Combining Conventional, Molecular and Farmer Participatory Breeding Approaches to Improve Andean Beans for Resistance to Biotic and Abiotic stresses

 Principle Investigators
James D. Kelly, Michigan State University, USA  
Eduardo Peralta, INIAP, Ecuador  
Augustine Musoni, ISAR, Rwanda

Collaborating Scientists
George Abawi, Cornell University, USA  
Sieglinde Snapp, MSU, USA

Abstract of Research Achievement and Impacts

In Michigan, three new bean varieties were released in black, pinto and Otebo commercial classes; high-yielding black, navy, pinto and kidney lines with resistance to common bacterial blight were identified; and two markers linked to major disease resistance genes for rust were identified on separate linkage groups on the bean map. In NY, root rot screening of new US germplasm nursery was conducted in the field; and germplasm from Ecuador was screened in the greenhouse against isolates of Rhizoctonia. In Ecuador three new lines are in the pre-release stage and are under seed multiplication prior to final release to CIALs. These include large red mottled line INIAP 430 Portilla, AND 1005 for green shell and medium-sized Canario seed type INIAP 480 Rocha. The program in Ecuador continues to actively use marker-assisted selection in breeding for disease resistance and all new lines under consideration for release have been preselected and seed increased through the local CIALs in the different production areas. In Rwanda six large seeded red and red-mottled lines are in the pre-release stage. These include the bush beans: RWR 2245, RWR 1145, Nyirabukara and the mid-maturity climbing bean lines MAC 49, MAC 9, and MAC 44. The program also received ten nurseries from Michigan, Puerto Rico and Ecuador that are being evaluated under local conditions and will serve as parental donors of useful traits in future breeding efforts. On farm evaluation of advanced lines continues to be a critical component of that breeding program. Two female students one from Rwanda and one from the U.S. initiated their doctoral studies at MSU.

Project Problem Statement and Justification

Common bean (Phaseolus vulgaris L.) is the most important grain legume (pulse) consumed in Ecuador, and the most important protein source in Rwandan diets. Around 120,000 hectares of beans are cultivated annually in Ecuador, and common bean is the most widely grown pulse in Rwanda on 300,000 hectares. Both bush and climbing beans constitute an important economic income for farmers, and staple food for thousands of Ecuadorian families, and the vast majority of small scale farmers in Rwanda. Improvement of bean genotypes for Ecuador environments has a potentially significant spinoff in terms of the high potential for adaptation to Rwanda upland farming systems, which is one of the most bean-dominated production areas in the world. Smallholder farmers, many of them widows supporting families, are keenly interested in rebuilding their bean genetic stocks and expanding into new market opportunities as stability has returned to their country. Building on international bean germplasm, but particularly on the Ecuador experience and germplasm, a tremendous opportunity is present to develop and deploy improved bean varieties in Rwanda, using the latest molecular and client-oriented plant improvement techniques. An improved understanding of plant traits and genotypes with resistance to multiple stresses from abiotic (e.g. drought) and biotic (root rot and foliar pathogens) sources will provide unique materials for small-scale farmers, while providing insights into plant tolerance mechanisms for enhanced plant breeding
methods. Results of this project would contribute to improved yield, farm profitability and human resources in the host countries and indirect benefit to participating U.S. Institutions and bean producers.

**Planned Project Activities for April 1, 2008 - September 30, 2009**

**Objective 1:** Develop through traditional breeding and marker-assisted selection (MAS) a range of large-seeded Andean bean germplasm with differing combinations of resistance to major foliar diseases in contrasting bean growth habits for distribution and testing in the highlands of Ecuador, Rwanda and the Midwestern U.S.

**Approaches and Methods:**
1. Review breeding research activities, past and present in Ecuador
2. Review breeding research activities, past and present in Rwanda during in March-June growing season
3. Assemble a nursery of 20 bush types that includes collection of advanced lines in March four seed types from Ecuador and include 3 recently released climbing types
4. Increase seed in Ecuador for shipping to Rwanda prior to main planting season in September planting main cropping season. Include Andean types from the U.S.
5. Select parental breeding materials for crossing in Ecuador, Rwanda and U.S.
6. Identify select group of lines from Rwandan breeding for crossing with new introduced lines from Ecuador
7. Cross Rwandan sources of resistance for Fusarium wilt and Pythium and major foliar pathogens into large seeded lines with contrasting colors
8. Utilize markers in early-generation selection for major disease resistant traits in Ecuador
9. Initiate marker-assisted selection in Rwanda
10. Yield evaluation of advanced lines in range of seed types in Ecuador, Rwanda and U.S. Exchange of most promising materials among the three breeding programs
11. Initiate seed increase of most promising lines
12. On farm trials with advanced lines in Rwanda and Ecuador
13. Release of three bean varieties in three commercial classes for production in Michigan

