers for valuable traits or markers with greater versatility would benefit the entire bean research community.

Resistance to charcoal rot caused by *Macrophomina phaseolina* has been reported to be associated with drought tolerance and it has been recommended that breeding for terminal drought tolerance should include breeding for resistance to charcoal rot. The charcoal rot resistance in the breeding line BAT 477 was found to be controlled by the dominant complementary genes \( Mp-1 \) and \( Mp-2 \). A RIL population derived from the cross ‘DOR 364 x BAT 477’ was acquired from CIAT and evaluated at the Isabela Substation during two growing seasons for reaction to charcoal rot. Lines resistant and susceptible to charcoal rot were selected. These lines will be used to identify putative markers for resistance to this disease using AFLP markers and bulk segregant analysis. Greenhouse screening techniques using inoculation with *Macrophomina* at germination and inoculation of stems with *Macrophomina* infested toothpicks are being optimized.

Project personnel (Porch and Beaver) will collaborate with Dr. Mildred Zapata (UPR) in the evaluation of a bean population that may lead to the identification of genes and new molecular markers for resistance to common bacterial blight. The project also plans to
evaluate the effectiveness of molecular markers identified by Mbogo and Myers to identify bean lines with resistance to bruchids.

Although marker-assisted selection is routinely used by some breeding programs, it is currently used by only a few programs in Latin America and the Caribbean. The molecular marker lab at Zamorano will assist other bean research programs in the region in the use of this new technology by providing informal training and assistance in screening elite bean breeding lines and in the application of any new molecular markers developed by this project.

Ongoing research projects in the U.S. to sequence the common bean genome and plans to develop a genetic map based on SNPs may provide powerful tools to identify new molecular markers for traits of economic importance. Project personnel will keep abreast of research progress and seek opportunities to apply this new technology.

**Objective 4:** Evaluation of other dry pulse crops for Central America and the Caribbean.

**Collaborators**
James Beaver, University of Puerto Rico
Juan Carlos Rosas, Escuela Agrícola Panamericana-Zamorano (EAP), Honduras
Emmanuel Prophete, National Seed Program, Ministry of Agriculture, Haiti
António Chicapa Dovala and António Francisco Castame, Instituto de Investigación Agronómica (IIA), Angola

**Approaches and Methods:** The Lima bean (*Phaseolus lunatus* L.) is a heat and drought tolerant dry grain pulse crop that is produced and consumed throughout the Caribbean. Most landrace varieties are indeterminate, short day plants that produce pods during the dry season when there is often a scarcity of common beans. Because Lima beans grow well in fence rows or on walls, the crop is well suited for urban agriculture. Lima bean landraces have been cultivated in the Caribbean during the past 500 years and may have acquired unique traits of economic value. At present, the USDA and CIAT bean germplasm collections contain very few accessions from the region. The germplasm collections currently have 2 accessions from Haiti, ≤3 accessions from Puerto Rico and no accessions from the Dominican Republic. We plan to collect and characterize the agronomic traits of at least 20 Lima bean landrace varieties from Puerto Rico and Haiti. Passport data will be collected so that the germplasm can be included in the CIAT and USDA germplasm collections. Seed of superior Lima bean accessions will be increased for further evaluation and possible release in the country of origin.

Cowpea [*Vigna unguiculata* (L.) Walp] is produced on a limited scale in Central America and the Caribbean. During the two-year extension period, the project plans to test in the region cowpea breeding lines from the University of California, Riverside. Zamorano will conduct preliminary evaluations of cowpea lines and will provide seed of the best adapted lines to institutions and organizations in Central America and Haiti interested in this crop. Potential areas of adoption of new cowpea lines are the semi-arid regions in northern Nicaragua and southern Honduras where the crop is used as an alternative to common beans during the 'postrera' season. We also plan to collaborate with the
University of California, Riverside Dry Grain Pulse CRSP project in the evaluation cowpea landrace varieties from Angola as part of the M.S. degree research of Antonio David.

The project will provide collaborators in Haiti with seed of pigeonpea \([Cajanus cajan (L.) Millsp.]\) breeding lines that have been selected in Puerto Rico for resistance to the pigeonpea pod fly \([Melanagromyza obtusa]\).

