Bean/Cowpea CRSP
LAC REGIONAL WORKPLAN/ANNUAL PROGRESS REPORT
October 1, 2000-September 30, 2001

I. REGIONAL PROJECT WORKPLAN/ANNUAL PROGRESS REPORT FOR FY 2001

I.A. Constraint #1: Insufficient Natural Resource Management and Production Technologies for Lowland and Highland Agriculture

I.A.1. Research area: Variety release and sustainable seed production for lowlands/biotech

I.A.1.a. Background: Biotic and abiotic factors are major constraints to sustainable bean production and to increased yield of beans in the LAC region. Less dependence on pesticides would reduce production costs and benefit the environment. Terminal drought, low soil fertility and high temperatures are important abiotic constraints in the lowlands of the LAC region.

Indigenous bean landraces have low yields and are susceptible to numerous diseases such as bean golden yellow mosaic, common bacterial blight, rust, web blight and angular leaf spot. The development of disease resistant bean varieties will enhance yield potential, ensure greater profitability for small landholders and increase the availability of beans for the rural and urban poor. National research programs do not have the operational resources and trained personnel to execute the required research and technology transfer to increase bean production. The LAC regional project has enabled National programs to develop comprehensive programs to reduce yield and disease constraints.

Much already has been accomplished through classical breeding methods. Bean golden yellow mosaic virus (BGYMV) resistant small red, pink and white bean varieties have been released ('Tio Canela-75', 'Morales' and 'Rosada Nativa'). The black bean variety 'Arroyo Loro Negro' and the small red breeding lines MD23-24 and PR9609-2-2 have high yield potential and resistance to web blight (WB). The red mottled varieties 'JB178', 'CIAS 95' and 'Saladin 97' were released in the Dominican Republic. 'Chase' is the first pinto bean and 'GN Weihing' is the first great northern variety with resistance to common bacterial blight (CBB), bacterial brown spot and rust. BGYMV resistant red mottled (PR9745-232) and light red kidney bean breeding lines (PR9443-4) have been developed. LAC project personnel have selected breeding lines that combine resistance to several different diseases.

Biotechnology can be used to generate information on variability of the pathogens and to assist in breeding. Marker assisted selection (MAS) is being used to enhance the common blight resistance of Chase and GN Weihing to determine feasibility for seed production in humid regions of the U.S. Molecular markers have been used to map QTL for (1) seed size, (2) field and physiological resistance to white mold, (3) and for resistance to common blight, brown spot and halo blight bacterial diseases. This provides information on the relationships of genes for useful traits in the bean genome, and for subsequent studies on their utility for MAS.

Past efforts have molecularly characterized four bean-infecting geminiviruses in the Western Hemisphere. Bean golden mosaic virus (BGMV) is the major virus in Brazil (BGMV type I); bean golden yellow mosaic virus (BGYMV, previously designated BGMV type II) is found in Central America and the Caribbean Islands; bean calico mosaic virus (BCMoV) is in northern Mexico; and bean dwarf mosaic virus (BDMV) was collected in Colombia. Several antiviral strategies have been explored. The coat protein-mediated resistance, which has been very successful with RNA viruses, was evaluated in transgenic beans. The first transgenic beans were developed in collaboration with Agracetus, Inc., by application of the particle gun technology, but unfortunately, these transgenic beans did not accumulate the viral coat protein and were susceptible to BGYMV. Most research effort has been devoted to the evaluation of another antiviral strategy, trans-dominant interference. This research initially showed that the *rep* gene was essential for replication of BGYMV and mutational analyses demonstrated that individual amino acids were essential for *rep* gene function in both a DNA-nicking domain and a NTP-binding domain. Mutant Rep proteins in either of these domains interfered with the replication of BGYMV in a transient assay system. Because of the encouraging results with transgenic tomatoes, it is possible that beans can be engineered for resistance to BGYMV with the mutant *rep* genes. Another antiviral strategy has been investigated with Brazilian colleagues, who have engineered beans with particle gun technology with antisense genes of BGMV (not BGYMV) and these plants showed attenuated and delayed symptoms. Currently, a mutant *rep* gene of BGMV is being engineered into beans by the Brazilians.

I.A.1.b. Proposed research area workplan and subsequent annual progress report

I.A.1.b.(1) Activity #1: Develop Andean and Middle American bean varieties with enhanced levels of disease resistance.
I.A.1.b.(1)(a) Priority: (1) Essential
I.A.1.b.(1)(b) U.S. researchers: Beaver, Coyne, Kelly, Steadman
I.A.1.b.(1)(c) HC researchers: Rosas, Arnaud-Santana, Acosta, Prophete, Godoy-Lutz
I.A.1.b.(1)(d) Methodology: Conventional and molecular plant breeding techniques will be used to develop bean lines with enhanced levels of disease resistance. One area of special focus will be the breeding of small black beans which is an important seed class in Mexico, Guatemala and Haiti. Jorgé Acosta has developed lines with disease resistance and tolerance to terminal drought. Black bean lines will be exchanged among the bean breeders in Mexico, Central America and Haiti for field evaluation. Elite small red lines will be used to develop black beans with resistance to BGYMV, angular leaf spot and web blight. In addition to breeding small red beans for Central America, Dr. Juan Carlos Rosas will be coordinating the PROFRIJOL black bean breeding and varietal testing program. Black bean lines with resistance to the necrotic strain of bean common mosaic virus need to be developed for the Dominican Republic and Haiti.

Participatory plant breeding (PPB) approaches for selecting disease resistant bean breeding lines will continue to be used. The goal of PPB is to increase the effectiveness of field-testing and achieve greater and more rapid adoption by farmers of improved bean lines. PPB activities will be conducted in collaboration with NGOs as well as NBR programs in Honduras, Nicaragua and Costa Rica.

