Development, Testing and Dissemination of Genetically Improved Bean Cultivars for Central America, the Caribbean and Angola

Principle Investigators
James Beaver, University of Puerto Rico, Puerto Rico

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

Abstract of Research Achievements and Impacts
Significant progress was made toward research and training objectives. Breeding lines were multiplied and tested in Angola, Haiti and Central America (CA). Small red and black bean regional performance trials were distributed to collaborators in CA and Haiti. Web blight and drought performance trials were distributed to collaborators. Andean bean breeding lines were sent to Rwanda for evaluation. The PASEBAF validation trial in Honduras included drought, low fertility tolerant lines developed with support from the Bean/Cowpea CRSP and Red SICTA. The Agrosalud trial included small red lines with greater mineral content (iron and zinc) that were developed in collaboration with CIAT and INTA/Nicaragua. At least one promising line currently under validation may be released during FY10 in Haiti and the CA countries that are currently participating in the project. The small red bean cultivars “CENTA Nahuat” and “CENTA CPC” were released in El Salvador. Both cultivars were developed with support from the Bean/Cowpea CRSP. Validation trials were conducted with support from the Dry Grain Pulse CRSP. Certified seed of small red cultivars developed by the project was produced and distributed by governmental bean seed and fertilizer dissemination programs in El Salvador, Honduras and Nicaragua. These seed programs have benefited more than 200,000 farmers in CA. A significant amount (12 MT) of seed of the black bean cultivars ‘Aifi Wuriti’ and ‘Arroyo Loro Negro’ were multiplied in Haiti during the past year. This seed was used to establish demonstration plots in the fields of 300 cooperating farmers, in the Vallée de Jacmel area in southeastern Haiti in cooperation with the NGO ACDIVOCA. The multiple disease resistant light red kidney bean cultivar ‘Badillo’ was developed and jointly released by the University of Puerto Rico and the USDA-ARS Tropical Agriculture Research Station. Bean lines with greater nodulation scores, root, shoot and total dry matter accumulation under low N conditions were identified in greenhouse trials conducted at Zamorano. In Puerto Rico, F3 lines derived from crosses between sources of tolerance to low N soils and sources of disease resistance were evaluated at two sites near Isabela, Puerto Rico. Recombinant inbred lines were selected for resistance and susceptibility to ashy stem blight in a replicated field trial that was inoculated with the pathogen. Phenotypic data will be used to identify molecular markers for resistance genes. Seed of landrace varieties of Lima beans were collected and evaluated in Puerto Rico and Honduras. A Haitian graduate completed requirements for a M.S. degree at the University of Puerto Rico. Two students from Angola initiated studies at the University of Puerto Rico for M.S. degrees in plant breeding. Workshops describing bean research techniques were conducted in Angola and Honduras.

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 the urban consumer of beans.
Planned Project Activities for April 1, 2008 - September 30, 2009

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

**Approaches and Methods:** Plant breeders will focus on the combination of disease (BGYMV, BCMNV, rust, common bacterial blight, anthracnose 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 initiate collaborative research with Mr. Antonio Chicapa Dovala, Head of the Legume Program of the Instituto de Investigacão Agronómica in Angola. Promising bean breeding lines from Central America, the Caribbean and the U.S., primarily of medium-sized market classes, will be provided to the Angolan bean research program for evaluation for local adaptation and consumer acceptance.

**Results, Achievements and Outputs of Research:**

*Development of breeding populations*

Several different (> 50) small red, black and Andean bean breeding populations were developed and evaluated during the past year. The overall goal is to combine resistance to diseases with drought and low fertility tolerance already available in improved cultivars and breeding lines. This should lead to the release of improved small red, black and Andean bean cultivars with enhanced adaptation and greater consumer acceptance. Parents used in the crosses included promising breeding lines, improved cultivars and landraces, and sources of disease resistance and tolerance to abiotic factors from the bean breeding programs of the UPR, the USDA-ARS, Zamorano and CIAT. Some of these populations were developed for greater adaptation to the highlands of Honduras, Guatemala and Haiti, while others for the lowlands of all Central American countries and Haiti. During past year, F₁ populations were developed and F₂ plants were evaluated and selected for highly heritable traits. Breeding lines from these populations will be tested in Honduras and Puerto Rico during the 2009 ‘postrera’ growing season. Crosses were made in Honduras to improve small red landraces carrying the “Rojo de Seda” bean seed type for Central America and black bean cultivars for Guatemala and Haiti. A group of populations derived from crosses including local landrace cultivars were developed for testing and selection using participatory plant breeding (PPB) approaches in collaboration with farmers groups and researchers from El Salvador, Honduras and Nicaragua. Early generation populations have been developed at the University of Puerto Rico from crosses among sources of disease (BGYMV, BCMNV, common blight, rust and web blight), pest (leafhopper and bruchid) resistance and tolerance to low N soils. During the past year, individual plants were selected in F₂ and F₃ generations based on agronomic characteristics and seed type (black, red mottled and yellow). Lines will be screened in later generations for disease and pest resistance and
tolerance to low N soils. During the past year, seed of seven bean landraces were collected in Angola. These will be used as recurrent parents in backcrosses to incorporate genes for resistance to BCMV, BCMNV, anthracnose, rust and ALS.

Evaluation of breeding populations
More than 3,000 breeding lines developed with funding from the Bean/Cowpea and the Dry Grain Pulse CRSPs were tested and advanced in Honduras during the past year. Field evaluation included the following breeding materials: advanced lines with high nutritional value (high iron x elite small reds and black bean lines), lines from triple and double crosses of drought and angular leaf spot (ALS) resistant lines, lines from populations of the second cycle of recurrent selection for drought tolerance, lines from different populations (landrace x improved lines or cultivars) for PPB activities in Honduras, El Salvador, Nicaragua and Costa Rica, web blight resistant lines from the second cycle of recurrent selection, lines with resistance to ALS (Andean x Mesoamerican sources), lines resistant to rust (improved cultivar or line x multiple genes rust source), lines from several populations of improved cultivar x landrace, improved cultivar x ALS, improved cultivar x drought and high iron x ALS for El Salvador, Honduras and Nicaragua, inbred backcross lines (drought x improved cultivar), and several hundred lines developed by S. Beebe at CIAT (drought, BGYMV, high iron/zinc and seed quality).

