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

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Abstract of Research Achievements and Impacts

Significant progress was made in initiating research activities. Breeding lines previously developed with funding from the Bean/Cowpea CRSP were tested and advanced a generation during the past six months. Small red and black bean regional performance trials were distributed to collaborators in Central America and Haiti. A web blight performance trial was also distributed to collaborators. Andean bean breeding lines and other promising germplasm were sent to Angola and Rwanda for evaluation. Two sets of on-farm validation trials are being conducted in Honduras. A validation trial known as “Drought and low fertility tolerant on-farm bean trials” (PASEBAF) includes drought, low fertility tolerant lines developed with support from the Bean/Cowpea CRSP. The Agrosalud 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 2009 at least one line from each trial will be released as a cultivar in Honduras and Nicaragua. 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. Validation trials were conducted with support from the Dry Grain Pulses CRSP. Certified seed of small red cultivars developed by the project was produced and distributed by governmental bean seed and input distribution programs in El Salvador, Honduras and Nicaragua. These seed programs have benefited more than 200,000 farmers in Central America. The multiple disease resistant white bean cultivar ‘Verano’ was developed and jointly released by the University of Puerto Rico and the USDA-ARS Tropical Agriculture Research Station. Greenhouse experiments conducted at Zamorano identified bean lines with greater nodulation scores, root, shoot and total dry matter accumulation. In Puerto Rico, the bean breeding lines VAX 3, PR0443-151 and RBF 19-63 produced mean seed yields > 1,500 kg in the –N plots. These mean seed yields were significantly greater than the check varieties Amadeus 77 and Salagnac 90A. Seed of lines, which are expected to segregate for resistance and susceptibility to ashy stem blight, were planted in Puerto Rico in a 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 in Puerto Rico and Haiti.

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 Investigación 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
More than 20 small red and black bean breeding populations were developed during the past six months. Parental materials used in the crosses to develop these populations included breeding lines, improved cultivars and landraces from Honduras, El Salvador, Guatemala and Nicaragua, and the bean breeding programs of the UPR and CIAT. The emphasis on these crosses was to combine multiple disease resistance, tolerance to abiotic stress and commercially desirable grain quality. Some of these populations were developed for adaptation to the highlands of Honduras, Guatemala and Haiti. During this period of funding, these populations were advanced to the F2 generation and are ready for F3 family testing during the 2008 ‘postrera’ growing season.

Early generation populations have been developed at the University of Puerto Rico from crosses among sources of disease (BGYM, BCMNV, common blight, rust and web blight), pest (leafhopper and bruchid) resistance and tolerance to low N soils. Individual plants will be selected in F2 and F3 generations based on agronomic characteristics and seed type. Lines will be screened in later generations for disease and pest resistance and tolerance to low N soils.

Evaluation of breeding populations
More than 3,000 breeding lines previously developed with funding from the Bean/Cowpea CRSP were tested and advanced in Honduras during the past six months with support from Dry Grain Pulses CRSP. Breeding materials under field evaluation included 48 F7 families from 5 populations (breeding lines with high levels of iron x elite small reds and black bean lines), 69 F8 families from eight populations [triple and double crosses of drought and angular leaf spot (ALS) resistant lines], 149 F8 lines from 21 populations (from the second cycle of recurrent selection for drought tolerance), 223 F5 families from seven populations (landrace x improved lines or cultivars) for Participatory Plant Breeding (PPB) activities in Honduras, 1066 F3 families from 23 populations (landrace x improved lines or cultivar, improved cultivar x line) for conventional and PPB activities in Nicaragua, El Salvador, Honduras and Costa Rica, 121 F7 families from 19 populations (from the second cycle of recurrent selection for
resistance to web blight), 39 $F_5$ and $F_6$ lines (ALS Andean x Mesoamerican resistant to ALS), 151 $F_4$
families resistant to ALS (triple crosses of improved cultivar x $F_1$ ALS Andean x Mesoamerican), 71 $F_7$
families from five populations resistant to rust (improved cultivar or line x multiple genes rust source), 491 $F_3$
families from 12 populations (combinations of improved cultivar x landrace, improved cultivar x ALS, improved cultivar x drought and high iron x ALS) for El Salvador, Honduras and Nicaragua, 23 $BC_1S_4$ families (drought/drought/improved cultivar), 124 $F_6$ families from 16 populations for increase nutritional value (improved x source of high iron and zinc), and 131 $F_6$ families and 595 $F_3$families developed by S. Beebe at CIAT (drought, BGYMV and seed quality for collaboration under the Red SICTA Project).