LAC project personnel also will collaborate with CIAT researchers to evaluate the performance of bean breeding lines. Bean germplasm will be screened to identify new sources of resistance to BGYMV, BCMV, rust, CBB, angular leaf spot, anthracnose, powdery mildew, white mold and web blight. Studies will be conducted to identify molecular markers for disease resistance genes. The effectiveness of different disease screening techniques will be tested. Research will be conducted to determine the merit and the inheritance of adult plant resistance to rust.

There will be increased collaboration with Haiti including on-farm evaluation of BGYMV resistant lines, evaluation of disease resistant lines on low fertility soils and under warmer conditions, seed multiplication of promising breeding lines and identification of sources of resistance to powdery mildew.

Phaseolus coccineus lines will be screened in Honduras and Puerto Rico for resistance to rust, common bacterial blight, web blight and BGYMV. Interspecific crosses will be used to introgress resistance genes into elite Mesoamerican and Andean breeding lines.

Markers linked to QTL's will be used at the University of Nebraska to pyramid genes for common blight resistance. Recombinant inbred lines from the cross 'PC50 x XAN159 will be used to map genes for resistance to halo blight. Andean and Mesoamerican breeding lines will be developed that combine different sources of common bacterial blight resistance. The inheritance of resistance to leafhopper injury will be determined in Nebraska.

I.A.1.b.(1)(e) Anticipated (1 year) results of activity: Small red, black, red mottled, red kidney, pinto and white bean varieties with enhanced levels of disease resistance will be released in the LAC region and the U.S. New sources of resistance to bean diseases will be identified and more efficient techniques for screening beans for disease resistance will be developed.

I.A.1.b.(1)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Disease-resistant bean varieties will be adopted by farmers in the LAC region and the U.S. resulting in increased or more stable bean yield and reduced use of inputs to control diseases Long-term release of disease-resistant varieties will result in increased profitability for bean production in the LAC region and the U.S.	FY 01-02	Increased demand for disease resistant bean varieties Project personnel will collaborate with LAC social scientists to estimate the impact of released disease resistant varieties Results from adoption studies show acceptance of varieties by farmers/consumers Increased profitability using disease-resistant bean varieties

I.A.1.b.(1)(g) Budget:

Dominican Republic	$ 17,750
Honduras	25,000
Mexico	4,000
MSU (Kelly)	9,000
UNL	28,000
UPR	25,000
Total (Direct Costs only)	$108,750

I.A.1.b.(1)(h) Major changes: Central America had a drought that severely reduced bean and maize production during the first growing season of 2001. Southern Honduras and Northern Nicaragua was the region most affected by the drought. The U.N. World Food Program estimates that at least 600,000 people are currently experiencing food shortages. Because the first growing season is often used to multiply seed, many farmers faced a shortage of seed for the second growing season. During the past year, Bean/Cowpea CRSP project personnel participated in two USAID/Honduras supported projects at Zamorano to provide seed, training and technical assistance to bean producers. A post-Mitch project to revitalize the agricultural sector provided nearly 5,000 farmers from the east-central region of Honduras, where approximately 50% of the beans are produced, with seed of improved bean varieties (approx. 1,300 quintals), training and technical assistance related to crop and post-harvest management, administration and adding value to the bean crop. In response to the severe drought in Central America, which affected bean and maize production during the first planting season of 2001, more than 700 quintals of seed of improved bean varieties were distributed to nearly 1000 farmers in the southern region of Honduras.

I.A.1.b.(1)(i) Progress during the past year: The plant breeding programs at Zamorano and the UPR are responsible for the improvement of the major market classes of beans produced in the lowlands of Central America, Mexico and the Caribbean. These breeding programs focus on the development of small red, black and red mottled bean cultivars with enhanced levels of disease resistance and superior yielding ability in both low input farming systems and in environments with improved production technologies. Recently released small red cultivars yield, on average, 15-20% more than local cultivars under low input conditions, but are capable of producing yields comparable to those obtained in developed countries (1,500-2,000 kg/ha) when improved technologies are used. The improved cultivars and breeding lines developed by the LAC lowland bean breeding team have resistance to several important bean diseases, including BYMGV, BCMV, BCMNV, anthracnose, rust, common bacterial blight and web blight.

Two small red cultivars, Tio Canela-75 and Bribri, developed with support from the Bean/Cowpea CRSP were formally released during the past year in El Salvador, Nicaragua and Costa Rica. Seed of these cultivars is currently being multiplied and disseminated in these countries. In addition, Tio Canela-75 is being considered for release in Haiti and has been multiplied and distributed to relief projects. Several advanced generation small red lines are currently being tested and validated in Central America, Panama and Haiti. The promising lines include the following: EAP 9510-77 (proposed cultivar name 'Amadeus 77'), SRC1-12-1 (proposed cultivar name 'Milenio'), MD 23-24, SRC1-1-18A, EAP 9020-14, MD 30-19 and EAP 9504-30B. These lines have been selected under moderate to severe disease and abiotic (drought, heat and low fertility) stress, which are factors that significantly affect bean yield in the LAC region.

Foundation seed of recently released bean cultivars and promising breeding lines were provided to NBR programs for on-farm testing and validation trials; to NGOs for artisan seed production; and to private seed companies for certified seed production. In addition, foundation seed produced by the Bean/Cowpea CRSP project was used by Zamorano, with support from USAID/Honduras, to produce certified bean seed that was distributed during the past year to nearly 5,000 Honduran farmers. Most of the certified seed was Tío Canela-75 although some seed of 'Dorado' and Milenio was produced and distributed. Acceptance and adoption studies of recently released varieties were conducted in Central America in collaboration with Rick Bernsten. Due to the earthquakes and drought which occurred in El Salvador, the farmer and consumer acceptance study of Tio Canela-75 was delayed until the 'postrera' season of 2001.