Regional performance trials
During the past year, Zamorano distributed 12 small red and small black adaptation nurseries (VIDAC) and 24 yield and adaptation trials (ECAR) to five Central American countries and to Haiti. The majority of the advanced lines included in these regional nurseries were developed by Zamorano and UPR, and in collaborations with CIAT and national bean research (NBR) programs. Zamorano has been responsible since 1996 for the development and distribution of these nurseries and trials to members of the regional Bean Research Network.

Fourteen advanced lines trials including 76 web blight resistant lines and four checks (ERMUS), were distributed for regional testing to collaborators in Central America, Puerto Rico and Haiti. The entries in this trial included breeding lines from the cross ‘Tio Canela 75 x VAX 6’, lines from the second cycle of recurrent selection program, and breeding lines derived from an interspecific hybridization between a resistant accession of *P. coccineus* and *P. vulgaris*. Some of the lines also have resistance to common bacterial blight and BGYMV. The most promising lines will be considered for release as cultivars or breeding lines.

Seed for regional performance trials were prepared at the University of Puerto Rico and sent to Haiti, Angola and Rwanda. Entries in the trials included the differentials for rust, angular leaf spot and anthracnose and improved bean breeding lines from Michigan State University, the University of Puerto Rico, USDA-ARS Tropical Agriculture Research Station, Zamorano and INIAP. The information from these trials will be valuable to identify the most important biotic and abiotic constraints and to select bean lines that can serve as valuable parents in a breeding program for Angola. Preliminary results from trials planted in Huambo, Angola in October 2008 identified red mottled and small red bean breeding lines that were well adapted and expressed good yield potential and resistance to disease (Tables 1 and 2).
Table 1. Performance of red mottled lines planted in Huambo, Angola in October 2008.

<table>
<thead>
<tr>
<th>Name</th>
<th>Traits</th>
<th>Vigor$^1$</th>
<th>Disease score at 45 days$^2$</th>
<th>Disease score at 60 days$^2$</th>
<th>Seed yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR0723-12</td>
<td>bgm,bc3</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>1777</td>
</tr>
<tr>
<td>PR7947-232</td>
<td>bgm,l</td>
<td>2.0</td>
<td>3.5</td>
<td>3.0</td>
<td>2237</td>
</tr>
<tr>
<td>PR0637-116</td>
<td>bgm,bc3</td>
<td>4.5</td>
<td>3.5</td>
<td>4.0</td>
<td>1546</td>
</tr>
<tr>
<td>PR0633-4</td>
<td>bc3</td>
<td>3.5</td>
<td>5.5</td>
<td>5.0</td>
<td>2237</td>
</tr>
<tr>
<td>PR0637-38</td>
<td>bgm,bc3</td>
<td>5.5</td>
<td>4.0</td>
<td>4.5</td>
<td>1777</td>
</tr>
<tr>
<td>PR0737-5</td>
<td>bgm,bc3</td>
<td>5.5</td>
<td>2.5</td>
<td>2.5</td>
<td>1579</td>
</tr>
<tr>
<td>PR0737-6</td>
<td>bgm,bc3</td>
<td>6.0</td>
<td>3.5</td>
<td>3.5</td>
<td>1711</td>
</tr>
<tr>
<td>Salagnac 90A</td>
<td>Low soil fert.</td>
<td>3.0</td>
<td>5.0</td>
<td>6.0</td>
<td>1777</td>
</tr>
<tr>
<td>PC-50</td>
<td></td>
<td>5.5</td>
<td>5.5</td>
<td>8.0</td>
<td>395</td>
</tr>
<tr>
<td>JB-178</td>
<td></td>
<td>2.5</td>
<td>3.0</td>
<td>3.5</td>
<td>1448</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>4.5</td>
<td>4.3</td>
<td>5.1</td>
<td>1284</td>
</tr>
</tbody>
</table>

$^1$ Based on a scale from 1-9 where 1 = excellent and 9 = very poor.

$^2$ Based on a scale from 1-9 where 1 = no symptoms and 9 = very severe symptoms.

Table 2. Performance of small red lines planted in Huambo, Angola in Oct. 2008.

<table>
<thead>
<tr>
<th>Nome</th>
<th>Traits</th>
<th>Vigor$^1$</th>
<th>Disease score at 45 days$^2$</th>
<th>Disease score at 60 days$^2$</th>
<th>Seed yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tio Canela 75</td>
<td>BGYMV, BCMV, adaptation</td>
<td>4.0</td>
<td>2.5</td>
<td>2.5</td>
<td>2764</td>
</tr>
<tr>
<td>DEORHO</td>
<td>BGYMV, BCMV, yield</td>
<td>4.0</td>
<td>2.5</td>
<td>3.5</td>
<td>2698</td>
</tr>
<tr>
<td>Cardenal</td>
<td>BGYMV, BCMV,</td>
<td>3.5</td>
<td>2.5</td>
<td>2.5</td>
<td>2698</td>
</tr>
<tr>
<td>IBC 301-204</td>
<td>BGYMV, BCMV, low fertility, drought</td>
<td>5.0</td>
<td>3.0</td>
<td>3.5</td>
<td>3619</td>
</tr>
<tr>
<td>IBC 302-29</td>
<td>BGYMV, BCMV,</td>
<td>4.5</td>
<td>2.5</td>
<td>3.0</td>
<td>2500</td>
</tr>
<tr>
<td>Carrizalito</td>
<td>BGYMV, BCMV, highlands</td>
<td>4.0</td>
<td>4.0</td>
<td>2.5</td>
<td>1777</td>
</tr>
<tr>
<td>CENTA Pipil</td>
<td>BGYMV, BCMV, heat tol.</td>
<td>5.0</td>
<td>3.0</td>
<td>3.0</td>
<td>2106</td>
</tr>
<tr>
<td>Amadeus 77</td>
<td>BGYMV, BCMV, adaptation</td>
<td>4.0</td>
<td>3.5</td>
<td>2.5</td>
<td>1908</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>4.8</td>
<td>3.3</td>
<td>3.6</td>
<td>2020</td>
</tr>
</tbody>
</table>

On-farm validation of promising breeding lines

Two on-farm validation trials are being conducted in Nicaragua and Honduras in collaboration with the National Bean Research programs, Local Agricultural Research Committees (CIAL), NGOs and other extension organizations. The PASEBAF validation trial includes drought, low fertility tolerant lines developed with support from the Bean/Cowpea CRSP and the Red SICTA. The Agrosalud (COVAMIN) trial includes small red lines with greater mineral content (iron and zinc) developed in collaboration with CIAT and INTA/Nicaragua. It is expected that during FY10, at least one line from each trial will be
released as a cultivar in Honduras and Nicaragua. The PASEBAF trial was supported by IICA/COSUDE. The Agrosalud trial will continue to be supported by CIAT/CIDA for an additional year. The same trials have been distributed for on-farm validation in El Salvador and Costa Rica.