**Objective 5: Capacity Building**
Increase the capacity, effectiveness and sustainability of agriculture research institutions that serve the bean and cowpea sectors in Central America, Haiti and Angola.

**Collaborators**
James Beaver, University of Puerto Rico
Timothy Porch, USDA-ARS Tropical Agriculture Research Station, Mayaguez
Juan Carlos Rosas, Escuela Agrícola Panamericana-Zamorano (EAP), Honduras
Emmanuel Prophete, National Seed Program, Ministry of Agriculture, Haiti
António Chicapa Dovala and António Francisco Castame, IIA, Angola
Jeff Ehlers, University of California, Riverside, California
Phillip Roberts, University of California, Riverside, California

**Degree Training:**

*Trainee # 1*
First and Other Given Names: Monica
Last Name: Mmbui-Martins
Citizenship: Angolan
Gender: Female
Degree Program for Training: Masters
Program Areas or Discipline: Plant Breeding and Genetics
Host Country Institution to Benefit from Training: Angola
University to provide training: University of Puerto Rico
If enrolled at a US university, will Trainee be a “Participant Trainee” as defined by USAID? – No
Supervising CRSP PI: Tim Porch or James Beaver
Start Date: August 2009
Projected Completion Date: January 2012
Type of CRSP Support (full, partial or indirect): Partial
If providing Indirect Support, identify source(s) of leveraged funds
Amount Budgeted in Workplan, if providing full or partial support:
  Direct cost: $40,000 (two years)
  Indirect cost: None
U.S. or HC Institution to receive CRSP funding for training activity: The University of Puerto Rico

*Trainee # 2*
First and Other Given Names: Antonio
Last Name: Ndengoloka-David
Citizenship: Angolan
Gender: Male
Degree Program for Training: Masters
Program Areas or Discipline: Plant Breeding and Genetics
Host Country Institution to Benefit from Training: Angola
University to provide training: University of Puerto Rico
If enrolled at a US university, will Trainee be a “Participant Trainee” as defined by USAID? – No
Supervising CRSP PI: Tim Porch or James Beaver
Start Date: August 2009
Projected Completion Date: January 2012
Type of CRSP Support (full, partial or indirect): Partial
If providing Indirect Support, identify source(s) of leveraged funds
Amount Budgeted in Workplan, if providing full or partial support:
  Direct cost: $40,000 (two years)
  Indirect cost: None
U.S. or HC Institution to receive CRSP funding for training activity: The University of Puerto Rico

Trainee # 3
First and Other Given Names: TBD
Last Name: TBD
Citizenship: TBD
Gender: Female
Degree Program for training: B.S.
Program Areas or Discipline: Plant Science
Host Country Institution to Benefit from Training: TBD
University to provide training: Zamorano
If enrolled at a US university, will Trainee be a “Participant Trainee” as defined by USAID? - No
Supervising CRSP PI: Juan Carlos Rosas
Start Date: January 2010
Projected Completion Date: December 2010
Type of CRSP Support (full, partial or indirect): Partial
If providing Indirect Support, identify source(s) of leveraged funds
Family support
Amount Budgeted in Workplan, if providing full or partial support:
  Direct cost: $ 4,000.00
  Indirect cost: 0
U.S. or HC Institution to receive CRSP funding for training activity: Zamorano

Short-term Training:

Training activity # 1
Type of training: Informal training for seed production and storage on small farms
  Emmanuel Prophete, Gasner Demosthene
Location: Haiti
Duration: One week
Scheduling of training activity: Winter months 2010-2011
Participants/Beneficiaries of Training Activity: Bean producers in Haiti
Anticipated numbers of Beneficiaries (male and female): 30 people
Amount Budgeted in Workplan
  Direct cost: $1,500
  Indirect cost: 0
If leveraged funding is to be used to Support this Training Activity, indicate the Source and Amount:
  None

Training activity # 2
Type of training: Informal training for the production, storage and use of Rhizobium inoculum
  Consuelo Estevez de Jensen, Antonio Chicapa, Antonio Castame
Location: Angola
Duration: One week
Scheduling of training activity: November 2010
Participants/Beneficiaries of Training Activity: IIA Grain Legume Program
Anticipated numbers of Beneficiaries (male and female): 20 people
Amount Budgeted in Workplan
  Direct cost: $1,500
  Indirect cost: 0
If leveraged funding is to be used to Support this Training Activity, indicate the Source and Amount:
  None
**Contribution of Project to Target USAID Performance Indicators**