The capacity of the LAC lowland bean breeding team to select bean lines with disease resistance and tolerance to abiotic stress continues to improve. Both Zamorano and the University of Puerto Rico have established laboratories that permit the use of marker assisted selection. Bean lines already have been screened for the presence of markers linked to BGYMV and BCMV resistance genes. Zamorano has initiated an effort to combine genes for resistance to angular leaf spot from Mesoamerican and Andean gene pools. Recurrent selection was initiated to develop bean lines with enhanced levels of resistance to web blight. Both Zamorano and the UPR strive to identify the most effective sites for screening bean populations for disease resistance and tolerance to abiotic stress. Collaboration with NBP in Central America and the Caribbean provides access to a wide array of environments. The southern Pacific coast of El Salvador has proven to be a good site for screening beans for heat tolerance. Haiti has a good site for evaluating lines for tolerance to low soil fertility.

Small red and black bean breeding lines are included as entries in the Regional Adaptation Nurseries (VIDAC) which are conducted in collaboration with PROFRIJOL and CIAT. Based on the results from the VIDAC, the most promising lines are included as entries the following year in ECAR (yield and adaptation) trials. Each NBR program selects under their own conditions the best lines from the VIDAC and ECAR trials, which are subsequently included as entries in National Yield and Adaptation (ENAR) trials. The performance of promising lines from the ENAR trials are validated in on-farm trials prior to their release. Forty nine nurseries and trials were distributed by Zamorano to members of the PROFRIJOL bean network in 2000. It is estimated that more than 60 nurseries and trials will be distributed before the end of 2001.

An angular leaf spot (ALS) nursery from CIAT (G. Mahuku), containing several sources of resistance from the Andean and the Middle American gene pools, was evaluated in Honduras. Several Andean sources, including G05686 and G06727 were among the most resistant. The only Mesoamerican line that maintained moderate levels of resistance during the last three years is the small red cultivar 'Don Victor.' Results from the evaluation of ALS differentials used to monitor virulence patterns of the pathogen suggest that 31-63 and 63-63 are the predominant races in testing sites in Honduras. Sources of ALS resistance are being used in crosses with small red and black bean lines. An inheritance study was conducted last year using F_2 and F_3 populations from the cross Tio Canela 75 x G06727. Based on phenotypic reactions after artificial inoculation, the resistance to race 63-63 appears to be a single recessive gene. The parents and the majority of the F_4 families contain the SCAR marker for the gene *Phg 2* identified on Cornell 49-242. However, this gene alone does not confer resistance to one of the most virulent races (63-63) in Honduras.

In addition to testing in Honduras several different sources of rust resistance, we increased seed of a new set of rust differentials assembled by M. Pastor (USDA/Beltsville) and J. Steadman. This rust nursery includes a set of lines with specific combinations of rust resistance genes. The rust differential nursery will be distributed to other countries in the LAC region. The new set of rust differentials has been tested at Zamorano and on farm fields using the mobile nursery technique.

Sources of resistance to CBB were evaluated at Zamorano in the screenhouse and field using artificial inoculation of Honduran isolates of the CBB pathogen. The most resistant lines were Wilk2, VAX 3, 4, 5 and 6, and XAN 159. Resistant lines were identified from populations developed by R. Smith (USDA/ARS Research Geneticist, Mayaguez, Puerto Rico) and J. Beaver, using CIAT VAX lines as sources of resistance. Some small red lines from Puerto Rico combine high levels of resistance to both CBB and BGYM.

Small red lines from Puerto Rico which combine the recessive *bgm1*, *bc3* and *i* genes were used at Zamorano in crosses with the Salvadoran bean landrace 'Rojo de Seda', to produce BGYM and BCM resistant lines that are not affected by the crisomelid transmitted bean severe mosaic (BSM) virus, which has been observed to affect bean production in some areas of Central America. MAS is being used in combination with conventional methods to screen these populations.

In response to the appearance of the necrotic strain of the bean common mosaic virus (BCMNV) in the Dominican Republic and Haiti, bean populations were developed to combine the *bc3* gene for BCMNV with the *bgm-1* gene for BGYMV resistance into tropically adapted black and white-seeded beans. F_2 populations were generated at the UPR from crosses between the black seeded cultivar Raven (I and bc 3 gene source) and X003-124, X003-132 and PR 9603-22 (tropically adapted *bgm1* gene sources) The populations were sent to the University of Nebraska where they were inoculated by Dr. Graciela Godoy with virulent strains of BCMNV. DNA was extracted from the surviving plants and amplified with SCAR marker SR2 to select for progenies homozygous for *bgm-1*. Over 45 small red, white and black seeded F_3 lines homozygous for the *bgm1* and *bc3* genes were selected for further evaluation. The small red and black-seeded F_3 lines that combine resistance to both viruses will be evaluated in 2002 in the Dominican Republic and Honduras. The white-seeded lines with virus resistance were sent to Puerto Rico. This is an excellent example of the benefits of collaborative research.

Other F_2 populations were developed at the University of Puerto to transfer the *bc3* gene for resistance to bean common mosaic necrotic virus and Mesoamerican rust resistance genes (*Ur11* and *Ur6*) into red mottled beans of Andean origin. Lines will be screened at the University of Nebraska for BCMNV and rust resistance.

Two *Phaseolus coccineus* lines (G35006 and G35066), which had been selected in Puerto Rico for resistance to web blight, were screened in the field at Zamorano for reaction to rust and angular leaf spot. Both lines were resistant to the highly virulent races of the rust pathogen in Honduras, which suggests that interspecific crosses between *P. coccineus* x *P. vulgaris* could provide novel resistance genes for different bean diseases. Collaborators at the University of Florida have already developed F_2 populations from interspecific crosses that will be available for screening for web blight and rust resistance.