Ten of the most promising small red bean cultivars and lines for Central America, developed under the Bean/Cowpea CRSP, were sent to our HC collaborator in Guatemala (J.C. Villatoro), for testing in the most important lowland regions for bean production, such as Petén and Jutiapa. Small red bean production for export has increased in this region and cultivars with higher yield potential and greater disease resistance are needed in Guatemala.

The performance of small red lines were validated in Honduras, Nicaragua and El Salvador by farmer groups involved in PPB activities. In Honduras, the cultivars ‘La Majada AF’, ‘Briyo AM’ and ‘Milagrito’ were released by CIALs of the Yojoa Lake region. These locally released cultivars are mainly adopted by farmers groups from the participating communities. However, some of these PPB cultivars have been adopted in other regions, mainly when an adequate seed production and distribution mechanism is implemented by the farmer groups. A total of 11 PPB cultivars have been released in Honduras since 2003; these cultivars are being used as the main cultivar for at least 5,000 farmers resulting on increases in production, food security and income generation for these families and their communities.

During FY08, a set of 15 small red lines of the ‘Rojo de Seda’ market class was provided to the agricultural division of the Lafise Bank for field and consumer validation trials in Nicaragua. The bank has expressed interest on producing certified seed of at least one of the selected lines. The seed production company Agrovessa from Guatemala was involved in exporting seed of ‘ICTA Ligero’ to Haiti to address a FAO seed distribution request in that country after initial contact our project made with Abelardo Viana from the IICA office in Guatemala. Agrovessa is interested in producing seed of the bean variety ‘Aifi Wuriti’ for export to Haiti. The seed company Semillas del Trópico from Guatemala is testing advanced bean breeding lines and cultivars from the project, and is interested in producing and exporting seed of small red and black bean cultivars in the near future. The contacts in these two seed companies are Zamorano graduates. These companies would be good partners in producing seed for small farmers for government or private initiatives to be implemented in Guatemala, after the recent drought-related famine in some regions of this country. We plan to involve these companies in the Dry Grain Pulse CRSP seed production project recently approved for Guatemala and Haiti.

**Release of cultivars and seed multiplication**

The small red bean cultivars “CENTA Nahuat” and “CENTA CPC” were released in El Salvador on August 2008. Both cultivars were developed with support from the Bean/Cowpea CRSP Project, but a portion of the seed increase, validation trials and release process were conducted with support from the Dry Grain Pulse CRSP. Seed multiplication of these new varieties is being supported by the project in order to increase availability of the seed and enhance adoption by farmers. Foundation seed of these two cultivars has been provided to our collaborators from CENTA.

In Nicaragua, the small red line SRC2-18-1 is currently under on-farm validation and is expected to be released as the cultivar ‘INTA Matagalpa’ during FY10. There has been similar progress with the black seeded line MHN 322-9 which is being validated in Guatemala and considered for release as the cultivar ‘ICTAZAM’. In Costa Rica, the white seeded line MEB 2232-29 is expected to be released this year. In El Salvador, the small red line MER 2226-41 is considering for release during FY10.

As in previous years, certified seed of small red cultivars developed by the project was produced and distributed by governmental bean seed and fertilizer distribution programs in El Salvador, Honduras and
Nicaragua. During the past year, these programs have benefited more than 180,000 farmers in Central America.

The University of Puerto Rico has developed red mottled bean lines that combine resistance to Bean Golden Mosaic Yellow Virus, Bean Common Mosaic Virus, Bean Common Mosaic Necrotic Virus and common bacterial blight. Seed of these lines was increased in Puerto Rico during the past year. Another seed increase will be conducted in Puerto Rico during the upcoming year so that on-farm trials can be conducted in Haiti during 2010.

The University of Puerto Rico, the University of Nebraska, the USDA-ARS Tropical Agriculture Research Station and IDIAF have developed a tropically-adapted pinto bean lines that have resistance to Bean Golden Yellow Mosaic Virus, Bean Common Mosaic Virus, Bean Common Mosaic Necrotic Virus and rust. This breeding line may be of potential benefit to countries such as Haiti and Angola where pinto beans are consumed. In Haiti, the pinto bean breeding lines PT-38 and PT-47 were resistant to virus and rust and yield well in a low fertility soil. Susceptibility to powdery mildew is the most serious weakness of the pinto breeding lines.

The University of Puerto Rico and the USDA-ARS Tropical Agriculture Research Station released the high-yielding, light red kidney bean cultivar ‘Badillo’ that has resistance to common bacterial blight and BCMV. Badillo should reduce damage caused by common bacterial blight and increase the yield of marketable beans in Puerto Rico and other Caribbean countries that produce light red kidney beans.

A significant amount (12 MT) of the black bean cultivars ‘Aifi Wuriti’ and ‘Arroyo Loro Negro’ were multiplied in Haiti during the past year. This seed was used to establish demonstration plots in the fields of 300 cooperating farmers, in the Vallée de Jacmel area in South Eastern Haiti in cooperation with the NGO ACDIVOCA. It was expected that 10 tons of seeds would be bought back from some selected farmers. At the end, only five tons of seeds were collected from the participating farmers, because neighboring farmers, in recognition of the superior performance of these cultivars, were buying the seeds directly. Supplemental funds were provided by the Management Office to purchase a thresher that will facilitate seed multiplication during the upcoming year.