All of the host countries participating in this Dry Grain Pulse CRSP project are USAID-eligible countries. Increased or more stable bean yields contribute to economic growth and improve the lives of the families who produce the crop. A more reliable supply of staple crops such as beans fosters stability in the Latin American and Caribbean region. With the advent of CAFTA, increased opportunities exist to link bean markets within the region and to export beans to niche markets in the U.S. Because Central America is one of the Centers of Domestication of the common bean, collaboration with bean research programs in LAC provides U.S. bean breeding programs with greater access to bean germplasm with traits of potential economic value. Disease pressure is often more severe in LAC, which permits the development of bean lines having greater levels of disease resistance. Bean research in Central America and the Caribbean helps to identify emerging bean diseases and permits researchers to respond more rapidly and effectively when new diseases threaten bean production in the U.S. All of the abovementioned activities support U.S. foreign policy in Latin America and the Caribbean (http://www.usaid.gov/locations/latin_america_caribbean/issues/trade_issue.html).

The development of bean cultivars for Angola with enhanced levels of resistance to biotic and abiotic constraints contributes directly to the Presidential Initiative to End Hunger in Africa (IEHA) (http://www.usaid.gov/locations/sub-saharan_africa/initiatives/ieha.html). The proposed research provides the innovations needed to reduce vulnerabilities and risks of bean producers in Angola. The proposed Dry Grain Pulse CRSP project will establish collaborative research and training activities among U.S., LAC and Angolan bean research institutions that are in accord with the IEHA science and technology strategy.

This project addresses two of the four global themes of the Dry Grain Pulse CRSP. The development and release of bean cultivars with enhanced disease resistance and greater tolerance to abiotic stress should reduce production costs and risks for bean producers in Central America, the Caribbean and Angola. Lines with resistance to bean diseases, such as rust, should also be useful germplasm for U.S. bean breeding programs. Disease and pest resistance are key components in effective crop management systems. Bean breeding lines developed by the project will be screened for tolerance to drought and low soil fertility. Bruchid resistance should improve the quality of bean seed.

Participatory plant breeding methods and multiplication of basic stocks on underutilized research stations should result in more sustainable seed production and distribution systems. The project will use informal training to strengthen the capacity of the bean research programs in Central America, the Caribbean and Angola.

**Target Outputs**

The most important output of the proposed Dry Grain Pulse CRSP project is the release and dissemination of bean cultivars having enhanced levels of resistance to disease, pests and abiotic stress. The research team has a proven record of success. At present, more than 100,000 farmers in Central America plant small red bean cultivars developed by the Bean/Cowpea CRSP project. We propose to use a similar approach to develop, release and disseminate improved black bean varieties. Because promising black and red mottled bean lines are already in an advanced stage of development, it is likely that the project
will demonstrate significant impact in Central America and the Caribbean during the next 24 months of funding from the Dry Grain Pulse CRSP through the dissemination and release of improved bean breeding lines. We expect to test and release at least two improved black bean cultivars in Central America. In Haiti, we expect to test and release at least two black and one red mottled cultivar. In El Salvador, Honduras and Nicaragua, we expect to release at least two new small red cultivars in collaboration with CIAT and national bean programs. In Puerto Rico, we expect to release pink and white bean cultivars. At the end of the two year extension period, sufficient seed stocks of these cultivars will be produced to initiate on-farm testing of these cultivars throughout Central America and the Caribbean.

Research achievements in Angola are expected to be more modest. The project has identified potential sources of resistance to the principal biotic and abiotic constraints and has initiated the development of bean breeding populations. The project plans to continue to conduct informal training that will strengthen bean research capabilities in Angola. At the end of the two-year extension period, bean research personnel in Angola should have sufficient experience and skills to develop, test and release improved bean lines. The M.S. degree training of Monica Mmbui and Antonio David at the University of Puerto Rico includes training in plant breeding, plant pathology, and molecular methods. Upon their return to Angola, Ms. Mmbui and Mr. David should be able to strengthen the capacity of IIA to conduct common bean and cowpea research.