Nurseries were planted in Puerto Rico during the summer of 2001 to screen bean lines for bean golden yellow mosaic resistance. Nurseries planted during the previous two years had not been successful due to the release by USDA-APHIS of natural enemies of the whitefly. Spreader rows of soybean were planted three weeks before the BGYM nursery was established in order to increase the population of whiteflies. Insecticides were applied weekly to reduce the populations of the natural enemies of whiteflies on the soybeans. In addition, pots from the greenhouse with bean plants infected with BGYM were placed in bean spreader rows. This approach resulted in a high level of BGYM infection in the field. It also demonstrates how the misuse of insecticide can contribute to greater levels of BGYM infection.

Recombinant inbred lines expected to segregate for a pod deformation trait, controlled by the dominant gene *Bgp*, were screened in field trials in Puerto Rico during the summer of 2001 for reaction to BGYM. Lines identified to have normal and deformed pods in the presence of BGYM will be used to identify potential molecular markers for this gene for disease resistance. In addition, F_1, $F_{2,}$, BC_1 and BC_2 populations were developed to confirm the inheritance of this trait. This is a portion of the M.S. thesis research of Maracelis, Acevedo, graduate student in the Dept. of Agronomy and Soils of the University of Puerto Rico.

A total of 132 recombinant inbred lines were screened in field trials in Puerto Rico during the summer of 2001 for reaction to BGYM. Preliminary results suggest that these lines segregate for a novel recessive gene for resistance to BGYM. The resistance is expressed as an absence of chlorosis similar to the resistance conferred by *bgm*-1 gene. The resistant lines, however, do not have the SCAR marker SR2 for the *bgm-1* gene. The recombinant inbred lines will be used to identify potential molecular markers for this resistance gene. Populations were also developed for allelism tests and for inheritance studies of this possible new source of BGYM resistance. This is a portion of the M.S. thesis research of Juan Manuel Osorno, graduate student in the Dept. of Agronomy and Soils of the University of Puerto Rico.

Five potential molecular markers for the *bgm-2* gene for BGYM resistance have been identified. At present, F_2 populations are being evaluated to estimate the degree of linkage of the potential molecular markers and the *bgm-2* gene for BGYM resistance. This is a portion of the M.S. thesis research of Carlos German Muñiz, graduate student in the Dept. of Agronomy and Soils of the University of Puerto Rico.

Andean landrace varieties from the Caribbean have proven to be a valuable source of traits of economic importance such as rust (PC 50) and common bacterial blight (Pomjor 17) resistance. Landrace collections from Haiti, the Dominican Republic and Puerto Rico were evaluated in the field for morphological and agronomic characteristics. In addition, the lines were screened with primers to detect RAPDs. A cluster analysis will be conducted to measure differences and similarities among the Andean landrace varieties from the Caribbean. This is a portion of the M.S. thesis research of Luis Duran, graduate student in the Dept. of Agronomy and Soils of the University of Puerto Rico.

Seed of different sources of resistance to web blight was increased in Puerto Rico. In collaboration with PROFRIJOL, these lines will be tested in different countries in Central America and the Caribbean to measure the degree of variability of virulence patterns of the web blight pathogen. In August 2001, these lines were inoculated in the field with a local isolate of the web blight pathogen. Some sources of web blight resistance such as BAT 93 and Talamanca have moderate levels of resistance in a wide range of environments whereas other lines such as G1414 appear to provide resistance at specific locations. The sexual stage of the web blight pathogen tends to be more important in countries where Andean beans are produced (Panama, Colombia and the Caribbean).

A recurrent selection scheme was initiated to develop bean lines with enhanced levels of web blight resistance. A group of 15 sources of web blight resistance were intermated in a crossing block conducted in Puerto Rico. The F_1 and F_2 generations were grown in Honduras. F_4 lines from these crosses will be evaluated for web blight reaction in replicated field trials that will be conducted in Honduras and Puerto Rico during the summer of 2002.

During the past few years, two different sources of common bacterial blight resistance have been used as parents in Puerto Rico. Numerous crosses have been made with the CIAT lines, VAX 2, VAX 3, VAX 5 and VAX 6. These lines derive much of their resistance from tepary beans (*Phaseolus acutifolius*). The other source of common bacterial blight resistance used in Puerto Rico are ICB 3 and ICB 6 which are breeding lines that derive their resistance from scarlet runner beans (*Phaseolus coccineus*). This approach should help to broaden the genetic base of common bacterial blight resistance for small red, black and white-seeded beans for LAC.

In collaboration with PROFRIJOL and CIAT bean researchers, Caribbean Adaptation Nurseries (VICARIBE) were conducted in Haiti, the Dominican Republic, Panama and Puerto Rico. The red mottled VICARIBE had 21 entries and the light red kidney VICARIBE had 24 entries from Puerto Rico. Molecular markers and results from field trials conducted in Puerto Rico confirm that the red mottled bean lines PR9909-5, PR9745-232 and PR9745-140 and the light red kidney breeding lines PR9847-8, PR9847-12 and PR9847-13 have the *bgm-1* gene and are resistant to BGYM. In the VICARIBE conducted at the Isabela Substation, the BGYM resistant red mottled lines yielded significantly more than PC-50. In the Dominican Republic and Haiti, yields of the BGYM resistant red mottled lines were similar to PC-50. A 193 and Salagnac 90A were among the highest yielding red mottled lines in the VICARIBE and were the only lines in the Dominican Republic with resistance to powdery mildew. A 193 has been reported to by researchers in Costa Rica to have resistance to anthracnose, web blight and angular leaf spot. In Haiti, Ing. Emmanuel Prophete conducted a seed increase of some of the most promising bean breeding lines. Results from the VICARIBE nurseries will be used to identify BGYM resistant red mottled lines to be tested in on-farm trials.