Regional performance trials

During the past six months, Zamorano distributed 16 small red and small black adaptation nurseries (VIDAC) and 18 yield and adaptation trials (ECAR) to all five Central American countries and to Haiti. The majority of the advanced lines included in these regional nurseries and trials 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.

Seven advanced lines trial 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 resistant lines included in this trial were selected from populations derived from crosses between the cultivar Tio Canela x VAX 6, crosses from a second cycle of recurrent selection program, and from interspecific hybridizations with a $P. coccineus$ resistant accession. Some of the lines also have resistance to common bacterial blight and Bean Golden Yellow Mosaic Virus. The most promising lines will be considered for release as cultivars or breeding lines.

Thirty four lines including the 12 ALS differentials, 18 small red and black lines and cultivars and four cultivated $P. coccineus$ accessions from Honduras were sent to Angola for testing. In addition, 50 small red and black bean cultivars and promising lines were sent to Julie G. Lauren, Cornell University, for testing in Kenya, as part of our Dry Pulses CRSP collaboration with Jonathan Lynch, Penn State University.

Seed for regional performance trials for Ecuador, Angola and Rwanda were prepared at the University of Puerto Rico. Entries in the trials included lines from Michigan State University, the University of Puerto Rico, USDA-ARS Tropical Agriculture Research Station, Zamorano and INIAP. U.S. and HC researchers plan to evaluate the performance of the lines in the nurseries in Angola during an upcoming visit. The information from these trials will be valuable to detect the most important biotic and abiotic constraints and to identify bean lines that might serve as valuable parents in a breeding program for Angola.

On-farm validation of promising breeding lines

Two on-farm validation trials are being conducted in collaboration with the National Bean Research program, associations of Local Agricultural Research Committee (CIAL), NGOs and other extension organizations in Honduras and Nicaragua. The validation trial known as “Drought and low fertility tolerant on-farm bean trials” (PASEBAF) includes drought, low fertility tolerant lines developed with support from the Bean/Cowpea CRSP. The Agrosalud 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 2009 at least one line from each trial will be released as a cultivar in Honduras and Nicaragua. The PASEBAF trial is supported by IICA/COSUDE and the Agrosalud trial by CIAT/CIDA. The same trials have been distributed for on-farm validation in El Salvador and Costa Rica.
Ten of the most promising small red improved 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 bean production lowland regions, such as Peten and Jutiapa, where small red bean production for export has increased and cultivars with higher yield potential and greater disease resistance cultivars are needed.

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 lines. The bank provides seed and other inputs to small farmers to produce beans that are exported to the U.S. If an agreement is reached between Zamorano and Lafise, foundation and registered seed will be produced at Zamorano, and certified seed and commercial beans with farmers identified by the bank.

**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 part of the seed increase, validation trials and release process were conducted under the current Dry Pulses CRSP.

As in previous years, certified seed of small red cultivars developed by the project was produced and distributed by governmental bean seed and input distribution programs in El Salvador, Honduras and Nicaragua. These programs have benefited more than 200,000 farmers in Central America. The multiple disease resistant white bean cultivar ‘Verano’ was developed and jointly released by the University of Puerto Rico and the USDA-ARS Tropical Agriculture Research Station (*J. of Plant Registrations*. 2:187-189). Verano combines resistance to Bean Golden Mosaic Virus, Bean Common Mosaic Virus and common bacterial blight. Seed of Verano is currently produced and sold to farmers by the Seed Program of the University of Puerto Rico.

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 will be increased in Puerto Rico so that on-farm trials can be conducted next year in Haiti.

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 line that has 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.

The University of Puerto Rico and the USDA-ARS Tropical Agriculture Research Station developed a high-yielding, light red kidney bean line with resistance to common bacterial blight and Bean Common Mosaic Virus. This line is being considered for release in Puerto Rico.

