

Combining Conventional, Molecular and Farmer Participatory Breeding Approaches to Improve Andean Beans for Resistance to Biotic and Abiotic Stresses in Ecuador and Rwanda

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Abstract of Research Achievements and Impacts

The bean breeding program at MSU released a new vine cranberry bean variety Bellagio. The variety has improved plant structure, uniform maturity, resistance to anthracnose and bean common mosaic virus and excellent seed quality for canning. In statewide trials in 2011 it outperformed the commercial variety Chianti and the new variety should help recover cranberry bean acreage in the state. The breeding program continues to evaluate black, navy, red, pink, pinto, great northern and kidney lines for yield and resistance to common bacterial blight, rust, white mold, virus and anthracnose and drought tolerance. In NY, root rot screening of new germplasm from MSU and Puerto Rico was conducted in the field and selections were made and returned to the research programs for use in breeding; greenhouse screening of lines from Ecuador against *Rhizoctonia* was also conducted. In Ecuador two new bean varieties were released to farmers in the northern valleys. INIAP 483 Intag is a large-seeded red mottled type and INIAP 482 AfroAndino is a small black-seeded variety released for canning industry. The new red mottled variety Intag is the first to possess resistance to three important diseases (rust, anthracnose and angular leaf spot) and it is making impact into a broad area of the Intag Valley supported by the substantial outreach component of the program and the interest and need for new bean varieties in the region. The varieties were released through the process of evaluation and participatory selection with members of the CIALs in the provinces of Carchi, Imbabura and Intag. Ten tons of basic seed of five varieties was produced for distribution to growers in the region and the program continues to refine its non-conventional seed production in the Mira and Chota Valleys working with specialized seed growers. In Rwanda, the breeding expanded crossing program and successfully produced 10 ton of breeder and pre-basis seed of bush and climbing beans that was distributed to NGO partners and seed companies for additional seed multiplication and distribution in small quantities to small farmers. Four climbing bean varieties for high altitude zones are under consideration for release in Rwanda in 2012. The lines are white, red, and red mottled seeded types and have high yield potential (>3 t/ha) and the red line has over 90 ppm seed Fe. Two doctoral students conducted field research in Rwanda in 2011; one was screening genetic populations for drought tolerance and the other was evaluating participatory cropping systems in grower fields comparing inter-planting of climbing bean varieties with and without maize. Bulletins, promotional materials and booklets were produced in both countries to disseminate information on new bean varieties and bean production systems.

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 valuable 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 should contribute to improved yield, farm profitability and human resources in the host countries and indirect benefit to participating U.S. Institutions and bean producers.

Progress on Project Activities for the Report Period by Objectives

Objective 1: Develop through traditional breeding and marker-assisted selection (mas) in 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. Continue to select parental breeding materials for crossing in Ecuador, Rwanda and U.S.
2. Expand group of lines from Rwandan breeding for crossing with new introduced differential lines from Ecuador, MSU, UPR and CIAT/PABRA-interchange.
3. Cross Rwandan sources of resistance for bean common mosaic virus (BCMV), angular leaf spot (ALS), rust, anthracnose, Fusarium wilt and Pythium and major foliar pathogens into large seeded lines with contrasting colors.
4. Confirm resistance of selected parental lines to target root pathogen(s) including *Macrophomina* in screenhouse/greenhouse tests, as needed in Rwanda or at Cornell.
5. Utilize markers in early-generation selection for major disease resistant traits in Ecuador and conduct inheritance studies in the greenhouse for anthracnose in Yunguilla and rust resistance in JE.MA.
6. Initiate marker-assisted selection at one central lab (Rubona) in Rwanda.
7. Initiate selection for diseases resistance under screenhouse inoculation condition at Rubona.
8. Yield evaluation of advanced lines in range of seed types in Ecuador, Rwanda and U.S. and continue to exchange most promising materials among the three breeding programs.
9. Initiate characterization of biofortified lines for Fe and Zn for use as parents in Ecuador and in Rwanda.

10. Evaluate lines and varieties for canning industry in both the field and lab in Ecuador.
11. Continue seed increase of most promising lines in all three countries.
12. Expand on farm trials with advanced lines in Rwanda and Ecuador.
13. Release elite climbing and bush beans varieties in different commercial types across agro-ecological zones in Rwanda; and a bush bean variety with broad disease resistance for production in Ecuador

Results, Achievements and Outputs of Research

- Foundation seed increases of the new vine cranberry bean variety Bellagio, released by the MSU breeding program, were produced in the western US in 2011. Bellagio is full-season variety with resistance to anthracnose and mosaic virus. The plant type is less decumbent than the current vine varieties, and it produces a large (55g) round seed with excellent canning quality. The seed type would have commercial appeal in both Ecuador and Rwanda. A group of anthracnose resistant cranberry breeding lines from MSU was sent to Rwanda and Angola for testing in 2011.
- A total of 5600 plots were harvested for yield and over 2600 single plant selections were made in the early generation nurseries as part of the MSU breeding program activities in 2011. Three new lines in three different market classes (pink, pinto, white kidney) are under consideration for release in 2012; based on continued high performance of upright full-season pinto line P07863 with white mold avoidance, early-season white kidney K08961; and an upright pink line S08418 with good seed color. Sources of common blight resistance were identified in advanced kidney and cranberry bean lines.
- Research continues to develop a stable transformation system for common bean. Progress has been slow and the research is no longer being handled as a student project and has been fully assigned to the Plant Transformation Center as a research objective.
- The bean breeding program in the Rwanda Agriculture Board (RAB, formerly ISAR) increased the number of crosses in 2011. More than 200 single and backcross crosses were made during this reporting period to incorporate multiple resistances to anthracnose, angular leaf spot, bean common mosaic virus and/or micro-nutrients, Fe and Zn. The populations were created using some of the differential cultivars as sources of resistance against bean rust, angular leaf spot (MEX 54), anthracnose (G2333) and BCMNV (USCR-7, USCR-9).
- In other cross combinations, 10 crosses with novel and unadapted Fe sources that were acquired through CIAT were developed. 150 F1/BC1 simple, double and 3-way crosses were initiated. An evaluation of new high iron bean populations introduced from CIAT headquarters last year and further screening of rich micronutrients (Fe and Zn) advanced lines were undertaken at Rubona, Rwerere, and Karama stations.
- Different lines have been evaluated as high iron content at different sites both on RAB research stations and farmer fields. These trials were set in two groups. The first group include preliminary yield trials (PYT) with an evaluation of 104 biofortified bush bean lines introduced from CIAT at Rubona station; an evaluation of 182 biofortified climbing beans introduced also from CIAT (under observation nursery) both in Rubona and Rwerere station; the second group that include an evaluation of 13 advanced high iron content bush bean types. 28 high Fe content and drought resistant varieties were evaluated in a preliminary yield trial (PYT) at Rubona station. Among these lines 14 lines were selected in the advanced yield trial (Phase I) in this cropping season (2012A) at three sites.
- The phenotypic evaluation of 125 RIL population from the cross of SEA5 x CAL96 was

conducted by Gerardine Mukeshimana in Rwanda for two growing seasons (Nov., 2010 to March 2011 and April to July, 2011). The experiments were located in dry-land research stations at Karama and Nyagatare. Both irrigated versus non- irrigated treatments were applied at both locations. Experiments in Nyagatare were lost due to necrotic strains of BCMNV and root rot diseases. Geometric yields ranged from 428 to 2342 kg/ha and phenological and harvest index data were also collected for use in QTL analysis.