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

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 one cycle of recurrent selection to develop Mesoamerican and Andean breeding lines with greater adaptation to low soil N. A second cycle of RS would be conducted if the project is extended beyond the initial 30 months of funding. Preliminary screening conducted in Honduras and Puerto Rico has identified disease resistant bean breeding lines that could be used to form the base population for 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 (Peter Graham, personal communication). The root rot resistant black bean
line PR0443-151 from Puerto Rico and CIAT bean breeding lines A 774 and VAX 3 have performed well in a low N soil 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 developed at the University of Puerto Rico with enhanced levels of root rot resistance, will serve as a source of root rot resistance. In the proposed project, breeding lines will be evaluated in the F3 and F4 generations in replicated field trials. The field trials will receive low levels (20 kg/ha) of N fertilizer. The bean lines will be inoculated with recommended bean Rhizobium strains to create conditions favorable for biological nitrogen fixation. Dr. Tim Porch will evaluate the F4 generation for root rot resistance in a field maintained specifically for root rot screening and selection. The most promising F3 lines will be screened using molecular markers for disease resistance and traits associated with tolerance to low P soils. The most promising lines from each cycle of recurrent selection will be included as entries in regional performance trials in Central America and the Caribbean.

Results, Achievements and Outputs of Research: Greenhouse trials were conducted in Honduras to identify lines with better performance under low N conditions, by expressing greater nodulation and BNF along with other mechanisms which allow beans to have greater accumulation of dry matter and seed yield under low N. The trials were conducted using soil: sand substrates that have low organic matter and N content, conditions which normally produces symptoms of N deficiency and low yield in bean genotypes with poor BNF ability. A preliminary trial including 180 bean accessions from the working collection of Zamorano breeding program inoculated with a mixture of two Rhizobium strains, CR 477 (R. etli) y CIAT 899 (R. tropici). The plants were grown in a soil: sand (1:1) substrate low in organic matter (1.24%) and N (0.06%). Significant variation for nodulation using a 1 to 9 scale (1= none or very few, small nodule; 9= maximum number of large nodules), root, shoot and total dry weight (DW), and root/shoot ratio were observed between genotypes. The cultivars and lines with higher nodulation scores also had greater root, shoot and total DW and the lowest shoot/root ratio.

The 35 accessions with the highest nodulation scores and total plant DW, and five accessions with poor performance from the previous trial, were included in a second trial, to test their performance under Rhizobium inoculation (strains CIAT 899 and CR 477) and treatments of added (70 ppm of N) or no added nitrogen. The soil: sand (1:3) substrate was quite low in organic matter (0.86%) and N (0.04%). Significant differences were observed in nodulation, root, shoot and total DW among treatments and genotypes, but not for the T x G interaction. Greater nodulation were observed in the inoculation treatment than the treatments with or without added N. Larger root, shoot and total plant DW were found in the added N treatment. Although T X G interaction was not significant, there were some genotypes that had better nodulation using the Rhizobium strain CIAT 899 and other accessions that had better nodulation with the CR 477 strain. These results suggest that strain x genotype interaction should be taken into consideration when evaluating bean lines in a low N soil.

Twenty five accessions with the higher nodulation and total plant DW from the first trial were inoculated with a mixture of Rhizobium strains (CIAT 899 and CR 477) and grown in a soil: sand (1:2) substrate low in organic matter (1.41%) and N (0.07%). The best nodulation was observed in the Rhizobium inoculated treatment without N; and the greatest root, shoot and total plant DW were observed in the added N treatments, and both were superior to the without inoculation and no added N treatment. Significant differences were observed between genotypes for all variables; nodule DW ranged from 225 to 477 mg/pl and total plant DW from 3.2 to 5.4 g/pl. The genotypes with higher nodulation have almost twice nodule DW and 50% greater plant DW, than those with lower nodulation.
Field trials were conducted during FY09 with the selected genotypes from the previous greenhouse experiments. A trial including 16 genotypes and four checks (‘Cardenal’, BAT 477, ‘Amadeus 77’ and ‘Rojo de Seda’) was carried out during the dry season using sprinkler irrigation; drought stress was imposed at four weeks after planting (total irrigation of 100 mm). The same trial was conducted during the primera season under normal rainfall but using fertilized and non-fertilized plots. Genotypes with superior performance under drought and low soil fertility (mainly N and P) will be identified from these greenhouse and field trials conducted the past year.

Thirty-four elite bean breeding lines were evaluated in a low N soil at Isabela Puerto Rico over a two-year period (Tables 1 and 2). PR0443-151, a black bean, had the best overall performance. The seed yield of this line was ranked no lower than 3rd in both + N and – N treatments. VAX 3, a common bacterial blight resistant small red bean germplasm, produced seed yields similar to PR0443-151 in the – N treatment. These lines also had the greatest efficiency of N use (kg of seed yield in the – N plots / kg of N in the soil). PR0443-151 also had the greatest agronomic efficiency (kg of seed yield / kg of N applied) and the greatest amount of N accumulated in the seed. These trials were part of the M.S. thesis research of Ronald Dorcinvil.

PR0443-151, VAX 3 and other promising breeding lines were crossed with elite breeding lines having disease resistance (BGYMV, BCMV, BCMNV and web blight). During the past year, individual plants were selected from an F2 nursery based on agronomic characteristics and commercial seed type. In June 2008, approximately 500 F3 lines from 12 different populations were evaluated at two sites. One site was a low N soil at the Isabela Substation that received at planting only 20 kg/ha of N that in the form of a granular fertilizer. The other field at the USDA-ARS research farm at Isabela was not fertilized and is often used to screen beans for root rot resistance. A few of the populations had much better overall performance. The F4 lines will be screened in the greenhouse for reaction to BCMNV and in the laboratory for the molecular marker associated with a gene for resistance to BGYMV. During the upcoming year, the most promising F3:4 lines will be evaluated in replicated field trials in Puerto Rico.

Superior bean breeding lines selected from the field studies conducted in low N soils at Isabela, Puerto Rico, and from the greenhouse and field studies at Zamorano, will be used to initiate the first hybridization cycle of a recurrent selection program to develop cultivars with greater yield potential in low N soils.