The development and release of bean germplasm better adapted to low N soils will be of potential benefit throughout the Tropics where inputs such as fertilizer are beyond the means of many small-scale bean producers. Bean producers in the U.S. would also benefit from bean cultivars that have a lower requirement for N fertilizer. At the end of the two-year extension period at least one bean germplasm line with greater adaptation to low N soils is expected to be released.

Molecular markers have become an important tool for bean breeders in developed countries. There is a need, however, to continue to develop molecular markers for genes of economic importance, particularly for traits that are needed for the improvement of beans for the Tropics. During the two-year extension period, the project would focus on the development of molecular markers for the putative dominant genes for resistance to charcoal rot. These molecular markers will improve the efficiency and effectiveness of selection for resistance to this disease and should contribute to the development of breeding lines having greater levels of resistance to terminal drought. A manuscript describing the protocol to use the molecular markers will be prepared for the Annual Report of the Bean Improvement Cooperative.

At least 20 Lima bean landraces will be collected from Puerto Rico and Haiti. Morphological, phenological and agronomic traits of the landraces will be collected at the Isabela Substation. Arrangements will be made to include the Lima bean landraces in the USDA and CIAT germplasm collections. Landraces with superior performance will be considered for release in Haiti and/or Puerto Rico.
Project personnel will collaborate with the Dry Grain Pulse CRSP cowpea breeding project in the evaluation of cowpea breeding lines in Haiti and Central America. A cowpea breeding line with superior performance will be considered for release as a cultivar.

**Engagement of USAID Field Mission(s)**
U.S. and Host Country Principal Investigators will maintain USAID Missions in Central America, Haiti and Angola informed of progress in achieving research and training objectives. Project personnel will meet with USAID Mission representatives during visits to the Host Countries to identify additional research and training activities that might lead to buy-ins.

**Networking Activities with Stakeholders**
Collaborative research has been a key element in the success of the small red bean breeding activities in Central America. The Dry Grain Pulse CRSP project will build upon these achievements by placing greater emphasis on the improvement of black bean lines. This collaboration will enhance the impact of the Dry Grain Pulse CRSP project research in Guatemala and Haiti where the black bean is the preferred seed type. Mr. Emmanuel Prophete and the recent Bean/Cowpea CRSP trainee from Haiti, Gasner Demosthenes, speak Spanish, which facilitates communication with other bean researchers in Central America and the Caribbean. The proposed Dry Grain Pulse CRSP project will collaborate with the bean research network in Central America and the Caribbean in the evaluation of bean lines and the multiplication of basic seed stocks of recently released cultivars. Dr. Rosas will coordinate regional performance trials for black and small red beans in Central America and the Caribbean. At least 20% of the funds assigned to the Escuela Agrícola Panamericana will be used to support activities of national bean research programs in Central America. James Beaver will coordinate the evaluation of red mottled and light red kidney bean regional performance trials in the Caribbean and will provide seed of these seed types to collaborators in Ecuador and Africa. Dr. Tim Porch will collaborate with Mr. Antonio Chicapa Dovala in the evaluation of bean lines in Angola. Ing. Emmanuel Prophete will be responsible for the evaluation and on-farm testing of black, white and red mottled bean lines in Haiti. The project will also collaborate with NGO’s and participatory plant breeding programs in Central America and the Caribbean to promote the dissemination and adoption of bean cultivars. As project personnel learn more about the bean subsector and ongoing research and extension activities in Angola, opportunities for greater collaboration will be pursued. For example, additional informal training activities with Agostinho Neto University in Huambo, Angola could be developed. Dr. Porch has communicated with CIAT bean scientists and Dr. Rowland Chirwa to identify opportunities for collaboration with the SABRN bean research network. He has also communicated with Mr. Kennedy Mmbui of the ZARI bean research program to determine if Dry Grains Pulse CRSP activities in Angola can benefit bean research in Zambia.
Leveraging of CRSP Resources
The Dry Grain Pulse CRSP has access to mature bean breeding projects at the Escuela Agrícola Panamericana in Honduras and the University of Puerto Rico. Both breeding programs have alternative sources of funding that will indirectly benefit the research goals of the project. Promising bean breeding lines are already in an advanced stage of development that will enable the project to achieve significant impact in a short period. Ing. Emmanuel Prophete is the leader of the Ministry of Agriculture seed program in Haiti that will provide resources for the multiplication and distribution of bean cultivars developed by the proposed Dry Grain Pulse CRSP project. The EAP is an active participant in the Central American bean research network supported by IICA/COSUDE that provides a limited amount of resources for activities that complement proposed research and training activities. Dr. Rosas is a leader of a participatory plant breeding program supported by the Norwegian Development Fund that funds bean research in Central America. Dr. Beaver and Dr. Porch are PIs for Regional Hatch Project W-1150 that shares many research objectives with the Dry Grain Pulse CRSP. Project personnel will continue to attempt to obtain additional support for research and training activities from USAID Missions. The project will also seek opportunities for support or collaboration with NGO’s and private companies.
**TMAC EVALUATIONS AND RECOMMENDATIONS**  
**PLUS PI RESPONSES**