- The same RIL population is being genotyped at MSU with Simple Sequence repeat (SSR) markers with the goal of mapping QTL associated with drought resistance in beans. Parents were screened with 460 SSR markers of which 148 were polymorphic representing a polymorphism level of 32 % between the parents. The genotyping of the entire mapping population is being conducted. The population has already been evaluated with 74 polymorphic primers.
- Thirty-five bush bean lines for canning were introduced from CIAT Kawanda (Uganda) and evaluated at Rubona for adaptability and further seed increase. These lines are under test this season at two new sites, Mutara and Bugesera. Confirmation of their canning quality will be done later when sufficient quantity of seeds needed for the test will be available. We are waiting to receive the working collection of traditional canning (navy beans) from Ethiopia to be evaluated in Rwanda.
- The characteristics of the four new varieties (RWV3316, RWV3006, RWV2872, and RWV236) planned for released in Rwanda in 2012 are shown on table 1. They are well adapted to highland of Rwanda, their yield potential is high (>3.4 tons per ha) and they meet farmer preferences in terms of seed size and color. Results from two different labs showed that some of the advanced lines and will be released in 2012 B season as high iron content lines. The best line based on the iron contain was RWV3316. This variety was generated from a cross (CAB2 x LAS400) of CAB2 (white seeded) and LAS400 (a large seeded red bean variety). The micronutrient concentrations of RWV3316 are 93.0 ppm for iron and 31 ppm for zinc.
- Increasing seed of bush and climbing beans identified as micronutrient (Fe and Zn) rich lines among the ISAR improved varieties was planned to facilitate the dissemination of these new bean varieties. The lines involved in this seed increase were RWV3316, RWV3006, RWV2872, RWV2361, RWV1129, MAC44, and RWR2245. The target for seed micronutrients is over 70 ppm for iron, and over 30 ppm zinc.
- The program identified three bean varieties (MAC44, SER 16, and SER30) with moderate levels of drought resistance from among the 15 recently released lines (Listed in table 1. in 2010 annual report). About 150 kg of breeder seed have been produced for each variety this cropping season in Nyagatare. At the three research stations (Nyagatare, Karama and Ngoma) the program produced about 1,000 kg of foundation seed for each variety to be distributed to farmer associations involved in seed multiplication.
- On May 31, 2011 the National Grain Legume (PRONALEG-GA) team in INIAP, Ecuador launched the first bush black bean variety Afroandino – INIAP 482 in Tumbatú (Carchi) Chota Valley. Afroandino is a small seeded black bean that originates as the CIAT line A55 (INT272 x INT244). The line was introduced to Ecuador in 1998 and from 2005-08 was evaluated in Tumbaco for resistance to different root rot diseases (*F. solani* and *F. oxysporum*). In 2008 the line was evaluated by growers in CIALs and chosen for its adaptation, yield and seed quality. In 2010 it was released to growers as the first black bean variety released by INIAP for direct consumption or for use in the local canning industry.

The variety is resistant to anthracnose, root rots (2.1 vs 6.1=S), and yield averaged 1.6 t/ha over seven locations compared to 1.3 t/ha for the local check.

- The new large seeded red-mottled variety INIAP 483 INTAG with resistance to three foliar diseases was released by INIAP in 2011. Intag was derived from the backcross (Concepción */ G916) made in 2003 at the Experimental Farm Tumbaco. In the F2 generation selection was made from eight individual plants and the best three progenies were selected in the F3. In 2005, the three F4 lines were evaluated and the line Concepción */ G916 -1 was selected as the most promising. In 2006, the F5 line was evaluated in adaptation and performance tests, and was selected for long pods and large red-mottled seed. In 2008 and 2010 the line was evaluated for resistance to angular leaf spot and rust in the valley of Intag, Tumbaco and Concepción. The line was resistant to the two pathogens in all locations, while the control variety Concepción was susceptible to angular leaf spot and intermediate resistance to rust. In addition the Concepción */ G916 -1 line produced an average yield of 1.6t / ha greater than the control with 1.0t / ha. In 2007 and 2008 the same line was selected by the participatory Local Agricultural Research Committee (CIAL) in Intag (Imbabura). During 2009 and 2010, seed of this line was increased by the same CIAL and on September 9, 2011 in a field day "Tollo Intag" the variety was officially handed over bush bean producers in the area of Intag as the improved variety of bush bean variety INIAP 483 named Intag. Two leaflets describing the new varieties available for distribution and the pdf file can be viewed @<http://www.iniap.gob.ec>
- The breeding program in Ecuador continues to combine resistance to rust, anthracnose, angular leaf (ALS) and Fusarium wilt in all new breeding materials, using double and triple crosses combined with cyclic selection in a range of selection environments, both on station and in growers' fields. Crosses were made using varieties and promising lines of commercial seed and parents of Mesoamerican origin for resistance to rust, anthracnose and ALS. At harvest, individual F2 plants were selected and 66 F3 progenies derived from crosses for resistance to *Fusarium oxysporum*, (derived from resistance sources CMR 27, CMR 20 and TP6), were combined with susceptible varieties Portilla, Concepción, and Paragachi Andino. At harvest, 23 progenies were selected that exceeded the controls in plant vigor, resistance to rust, pod load and performance. In the next cycle, the 23 progenies were re evaluated and eight lines were selected for resistance to rust, *Fusarium oxysporum* and *Empoasca*, good vigor of growth, overall yield and grain quality. In addition to selecting bush types, selections with type II growth habit in red mottled seed color were identified with high levels of resistance to rust and anthracnose and to *Empoasca*, good pod load, seed quality and yield.
- Seed increases were initiated on the following promising red seeded bush bean lines: BRB 195, ICA QUIMBAYA, INIAP 402, DRK BRB 194 and 105; black seeded Condor, and AFROANDINO; red mottled line; S143 (Yunguilla x POA 10) -3; and four top promising lines with multiple disease resistance (AMPR3XCAL143) 1F2-1F4 (AMPR3XCAL143) 1F2-3PF4, (AMPR5XCAL143) 4F2-1F4 and (AMPR5XG916) 2F2-7PF4. Seed of all new and old varieties: Intag, Portilla, Paragachi Andino, Chota, Rocha, Rojo del Valle, Guarandefío and Conception continues to be multiplied for distribution to the CIALs.
- In the Department of Nutrition and Quality at INIAP twelve bush bean genotypes were assessed for the canning process by applying heat treatment and evaluation based on physical parameters, nutritional and sensory properties. Based on analysis of crude seed, Condor had the lowest hardness (3.6 mm) and the highest protein content (30.0%); NSL had the highest starch content (74.5%); G21212 the highest content of anthocyanins (534 mg /100g beans)