More progress has been made in developing small-seeded Middle American bean lines that are adapted to low N soils. During the upcoming year, we plan to evaluate Andean bean landraces from Haiti, Dominican and Puerto Rico for adaptation to low N soils. Traditionally, these landraces have been planted with few or no external inputs. Most of these landraces have an indeterminate (type III) growth habit that may confer some advantages when produced in low fertility soils.

**Objective 3:** Develop molecular markers for disease resistance genes.

**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 two dominant complementary genes. The RAPD B386_900 has been reported
to be linked in coupling with one of the resistance genes \((Mp-I)\) whereas \(B459_{1600}\) was reported to be linked in repulsion with the other resistance gene \((Mp-2)\). The utility of these markers has not been confirmed because the presence of the markers has not been surveyed in susceptible lines and in other sources of resistance to charcoal rot. The Dry Grain Pulse CRSP project will evaluate the usefulness of the putative molecular markers. If proven to be useful, Dr. Tim Porch will convert these RAPD markers to SCAR markers. If the putative RAPD markers are proven to be ineffective, recombinant inbred lines will be developed from crosses between BAT 477 and susceptible bean lines to attempt to identify new molecular markers for the charcoal rot resistance genes using bulk segregant analysis (BSA).

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.

**Results, Achievements and Outputs of Research:** The RAPD markers previously reported to be linked to genes for charcoal rot were screened with a set of susceptible and resistant genotypes. Seven susceptible genotypes, ‘ICA Pijao’, ‘Sanilac’, ‘Pinto Villa’, ‘Rio Tibagi’, DOR 364, ‘Morales’, ‘Tapatio’, and eight resistant genotypes, A 300, Tacana, SEA 5, TLP 19, BAT 477, Tio Canela 75, G 5059, and XAN 176, were tested. RAPD \(B386_{900}\) (coupling) was not amplified in BAT 477 nor in other resistant genotypes, while \(B459_{1600}\) (repulsion) was not amplified in any susceptible genotypes. Bands of other sizes were amplified with each RAPD marker but were not associated with resistance. The PCR cocktail and PCR amplification conditions were then modified in order to optimize amplification and to reproduce the reported bands, but they were not reproducible. Consultation with another group working with *Macrophomina phaseolina* in common bean confirmed that \(B386_{900}\) and \(B459_{1600}\) do not have utility for charcoal rot (Mayek, pers. comm.).

Because the putative RAPD markers were proven to be ineffective, recombinant inbred lines (RILs) from crosses between BAT 477 and susceptible bean lines were pursued for the development of novel markers. Seed of RILs from the cross DOR 364 x BAT 477, which are expected to segregate for resistance and susceptibility to ashy stem blight, were obtained from CIAT by Dr. Tim Porch. In September 2008 and 2009, these lines were planted at Isabela, Puerto Rico in a replicated field trial that was inoculated with the pathogen. The disease reactions of the RILs will be used to initiate the search for molecular markers for resistance to ashy stem blight using bulk segregant analysis (BSA).

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

**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 30 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.
Cowpeas [*Vigna unguiculata* (L.) Walp] are produced on a limited scale in the Caribbean. Ing. Emmanuel Prophete has expressed interest in evaluating promising cowpea breeding lines from the University of California, Riverside and IITA. The Dry Grain Pulse CRSP project will serve as a facilitator in obtaining cowpea breeding lines for testing in Haiti. The project will also attempt to identify research programs in Central America that might be interested in evaluating cowpea breeding lines. Zamorano will conduct preliminary evaluations of cowpea lines and will provide seed of the best adapted lines to other programs and organizations 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 in Angola in the evaluation of beans, cowpeas and other grain legumes, such as Lima beans or pigeonpeas.

**Results, Achievements and Outputs of Research:** Field experiments were planted at the Isabela Substation in September 2008 to compare the performance of 16 lima bean landrace varieties from Puerto Rico and one landrace from Haiti. Phenological and agronomic traits and pest and disease problems were noted for each line by graduate student Luis Ruiz as part of a special topic course. A few of the landraces produced seed throughout most of the dry season. This would represent an important source of protein during a period when there are often shortages of beans.

Dr. Rosas planted the Lima bean landraces in Honduras in June, 2009. A few of the landraces were insensitive to photoperiod suggesting that Lima beans could be produced throughout the year in Central America and the Caribbean. The project is collaborating with Ms. Emmalea Ernst, at the University of Delaware in the evaluation of the HCN levels in the seed and leaves of the Lima bean plants. Seed of many of the landraces HCN levels > 100 ppm which are unsafe levels if the Lima beans are cooked improperly. The results from the Lima bean research will be presented at the 2009 meeting of the Bean Improvement Cooperative.

The most promising Lima bean line will be considered for release in Puerto Rico. Dr. Molly Welsh, curator of the USDA bean germplasm collection in Prosser, Washington, visited the Lima bean plots in February, 2009. Once sufficient seed has been produced, the varieties will be sent to the USDA and CIAT bean germplasm collections.

Photoperiod sensitive cowpea lines from the University of California, Riverside (PI-UCR-1 project) were evaluated at Isabela, Puerto Rico (18° N latitude). A trial was planted at the Isabela Substation in January 2008 to increase seed and to conduct a preliminary evaluation for adaptation. All of the cowpea lines from the University of California, Riverside flowered within 45 days and produced seed. Another trial was planted at the Isabela Substation in June 2008 to observe the performance of the cowpea lines during longer days. The cowpea lines tended to flower later and produce more biomass during the summer months. In fact, there was so much vegetative growth that the plants tended to grow together when planted at a 0.76 m row width. Another trial was planted at the Isabela Substation in February 2009. The plants were harvested at approximately 60 days after planting to measure biomass production. The line UCR 2532 produced 8 T/ha of biomass whereas the UCR 739 had the best combination of dry matter yield (7.9 T/ha) and % protein (18.7%) (Table 3). These results suggest that these cowpea lines have potential either as a forage or as a cover crop.
Table 2. Performance of cowpea lines planted at Isabela, Puerto Rico in February 2009 and harvested approximately 60 days after planting.