**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:** Three greenhouse trials were conducted in Honduras
to identify lines with higher performance under low N conditions, by expressing greater nodulation and N
fixation 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 most
bean genotypes. The first trial included a screening of 180 bean accessions from the working collection of
Zamorano breeding program under inoculation 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 root/shoot ratio.

The 35 accessions with the highest nodulation scores and total plant DW, and five accessions with poor
performance in the previous trial, were included in a second trial, to test their performance under
*Rhizobium* inoculation by two individual strains (CIAT 899 and CR 477) and treatments of added or no
added nitrogen, using a nutrient solution with 0 or 70 ppm N, respectively. 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 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 root/shoot ratio.
interaction was not significant, there were some genotypes that had better nodulation by the _Rhizobium_ strain CIAT 899 and other accessions that had better nodulation with the CR 477 strain. These results suggest that some strain x genotype interactions are more effective than others under low N.

The third trial included the 25 accessions with the higher nodulation and total plant DW from the first trial: These lines 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.

A group of bean breeding lines, previously screened in two field trials for tolerance to low soil fertility, were planted at the Isabela Substation in January 2008 (Table 1). A split pot arrangement of a RCB design was used to test the lines at three levels of fertilization [(+N, +P), -P and –N]. Nitrogen proved to be the most limiting soil nutrient in the trial with most lines producing significantly lower seed yields in the –N fertilizer plots. Nevertheless, several lines were identified that had mean seed yields > 1,000 kg/ha in the –N plots. VAX 3, PR0443-151 and RBF 19-63 had mean seed yields > 1,500 kg in the –N plots. These mean seed yields were significantly greater than the check varieties Amadeus 77 (699 kg/ha) and Salagnac 90A (831 kg/ha). These trials are part of the M.S. thesis research of Haitian graduate student Ronald Dorcinvil. He is currently using Whin-Rhizo to study the root characteristics of some of the lines that performed well in the –N fertilizer plots. Mr. Dorcinvil expects to complete requirements for a M.S. degree during the upcoming year.

Table 1. Performance of bean breeding lines planted at the Isabela Substation in January, 2008 at different levels of fertilization.

<table>
<thead>
<tr>
<th>Line</th>
<th>Fertilizer treatment</th>
<th>Seed yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+N, +P</td>
<td>- P</td>
</tr>
<tr>
<td>VAX 3</td>
<td>1929 a</td>
<td>2227 a</td>
</tr>
<tr>
<td>PR0443-151</td>
<td>2544 a</td>
<td>2821 a</td>
</tr>
<tr>
<td>RBF 19-63</td>
<td>1686 a</td>
<td>1958 a</td>
</tr>
<tr>
<td>Verano</td>
<td>2078 a</td>
<td>2128 a</td>
</tr>
<tr>
<td>IBC 309-23</td>
<td>2184 a</td>
<td>2183 a</td>
</tr>
<tr>
<td>IBC 308-15</td>
<td>2169 a</td>
<td>2069 a</td>
</tr>
<tr>
<td>A774</td>
<td>2162 a</td>
<td>2464 a</td>
</tr>
<tr>
<td>MER2226-28</td>
<td>2205 a</td>
<td>1872 a</td>
</tr>
<tr>
<td>Amadeus 77 (check)</td>
<td>2777 a</td>
<td>2289 a</td>
</tr>
<tr>
<td>Salagnac 90 (check)</td>
<td>1198 a</td>
<td>1429 a</td>
</tr>
</tbody>
</table>

The most promising sources of tolerance to low N were crossed in Puerto Rico with breeding lines with multiple disease resistance. During the upcoming year progeny from these crosses will be screened for both disease resistance and tolerance to low N soils. The most promising breeding lines from these populations ultimately will be evaluated in Central America and Haiti in regional performance trials.
Superior bean genotypes selected from the field studies conducted in low N soils at Isabela, Puerto Rico, and from the greenhouse studies at Zamorano, will be used to initiate the first hybridization cycle of a recurrent selection program to develop cultivars with greater efficiency for low N production conditions.