**Results, Achievements and Outputs of Research:**
- Drs. Abawi and Kelly travelled to Rwanda in May 2008 to meet with HC PI Augustine Musoni, collaborators and administrators involved in the CRSP project, reviewed previous and on-going bean research in Rwanda, visited the major experiment stations around the country to observe research facilities and to assess needs, and discussed the initial project plans for 2008 with collaborators and administrators of the project. To assess the status of breeding program, a request was made for an inventory of the bean varieties released by ISAR bean program over the last 20 years. A listing of 37 released varieties in Rwanda and their characteristics is shown in Table 3. A nursery of the most popular old and new varieties was planted in Nyagatare to renew seed viability. In addition potential sources of resistance to major diseases were also identified and some of these sources and selected differential cultivars were planted to make crosses with selected commercial varieties during September/December season. The harvested F1 generation seed will be planted during subsequent seasons to make 3-, 4-way and backcross crosses to improve the local commercial lines that are susceptible to anthracnose, ALS, rust and BCMV.
- In collaboration with CRSP program in Puerto Rico a nursery was assembled from elite resistant and released lines from Ecuador, UPR, MSU and EAP and sent to the two new programs in Angola and Rwanda. The program in Ecuador provided seed of six new varieties from their program along with a F2 population that will be used to map QTL for drought tolerance. Ten nurseries of Andean or Mesoamerican origin that consisted of six different bean market classes: red mottled, red, small and large whites, pintos and sugars types; and differentials for anthracnose, angular leaf spot and rust were sent to Rwanda (Table 1). The materials were
planted in 2 replications at Nyagatare research station as observation nurseries and for the purpose of seed increase before testing widely in other locations. Local checks were planted at intervals among the introduced entries for comparison purposes.

- Forty-six growers participated in the field day in San Clemente for the pre-release of three new bean varieties in Ecuador. Sucro 23 was released as a new red-mottled variety INIAP 430 Portilla. Farmers like Portilla for its larger plant size and height, its vigor due to improved root architecture, long pods and high pod number, and excellent seed quality at harvest. Promotional material regarding the variety was distributed. In addition CIAT line AND 1005 that was evaluated and selected during the 1990’s was released as INIAP-429 “Paragachi Andino” principally for green shell market. AND 1005 has a round red-mottled seed like Paragachi but with additional anthracnose resistance. In addition, Sucro 26 was released as INIAP 480 Rocha for canario seed color and rust resistance. Roche is 15-days earlier than Canario Chota and has a high number of pods per plant (smaller plant). It exhibits high emergence rate equivalent to blacks and reds, whereas other yellow seeded types have lower emergence rates under less favorable conditions. The seed color of Rocha is little darker than Canario Chota and is preferred color in local markets. The intent is to release all three varieties officially in 2009 when adequate seed quantities have been produced and when farmers have had greater opportunity to see them in the field with different CIALs. The new varieties Paragachi Andino, Portilla and Rocha will be officially released in April 2009 to coincide with the celebration of the 50th anniversary of the founding of INIAP.

- Six large seeded red and red-mottled lines were planted for final characterization, demonstration and seed increase prior to their release next year in Rwanda. These include the bush beans: RWR 2245, RWR 1145, Nyirabukara and the climbing bean lines: MAC 49, MAC 9, and MAC 44. The lines are being considered for release for higher yield potential of up to 2t/ha for the bush and 3.5 t/ha for the climbers. The climbers also exhibit early maturity and tolerance to drought. In Rwanda, crossing is planned with new sources of resistance to major diseases and local cultivars listed on Table 3. New materials will be included in the crossing block following Nov-Feb season when lines received from Puerto Rico, Ecuador and Michigan (Table 1) have been grown and evaluated for adaptation.