<table>
<thead>
<tr>
<th>Line</th>
<th>Seed type</th>
<th>Dry matter yield (T/ha)</th>
<th>% protein in the biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCR 739</td>
<td>Red-brown</td>
<td>7.9</td>
<td>18.7</td>
</tr>
<tr>
<td>UCR 2532</td>
<td>Grey-brown</td>
<td>8.2</td>
<td>16.4</td>
</tr>
<tr>
<td>CC 27</td>
<td>Cream</td>
<td>6.0</td>
<td>14.6</td>
</tr>
<tr>
<td>CC 36</td>
<td>Cream black eye</td>
<td>6.2</td>
<td>15.1</td>
</tr>
<tr>
<td>IT95K-1093-5</td>
<td>Brown cream</td>
<td>5.3</td>
<td>18.3</td>
</tr>
<tr>
<td>Lenteja</td>
<td>Cream small</td>
<td>7.5</td>
<td>14.1</td>
</tr>
<tr>
<td>Gorda</td>
<td>Cream black eye</td>
<td>7.1</td>
<td>14.7</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>6.9</td>
<td>16.0</td>
</tr>
<tr>
<td>LSD(0.05)</td>
<td></td>
<td>1.5</td>
<td>2.9</td>
</tr>
<tr>
<td>CV(%)</td>
<td></td>
<td>16.3</td>
<td>13.7</td>
</tr>
</tbody>
</table>

Zamorano recently received a collection of 19 cowpea lines from Jeff Ehlers, UC-Riverside that will be tested during FY10. With the permission of Dr. Ehlers, a portion of seed of each of these cowpea lines was provided to Gasner Demosthene from Haiti during the Bean Breeding Workshop held at Zamorano last August.

**Explanation for Changes**

Monica Mmbui and Antonio David delayed initiation of graduate studies at the University of Puerto Rico, Mayaguez Campus until August 2009. It was not possible to obtain their J-1 visas to begin studies in January 2009.

During the past year, there was severe damage to crops in Haiti caused by flooding. Therefore, it was not possible to make a collection of Lima bean landraces in Haiti. Ing. Prophete plans to make the collection of the Lima beans during the upcoming year.

During the trip to Angola in November 2008, Ascochyta blight was identified as an important bean disease. Some breeding for Ascochyta blight resistance has been conducted in Ecuador. We plan to request breeding lines that have been reported to have moderate levels of resistance.

Dr. Consuelo Esteves and Dr. Mildred Zapata will join the project as collaborators. Their expertise in plant pathology and biological nitrogen fixation will strengthen the capacity of the project to achieve objectives.

**Networking Activities with Stakeholders**

This project, in collaboration with the Michigan State University (PI-MSU-1) project, prepared a set of regional nurseries that were planted in Angola and Rwanda. The nurseries included elite breeding lines from Michigan State University, the University of Puerto Rico, Zamorano and INIAP. Given the similarities in climate, seed type and biotic constraints, the bean research programs in Ecuador and Angola should strengthen collaboration.

Fifty small red and black bean cultivars and promising lines were sent from Zamorano to Julie G. Lauren, Cornell University (PI-CU-1), for testing in Kenya. In addition, 33 bean lines and germplasm accessions with resistance to ALS were sent to Dr. Paul Gets, UC-Davis, for testing in East Africa. Twenty small red and black lines and cultivars were sent to Dr. Robert Shank, Ministry of Agriculture, for testing in Belize. The bean rust differentials nurseries and the ERMUS trial were provided to Angel Murillo, INIAP,
Ecuador, and the anthracnose and rust differentials nurseries to Julio Cesar Villatoro, ICTA, Guatemala, during the Bean Breeding Workshop held at Zamorano, August 10-14, 2009.

Interspecific (P. vulgaris x P. coccineus) lines, originally developed in Puerto Rico for web blight resistance, were screened at the University of Idaho for white mold resistance. Three lines were identified that had high levels of resistance to white mold. (Singh et al. 2009). Scarlet runner bean germplasm accessions G 35006 and G 35172 possess resistance to multiple diseases of common bean. Ann. Rep. of the Bean Improv. Coop. 52:22-23).

The UPR bean breeding program collaborated with Dr. Graciela Godoy-Lutz, Instituto Dominicano de Investigaciones Agropecuarias y Forestales (IDIAF) plant pathologist, in the preparation of a proposal entitled “Evaluación, multiplicación y adopción de líneas avanzadas de habichuela con resistencia a limitantes bióticas desarrolladas en el proyecto Bean/Cowpea CRSP” that was submitted and approved by the Consejo Nacional de Investigaciones Agropecuarios y Forestales (CONIAF). Although the project will not provide any additional funding for research in Puerto Rico, it will provide an opportunity to continue to test in the Dominican Republic the most promising lines from our breeding program. This collaboration should result in the release of disease resistant black and red mottled bean cultivars.

BGYMV has become an important production constraint for snap bean producers in Costa Rica. The UPR bean breeding program provided Ing. Juan Carlos Hernández, Ministry of Agriculture bean researcher in Costa Rica with seed of snap bean breeding lines that should combine resistance to BGYMV and BCMV. The performance of these lines is currently being tested in the field in Costa Rica.

The UPR bean breeding program provided Ing. Emigdio Rodríguez, IDIAP bean researcher, with seed of white bean breeding lines. The most promising white bean lines produced seed yields (> 2,000 kg/ha) that were significantly greater and web blight scores that were significantly lower that the local white bean check variety.

The UPR and Zamorano bean breeding programs provided Dr. Doug Maxwell with seed of black bean breeding lines that combine resistance to BGYMV, BCMNV and BCMV. These lines were tested on small-scale farms in Guatemala and Aifi Wuriti was the principal cultivar selected by farmers of the southeastern region, recently affected by the severe drought observed on their farms. A seed increase will be conducted to permit distribution of this well-adapted cultivar to farmers stricken by the drought.

Leveraged Funds
Name of PI receiving leveraged funds: Juan Carlos Rosas
Description of leveraged Project: Development and testing of drought/low fertility tolerant lines in Nicaragua and Honduras
Dollar Amount: $240,000
Funding Source: Red SITCA

Name of PI receiving leveraged funds: James Beaver
Description of leveraged Project: Research assistantship for Ronald Dorcinvil to study soil nutrition problems on the Mycogen Research
Dollar Amount: $15,000
Funding Source: Mycogen

List of Scholarly Activities and Accomplishments
The President of El Salvador, Elías Antonio Saca, participated in an official ceremony where seed (10 kg sacks) of small red bean varieties CENTA Pipil, CENTA San Andrés e INTA Rojo were distributed to
farmers. The program has distributed approximately 30,000 hwt of seed to 120,000 farmers in El Salvador. The contribution of the Bean/Cowpea CRSP was recognized at the ceremony.