and the higher iron content (89.2 ppm); BRB 195 the lowest tannin content (139 mg/100 g beans); and ICA Quimbaya had the highest zinc content (46.9 ppm). Soaking in the trial determined that the rate of hydration was related to seed size. The very small size took 2 to 3 hours to reach the proper moisture ratio (1.8) to start the thermal seed processing. Small seeds required between 3 to 5 hours, the medium from 5 to 7 hours and large-seeded genotypes reached optimal hydration ratio of 6 to 8 hours. At the end of soak period, the seed reached between 49 to 55% humidity. The thermally processed grain was characterized for physical, chemical and sensory properties. Canning brine with CaCl_2 produced the best seed size characteristics, greater hardness, better color characteristics, lower viscosity and solids suspended in the liquid of lesser degrees of failure and degree of agglomeration of the seed, lower drained weight, higher protein content, starch, anthocyanins, tannins, iron and zinc, lower moisture content. Brine without Ca exhibited opposite characteristics. Acceptability analysis revealed that genotype BRB 194 showed the highest preference among the panelists. This material also had the highest total weighted score required for canning. An economic analysis of pilot plant level, determined that the unit cost of producing each unit of processed product is equal to \$ 1.03. The calculated return on equity was 17.8% and 10.7% of total investment.

- Flour quality of six bean genotypes was assessed in three stages: first, the milling quality was assessed using three pre-treatments (toasted, seed conditioning and seed coat removal) in order to determine the best yielding bean flour; the functional and rehydration properties of the flours with higher extraction rate were assessed; and quality parameters of various formulations with different levels of substitution in flour-based bean biscuits. The pre-treatment with the higher flour yield (67 - 75%) came from the preparation, in which the bean seeds were soaked at 50 ° C for a period of two hours, steam cooked for 5 minutes, dried at 60 ° C to 14% moisture and subjected to milling. Flour was selected from Portilla after analyzing the functional and hydration properties of flour. The flour contains 25.7% protein, 10.6% amylose and 89.3 % amylopectin with high falling number greater than 400 seconds. Bean flour mixtures with different levels (5, 10, 15, 25 and 50%) of substitution with cereals were tested to produce biscuits. All formulations showed a pseudoplastic behavior so the sensory analysis of biscuits was made from mixtures with higher content of bean flour. Levels of 25 and 50% did not significantly alter the color and aroma of the biscuit, while substitutions above 25% produced noticeable changes in flavor and texture.

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. Evaluate specific populations developed at CIAT and MSU/Ecuador at two sites for reaction to drought and non-stress in Rwanda.
2. Continue with the selection of lines with tolerance to drought and root rots in Ecuador
3. Evaluate sub-set of best drought tolerant lines from thesis study of Louis Butare at two locations in Rwanda; and from other sources.
4. Continue characterization of new local traditional lines (bush, climbers) collected from growers in Ecuador to determine level of drought tolerance and root rot in Tumbaco.
5. Complete survey to identify field sites for root rot evaluation (Pythium, Fusarium wilt and

Macrophomina), and initiate screening of promising germplasm in Rwanda. Field identification will be accomplished by surveys or bioassay of soil samples with beans (known to be susceptible to target pathogens) in greenhouse/screenhouse tests.

6. Field trials and greenhouse screening will be conducted to identify root rot resistance sources in Ecuador and Rwanda.
7. Characterize germplasm for reaction to individual root pathogens at Cornell using selected promising germplasm for Rwanda, Ecuador, MSU and TARS (UPR).

Results, Achievements and Outputs of Research

- 100 Recombinant Inbred Lines (RILs) from an interspecific cross of common and runner bean for drought and aluminum toxicity resistance were introduced in Rwanda in 2010. The material originated as part of Louis Butare's doctoral research at CIAT headquarters. The RILs were evaluated several times at Rubona and Nyamagabe research stations, and selected lines have now been evaluated in PYTs.
- From 15 lines (Mesoamerican bean genotypes, small red) in another trial evaluated in 2011B cropping season at Karama station, six varieties (SER51, SER101, NCB275, SAB659, SER83, and SER111) were selected and submitted to further evaluation using on farm Participatory Variety Selection (PVS) approach in multi-location trials. Phenotypic description of these six lines will be undertaken and their potential yields on farmer field conditions will be determined.
- Greenhouse experiments at MSU conducted by Gerardine Mukeshimana to identify bean lines with higher levels of drought tolerance in the shoot were concluded in 2011. The test used small pots to restrict root growth in order to identify those genotypes with tolerance in the shoot. Cultivar B98311 which has a deep tap root that sustains it through intermittent droughts was the more susceptible in this study based on the above variables. The capacity of seedlings to set pods after the recovery from the drought was determined. Cultivars Jaguar, Phantom, and Blackhawk did not show any difference in pod number under both stress and no stress while Jaguar and TARS-SR05 did not show a significant loss of biomass under both treatments. It is hoped to better separate root and foliage responses to drought so that these can be combined into a single cultivar to further enhance tolerance to drought.
- The mapping population (CONCEPCIÓN * 2/RAB651) was sent to Rwanda for an initial seed increase. The population will be evaluated under moisture stress in Rwanda in 2012 to identify QTL for drought tolerance. Problems with BCMNV are not expected to compromise this study of this population in the field in Rwanda as the dominant I gene may be protected in this cross. In the interim, genotyping of the parental lines with SSR markers continues.
- Field evaluation of bean breeding lines and germplasm for root rot resistance in New York: A replicated field trial consisting of 34 advanced materials provided primarily by Drs. J. Kelly and T. Porch were established in the bean root rot nursery at the Vegetable Research Farm, NYSAES, Cornell University near Geneva, NY. Twenty of the materials included in the 2011 evaluation were included for the first time, whereas the others were advanced from the previous evaluations. These bean lines differed significantly in their reaction to root rot pathogens when determined at the full flowering stage. For example, the average root rot severity ratings of CLR Kidney, TARS-RR-2011-5, TARS-RR-2011-2, B04554 (Zorro), and P07863 (pinto being considered for release) were 6.0, 3.4, 3.6, 3.4, and 3.4, respectively on a scale of 1 (no disease symptoms, healthy) to 9 (>75% of root and stem tissues affected and at later stages of decay). These results were similar to those obtained from the 2010 field trial

(BIC 54: 142 – 143). The tested lines also exhibited significant differences in their reactions to common bacterial blight and vigor. Seed yield of a number of the promising lines is currently been completed and summarized.