The 1999 red kidney VICARIBE was planted in Mexico. Several of the bean breeding lines from the Caribbean were well adapted to this higher altitude environment. Mean yields of several lines were > 2,500 kg/ha. Red kidney lines with useful levels of resistance to common bacterial blight, halo blight and phytophtora root rot were identified in the trial. The 1999 red mottled VICARIBE was also planted in Mexico. Three Dominican landrace varieties , Pomjor 17, Pompadour K and Larga Comercial were very well adapted with mean yields > 3,000 kg/ha. This is a good example of the advantages of the exchange of bean germplasm between the highland and lowland bean breeding programs.

There is increasing interest in Puerto Rico in snap bean production for the local market. A tropically adapted snap bean with the *bgm-1* gene for BGYM resistance has been developed and will be tested on a commercial scale during the upcoming year.

During the summer of 2001, red mottled breeding lines from the Dominican Republic were screened in the field in Puerto Rico for BGYM reaction. The most resistant lines will be included as entries in the 2002 VICARIBE. Andean bean breeding lines have been developed in Puerto Rico that may combine both the *bgm-1* and *bgm-2* genes for BGYM resistance.

A total of 730 small red and 161 black-seeded F_3 lines were planted in Puerto Rico in November 2000. Individual plants were selected from the most promising rows. During a visit to Puerto Rico in September 2001, Dr. Eladio Arnaud Santana, Ing. Segundo Nova and Ing. Julio Cesar Nin participated in the evaluation of the black lines for seed type. The F_4 generation will be evaluated in 2001 in Honduras and the Dominican Republic.

A total of 365 red mottled and 271 light red kidney lines were planted in Puerto Rico in November 2000. Individual plants were selected from the most promising rows. The F_4 generation was screened for BGYM resistance in field trials planted at the Isabela Substation during the summer of 2001. The BGYM resistant lines will be evaluated in for agronomic performance and resistance to rust. The most promising lines will be evaluated in the Dominican Republic and Puerto Rico during 2002.

Tropically adapted pinto bean lines have been developed in Puerto Rico that combine the *bgm-1* gene for resistance to BGYM and the *Ur6* and *Ur11* rust resistance genes. Six of the lines yielded > 2,400 kg/ha in field trials conducted at the Isabela Substation during 2001. These lines will be included as entries in the 2002 Caribbean Adaptation Nursery. In the Dominican Republic, some of these pinto lines were resistant to powdery mildew.

BelMiDak and BelDakMi lines have been used in Puerto Rico as sources of rust and bean common mosaic resistance. Red mottled and pinto bean lines were crossed to transfer the *Ur6* and *Ur11* rust resistance genes into BGYM resistant red mottled beans. F_3 lines from these crosses will be screened at the University of Nebraska using highly virulent rust races.

The BGYM and rust resistant pink bean variety PR9443-1 (Rosada Nativa) is being considered for release in the Dominican Republic as 'Charlona'. This heat tolerant line yields significantly more than red mottled varieties. Consumer acceptance of the pink seed type has been favorable. Rosada Nativa is currently being tested on farms in the San Juan de la Maguana valley. In Mexico, PR9443-1 was found to be among the most drought tolerant bean breeding lines.

A *Crop Science* paper by Raul Macchiavelli and James Beaver described the distribution of the proportion of original F_2 plants represented after advancing populations to the F_6 generation when using the multiple-seed procedure of single seed descent. A simulation was run using SAS to estimate the probability distribution. An increase in the size of the population advanced from the F_2 to the F_6 generation did not influence significantly the mean proportion of F_2 plants represented in the F_6 generation but decreased its variability. An increase in the number of seed per pod from 2 to 6 reduced the mean proportion of F_2 plants represented in the F_6 generation from 0.45 to 0.35, but did not significantly reduce the standard deviations of the distributions. Using the multiple-seed procedure of single seed descent, grain legume breeders could expect, on the average, that at least every third F_6 line would be derived from a different F_2 plant. This should generate considerable genetic variability for the selection of quantitatively inherited traits such as seed yield.

The USDA-ARS core germplasm collection containing 418 accessions was planted at the Isabela Substation in January 2001. Some of the accessions showed no local adaptation whereas other lines were infected with bean common mosaic. Seed harvested from healthy rows was planted at the Isabela Substation in August 2001. Natural infection of BGYM was sufficient to screen lines for resistance. Only a few lines showed no BGYM infection in both replications. The BGYM reaction of these lines will be confirmed in the greenhouse. The core germplasm collection at the Isabela Substation was also inoculated with the web blight pathogen. Only one line, which appears to be a tepary bean, had $< 10\%$ of leaf area damaged by web blight in both replications. This line will be screened in the greenhouse for physiological resistance to web blight.

A total of 69 red mottled lines from the Dominican Republic were screened in Puerto Rico for BGYM resistance. Two lines, which were identified to be resistant to BGYM, will be included as entries in the 2002 VICARIBE.

Eighteen small red lines from the cross 'Tio Canela 75 x XAN 176' were selected by Dr. James Smith, USDA-ARS Research Geneticist, for resistance to common bacterial blight. During the summer of 2001, these lines were screened in Puerto Rico for BGYM resistance. Eight lines did not express BGYM symptoms in the field trial. Their resistance will be confirmed using molecular markers.