- Three bean varieties released by MSU in 2008 included: high-yielding upright black bean Zorro; white mold resistant upright pinto suitable for direct harvest Santa Fe; and Otebo white bean, Fuji with resistance to BCMV. High levels of resistance to common bacterial blight (CBB) were identified in field trials in advanced navy, black, red, pink, pinto, red and white kidney lines, many of which are potential release candidates. The material represents first advanced high-yielding lines with resistance to CBB in our breeding nurseries. In addition we identified high levels of anthracnose resistance conditioned by the Co-4(2) gene in many materials. All resistances will be confirmed by screening with markers linked to resistance genes during the winter season.

- Identified marker linked to the Ur-11 gene for rust resistance. The marker is not tightly linked to the gene (12cM) but since the resistance source is highly valued by many breeding programs the marker should have wide application. Markers previously identified for the Ur-11 gene were either repulsion phase or had inconsistent expression in different genetic backgrounds. The application of the new marker still needs to be tested in a broader array of genetic backgrounds but the expectations are good given the size and quality of the band. The marker was originally linked to the Co-2 gene for anthracnose resistance and has now been shown to be loosely linked with the Ur-11 gene as it most likely identifies a resistance gene cluster on linkage group B11.

- QTL for yield that accounted for 19% of the variation was identified in an advanced black bean population. The QTL on linkage group B10 will provide opportunity to further improve yield potential in this bean class as parental material is in elite germplasm and could be transferred to other elite lines in a single cross. This is the first report of the localization of a QTL with large effect for yield in beans.
A new strain of rust was identified in Michigan in 2007 that overcomes the Ur-3 gene which is widely deployed in most MSU bean varieties. The strain reappeared in 2008 but it was not widespread. We have identified resistance to the new strain in advanced black bean lines and have mapped and tagged the resistance to linkage group B4. The new TRAP marker is tightly linked to resistance gene (3cM) and the gene may have originated in the small red bean variety, Dorado. This is the first report of a TRAP marker linked to resistance in beans. The marker should provide an opportunity to quickly introgress the new resistance into breeding populations in anticipation that the strain will continue to reappear and possibly expand. This is the first report of the breakdown of Ur-3 resistance in North America and could be of concern to breeders in other production areas.

**Objective 2:** Develop inbred backcross lines in a range of commercial seed types for testing under drought and root rot pressure in Ecuador, Rwanda and the U.S.

**Approaches and Methods:**
1. Four inbred backcross line (IBL) populations will be evaluated in growers field under conditions of drought in Ecuador
2. Identify specific populations for in depth study in Rwanda
3. Advance other IBL populations with specific drought and root rot resistance traits are being developed
4. Evaluate 120 drought tolerant lines in a range of seed types from CIAT in Ecuador; a sub-set of the best lines will be tested in Rwanda
5. Complete characterization of 80 new local traditional lines collected from growers in Ecuador to determine level of drought tolerance
6. Trials will be conducted for root rot resistance sources in Ecuador each season
7. In Rwanda two screening locations have been identified for drought based on lower rainfall levels – no irrigation available; identify field site for root rot evaluation
8. Characterize germplasm for individual root pathogens at Cornell

**Results, Achievements and Outputs of Research:**
- A large germplasm evaluation trial was conducted in the experimental root rot field at the NYS Agricultural Experiment Station in Geneva, New York. A total of 38 bean germplasm were included in this trial including 15 and 18 dry bean germplasm from the MSU and NY breeding programs, respectively. Root rot severity ratings determined at full bloom ranged from 4.0 to 6.7 on a scale of 1 (no disease symptoms observed, health roots) to 9 (most severe symptoms with root at later stages of decay). For example, the MSU lines B05055, B04554 (Zorro), N05311, and K06012 (DRK) scored 4.9, 5.0, 5.3, and 6.7, respectively. Also, B05055 was the most tolerant to CBB that occurred naturally in the plot area.
- A total of 29 dry bean lines including materials form the Ecuador breeding program were evaluated under greenhouse conditions for resistance to Rhizoctonia solani in soil artificially infested with an isolate of this pathogen. Untreated seeds were used in this test. Although there were differences in the initial emergence count among the lines tested, all become heavily infected and eventually died probably due to the heavy infestation level and most favorable disease development conditions provided. This test will be modified and repeated soon.
- A study on the genetic diversity of Rhizoctonia solani and Rhizoctonia-like fungi attacking vegetables in New York, including beans was completed recently as the M.Sc. thesis by Mana Ohkura. One of the interesting results obtained was that a number of the isolates of this pathogen recovered from vegetables has developed the ability to infect and survive on grain crops, especially corn. A recently completed experiment in the greenhouse showed that isolates of R. solani and Rhizoctonia-like fungi that are the most virulent on grain crops are also highly virulent
to beans. The latter has significant implication on the managing of diseases caused by Rhizoctonia through crop rotations and cover crop use.