- Cover crops for managing root diseases of beans and other agronomic crops: An on-going collaborative project is assessing the efficacy of selected cover crops (rye grain + hairy vetch, oat, sudex, forage radish, red clover, rapeseed, buckwheat, wheat, and a fallow check) in suppressing root pathogens, including *Fusarium*, *Pythium*, *Rhizoctonia*, *Thielaviopsis*, *Pratylenchus* and *Meloidogyne*) and improving yield as well as soil health and quality. The replicated cover crop treatments are arranged in large strips (4.5 x 60 m) and replicated 3 times per evaluation field. Four fields with different previous management histories and root disease pressure were been used in this investigation. Bean cv. Caprice was machine planted in all the cover crop plots in early June 2011. In general root rot severity was lowest and yield of bean was highest in the field with the highest soil quality and lowest disease pressure. In this field, bean yield was highest in the rye+vetch cover crop and lowest in the buckwheat cover crop plots. All the cover crop treatments were re-established in Sep. 2011 for another cycle of evaluations in 2012.
- Long-term tillage, rotation, and cover crop trail (soil health site): this collaborative site of the Cornell soil health team was planted to beans in 2011. The trial consists of about 14 acres divided into a total of 72 plots (18 treatments replicated 4 times). The treatments are represented by three tillage systems (no-till/ridge-till, zone-till, and plow/conventional-till), three cover crops (no cover, rye grain, and vetch), and two rotations. One rotation includes primarily high value vegetable crops (R-1), whereas the second rotation also includes season long soil building crops (R-2). The no-till system is converted to a ridge system whenever the plots are planted to direct seeded vegetable crop in R-1. The 2011 season was characterized by a very wet spring that delayed planting, a very dry mid-season (June-July) and then a very wet late season/fall. Interestingly, we were able to machine harvest beans in the zone-till and no-till plots without much difficulty, but not the plow-till plots? We had to hand-harvest a number of the beans in the plow-till plots, as the harvester was getting stuck and extremely rutting and compacting the soil. The latter clearly indicated the benefit of the reduced tillage systems under such wet weather conditions. The data is still been analyzed, but the yield of beans was highest in the ridge-till system, in rotation R-2, and after vetch. The trial is continuing and data will be collected on root health, soil health indicators, and other parameters.
- Evaluation of selected pea varieties for resistance to root pathogens: Root rot diseases of peas are prevalent and damaging to peas. In recent years, disease symptoms commonly observed on roots of infected plants in New York were those of *Fusarium*-root rot and less frequently symptoms of *Fusarium*-wilt. However, symptoms of infections caused by *Thielaviopsis*, *Pythium* and *Aschochyta* were also observed at times. Recently, large number of varieties and promising lines were evaluated in commercial fields with known histories of severe disease incidence and also in greenhouse tests using naturally infested soil. In 2011, a total of 47 varieties and lines were again evaluated in the greenhouse. Root rot severity ratings varied greatly among the peas tested, ranging from 8.8 to 3.3 on the 1 (healthy) to 9 (most severe, dead) evaluation scale. June, Marias, BSC 3048 generally exhibit the most susceptible reaction, whereas Boogie, Pendleton, and Lil'mo were among the most tolerant.
- Thirteen RILs previously selected under normal irrigation were evaluated for pod load growth and reaction to rust, Empoasca and seed quality. The same selected RILs plus two

checks were evaluated under two treatments with and without drought stress. The trial under drought stress was watering every 15 days and no stress test was normal watering every eight days. Vigor data were taken and pod load at harvest number of pods per plant, number of grains per pod and dry grain yield. Under drought stress, obtained yields 10 lines between 1.7 and 2.0 t / ha while the Portilla and Concepción checks yielded 1.6t / ha. Under normal watering every week there was no difference in performance between the lines and the control.

- Twenty-eight black bean lines were subjected to terminal drought (drought stress from pod-filling). Pod load data were collected, plant health and seed yield. Under these parameters 10 lines were selected for high performance and plant health, superior to the control Afroandino. All 10 lines were superior in performance to the check Afroandino. They were also resistant to *F. oxysporum* and drought tolerant. Five lines were selected based on superior performance, rust resistance and vigor.

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

Approaches and Methods

1. Continue surveys to diagnose major root diseases in Rwanda and collect isolates of root pathogens for additional characterization.
2. Maintain the collection of root rot isolates previously collected in different production zones of Ecuador.
3. Further characterization of root rot isolates collected previously in both Northern and Southern production regions of Ecuador at Cornell and/or Ecuador.
4. Phenotypic evaluation of Rwandan germplasm for resistance to local isolates of anthracnose, ALS and BCMV under field conditions, greenhouse and MAS.
5. Continue the collection of isolates of anthracnose, and ALS in Rwanda and Ecuador from diverse agro-ecological zones for race typing.
6. Increase seed of the differentials for anthracnose, ALS and rust in Rwanda; and continue characterization of ALS in Ecuador. Continue race characterization of Fusarium wilt pathogen and the aggressiveness of isolates of *Macrophomina*, *Rhizoctonia*, and *F. solani* will be conducted on selected bean germplasm.
7. In Rwanda, document and summarize past studies on mapping and/or variability of Fusarium wilt, *Pythium*, ALS, anthracnose by CIAT/ISAR and MS theses since many of the studies are in French.
8. Continue to document and publish results of recent and on-going breeding activities in Rwanda.

Results, Achievements and Outputs of Research

- Anthracnose was a problem in Michigan in 2011. Isolates were collected from growers' fields and all typed out as race 73. Adequate levels of resistance to this MA race are present in current cultivars, but farmer continue to plant 'bin-run' seed of susceptible varieties with having it verified to be disease free. The problem is most obvious on white beans as the anthracnose lesions are quite noticeable but is less obvious on black beans where the problem continues to persist. New navy and black bean lines with resistance to anthracnose are currently being evaluated in yield trials.