Common bacterial blight (CBB) in common bean caused by *Xanthomonas campestris* pv. phaseoli (Xcp), reduces bean yields and quality. There was progress at the University of Nebraska in pyramiding genes for increased resistance to common blight. Pinto Chase is a high-yielding variety with moderate resistance to *Xcp* derived from great northern (GN) NE #1 selection 27, whose resistance is derived form tepary #4 (P. *acutifolius*) bean source. XAN-159 is a black mottled small seeded breeding line with different genes for high resistance to *Xcp* derived from a different tepary source (PI 319443). The objective was to pyramid different genes for *Xcp* resistance from the donor parent XAN-159 into the rust-resistant recurrent parents pinto Chase and GN Weihing using the classical backcross (BC) breeding method, with confirmation of resistance using RAPD BC420 (SCAR) marker. Resistance to CBB was confirmed in some pinto BC4F5 and BD5F4 lines in the field (2001). Line and single plant selections were made in the field in 2000 and were increased in PR for use in replicated yield field tests in Summer 2001. The data has not yet been analyzed for yield and seed coat color. Advanced CBB resistant BC pinto Chase lines are being used to BC the XAN-159 genes into GN Weihing because the F_1 of the cross XAN-159 x GN Weihing was lethal due to the presence of dominant DL1 and DL2 genes in the parents. CBB resistant selections were made in BC1F2. Further BCs will be made in Fall 2001.

The potato leafhopper (LH) *Empoasca fabae* Harris is the most important *Empoasca* species attacking dry beans in North America. Yield losses of about 20% were reported on susceptible bean varieties in North Platte (NP), NE. Resistance (R) to LH injury has been identified but genes or QTL for R have not been reported. The objective of the research conducted at the

University of Nebraska was to map QTL for R to LH (*E. fabae*) injury in the F2-derived and recombinant inbred line (RIL) dry bean populations. Ninety F2 progenies form the cross resistant (R) dry bean pinto Sierra and the susceptible (S) great northern Starlight, and 55 RILs from the cross Belneb RR-1 (R) x A-55 (S) were evaluated for leafhopper injury during two years under field conditions at NP, NE. Visual scores 1 = no injury to 5 = severe injury were used to rate LH injury. SAS statistical procedures were used to analyze the phenotypic data. Molecular (103 RAPDs for the F2 population; 240 RAPDs and 1 SCAR for the RIL population) and phenotypic data were used to detect QTL associated with R to LH injury in both populations using the composite interval mapping procedure. QTL on linkage groups (LG) 5 and 8 were common to both populations for R to leafhopper injury. Low heritability estimates for this trait indicated that molecular markers linked to QTL for R to LH injury may be useful for marker-assisted selection.

The inheritance of resistance to halo blight bacterium was investigated at the University of Nebraska using recombinant inbred lines (RIL) derived form the cross PC-50 x XAN-159. Both parents were susceptible to the HB isolates used in the test. Some transgressive segregate resistant RIL lines were observed indicating that the parents contributed some different genes for resistance. The resistance of these lines needs to be confirmed in a subsequent test. The original population could not be used to map these genes for resistance. Crosses of R x S lines need to be made to develop populations to map the genes.

There was progress at the University of Nebraska in breeding great northern and pinto dry beans (middle American gene pool- Durango Race) with multiple disease combined with improved seed quality yield and plant type. The non-structured recurrent selection program was continued in NE top incorporate resistance to common blight (CB), halo blight, bacterial brown spot, rust, BCMV, and for upright Type II plant habits with canopy avoidance to white mold in great northern and pinto dry beans. Inoculated CB and BCMV tests were conducted in the greenhouse and a rust inoculated test was conducted in the field. In addition, a white mold disease nursery was arranged under a sprinkler irrigation system to promote WM. Due to weather conditions WM and rust did not develop in the field in 2001. However, a severe natural infection of CB occurred in the field at one location, which permitted good separation of R and S lines. Seed was also harvested in lines grown in non-disease nurseries. Seed yield, seed size, and resistance to seed coat cracking are now being recorded. Promising advanced lines based on resistance to the above diseases combined with competitive yields and seed quality traits are as follows; GN NE1 01 4, GN NE1 01 10, GN NE3 01 7, Pinto NE 2 01 4, Pinto NE 2 01 9, and Pinto NE 4 01 10. These will be increased and evaluated in several tests in 2002 to determine merit for release.

The Cooperative National Dry Bean Nursery, the Mid-West Regional Performance Nursery, and the Cooperative White Mold Monitor Nursery were planted in NE. Yield data is now being recorded. White mold did not develop in the White Mold Monitor Nursery. It was noted that lines with Type II a and b plant habits are more susceptible to stem breakage and have poorer recovery form hail injury on the high western plains.

In cooperation with M. Pastor-Corrales, USDA-ARS, a trial consisting of RILs varying in R and S to APR was planted at Beltsville, MD, to determine the merit of adult plant resistance (APR) to rust under severe rust infection. We have not been successful in previous years in NE to determine the merit of APR due to low rust infection. The trial was abandoned at Beltsville in 2001 due to damage in a severe flood.

Advanced red mottled and black-seeded lines derived from 10 crosses were evaluated in the Dominican Republic for yield and seed quality traits. Some lines had favorable trait

combinations and will be grown in 2001-02 tests. The web blight resistant germplasm was not planted due to environmental conditions unfavorable to disease development. In addition, 30 F5 pinto lines from the cross A 429 x DOR 308 had good resistance to BGMV but did not possess good commercial traits. Ten promising black seeded lines were selected from the cross HT-7719 x H-270. Lines (F_5) with low rust were derived from crosses with IAPAR-14.
I.A.1.b.(1) (j) Current status of the project: Several disease resistant small red bean breeding lines which are well adapted to the lowlands of Central America and the Caribbean are being tested by NBR programs and NGOs. The official release of at least two new varieties is expected in Central America. Adoption of recently released small red bean varieties is expected to continue to increase in Central America and possibly expand to Haiti and Panama.