Contribution to Gender Equity Goal
The development and dissemination of bean cultivars that produce greater or more reliable bean yields should contribute to economic growth and improve the lives of the families of bean producers in Central America, Haiti and Angola. The project also supports the participation of women in formal and informal training activities.

Progress Report on Activities Funded Through Supplemental Funds
The project received supplemental funds to conduct workshops in Honduras and Angola describing recent advances in bean and cowpea research. Approximately 20 researchers from Central America and the Caribbean and 20 researchers from Angola attended the workshops. Project personnel prepared PowerPoint presentations in Spanish and in Portuguese that were distributed to the participants in the workshop. Greater knowledge of research techniques should permit bean breeding programs to be more effective in the development of improved cultivars.

Equipment to improve the plant pathology laboratory in Huambo, Angola has been purchased. Materials have also been purchased to repair greenhouses in Huambo. Consuelo Estevez will visit Angola in December 2009 to review progress in the establishment of the plant pathology. Quotations have been obtained to purchase threshers for Haiti and Angola.

A significant amount of basic seed stock of bean cultivars was produced in Honduras and Haiti. This effort helped to disseminate seed of improved bean cultivars to farmers in Central America and the Caribbean.

Publications of project personnel during FY09


Capacity Building Activities: P1-UPR-1

Objective 6: Degree Training:

Trainee # 1
Name: Ronald Dorcinvil
Citizenship: Haitian
Gender: Male
Degree Program for Training: M.S.
Program Areas or Discipline: Soil Science
Host Country Institution to Benefit from Training: Haitian Ministry of Agriculture
University to provide training: University of Puerto Rico
Supervising CRSP PI: David Sotomayor and James Beaver
Start Date: August 2006
Completion Date: May 2009
Type of CRSP Support (full, partial or indirect): Partial

If providing Indirect Support, identify source(s) of leveraged funds:
- During the summer of 2008, Mr. Dorcinvil participated in an internship at North Dakota State University. He worked for the NDSU bean breeding program under the supervision of Dr. Juan Manuel Osorno.
- During the 2008/2009 academic year, Mr. Dorcinvil received a research assistantship from a project financed by Mycogen. He was responsible for conducting field research to improve soil nutrient management of corn nurseries planted on the Mycogen Research Station near Salinas, Puerto Rico.
- In August, Mr. Dorcinvil initiated studies at North Dakota State University to pursue a PhD degree in plant breeding and genetics.
- The Pulse CRSP project provided funds for field labor and materials for Mr. Dorcinvil’s thesis research. His thesis research was related to the screening of bean lines for adaptation to low soil fertility.

Amount Budgeted in Workplan, if providing full or partial support:
Direct cost: $1,000
Indirect cost: $200

U.S. or HC Institution to receive CRSP funding for training activity: University of Puerto Rico.

Trainee # 2
Name: Monica Mmbui Martins
Citizenship: Angolan
Gender: Female
Degree Program for Training: M.S.
Program Areas or Discipline: Plant Breeding and Genetics
Host Country Institution to Benefit from Training: Angola
University to provide training: University of Puerto Rico
Supervising CRSP PI: Tim Porch
Start Date: August 2009
Projected Completion Date: August 2011
Type of CRSP Support (full, partial or indirect): Full

If providing Indirect Support, identify source(s) of leveraged funds:
Amount Budgeted in Workplan, if providing full or partial support:
Direct cost: $20,000/year
Indirect cost: None

U.S. or HC Institution to receive CRSP funding for training activity: The University of Puerto Rico
Comments: Ms. Mmbui initiated graduate studies at the UPR, Mayaguez Campus in August 2009.
Trainee # 3

Name: Antonio Nkulo Ndengoloka David  
Citizenship: Angolan  
Gender: Male  
Degree Program for Training: M.S.  
Program Areas or Discipline: Plant Breeding and Genetics  
Host Country Institution to Benefit from Training: Angola  
University to provide training: University of Puerto Rico  
Supervising CRSP PI: James Beaver  
Start Date: August 2009  
Projected Completion Date: August 2012  
Type of CRSP Support (full, partial or indirect): Full  
  If providing Indirect Support, identify source(s) of leveraged funds:  
  Amount Budgeted in Workplan, if providing full or partial support:  
    Direct cost: $20,000 ((PI-UCR-1 project)  
    Indirect cost: None  
U.S. or HC Institution to receive CRSP funding for training activity: The University of Puerto Rico  
Comments: Mr. David initiated graduate studies at the UPR, Mayaguez Campus in August 2009.

Trainee # 4

First and Other Given Names: Paola  
Last Name: Alvarado  
Citizenship: Honduran  
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  
Supervising CRSP PI: Juan Carlos Rosas  
Start Date: January 2009  
Projected Completion Date: December 2009  
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: $2,000.00  
    Indirect cost: 0  
U.S. or HC Institution to receive CRSP funding for training activity: Zamorano
Trainee # 5

First and Other Given Names: Ruth
   Last Name: Valladares
   Citizenship: Salvadoran
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
Supervising CRSP PI: Juan Carlos Rosas
Start Date: January 2009
Projected Completion Date: December 2009
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: $2,000.00
   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 of bean research personnel in Angola
   Description of training activity:
   Participants: Tim Porch, Consuelo Estevez and James Beaver traveled to Angola to provide short-term training to IIA bean research personnel in Angola on research techniques used to screen bean lines for resistance to biotic and abiotic constraints. The first portion of the workshop was presented in November 2008 and the remainder of the topics of the workshop was presented in August 2009. The presentations in Portuguese were recorded on CDs and distributed to participants of the workshop.
Location: Huambo, Angola
Duration: One week
Participants/Beneficiaries of Training Activity: IIA pulse crop researchers and staff
   Anticipated numbers of Beneficiaries (male and female): 15 people
Amount Budgeted in Workplan:
   Direct cost: $10,000
   Indirect cost: $1,500
   If leveraged funding is to be used to support this training activity, indicate the source and amount:
      None.
Comments: Presentations and other materials for the workshop were prepared by project personnel. The presentations in Portuguese were recorded on CDs and distributed to participants of the workshop.
**Training activity # 2**

Type of training: Bean breeding workshop for Central American and Caribbean bean researchers.