- Rust was collected again from bean fields in Michigan, but it was more widespread and severe in 2010. The strain is similar to that collected over the last three seasons. The new strain characterized as race 22:2 defeats many of the current resistance genes deployed in MI. A similar race 20:3 was recently detected in North Dakota. Resistance has been identified in elite MSU black and navy bean germplasm and crossing has been initiated to transfer resistance. Given the persistence of this race an extensive screening of all MSU germplasm is being conducted in the greenhouse this winter. A new rust strain was recently reported in the high Great Plains region of Colorado and Nebraska, but no information on race type is currently available.
- The collection of new samples of leaves, roots infected with major pathogens (angular leaf spot, bean rust and anthracnose) has been a continuous activity in Rwanda since 2009. This activity has been ongoing mainly in the east and southern Rwanda. To date races 27 and 55 have been confirmed and race 3 is a tentative observation.
- Four new races of anthracnose (256, 300, 384, and 387) collected in the localities of Urcuquí, Mira and Pimampiro were characterized and the *Co-4*² and *Co-5* genes offer good levels of resistance to these races. A single race of angular leaf spot 62:0 was collected at three locations in Urcuquí, and Intag. This a highly virulent race on Andean beans, but it can be controlled with Mesoamerican germplasm.
- Fusarium wilt is becoming increasingly serious disease in many bean production areas of Ecuador. In addition some of the most recently released varieties such as Portillo have proven to be susceptible to the disease in certain localities. The program initiated the collection of isolates of *Fusarium oxysporum* in the localities de Urcuquí, Pablo Arenas and Intag. Some of these isolates did not prove to be pathogenic so additional collections will be made in order to have a virulent isolate for greenhouse screening. Dr. Abawi is assisting the local pathologist with the process of isolate identification and screening methodologies, as field screening at Tumbaco is limited to specific region of the farm where the pathogen currently is localized. The program continues to make good progress in selection for resistance to Fusarium wilt. The program has identified a hot screening site at Tumbaco where high levels of soil borne pathogen exist and allows for early generation screening to detect resistance.
- Efforts were made to develop and standardize inoculation methods for screening for ALS using detached trifoliolate leaves in Petri dish. Symptoms develop in 15 days after inoculation compared to delayed symptoms of 30 days on the intact plant. In order to standardize the protocol advanced lines with known resistance were inoculated to test the protocol. Additional work is needed to satisfactorily standardize the method which shows considerable promise for saving both time and resources.
- Since rust and ALS are highly variable pathogens, testing must be conducted at different locations in Ecuador to confirm resistance and identify new sources of resistance. Testing of 31 sources of resistance to ALS and rust using natural inoculation was conducted in the town of Peñaherrera (1800 m) in the Intag valley (new production area). The nursery was made up of Andean lines and varieties generated by the breeding program and CIAT. Eleven lines generated by the breeding program and 15 from CIAT were highly resistant to ALS, and 18 lines were resistant to rust with reactions from 1 to 3 on a scale of 1 to 9=S.
- The inheritance of resistance to rust in the JeMa cultivar was evaluated in a population of 165 F2 seeds derived from cross with AND277 (susceptible to rust) inoculated with rust race 0:61. The results suggest the presence of a single gene based on 130 resistant and 35

susceptible individuals. In order to confirm the 3:1 segregation ratio, F3 families will be evaluated and additional crosses with JeMa/ Red Small Garden(S) will be tested.

- Six promising lines were selected with combined resistance to rust, anthracnose and angular leaf spot in Ecuador. Angular leaf spot was evaluated in the field (La Concepcion, Carchi) and confirmed in greenhouse tests along with reaction to specific races of anthracnose; and rust was evaluated in the field at Tumbaco. The selected lines showed high genetic resistance to all the three diseases in comparison with the check Portilla which was susceptible to angular leaf spot and had an intermediate resistance to rust.
- Another objective of the visit to Rwanda in May, 2011 was to expand the survey to access the major soilborne pathogens and other pests impacting bean production in Rwanda in collaboration with the members of the national bean team. Again, the bean fly and BCMV were observed predominately during this trip, suggesting the need to devote more efforts for their management. Root diseases observed in the various research sites and growers fields visited were primarily Fusarium-cortical rot, Pythium-root rot, root-galling by the root-knot nematode, and a low incidence of Sclerotium-rot. In-country evaluations of bean germplasm against these pathogens and those observed previously (Macrophomina and Rhizoctonia) were suggested.

Objective 4: Employ participatory plant breeding and agroecological methods to assist the breeding process in Ecuador and Rwanda to enhance productivity and market quality of beans under development.

Approaches and Methods

1. Compare and contrast advanced line selection practiced by breeders and farmers in mid-altitude and high agroecological regions in Rwanda
 - Plan genotype by environment farmer participatory assessment of advanced lines within intercrops and sole crops, initiate trials in 2011 and terminate in 2012.
 - On-farm assessment of promising lines conducted in sole crop and intercrop on-farm trials at 8 sites in 2011/12.
2. Evaluation of 17 tests with 17 CIALs each growing cycle in Ecuador.
3. Expand non-conventional and conventional seed production in Ecuador and Rwanda.
4. Release two bush beans and one climbing bean in Ecuador using farmer participatory approach.
5. Continue to provide seed of elite and new varieties for post harvest quality evaluation at KIST.
6. Continue with farmer participatory approaches to identify appropriate and cost-effective innovations for staking climbing beans that would enhance the adoption in Rwanda.
7. Organize a visit of scientist(s) from Ecuador to Rwanda to interchange experiences on population management, germplasm bank, evaluation of early generation materials at different stations; interchange of experience on farmer participatory and seed production. (Depending on additional funding from CRSP).
8. Initiate interchange of experience in Rwanda on participatory methods and seed production for local community use with smallholder farmer members anticipated date Feb 2012. Training of trainers (extension, research technicians, NGO staff, expert farmers, seed company technicians) on seed and farming system production, and work with progressive farmers.

9. Draft a manuscript by August 2012 for review at Rwanda workshop and circulate for comment and input by collaborators. Based on initial on-farm assessment in Rwanda and literature review outlining strengths and challenges associated with sole crop vs. intercrop bean based cropping systems, in terms of plant breeding approaches and addressing farm family nutrition.

Results, Achievements and Outputs of Research

- Experimental research on cropping systems and bean varieties were conducted in northern Rwanda using a mother-baby-grandbaby trial system. In season 2011B (Feb-July) two on-station genotype by cropping system x environment “mother” trials were planted in northern Rwanda at ISAR Station Musanze and ISAR Station Rwerere with the objective of determining how genotypes perform differently under different cropping systems across different environments. Each on-station trial had four replications. Eight more single replications, or “baby” trials were planted on farmer fields with farmer associations in the sectors of Gakenke, Burera, and Muko for a total of 24 replications. One replication consisted of 14 plots. Bean genotypes RWV 3006, RWV 2070, RWV 3316, Gasirida, and double controls of Ngwinurare and a local mixture were each planted as sole beans and intercropped with PL9A maize variety. A plot of sole maize and a plot combining the local mixture and maize in a traditional mixture were also included. Data on yield, agronomic traits, leaf area index, canopy cover, and soil samples were collected at each site and plant biomass for total N analysis was collected from the research station trials.
- On-farm trials had the additional objective of understanding farmers’ preferences for cropping systems and bean varieties in a given system. At each farmer field site participatory variety selection was used near the end of season B to evaluate cropping systems and bean varieties under monocropping and intercropping. Approximately 105 farmers (71 women, 34 men) participated.
- In season 2012A (Sep 2011-Feb-2012) the same trials were replicated on-station and on-farm. Data collection is ongoing. Farmer discussions and evaluations from the first season indicated farmers were not satisfied with the design of the intercropping system. As a result we initiated the “grandbaby” phase of the trials with the objective of encouraging farmers to experiment and identify satisfactory cropping system designs. After discussions on experimentation with six associations, farmers chose two bean varieties from our baby trial to plant in an intercrop and a monocrop. They also planted a monocrop with the local mixture. Approximately 70 farmers participated. Design and yield data will be collected with farmers from each grandbaby site and participatory evaluation of the trials will be carried out at the end of the season.
- Survey and short structured interviews are being carried out in Season 2012A to collect data on the grandbaby trials, farmer preferences for cropping systems and bean varieties, socioeconomic status, and the effect of land use policies on farmers’ ability to experiment.
- A participatory workshop will be carried out at the end of season A with practitioners in plant breeding and agronomy. Participants will gain an understanding of theory, and new methodologies in participatory breeding and agronomy for improved bean-based farming systems. Focus areas will include: Trial designs, focus groups and practical tools that take into account livelihoods and sustainable production, including conservation and nutrition aspects of client-oriented research.
- About 44 lines combining drought and heat tolerance resistance with high mineral density

and high yield potential were subjected to participatory variety selection (PVS) in Rwanda. These lines were evaluated in two separate Genotype x Environment (GxE) trials. Twenty-one biofortified bush bean lines introduced from CIAT Kawanda evaluated for the first time in Rubona (season 2011A) on two more sites including the Districts of Muhanga and Ngoma. Another GxE evaluation was conducted with 23 climbing bean lines at Rubona, Muhanga, Rwerere, and Karama. For all these Genotype x Environment interaction evaluations, farmers were invited to participate using their criteria of preference in this selection process.