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\textsubscript{900} has been reported to be linked in coupling with one of the resistance genes (*Mp*-1) whereas B459\textsubscript{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, G 5059, and XAN 176, were tested. RAPD B386\textsubscript{900} (coupling) was not amplified in BAT 477 nor in other resistant genotypes, while B459\textsubscript{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\textsubscript{900} and B459\textsubscript{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, 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: Seed of landrace varieties of Lima beans were collected in Puerto Rico and Haiti. Variability in seed type, days to maturity and leaf type were observed among the 16 landrace varieties collected in Puerto Rico. During the upcoming year, the varieties will be planted in Haiti and Puerto Rico to multiply seed and to observe their performance. Once sufficient seed has been produced, the varieties will be sent to the USDA and CIAT bean germplasm collections. A few of the most promising landrace varieties will be considered for release in Haiti and Puerto Rico.

Photoperiod sensitive cowpea lines from the University of California, Riverside (PI-UCR-1 project) were evaluated at Isabela, Puerto Rico (18º N latitude). When the lines were planted in January (± 11 h photoperiod), the plants were relatively early in maturity. On the other hand, the lines were very late in maturity and produced a large amount of biomass when planted in June (± 13 h photoperiod). This photoperiod sensitivity permits the production of seed of the cowpea lines during the winter months. During the summer months, the cowpeas can be used for forage production or as a green manure. Due to the high price of imported grain, cattle and small ruminant producers in the Caribbean are increasingly interested in sources of locally-produced forage.

Explanation for Changes

Monica Mbui and Antonio David will delay initiation of graduate studies at the University of Puerto Rico, Mayaguez Campus until August 2009. It was not possible to complete the paperwork required for admission in January 2009 before the deadline.

Due to the severe damage to crops in Haiti caused by recent flooding, it may be necessary to use some Dry Pulse CRSP funds to purchase seed of adapted bean varieties for seed multiplication by the project in Haiti.
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 trainees from Haiti, Gasner Demosthenes and Ronald Dorcinvil, speak Spanish, which will facilitate 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 25% 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, formal or informal training activities with Augustinho 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 Muimui of the ZARI bean research program to determine if Dry Grains Pulse CRSP activities in Angola can benefit bean research in Zambia.

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 SICTA

Name of PI receiving leveraged funds: Juan Carlos Rosas
Description of leveraged Project: Improvement of farmer bean and maize cultivars thru participatory plant breeding
Dollar Amount: $30,000
Funding Source: Norway DF

Name of PI receiving leveraged funds: James Beaver
Description of leveraged Project: Research assistantship for Ronald Dorcinvil
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 and Dry Grain Pulse CRSPs were recognized at the ceremony.


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 having 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


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 is 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 reduce risk 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 and web sites to strengthen the capacity of the bean research programs in Central America, the Caribbean and Angola

Contribution to Gender Equity Goal

1. Dr. Consuelo Estevez will provide training in plant pathology research techniques at a workshop to be held in Angola in November 2008. She will also participate in the workshop to be held in Honduras in August 2009. The workshops in Angola and Honduras are expected to include several female trainees.
2. Two female technicians from El Salvador received short-term training in bean research techniques at Zamorano.

3. The participatory plant breeding techniques used in Honduras solicit the opinion of both men and women concerning the potential value of bean breeding lines.

4. Monica Mbui was chosen by the IIA in Angola to receive M.S. degree training in plant breeding at the UPR.

**Progress Report on Activities Funded Through Supplemental Funds**
Not Applicable

**Tables/Figures Cited in the Report**
None
Capacity Building Activities: P1-UPR-1

Degree Training:

**Student #1**

First and Other Given Names: Ronald  
Last Name: Dorcinvil  
Citizenship: Haiti  
Gender: Male  
Degree: M.S.  
Discipline: Soil Sciences  
Host Country Institution to Benefit from Training: Haiti  
Training Location: University of Puerto Rico  
Supervising CRSP PI: Beaver, James  
Start Date: 08/06  
Project Completion Date: 05/09  
Training Status: Active  
Type of CRSP Support (full, partial or indirect): Partial (Category 2b)

**Student #2**

First and Other Given Names: Monica  
Last Name: Mbui  
Citizenship: Angolan  
Gender: Female  
Degree: M.S.  
Discipline: Plant breeding  
Host Country Institution to Benefit from Training: IIA, Angola  
Training Location: University of Puerto Rico  
Supervising CRSP PI: Beaver, James  
Start Date: 08/09  
Project Completion Date: 08/11  
Training Status: Pending  
Type of CRSP Support (full, partial or indirect): Full (Category 1)
Short-term Training:

Type of Training: Informal training of bean research personnel in Angola

Description of training activity: Tim Porch, Juan Carlos Rosas and James Beaver will travel to Angola to provide short-term training to bean research personnel in Angola on research techniques used to screen bean lines for resistance to biotic and abiotic constraints. Dr. Rosas will share his experience using participatory plant breeding techniques in Central America to promote the adoption of bean cultivars.