Description of training activity: The workshop discussed recent advances in bean and cowpea breeding and reviewed standard techniques used to screen beans for resistance to biotic and abiotic stresses. The network for the testing and validation of bean lines were discussed. The presentations in Spanish were recorded on CDs and distributed to participants of the workshop.

Location: Zamorano

Duration: 5 days

Scheduling of training activity: August 2009

Participants/Beneficiaries of Training Activity: 20

Anticipated numbers of Beneficiaries (male and female): 15

Amount Budgeted in Workplan:
- Direct cost: $26,975
- Indirect cost: $3,025

If leveraged funding is to be used to Support this Training Activity, indicate the Source and Amount:FDN$ 1,000

Comments: Supplemental funds were provided by the Dry Pulse CRSP Management Office to support the workshop. A total of $30,000 was approved for the workshop, including funds ($3,725) to permit University of California, Riverside (PI-UCR-1 project) personnel to discuss cowpea research techniques at the workshop.

**Training activity # 3**

Type of training: Informal training of a Guatemalan bean researcher.

Description of training activity: Karla Ponciano, technician of the Biotechnology Lab, ICTA, Guatemala, received a short term training dealing with isolation, characterization of *Pheoisariopsis griseola* and screening of ALS resistant germplasm.

Location: Zamorano

Duration: 3 weeks

Scheduling of training activity: Nov-Dec, 2008

Participants/Beneficiaries of Training Activity: 1

Anticipated numbers of Beneficiaries (male and female): 1 female

Amount Budgeted in Workplan:
- Direct cost: $1,000
- Indirect cost: $150

If leveraged funding is to be used to Support this Training Activity, indicate the Source and Amount: N/A

Comments: Ms. Ponciano will help ICTA bean researchers on *P. griseola* race characterization and germplasm screening for resistance to ALS.
**Objective 1:** Development, release and dissemination of improved bean cultivars.

<table>
<thead>
<tr>
<th>Benchmark Indicators by Objectives</th>
<th>UPR</th>
<th>USDA</th>
<th>EAP</th>
<th>IIA</th>
<th>Haiti</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germplasm acquired for key abiotic and biotic stress factors of Angola</td>
<td>Y</td>
<td>N*</td>
<td>Y</td>
<td>N*</td>
<td>Y</td>
</tr>
<tr>
<td>Germplasm tested in Angola</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Breeding populations developed</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Breeding populations tested</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Advanced trials conducted</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Promising lines validated on farm</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cultivar released</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(Tick mark the Yes or No column for identified benchmarks by institution)*

**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   | X    | X   | X   | X     |
| Complete crosses for the first cycle of recurrent selection for enhanced BNF | X   | X    | X   | X   |       |
| Harvest F2 seed for the first cycle of recurrent selection | X   | X    | X   | X   |       |

**Objective 3:** Develop molecular markers for disease resistance genes.

| Sources of downy mildew resistance acquired | X   | X    | X   | X   | X     |
| Existing RAPD markers tested | X   | X    |     |     |       |
| Effectiveness of RAPD markers in acquired germplasm determined | X   | X    |     |     |       |
| RAPD products cloned and sequenced |     | X    | X   | X   |       |
| SCAR markers designed and initially tested |     | X    | X   |     |       |

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

| Complete collection of P. lunatus |     |     |     |     |       |
| Complete first year of field testing of cowpeas in PR, Haiti, and Central America | X   | X    |     |     |       |
| Characterize the phenological, morphological, and agronomic traits of P. lunatus (Haiti, PR) | X   | X    |     |     |       |

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

| M.S. training of Ronald Dorchov completed | X   | X    |     |     |       |
| M.S. training of Monica mmbui initiated | X   | X    |     |     |       |
| M.S. training of Antonio David initiated | X   | X    |     |     |       |
| Informal training in Angola in bean research techniques |     |     | X   | X   |       |
| Informal training in Honduras in bean research techniques |     |     |     |     |       |
| Workshop in Central America in bean research techniques and the discussion of a new strategy for the development and dissemination of bean cultivars |     |     |     |     |       |
| Name of the PI reporting on benchmarks by institution | James Beaver | Tim Porch | Juan Carlos Rosas | Antonio Chicapa | Emmanuel Prophete |

Name of the U.S. Lead PI submitting this Report to the MO: James Beaver

* Please provide an explanation for not achieving the benchmark indicators on a separate sheet.
Dry Grain Pulses CRSP
Research, Training and Outreach Workplans
(April 1, 2008 -- September 30, 2009)

PERFORMANCE INDICATORS/TARGETS
for Foreign Assistance Framework and the Initiative to End Hunger in Africa (IEHA)

**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):** Central America, Haiti, Angola

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Degree Training:</strong> Number of individuals who have received degree training</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of women</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Number of men</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Short-term Training:</strong> Number of individuals who have received short-term training</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of women</td>
<td></td>
<td></td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Number of men</td>
<td></td>
<td></td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td><strong>Technologies and Policies</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of technologies and management practices under research</td>
<td></td>
<td></td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Number of technologies and management practices under field testing</td>
<td></td>
<td></td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Number of technologies and management practices made available for transfer</td>
<td></td>
<td></td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Number of policy studies undertaken</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Beneficiaries</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of rural households benefiting directly</td>
<td></td>
<td></td>
<td>1,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Number of agricultural firms/enterprises benefiting</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Number of producer and/or community-based organizations receiving technical assistance</td>
<td></td>
<td></td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Number of women organizations receiving technical assistance</td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Number of HIC partner organizations/institutions benefiting</td>
<td></td>
<td></td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td><strong>Developmental outcomes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of additional hectares under improved technologies or management practices</td>
<td></td>
<td></td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10,000</td>
</tr>
</tbody>
</table>

*Note: Each breeding line and variety is considered as an individual technology.*