**Phase II Project:** PII-UPR-1, *Development, Testing and Dissemination of Genetically Improved Bean Cultivars for Central America, the Caribbean and Angola*

**Lead US PI:** James Beaver, University of Puerto Rico

**A. Comments Regarding the FY11 Workplan**

a. The TMAC views this as an important project for the Pulse CRSP, with the potential to have substantial impact, especially through the new Associate Award for Haiti and Central America.

b. The TMAC view was that this project was doing very well to meet the research, testing and dissemination objectives.

c. The TMAC believes, however, that the overall BNF effort of the Pulse CRSP could be strengthened by better integration of research and capacity building activities among the PII-UPR-1, PIII-ISU-2 and PII-PSU-1 projects.

d. The TMAC approved this workplan dependent upon satisfactory responses to the recommendations listed below.

**B. TMAC Recommendations and PI Responses**

1. The TMAC views the genetic improvement and BNF research in the CRSP project to be extremely important and that all projects working in this area should show integration. Thus, it requests the PIs to show how the BNF work in the PII-UPR-1 project is complementary to and coordinated with research and training activities in the PIII-ISU-2 (Iowa State University) and the PII-PSU-1 (Penn State University) projects. For example, the TMAC suggests that consideration be given to testing the Becker-Underwood Stacked inoculants being used in the PIII-ISU-2 project in Puerto Rico and perhaps Honduras. Also, the low N site in Puerto Rico might be considered as an ideal site for the testing of parental bean lines being assessed for BNF ability in the PIII-ISU-2 project. Other areas of integration of BNF activities should be considered to obtain greater impact in the future. Another suggestion was that the Dor364xBAT477 population might be a better population for the ISU-2 to work with than the ones that being proposed in the PIII-ISU-2 workplan.

**Response:**

There are numerous examples of cooperation among dry Grain Pulse CRSP projects in BNF research. Consuelo Esteves recently offered short term training in BNF research techniques to Jim Heilig, a PhD student from MSU under the supervision of Jim Kelly, and Ana Vargas, a technician working for the bean program at Zamorano. Juan Carlos Rosas breeds black and small red beans for both disease resistance and tolerance to abiotic stress that does a great job of utilizing germplasm and knowledge developed by the PII-PSU-1 and the PII-UPR-1 projects. Jim Beaver plans to attend the ASA-CSSA-SSSA meeting in November 2010 so there will be an opportunity to meet with Jonathan Lynch and Mark Westgate to discuss increased collaboration and coordination of BNF-related activities.
The evaluation of Rhizobia strains is fundamental for BNF research. The PII-UPR-1 project recently obtained eleven *Rhizobium tropici*, *R. etli* and *R. leguminosarum* strains from the University of Minnesota rhizobia collection (Dr. Michael Sadowsky). These strains will be used for testing with *Phaseolus* germplasm under controlled conditions. This research activity will include 15 *Phaseolus vulgaris* elite materials (selected by the different projects) to determine the best Rhizobia x *Phaseolus* interaction. Parallel to this research, strains CIAT 899, CIAT 632 and UMR 1597 will be tested in Puerto Rico, Honduras and Michigan with elite *Phaseolus* cultivars to determine the best strain for further use in inoculant production. The integration of BNF research and genetic improvement will depend on the results of the above studies and collaboration with the PIII-ISU-2 (Iowa State University) and the PII-PSU-1 (Penn State University) projects through the exchange of elite materials, rhizobia strains, and information.