Status of this activity: 
Reason if training activity not completed as planned: 
When did the activity occur?: 
Location: Huambo, Angola
Who benefited from this activity?: Pulse crop researchers and staff 
Number of Beneficiaries: 15
  Male: 
  Female: 
  Total: 

Type of Training: Informal training of Salvadoran researcher

Description of training activity: Aldemaro Clara and Aura Morales de Borja, technicians from the bean research program in El Salvador, received short-term training at Zamorano dealing with bean research techniques. The goal of the training is to increase the research capacity of the bean program in El Salvador.

Status of this activity: Completed as planned
Reason if training activity not completed as planned: 
When did the activity occur?: August 2008
Location: Zamorano
Who benefited from this activity?: The CENTA bean research program in El Salvador 
Number of Beneficiaries: 2
  Male: 
  Female: 2 
  Total: 2
Type of Training: Bean breeding workshop for Central American and Caribbean bean researchers.

Description of training activity: The workshop will discuss recent advances in bean breeding and review standard techniques used to screen beans for resistance to biotic and abiotic stresses. The testing and validation bean lines will be discussed.

Status of this activity:
Reason if training activity not completed as planned:
When did the activity occur?:
Location: Zamorano
Who benefited from this activity?: Not specified
Number of Beneficiaries: 15
   Male:
   Female:
   Total:
# Dry Grain Pulses CRSP

**Report on the Achievement of “Semi-Annual Indicators of Progress”**

*(For the Period: April 1, 2008 – September 30, 2008)*

This form should be completed by the U.S. Lead PI and submitted to the MO by October 1, 2008

**Project Title:**

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

| Benchmark Indicators by Objectives | Objective 1: Development, release and dissemination of improved bean cultivars. | Objective 2: Selection of beans for adaptation to low N soils. | Objective 3: Develop molecular markers for disease resistance genes. | Objective 4: Evaluation of other pulse crops for Central America and the Caribbean | Objective 5: Increase the capacity, effectiveness and sustainability of agricultural research institutions that serve the M.S. training of Ronald Dorcinvil completed | M.S. training of Luzia J. Baptista | Informal training in Angola in bean research techniques | 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 |
|-----------------------------------|-------------------------------------------------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
|                                   | Germplasm acquired for key abiotic and biotic stress factors of Angola | Germplasm tested in Angola | Breeding populations developed X Y | Breeding populations tested X Y | Advanced traits conducted X Y | Promising lines validated on farm X Y | Cultivar released X Y | Complete field and greenhouse evaluations to identify most promising sources of BNF germplasm X Y | Complete crosses for the first cycle of recurrent selection for enhanced BNF X Y | Harvest F2 seed for the first cycle of recurrent selection | Complete collection of P. funatus X Y | Complete first year of field testing of cowpeas in PR, Haiti, and Central America | Characterize the phenological, morphological, and agronomic traits of P. funatus (Haiti, PR) | M.S. training of Ronald Dorcinvil completed X N X N | Informal training in Angola in bean research techniques X Y | Informal training in Honduras in bean research techniques X Y | Workshop in Central America in bean research techniques and the discussion of a new strategy for the development and dissemination of bean cultivars X Y |

Provide abbreviated name of institutions in columns below

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

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

**Name of the PI reporting on benchmarks by institution:**

J. Beaver, T. Porch, J. C. Rosas, A. Douchal, E. Prophete

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

J. Beaver

**Signature**

30 September 2008
Dry Grain Pulses CRSP  
Research, Training and Outreach Workplan  
(April 1, 2008 – September 30, 2008)  

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

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(e): Angola

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