- A group of 123 lines from CIAT with tolerance to drought were evaluated under stress at Tumbaco, Ecuador. 13 lines exhibiting drought tolerance were selected and 12 showed rust resistance. One line SAB 680 was particularly vigorous and well podded under the stress conditions. The selected lines will be tested further before integrating them into the program. In addition, 92 germplasm collections made in the latter part of 2007 in bean production areas in the valleys del Chota y Mira, Pallatanga y el Corazón, were planted for evaluation and seed increase. 13 accessions were selected as possible donors of genes for resistance to root rot and drought stress. In September 2008, an additional 27 new accessions were collected in the provinces of Cañar, Azuay, and Loja and will be tested.

- Four F$_5$ generation IBL populations between commercial varieties Fanesquero, Canario del Chota and Concepción and sources of drought tolerance (L88-63, RAB-651) were evaluated for tolerance under water stress at Tumbaco and 17 lines were selected of which 13 will be evaluated further next season. Other sources of drought tolerance (SEA3, SEA11, PJ1, L88-63, CO3131, NSL, A55, SEQ1016) are being used in breeding with commercial parents (Concepción, Blanco Belén, Canario Chota, Portillo, Yunguilla).

**Objective 3**: Collect and characterize pathogenic and genetic variability of isolates of root and foliar pathogens in Ecuador and Rwanda.

**Approaches and Methods:**
1. In Rwanda conduct surveys to diagnose major root diseases and collect isolates of root pathogens for characterization. Initial survey will be conducted in Northern highland production region
2. In Ecuador complete characterization of root rot isolates collected previously in both Northern and Southern production regions at Cornell and Ecuador
3. Access potential for germplasm/isolate interaction in greenhouse at Cornell
4. Collect isolates of anthracnose, angular leaf spot (ALS) in Rwanda for race typing
5. Continue race typing of rust and anthracnose isolates, and initiate characterization of ALS in Ecuador

**Results, Achievements and Outputs of Research:**
- In Rwanda, crossing is planned with new sources of resistance to major diseases and local cultivars listed on Table 3. New materials will be included in the crossing block following Nov-Feb season when lines received from Puerto Rico, Ecuador and Michigan (Table 1) have been grown and evaluated for adaptation.
- A preliminary disease survey was done during May, when the collaborating host institution scientists from the U.S. visited several ISAR stations and on farm activities in the north, south and east of Rwanda. Angular leaf spot, root rots (*Rhizoctonia, Pythium and Fusarium spp*), bean rust, BCMV were among the most noticed prevalent diseases. A larger and more detailed nationwide survey and collection is planned for November through January, 2009. Characterization of the races of the different pathogens will follow the surveys and collection of the isolates.
- The program in Ecuador continues to combine marker assisted selection and routine greenhouse screening in breeding for resistance. Under greenhouse conditions 236 F2 plants were inoculated for resistance to anthracnose and angular leaf spot (ALS) and 142 were resistant to both diseases. Plants from the cross of AND277 were also selected using linked marker, SH13 and results coincided with the greenhouse inoculation (resistant individuals had the marker). 13 populations generated for resistance to ALS were evaluated for the SH13 marker linked to the Phg-1 gene. The line AND 277 used as the resistance source and carries the gene and was crossed with the varieties INIAP-424 “Concepción”, INIAP-420 “Canario del Chota” and the breeding line G 916; 146 individuals were evaluated and 24 lines had the
marker linked to the resistance gene. The marker was present in four populations indicating the presence of the Phg-1 gene that conferring resistance to ALS. In addition 344 F2 individuals from four populations with white and yellow seed types were inoculated for anthracnose and 112 were found resistant.

**Objective 4:** Employ participatory plant breeding to assist the breeding process in Ecuador and Rwanda to enhance productivity and marketability of beans under development.