We would prefer to work with the Becker Underwood inoculants after there they have been proven to perform well in the Tropics. I’m sending a report prepared by Consuelo Estevez containing preliminary results from field trials conducted in Puerto Rico that describe mixed results with the ‘Nodulator’ inoculant. Juan Carlos Rosas and Consuelo Estevez are using strains of *Rhizobium* that have been tested and proven to be effective by CIAT and Dr. Graham. Have the intellectual property right issues concerning the Becker Underwood strains been resolved?

The TMAC recommended that the ISU project should consider working with the ‘DOR 364 x BAT 477’ RIL population. Has BAT 477 been identified to have superior BNF capacity or does it have root rot resistance and better acquisition of N? We have seed of the RIL population but the lines should be grown in the greenhouse to make sure the seed is not infected with Macrophomina.

There is an urgent need to identify additional germplasm with enhanced BNF capacity. This is especially true for Andean germplasm. The project would be pleased to screen lines at the Isabela Substation or at Zamorano but we would need additional resources to evaluate a large number of lines. The breeding lines should be inoculated with representative strains of each of the three *Rhizobium* species that are known to nodulate common beans more effectively, in order to identify potential bean line x *Rhizobium* interactions. Since there is so much soil variability in the Tropics, it might be worthwhile to conduct an initial screening in the lab (with growth pouches). Zamorano has experience utilizing this technique.

In order to increase adoption of BNF technology in the target countries, this technology should be transferred to national programs and there should be facilities for local production and/or distribution of high quality inoculants. Training and technical assistance should be provided by leading institutions in each country. These institutions should have well-trained technical personnel and adequate lab and inoculant production facilities.
Biological nitrogen fixation is a complex problem. The Dry Grain Pulses CRSP should be prepared to provide support for at least five years to achieve significant impact. Communication is important, but research teams should have an opportunity to utilize different approaches to promote the fixation and acquisition of N. The following are a few approaches that could be utilized:

a. We should promote the use of crop rotations to reduce the incidence and severity of root rots. Healthier roots are better able to absorb N and other nutrients. We collaborate with the PII-MSU-1 project (with George Abawi and Jim Kelly) on selection for root rot resistant beans. These selections are made under low-fertility/root rot conditions at the USDA-ARS Tropical Agriculture Research Station.

b. In more humid regions, such as eastern Nicaragua or northern Guatemala, legumes such as velvet beans could be included in the crop rotation as green manure. Colleagues from Nicaragua, however, mentioned that the presence of venomous snakes may limit the use of green manures.

c. In more arid environments (e.g. Haiti) legumes such as pigeonpeas or cowpeas could be included in crop rotations. Both pigeonpeas and cowpeas fix more N than beans.

d. In the relay intercropping in Central America, we could possibly combine earlier maturity maize with a later maturity bean variety that would have greater seed yield potential and BNF capacity.

e. Since early maturity is such an important trait for bean varieties in Central America and Haiti (to avoid drought stress during the second growing season), we should select beans with more efficient acquisition and partitioning of N, in addition to BNF capacity. We have already identified a number of efficient lines of different seed classes that can be tested for improved BNF. These efficient materials could be crossed to selected land races from each country that has been screened for BNF capacity, as well as with the best BNF lines that are identified through extensive screening. We could thus cross the good by good materials. Bliss (1993) recommended modified pedigree or IBL selection methods, and selection on target soils. It would also be worthwhile to utilize recurrent selection, since so many genes need to be combined for the different traits under selection.

f. Many plant pathogens have strains that are more virulent to either Andean or Middle American germplasm. Is there evidence of co-evolution between *Rhizobium* strains and beans in different gene pools? Should different gene pools be inoculated with different strains of *Rhizobium*?