Several promising lines not formally released (such as Milenio in Honduras, EAP 9020-14 and MD 23-24 in Nicaragua) have been adopted by farmers in the LAC region. Small-scale farmers have selected these lines for disease resistance or better performance under drought or low soil fertility. The adoption of these lines can contribute to biodiversity and adaptation to specific environments. Seed types may be better attuned to local market preferences. During the past few years, collaborators throughout the region have commented about farmers using bean lines that were introduced by NBR on-farm trials. These lines have been adopted by innovative farmers who produce seed for their own use and to share with neighbors. It has been difficult to document the level of adoption and impact of these lines developed by the Bean/Cowpea CRSP.

Since 1999, the LAC lowland bean breeding team has increased efforts to improve black beans. The plant breeding program has emphasized the development of black-seeded breeding lines with resistance to BGYM and CBB and tolerance to abiotic stress. It is expected that in two years these efforts will generate a group of promising black lines that will be available for testing in VIDAC trials. This effort should help to expand the impact of the Bean/Cowpea CRSP project in Haiti, Guatemala, Costa Rica and the Mexican lowlands where the black bean is the preferred seed type.

The Andean bean breeding program for the Dominican Republic and Haiti will be scaled back during the next few years. Red mottled and light red kidney breeding lines under development will continue to be tested on experiment stations and farms. We expect to release bean golden yellow resistant red mottled and light red kidney bean varieties.
I.A.1.b.(1)(k) Documented impact: Improved cultivars developed by the lowland bean breeding team have been adopted throughout the LAC region. A significant portion of farmers in some Central American and Caribbean countries use bean cultivars developed by the project. A yield increase of at least 10-20% has been being obtained with the use of recently released cultivars. Larger yield increases are obtained when farmers use improved varieties and other recommended production practices. Farmers also need to use fewer applications of pesticide with improved bean cultivars.

Thirty percent of the bean producers in Honduras (30,000 farmers) are using the BGYM resistant and heat tolerant small red variety Tio Canela 75. Based a modest increase in yield of 100 kg/ha as the result of using Tio Canela 75, it is estimated that farmers in Honduras would have $1.8 million in additional annual income.

Public seed production programs and private companies produce and distribute seed of cultivars developed by the Bean/Cowpea CRSP. Artisan seed produced by farmers, with the assistance of NGO or PVO seed projects, are utilizing foundation seed produced at Zamorano or using other sources of seed of cultivars developed by the project. During the last three years, disaster relief and revitalization programs in Central America have distributed seed of cultivars developed with support from the Bean/Cowpea CRSP to nearly 30,000 small farmers.

Out of the six (6) varieties officially released in 1998, two red mottled varieties PC-50 and JB-178 and one black bean Arroyo Loro Negro, constitute the principal varieties in the Dominican Republic, while lesser amounts of the red mottled varieties CIAS-95 and Saladin-97, and the white seeded variety Anacaona are grown. Arroyo Loro Negro variety has also been well received in Haiti.

The recently released disease resistant GN Weihing variety was grown on about 2,000 acres in NE in 2001 with favorable reports from growers and dealers. The larger bright white seed of this variety is expected to improve overseas marketing of NE grown GN beans. The disease resistant pinto Chase variety is still being grown in NE. NE developed GN germplasm is being used in all public and private GN breeding programs in the US.

In cooperation with Dr. Phil Miklas, USDA-ARS, WA, NDSU, and CSU, three pinto germplasm lines US PT-CBB-1, US PT-CBB-2, US PT-CBB-3, and one great northern line USGN-CBB-4 with plant erectness and resistance to common bacterial blight, rust (Ur 3 gene), and BCMV (I and/or bc-1^2 genes) were released.

Collaboration with researchers at the University of Florida and the USDA-ARS resulted in the release of three McCaslan type, indeterminate, rust and bean golden yellow mosaic resistant snap bean germplasm. The BGYM resistance of McCaslan RGMR-5 is derived from a breeding lines developed in Puerto Rico. In addition, breeding lines were screened in the greenhouse in Puerto Rico for BGYM reaction. This indeterminate snap bean is the first variety for the U.S. with BGYM resistance. McCaslan RGMR-5 is being marketed by a private company as Genuine.

I.A.1.b.(2) Activity #2: Develop Middle American and Andean bean varieties for the lowland tropics with enhanced biological nitrogen activity or tolerance to terminal drought, heat or low soil fertility.
I.A.1.b.(2)(a) Priority: (2) High priority
I.A.1.b.(2)(b) U.S. researchers: Beaver, Kelly and Foster
I.A.1.b.(2)(c) HC researchers: Rosas and Acosta
I.A.1.b.(2)(d) Methodology: Conventional plant breeding techniques will be used to develop bean breeding lines with greater tolerance to terminal drought, heat or low soil fertility. Populations will be developed in Honduras by Juan Carlos Rosas to study the inheritance of, and identify the molecular markers for, heat tolerance and biological nitrogen fixation. A regional trial will be conducted to evaluate small red lines that combine BGYMV resistance and heat tolerance. Field screening techniques for terminal drought and high temperature tolerance will be conducted in Honduras and Mexico using RIL line populations developed from intergene pool crosses differing in drought adaptation. Detailed physiological studies under water stress will be conducted in a lowland site that has low fertility. A graduate student from Michigan State University will evaluate two RIL populations in Honduras and Michigan under drought and non-stress conditions. In Mexico, two different RIL populations will be evaluated in at least two lowland locations under drought and non-stress conditions. Results from these experiments will be used to identify lines with drought resistance in the lowland tropics.
I.A.1.b.(2)(e) Anticipated (1 year) results of activity: Small red, black, red mottled, red kidney and white bean breeding lines with enhanced levels of abiotic stress tolerance will be developed in the LAC region and the U.S. New sources of abiotic stress tolerance will be

identified and more efficient techniques for screening beans for terminal drought, heat and low fertility will be developed.