- Two field screening trials under drought stress were conducted to evaluate advanced bean varieties for yield potential through participatory plant breeding process at Karama research station. The total number of lines tested was 29, and from this set six lines were selected to be tested under multi-location trials on stations and on farm (Karama, Nyagatare, and Ngoma).
- To enhance the availability of seed and adoption of new improved varieties by farmers in Nyagatare, Gatsibo and Kabarore Districts in Umutara (Eastern Province), more than six tons of new bush bean varieties (RWR 1668, RWR 2245, RWR 1180, RWK 10) that are adapted to the region for their early maturity, desirable seed types and high yields (2.0 – 2.5 ton ha⁻¹) were multiplied. They were distributed to farmers in the districts directly by RAB or through RAB NGO partners based in the region, such as ADRA or through farmers' cooperatives. By using the small packaging of seed and loan distribution strategies, an estimated 6,000 farmers benefited from this seed multiplication and distribution exercise. Further seed quantities were used for secondary multiplication by the partners for eventual distribution to more producers.
- In all RAB stations, about 10 tons of breeder and pre-basic seed of the pre-released and released bush and climbing beans mentioned above were produced on research stations. Seed was sold and distributed to farmers and farmers cooperatives; NGOs such as ADRA and Seed companies: Win-Win and RWASCO, Urugaga-IMBARAGA, DRD, DERN, AFRICARE, CARITAS, COAMV, UNR (Facagro), TUBURA (Local Ngos) and PADAB partners for secondary seed multiplication and distribution to more producers.
- Evaluation and participatory selection of bush bean germplasm with local CIALs continued in Ecuador. In the town of La Concepción, eight lines with resistance to three diseases (rust, anthracnose and angular leaf spot) plus four checks (two resistant and two susceptible) were evaluated by members of the CIAL for plant and seed traits. Farmers selected four lines for planting in various fields in the next cycle. In the next cycle, CIAL members selected lines (X AMPR3 CAL143) - 1F2 - 1F4 (X AMPR3 CAL143) - 1F2 - 3PF4 and (X AMPR5 CAL143) - 4F2 - 1F4 and it is expected that the best single line for variety release will be identified in the next cycle.
- In the two growing cycles 10 t of basic seed of five varieties was produced. Six seed-producing CIALs in the Mira and Chota Valleys, multiplied seed of four bush bean varieties: Portilla (4500kg), Conception (450kg) AfroAndino (2835 kg) and Paragachi Andino (495kg); and the CIAL in the Intag Valley produced seed of the new Intag (1530 kg) variety.
- In Huigra (1300 m), Chimborazo, 10 bush bean varieties were planted at the request of the Grower Association Lucmas. Participatory assessments were performed on the plants, and most of the varieties were superior to the local controls. This was the first time that local farmers were introduced to INIAP varieties and researchers.
- In Cañar, five quintals each of Portilla and Rocha varieties were planted and evaluated at pod filling. Varieties showed good adaptability and farmers were content for the reintroduction of beans after 16 years since the crop disappeared from this region. Seed of bush varieties was

planted, multiplied and distributed to farmers in the province of Loja in the south (Zapotillo Farm).

- The important health benefits of beans were promoted during the preparation of the world's largest stew in San Miguel de Porotos (Cañar) following a 10 K road race where the prize was the bean stew. Seed of bush beans was sent to low-lying areas and next year a bean fair is planned to exhibit agricultural biodiversity and help with the recovery of climbing bean material that was lost due to drought and habit of consuming in these regions

Objective 5: Training

Degree Training

First and Other Given Names: Doctoral Training

- Gerardine Mukeshimana, Citizenship: Rwandan – Major Professor – Kelly; Program started August 2008; Research focus will be on the development and study of drought tolerance in beans and part of the work was conducted in Rwanda. (Research progress reported herein). She successfully completed her comprehensive examination and conduct field trials in Rwanda in two seasons 2010-2011. She was successful in securing a Borlaug LEAP fellowship which will provide her support to travel and conduct additional research work at CIAT and in Rwanda in 2011-2012. Expected conclusion date – Sept 2012.
- Krista Isaacs, U.S. - Major Professor – Snapp; Program started August 2008; Research focus is on agrodiversification of bean-based cropping systems and nutrition, and part of the research work will be conducted in Rwanda. Krista Isaacs successfully concluded her comprehensive examination and travelled to Rwanda in Jan 2011 to initiate field work – partial support from Fulbright fellowship. (Research progress reported herein). She plans on concluding two field seasons in March 2012 and will graduate later in 2012.

Non-degree Training – Extension Activities

- A booklet with promotional materials has been developed and 5,000 copies printed and distributed to Rwandan farmers and other related producers. The booklet promotes the bean production chain.
- Training on seed multiplication (for 28 participants including researchers and technicians from RAB research and extension programs) have been conducted in order to build their capacity in seed multiplication, increase the qualities of seed produced, and build a common understanding of some guidelines in the domain. Those technicians are supposed to train farmers and other technicians from collaborators institutions and Community based organization (CBOs).
- A bean stakeholder meeting was organized in Rwanda as a starting point in the establishment of an innovation platform for bean producers and traders. Participants from different organizations attended the meeting including privates sectors working in seed production and commercialization (RWASECO and Win-Win), International and local NGOs (Africare, DERN, DRD, CSC). Farmer associations and individual farmers were also represented. Key speakers for this workshop were CIAT scientists including Claude RUBYOGO, Eliud BIRASHI, David WETAKA Wozemba; and Senior scientists from RAB, Grace Akao (Seed specialist), and Enock (AGRA seed specialist). Discussions were focused on the following themes: Updates on bean breeding in Rwanda, seed system, role of ISAR seed program in promoting improved seed uptake and linkages with stakeholders in the seed industry; updates

on Rwanda and regional markets; small packs in dissemination of improved bean varieties; and update on Agriculture Extension and policies in Rwanda by Raphaël Rurangwa (MINAGRI, Planning Director General). Three working groups were formed to elaborate recommendations: Group 1: Roles and responsibilities in technology development and dissemination; Group 2: Accessibility of information on improved bean production and commercialization technologies to potential users; and Group 3: Seed increase of improved varieties and wide dissemination.