The PII-UPR-1 project plans to screen at Zamorano during FY11, a diverse group of genotypes from the Andean and Mesoamerican gene pools with strains of each of the three *Rhizobium* species (*R. etli, R. tropici and R. leguminosarum*) known to nodulate common bean plants, to develop a set of differential genotypes (Andean and Mesoamerican) that would help to identify the proper inoculant strain/species in different regions. This approach is based on the concepts used for the identification of
pathogen races of bean diseases using differentials. There are some references dealing with the co-evolution of bean/rhizobium [Rosas et al., 1998, Plant and Soil: 1-7; Kype-Nolt et al., 1992, New Phytol. 120:484-494; Meschini et al., 2008, Plant and Microbe Interact. 21(4):459-68] but this is an area that needs more research.

g. We recommend that the Dry Grain Pulse CRSP projects collaborate in the development of a document that could be posted on the Bean Improvement Cooperative web site which would provide an overview of research techniques for breeding for enhanced biological nitrogen fixation. The document should also describe how *Rhizobium* inoculum can be prepared, stored and utilized. The document should include techniques that can be used in developing countries.

2. Was Michael Peters at CIAT contacted about cowpea options for Central America?

Response:  
The UPR project was asked by the TMAC to contact Dr. Michael Peters at CIAT. He appears to be the leader of the Tropical Forages Program. Does he have expertise working with cowpeas?

3. A workshop is listed for Angola. Is this workshop still being planned and for when?

Response:  
One workshop will be held (in Spanish) at Zamorano for bean researchers from Central America and the Caribbean. The other workshop will be held (in Portuguese) at Huambo for bean researchers from Angola and Mozambique. If additional funds are available, it might be more useful to conduct a third workshop in Eastern Africa in English. The workshops at Zamorano and in Angola will be held during 2011.

4. Please revisit the target performance indicators for FY 11 for beneficiaries and hectares impacted to confirm that the estimates are accurate and achievable.

Response:  
We plan to review and revise the target performance indicators. The testing of improved bean breeding lines on farms in Angola has not progressed as fast as we had originally planned.

5. A workshop on BNF was approved by the TMAC for Honduras with funding from the “Institutional Capacity Building” line. The TMAC recommended to the MO that additional funds be made available to support the participation of U.S. and Host Country scientists from PIII-ISU-2. The organizers are also encouraged to extend the workshop for an additional day so that PIs from the various Pulse CRSP projects might coordinate their research and training activities relative to BNF.

Response:  
The workshop in Central America will be conducted in Spanish and the workshop in Angola will be conducted in Portuguese. We recommend that the additional funds be used to sponsor a workshop in Eastern Africa in English. Dr. Rosas and Dr. Estevez could help organize this workshop.
The workshops are a promising first step. We recommend the inclusion of M.S. degree training for each region in order to have a technical specialist in each area, able to manage the production of inoculants.

6. Total direct cost budgeted for US and HC institutions in FY11 are incorrect, and it has now been corrected.

**Directive to the Management Office:** USAID is making substantial investments to improve productivity in the area of BNF and adaptation to low fertility soils. To maximize the return on investment, it is imperative that three Pulse CRSP projects work together; PSU-1, ISU-2 and UPR-1.

- Action from MO: Individual calls from MO will be made to the PIs of these three projects to discuss this issue.
- If appropriate, MO will arrange a conference call to follow up on the individual discussions.
- A Workshop on BNF was approved for Honduras with funding from “Institutional Capacity Building.” Additional funds were recommended by the TMAC to ensure that scientists from PIII-ISU-2 and its collaborators including from Uganda are able to attend. The TMAC encourages the Pulse CRSP scientists working on BNF to extend their stay at the workshop to coordinate activities among the projects.
- Workplans for FY2011 for these three projects will be shared with the lead PIs.
**Project Title:** Development, Testing and Dissemination of Genetically Improved Bean Cultivars for Central America, the Caribbean and Southern Africa.

**Lead U.S. PI and University:** James S. Beaver, University of Puerto Rico

**Host Country(s):** Angola

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<th>2011 Target</th>
<th>2011 Actual</th>
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<td>Number of women organizations receiving technical assistance</td>
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<td>Number of HC partner organizations/institutions benefiting</td>
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<tr>
<td>Number of additional hectares under improved technologies or management practices</td>
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### Dry Grain Pulses CRSP : FY11

Development, testing and dissemination of genetically improved bean cultivars for Central America, the Caribbean and Angola.