**Approaches and Methods:**
1. Design and validate sustainable farming practices including integrated nutrient and pest management systems for small farmers in Rwanda
2. Compare and contrast advanced line selection practiced by breeders and farmers in different agroecological regions in Rwanda
3. Evaluation of 10 tests in 10 CIALs each growing cycle in Ecuador
4. Facilitate non conventional seed production in Ecuador
5. Release of two bean varieties using farmer participation in Ecuador
6. Organize visit of Rwandan scientists to Ecuador to participate to interchange experience between investigators, breeding population management, germplasm banks, screening, and crossing at different INIAP research stations; interchange of experience on participatory methods and seed production for local community use with small farmer members in CIALs in Choto and Mira, Ecuador- anticipated date November 2009.

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

- Seven advanced lines including 2 check varieties were planted at Karama, Nyagatare, Rwanda. These materials were replicated in six sites on farm in collaboration with an NGO, ADRA and among the watershed partner farmers. These included advanced drought tolerant lines and different sources and of early maturity climbers being tested for adaptation in multi-location trials.
- Ten tests were evaluated with advanced lines in 7 CIALs from the Choto Valley (Imbabura y Carchi). The farmers consistently selected Concepcion and Portilla, type I large Calima type seed, and lines TP6 and AND1005, type II. The farmers selected principally on basis of plant vigor, freedom from disease, good yield and pod and seed quality. In CIAL Intaga one test was evaluated at four locations and conditions favored the presence of web blight and the lines PJ-1 and ARME 2 showed intermediate resistance to the pathogen. In addition seed increase lots of the following lines were established with CIALs in the Chota valley: TP6 (type II, red-mottled), ARME2BC2 S143 (type II, red-mottled), ARME II (type II, red mottled) and two small black-seeded types, G21212, ICA PIJAO.

**Explanation for Changes**
None

**Networking and Linkages with Stakeholders**

In May 2008, Kelly visited the Agricultural Officer, Ryan Washburn and Fina Kayisanabo, Agribusiness Specialist in the USAID Mission in Kigali to discuss the role and work of the PULSE CRSP in Rwanda and introduce HC partners Mr. Musoni and Ms. Mukeshimana. The mission is housed in the new US Embassy recently dedicated by President Bush during his trip to Rwanda in 02/2008. Mr. Washburn was quite emphatic that there would be no support for training of Rwandan nationals from the mission if the project is not extended beyond the initial 30-month startup period. The Mission in Quito is aware of
CRSP activities in Ecuador and publications of project on variety releases and bean production practices prepared by INIAP were provided to the Mission Director during visit made by PI in 2006. Government Extension, Farmers cooperatives and seed production agencies, NGO in Rwanda; World Vision, CARE, ADRA, CARITIUS, Catholic Relief Services. NGO in Ecuador; PRODECI, PRODER, CRUZ ROJA, Agricultural Organizations; COPCAVIC, 10 CIALs, Grupo de Evaluadores de Frijol de Bolivar, Assoc. de Productores de Frejol de INTAG. Government Organizations; MAGAP, INIAP, Univ. Tecnica del Norte, and Univ. Catolica de Ibarra.

Funding through AGRA from Bill and Melinda Gates/Rockefeller Foundations is being pursued by HC PI in Rwanda. In Ecuador, the national government approved the project entitled: “Investigation and development of edible grain legumes (bush and climbing bean, peas, broad beans and lentils) to aid in the food security and safety in Ecuador”. The project will strengthen research being conducted by INIAP for a four year period to increase and improve the activities in edible grain legumes as part of the strategy of food security and safety. The project started July 3, 2008.

**Leveraged Funds**

Name of PI receiving leveraged funds: Eduardo Peralta  
Description of leveraged Project: Food Security in Ecuador  
Dollar Amount: Undisclosed  
Funding Source: Ecuador

**List of Scholarly Activities and Accomplishments**

Project PI, Kelly was recognized as 2008 Fellow of Crop Science Society of America;  
Plant Variety Protection Certificate No. 200700410, was issued for ‘Sedona’ pink bean variety on 4/7/2008;  
Plant Variety Protection Certificate No. 200700411 was issued for ‘Capri’ cranberry bean variety on 4/7/2008.