- The Southern Agriculture Zone Division of RAB recently received from Harvest-Plus project a XRF machine that assists in bean seed analysis for micronutrient concentration. Technicians from Rwanda and DRC were trained in its use and they will contribute in future in mineral analysis of beans for both Harvest-Plus, Bio-Innovate, and CRSP projects.
- Trip to Rwanda during May 9-23, 2011: Drs. J. Kelly and G. Abawi travelled to Rwanda to meet with collaborators at ISAR, review research activities, visit field research sites around the country and presented a 3-day workshop on bean pathology (major root and foliar diseases) and breeding – genetics of beans to the ISAR technical staff. A complete list of 23 participants and topics discussed was provided in an earlier trip report. Visual aids and powerpoint information was distributed to the participants.
- Dr. Snapp joined the trip in mid-May and we visited the research plots of Krista Isaacs and hosted the ISU CRSP team during their stay in Rwanda. In addition, we attended HarvestPlus field day activities at Muko near Musanze.
- Sara Jablonski, a MS student at MSU travelled to Ecuador for 6-week period in 2011 to conduct thesis research on “The nature of participation in Ecuador’s participatory bean improvement program.” The three main questions she attempted to address in interviews with CIAL members were: How do farmers and scientists participate in the selection and production of new bean varieties? What is the relationship between the CIALs engaged in varietal selection and their respective communities? What have been the results of this participation for target communities in northern Ecuador? Ms. Jablonski will graduate in 2012 and present her findings in her Master’s thesis.
- Research on canning and physical properties of 12 bean genotypes (reported herein) was conducted as part of the thesis study of a graduate in the Agribusiness National Polytechnic School in Quito.

Target Outputs

1. The development and release of locally adapted, acceptable and disease resistant bean cultivars for the major production regions in Rwanda, Ecuador and Michigan
2. Increased sustainable productivity and profitability of bean production due to increased yield and reduced inputs
3. Improved grower income and stability of bean production will contribute to better nutrition and health of farm families
4. Increased awareness and knowledge of participatory breeding methods, root health and soil health issues will further improve bean productivity, long-term land management, environmental risk, thus contributing to sustainability of bean production and agricultural communities
5. Identification of germplasm sources that are of benefit in the improvement of selected bean traits for the U.S. market

6. Enhanced human resource development, gender equity and improved infrastructure capacity of participating institutions in Rwanda and Ecuador

Engagement of USAID Field Mission(s)

Past visits were made to USAID Mission in Kigali on two occasions in 2008 and 2009 to discuss the role and work of the PULSE CRSP in Rwanda and introduce HC partners. 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 and again in 2010.

Networking and Linkages with Stakeholders

- The project also forged closer collaboration with Kigali Institute of Science and Technology (KIST). RAB provided KIST with 20 newly released varieties for post harvest and processing studies under CRSP MSU/ISU collaboration. This is intended to build synergy between the KIST lead PULSES CRSP ISU and the current project in integrating agronomic and market traits with the nutritional and quality attributes of new bean varieties released and being developed by RAB.
- RAB, farmers' cooperatives, and seed production agencies worked together to further dissemination of bean technologies. NGOs such as World Vision, AFRICARE, ADRA, CARITIUS, Catholic Relief Services, DERN; farmers organizations, COAMV in the North; RDO in the East; Iterambere ry'Abahinzi Borozi Muhanga (IABM) (South), and local Government Extension Agents (Country-wide), Musasu Watershed (south), Sogwe Watershed farmers Cooperatives (South), Gakiragi Watershed Cooperative (East), Umutara Polytechnic University (East), IMBARAGA (Umbrera farmer organization in the country), DERN, DRD, TIN, CSC, Rwanda Seed Company (RWASCO), AGRA Climbing Bean, N2 Africa, CIALCA, and individual farmers were also involved in promoting bean technology. Government institutions such as KIST, and Higher Training Institute of Agriculture and Livestock (ISAE) were among partners with RAB in scaled-up programs.
- The program interacts with the following NGOs 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.

Leveraging of CRSP Resources

- In addition to the Dry Grain Pulse CRSP project, funding was secured through Nitrogen fixation CRSP project with Iowa State University to the bean breeding program in Rwanda, AGRA (Alliance for a Green Revolution in Africa), Harvest-Plus, Bio-Innovate, ASARECA, ACTESA/COMESA, and PABRA network. Support from the Government also was provided to the bean program for both variety selection and further seed increase. Support from Borlaug LEAP fellowship for additional training of doctoral CRSP candidate.
- 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 in 2008 but due to the global recession, funding has been rescinded.

Scholarly Activities and Accomplishments

List of Publications

- Abawi, G. S., T. G. Porch, and J. D. Kelly. 2011. Field and greenhouse evaluation of bean germplasm for root rot and other diseases in New York, 2010. BIC 54: 142-143.
- Brisco, E.I., T. G. Porch, and J.D. Kelly. 2011. Comparison of choice versus no-choice tests of a dry bean IBL population for resistance to potato leafhopper. Annu. Rep. Bean Improv. Coop. 54:88-89.
- Mkwaila, W., and J. D. Kelly. 2011. Heritability estimates and phenotypic correlations for white mold resistance and agronomic traits in pinto bean. Annu. Rep. Bean Improv. Coop. 54:134-135.
- Mkwaila, W., K.A. Terpstra, M. Ender, and J.D. Kelly. 2011. Identification of QTL for resistance to white mold in wild and landrace germplasm of common bean. Plant Breeding 130:665-672.
- Miklas, P.N., S. P. Singh, H. Terán, J. D. Kelly, and J. R. Smith. 2011. Registration of common bacterial blight resistant cranberry dry bean germplasm line USCR-CBB-20. J. Plant Reg. 5:98-102.
- Roman-Avilés, B., J.M. Lewis and J.D. Kelly. 2011. Fusarium Genetic Control: A Long Term Strategy. In: Control of Fusarium Diseases, Editors: Fernando M. Alves-Santos and Julio J. Diez. 2011:000-000 ISBN: 978-81-308-0470-5.
- Wright, E.M., and J.D. Kelly. 2011. Mapping QTL for seed yield and canning quality following processing of black bean (*Phaseolus vulgaris* L.). Euphytica 179:471–484.

A booklet with promotional materials has been developed and 5,000 copies printed and distributed to Rwandan farmers and other related producers. The booklet promotes the bean production chain. Extension publications were published on new varieties in the US; in Spanish in Ecuador and in Kinyarwanda in Rwanda. Two leaflets describing the new varieties available for distribution in Ecuador and the pdf file can be viewed @[http:// www.iniap.gob.ec](http://www.iniap.gob.ec)

Professional Recognition, Awards and Accomplishments

Plant Variety Protection Certificate No. 201000268 was issued for ‘Zorro’ black bean variety on 8/18/2011.

Plant Variety Protection Certificate No. 201000269 was issued for ‘Santa Fe’ pinto bean variety on 8/18/2011.

Tables/Figures

Table #1: New Climbing Bean Varieties to be released 2012, their phenology, seed characteristics and yield potential.