<table>
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<th>HC or U.S. Institution (2)</th>
<th>HC or U.S. Institution (3)</th>
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<tr>
<td></td>
<td>UPR</td>
<td>USDA-ARS</td>
<td>EAP</td>
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<td>Angola</td>
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<tr>
<td><strong>j. Total Indirect Cost</strong></td>
<td>$7,125.00</td>
<td>$4,075.00</td>
<td>$8,500.00</td>
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**Cost Share**

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**Attribution to IEHA Objectives**

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**Attribution to Capacity Building (Theme "D")**

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**Name of PI & Institutional Affiliation:** James S. Beaver, Dept. of Agron. and Soils, Univ. of Puerto Rico, Mayaguez, PR 00681-9039
Dry Grain Pulses CRSP

Report on the Achievement of “Semi-Annual Indicators of Progress”
(For the Period: October 1, 2010 – April 1, 2011)

This form should be completed by the U.S. Lead PI and submitted to the MO by April 1, 2011

**Project Title:** Development, Testing and Dissemination of Genetically Improved Bean

<table>
<thead>
<tr>
<th>Benchmark Indicators by Objectives</th>
<th>UPR</th>
<th>USDA</th>
<th>EAP</th>
<th>IAP</th>
<th>IIA</th>
<th>Haiti</th>
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</thead>
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<tr>
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<td>Achieved</td>
<td>Target</td>
<td>Achieved</td>
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<td>4/1/11</td>
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<tr>
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<tr>
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<tr>
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<tr>
<td>Cultivar released</td>
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</table>

| Objective 2: Selection of beans for adaptation to low N soils. | | | | | | | | | | | | | | |
| Complete field and greenhouse evaluations to identify most promising sources of BNF germplasm | | | | | | | | | | | | | | X |
| Complete crosses for the first cycle of recurrent selection for enhanced BNF | X | | | | | | | | | | | | |
| Harvest F2 seed for the first cycle of recurrent selection | X | | | | | | | | | | | | |

| Objective 3: Develop molecular markers for disease resistance genes. | | | | | | | | | | | | | | |
| Sources of ashy stem blight resistance acquired | | | | | | | | | | | | | | X |

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Dry Grain Pulses CRSP

Report on the Achievement of “Semi-Annual Indicators of Progress”
(For the Period: April 1, 2011 – September 30, 2011)

This form should be completed by the U.S. Lead PI and submitted to the MO by October 1, 2011

**Project Title:** Development, Testing and Dissemination of Genetically Improved Bean

<table>
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<th>IAP</th>
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<tr>
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<tr>
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<tr>
<td>Cultivar released</td>
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</table>

| Objective 2: Selection of beans for adaptation to low N soils. | | | | | | | | | | | | | | |
| Complete field and greenhouse evaluations to identify most promising sources of BNF germplasm | | | | | | | | | | | | | | X |
| Complete crosses for the first cycle of recurrent selection for enhanced BNF | X | | | | | | | | | | | | |
| Harvest F2 seed for the first cycle of recurrent selection | X | | | | | | | | | | | | |

| Objective 3: Develop molecular markers for disease resistance genes. | | | | | | | | | | | | | | |
| Sources of ashy stem blight resistance acquired | | | | | | | | | | | | | | X |

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## Dry Grain Pulses CRSP FY 2011 Workplans

### Existing RAPD markers tested

<table>
<thead>
<tr>
<th>Objective 4: Evaluation of other pulse crops for Central America and the Caribbean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete collection of <em>P. lunatus</em></td>
</tr>
<tr>
<td>Complete first year of field testing of cowpeas in PR, Haiti, and Central America</td>
</tr>
<tr>
<td>Characterize the phenological, morphological, and agronomic traits of <em>P. lunatus</em> (Haiti, PR)</td>
</tr>
</tbody>
</table>

### M.S. training of Monica Mmbui

- M.S. training of Monica Mmbui
- Workshop in Angola concerning the production, storage and distribution of Rhizobium inoculum

### Name of the PI reporting on benchmarks by institution

| James Beaver | Tim Perch | Juan Carlos Rosas | Antonio Chicapa | Emmanuel Prophete |

### Name of the U.S. Lead PI submitting this Report to the MO

**Signature**  
**Date**

*Please provide an explanation for not achieving the benchmark indicators on a separate sheet.*