**Contribution of Project to Target USAID Performance Indicators**

No information provided

**Contribution to Gender Equity Goal**

Two women students currently in doctoral training at MSU

**Progress Report on Activities Funded through Supplemental Funds**

Louis Butare from Rwanda will visit program in Ecuador to review breeding methods, germplasm, program management and participatory breeding projects under with farmers and CIALs in November. He will be accompanied by PI Kelly.

**Tables/Figures Cited in Report**

No information provided
Literature Cited

Published papers:


### Capacity Building Activities: P1-MSU-1

#### Degree Training:

##### Student #1
- First and Other Given Names: Gerardine
- Last Name: Mukeshimana
- Citizenship: Rwandan
- Gender: Female
- Degree: Ph.D.
- Discipline: Plant Breeding and Genetics
- Host Country Institution to Benefit from Training: ISAR and National University of Rwanda
- Training Location: Michigan State University
- Supervising CRSP PI: Kelly, James
- Start Date: 08/08
- Project Completion Date: 08/11
- Training Status: Active
- Type of CRSP Support (full, partial or indirect): Full (Category 1)

##### Student #2
- First and Other Given Names: Krista
- Last Name: Isaacs
- Citizenship: US
- Gender: Female
- Degree: Ph.D.
- Discipline: Ecology, agronomy, nutrition
- Host Country Institution to Benefit from Training: US and Rwanda
- Training Location: MSU
- Supervising CRSP PI: Snapp, Sieglinda
- Start Date: 08/08
- Project Completion Date: 08/11
- Training Status: Active
- Type of CRSP Support (full, partial or indirect): Partial (Category 2b)
**Short-term Training:**

Type of Training: Participatory plant breeding

Description of training activity: Organize and conduct participatory plant breeding and root/soil health training workshop in Rwanda planned for third year in 2010 but may be offered earlier in 2009 if possible

Status of this activity:
Reason if training activity not completed as planned:
When did the activity occur?:

Location: Rubona, Rwanda

Who benefited from this activity?:
Number of Beneficiaries: 30

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:** Reciprocatory Breeding Approaches to Improve Andean Beans for Resistance to E

<table>
<thead>
<tr>
<th>Abbreviated name of institutions</th>
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<th>Cornell</th>
<th>Ecuador</th>
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(Tick mark the Yes or No column for identified benchmarks by institution)

- **Review breeding program**
  - x x
- **Andean bean nursery**
  - x
- **Plant Andean nursery**
  - x
- **Selection parental lines**
  - x
- **Selection elite lines**
  - x
- **Nursery evaluation**
  - x x x x x*
- **crossing**
  - x x x x x*
- **Marker assisted selection**
  - x
- **Advanced yield trials**
  - x x x x
- **On farm trials**
  - x x x x
- **Variety Release**
  - x x

**Objective 2**

- **Advanced Population development**
  - x x
- **Test Populations in Rwanda**
  - x x
- **Other population development**
  - x x
- **Characterize CIAT resistance sources**
  - x x
- **Increase, characterize local germplasm**
  - x x
- **Characterize germplasm to root path**
  - x x x x

**Objective 3**

- **Survey root pathogens in Rwanda**
- **Characterize root rot isolates**
  - x x
- **Root Pathogen x germplasm interaction**
- **Collect foliar pathogens in Rwanda**
- **Race characterization**
  - x x

**Objective 4**

- **Visit of Rwandan scientists to Ecuador**
- **Workshop Participatory in Rwanda**
- **Evaluation of elite lines in CIALs**
  - x x
- **Variety releases in Ecuador**
- **Non conventional seed production**
  - x x
- **Farmer vs. Breeder Selection**
- **Sustainable practices, nutrient mg**

| Name of the PI reporting on benchmarks by institution | James D. Kelly | George Abawi | Eduardo Peralta | Augustin Musoni |

| Name of the U.S. Lead PI submitting this Report to the MO | James D. Kelly |

| Date | Oct. 1/2008 |

* 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:** Combining Conventional, Molecular and Farmer Participatory Breeding Approaches to Improve Andean Beans for Resistance to Biotic and Abiotic Stresses  
**Lead U.S. PI and University:** MSU  
**Host Country(s):** Ecuador and Rwanda  

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<td></td>
</tr>
<tr>
<td>Number of additional hectares under improved technologies or management practices</td>
<td>5400</td>
<td>1200+1500=2700</td>
<td>7000</td>
<td></td>
</tr>
</tbody>
</table>

*Indicators are presented for Ecuador + Rwanda =Total*