Varieties	Days to Flowering	Days to maturity	Seed color	Seed size	Yield (Kg per ha)
RWV3006	58	110	White	Large	3,560
RWV2872	56	108	Red-mottled	Large	3,939
RWV2361	57	108	Red-mottled	Medium	3,485
RWV3316	58	110	Red	Large	4,000

Dry Grain Pulses CRSP
Report on the Achievement of "Semi-Annual Indicators of Progress"
(For the Period: April 1, 2010 – September 30, 2011)

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

Project Title: Combining Conventional, Molecular and Farmer Participatory Breeding Approaches to Improve Andean Beans for Resistance to Biotic and Abiotic Stresses

Benchmarks by Objectives	Abbreviated name of institutions											
	MSU			Cornell			Ecuador			Rwanda		
	Target	Achieved		Target	Achieved		Target	Achieved		Target	Achieved	
	10/1/11	Y	N*	10/1/11	Y	N*	10/1/11	Y	N*	10/1/11	Y	N*
<i>(Tick mark the Yes or No column for identified benchmarks by institution)</i>												
Objective 1												
Review breeding program												
Andean bean nursery-Increase												
Plant Andean nursery												
Selection parental lines												
Selection elite lines	X	X										
Nursery evaluation							X	X		X	X	
crossing	X	X					X	X		X	X	
Marker assisted selection	X	X					X	X		X	X	
Advanced yield trials	X	X					X	X		X	X	
On farm trials	X	X					X	X		X	X	
Biofortification for Fe, Zn							X		X	X	X	
Canning and quality evaluation	X	X					X	X		X	X	
Variety Release	X	X					X	X		X	X	
Objective 2												
Advanced Population development	X	X					X	X				
Test Populations in Rwanda										X	X	
Other population development	X	X					X	X				
Characterize CIAT resistance sources										X	X	
Increase, characterize local germplasm							X	X				
Evaluation for drought and root rot				X	X		X	X		X	X	
Characterize germplasm to root pathogens	X	X		X	X		X	X		X	X	
Objective 3												
Survey root pathogens in Rwanda				X	X					X	X	
Characterize root rot isolates				X		X	X	X		X	X	
Root Pathogen x germplasm interaction				X	X	X	X	X				
Collect foliar pathogens in Rwanda	X		X							X	X	
Race characterization	X	X		X		X	X	X		X	X	
Objective 4												
Visit of Rwandan scientists to Ecuador							X		X	X	X	
Workshop Participatory in Rwanda												
Evaluation of elite lines in CIAs							X	X		X	X	
Variety releases in Ecuador							X	X				
Farmer vs. Breeder Selection												
Evaluation of climbing beans				X	X	X	X	X		X	X	
Sustainable practices, nutrient mgt										X	X	
Name of the PI reporting on benchmarks by institution	James D. Kelly			George Abawi			Eduardo Peralta			Louis Butare		

Sustainable practices, nutrient mgt										x	x		
Name of the PI reporting on benchmarks by institution	James D. Kelly			George Abawi			Eduardo Peralta			Louis Butare			
Name of the U.S. Lead PI submitting this Report to the MO	James D. Kelly												
													
	Signature											Date	
* Please provide an explanation for not achieving the benchmark indicators on a separate sheet.													
MSU: pathogens being collected in Rwanda were retained in country due to quarantine concerns													
Cornell: Characerization of isolates and germplasm evaluation is continuing and need to be done in Rwanda too.													
Ecuador: Work with biofortified lines is not being continued with CIAT, no funding for interchange of scientists between Rwanda and Ecuador													
Rwanda:													

Dry Grain Pulses CRSP
Research, Training and Outreach Workplans
(April 1, 2008 – September 30, 2012)

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

Output Indicators	2008 Target (Apr 1-Sept 30, 2008)	2008 Actual	2009 Target (Oct 1 2008-Sept 30, 2009)	2009 Actual	2010 Target (Oct 1 2009-Sept 30, 2010)	2010 Actual	2011 Target (Oct 1 2010-Sept 30, 2011)	2011 Actual	2012 Target (Oct 1 2011-Sept 30, 2012)	2012 Actual
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Degree Training: Number of individuals w ho have received degree training										
Number of w omen	1			1	2	2	2	2	2	
Number of men			1		1	0	1	1	1	

Short-term Training: Number of individuals w ho have received short-term training										
Number of w omen			1	1	2	0	4	6	8	
Number of men			2	3	2	2	4	4	8	

Technologies and Policies										
Number of technologies and management practices under research	8	4	8	14	19	17	17	20	14	
Number of technologies and management practices under field testing	4	3	4	10	10	11	14	14	11	
Number of technologies and management practices made available for transfer	8	2	8	12	11	8	16	16	23	
Number of policy studies undertaken										

Beneficiaries										
Number of rural households benefiting directly	3000	2400	3100	8300	8000	10500	8800	17,000	8000	
Number of agricultural firms/enterprises benefiting	9	2	9	19	20	12	27	29	37	
Number of producer and/or community-based organizations receiving technical assistance	54	15	54	110	75	61	117	167	219	
Number of w omen organizations receiving technical assistance	8		8	15	13	21	51	31	102	
Number of HC partner organizations/institutions benefiting	18	8	18	38	38	30	40	40	47	

Developmental outcomes:										
Number of additional hectares under improved technologies or management practices	5400	1200	7000	14000	16000	18200	20500	29,000	27000	

***Number of public-private sector partnerships formed as a result of USAID assistar** 8

Rwanda: More than 200 T of seed of improved varieties has gone to farmers through ISAR and main partners (RADA, NGOs, CBOs and Farmers)
Ecuador: Over 250 T of seed of improved varieties has gone to farmers through INIAP- new variety INIAP INTAG released to growers
MSU & Cornell: Established active collaboration with USDA-ARS Mayaguez to evaluate root rot germplasm at Geneva NY
MSU & UPR: Established active collaboration with UPR and USDA-ARS Mayaguez to evaluate MSU germplasm in Angola

Change in rural households - Discrepancy between Target and Actual Nos in 2011
No changes for Ecuador - as values for target and actual numbers coincide quite well
Changes apply only to the Rwandan figures
The target number of household in Rwanda should have been 4000 not 1000 reported, Typo.
The total number of households for both countries should have been 8,800 not 5,800 reported
The reason for the dramatic change from 8,800 to 17,000 is based on changes in land policy in Rwanda
In Rwanda the current actual agricultural policies support consolidation and crop intensification.
As a result, the program reaches many more households with new technologies that are being tested or demonstrated on these larger land holdings.
The consolidation and crop intensification program make it easier to reach more end-users in the same location at the same time- rather than a few households as in the past
Farmer grow the same crop on a larger area - not the smaller diversified cropping patterns in the past, so the program works directly with a larger number of househ and is able to disseminate more than one technology more easily as more households are benefiting.
As a result, the program reaches many more households, producers and community based organizations with new technologies that are being tested or demonstrated on these large land holdings.