I.A.1.b.(2)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Progress in the development and release of bean varieties with abiotic stress tolerance will be slower than breeding for disease resistance because these traits tend to be quantitatively inherited. Bean varieties with greater tolerance to drought and low fertility will be of greatest benefit to small-scale producers who often produce the crop on land prone to these abiotic stresses.	FY 01-02	Increased demand for heat-tolerant bean varieties Heat tolerance permits expansion of bean production into new areas and during non-traditional growing seasons Results from field trials document potential benefit of bean lines with enhanced tolerance to abiotic stress Formal release of bean cultivars and germplasm with enhanced levels of tolerance to abiotic stress Manuscripts in refereed journal describing improved screening techniques for abiotic stress

I.A.1.b.(2)(g) Budget:

Honduras	$ 20,000
Mexico	6,000
MSU (Kelly)	12,000
UPR	10,000
Total (Direct Costs only)	$ 48,000

I.A.1.b.(2)(h) Major changes: Bean production in lowlands of LAC is often subjected to terminal drought, low soil fertility and high temperature. Progress in breeding for these traits has been slower than biotic traits due to the quantitative inheritance of abiotic stress tolerance. Research in the LAC region has resulted in the identification of new sources of tolerance to drought and low fertility, which are being used as parents in bean breeding programs. Results from inheritance studies and identification of molecular markers for these traits will facilitate future breeding efforts. Recombination of diverse sources of drought tolerance using recurrent selection methods has been initiated. Populations that recombine drought and low fertility tolerant sources with disease resistance from small red and black lines have been developed and are being screened under limited moisture and low fertility conditions. Specific populations were developed to study in Honduras and Puerto Rico the inheritance of tolerance to heat and low soil fertility. Greenhouse and field studies using mycorrhiza inoculant have generated promising preliminary results. Inoculated plants developed larger root systems, increased biomass and greater yields. This was associated with increased number of spores, hyphae and a greater rate of mycorrhiza infected roots. In addition, genotypic variation was observed in the response to inoculation among a set of improved and landrace bean varieties. Populations will be developed to study the genetic of the bean host/mycorrhiza relationship.

Farmers and technicians participating in PPB activities initiated by Zamorano in the year 2000, in two regions of Honduras, indicate that drought and low fertility are among the most important limiting factors for bean production on hillsides. Farmer selection criteria were applied to populations developed using local landraces as parental lines. The breeding lines are evaluated for agronomic adaptation (vegetative and reproductive vigor) under local conditions characterized by unstable rainfall distribution and low input agriculture. In order to increase adoption of improved varieties, which are well adapted to low input agriculture, bean breeding lines with superior seed characteristics are being developed.

The drought in Central America delayed progress in the development of beans with enhanced levels of biological nitrogen fixation and tolerance to abiotic stress. Supplemental funds was requested to produce seed of recently released varieties and promising breeding lines to permit bean research programs in Central America to resume on-farm trials.

I.A.1.b.(2)(i) Progress during past year: The first heat tolerant, BGYM resistant line with a superior commercial seed type is being validated and considered for release in Central America. Amadeus 77 (EAP 9510-77) was selected after intensive testing on the coastal regions of Honduras and El Salvador It is expected to be released in El Salvador and Nicaragua. Other BGYM resistant and heat tolerant lines have excellent type II, erect plant architecture and commercial seed types. Using participatory research, farmers from the Rio Cangrejal basin on the northern coast of Honduras selected Amadeus 77 and EAP 9504-30B as the most promising heat tolerant lines. On-farm testing of these two lines is being conducted with participating farmers. The heat tolerant trial (LITOLAT) including nine breeding lines and a local check is being evaluated in the northwest region of Costa Rica. Last year, this trial was distributed to several countries in Central America and Caribbean.

Several breeding populations were developed from crosses between drought and low fertility tolerant lines with black and small red bean lines with disease resistance. These breeding populations were evaluated for agronomic adaptation under low fertility and moisture stress as well as natural disease incidence. Selected families were advanced for further testing. Drought tolerant populations from Michigan State University were evaluated in Honduras during the summer of 2001, as part of the M.S. graduate research of Mark Frahm. A CIAT drought trial including 36 genotypes and two drought trials with eight bean genotypes were grown under different levels of fertility. These trials were conducted at Zamorano facilities. Sprinkler and furrow irrigation were used to provide both drought stress and favorable moisture conditions in these trials. Yield per se and drought indices were used as drought tolerance criteria. The most promising sources of drought tolerance were used as parents in the recurrent selection program.

Forty-nine bean genotypes were evaluated in Mexico for the combined effect of terminal drought and resistance to *Macrophomina phaseolina* (Mp). Since many soils in the tropical lowlands are infested with Mp, resistance is a needed trait if a bean genotype is to perform well under conditions of terminal drought. In addition, damage by Mp can be antagonized by drought and heat stress. Two subsets of genotypes, one containing a diverse array of drought resistant lines (from different sources, 27) and 29 black seeded lines were evaluated. Genotypes were sown in January 2001, during the dry season, under two water treatments, irrigation and terminal drought at Cotaxtla, Veracruz. At sowing time, the seed in the entire experiment was inoculated with a local isolate of Mp. An 8x7 rectangular lattice design was utilized and four replicates were fully irrigated and four were subjected to terminal drought, where irrigation was withheld from flowering onwards. Due to unusual rainfall in March, terminal drought stress was mild. Based on the average from all genotypes, terminal drought significantly enhanced maturity by seven days and reduced the 100-seed weight by 17% and yield by 19% (Table 1). Among top yielders under stress was the Andean line A 195 and genotypes known for their resistance to Mp, such as Rosada Nativa (Puerto Rico), BAT 477 (CIAT), Bambuí (EMBRAPA, Brazil) and most of the superior bred lines that have Negro 8025, a tolerant cultivar, in their pedigree. A 195 is a large cream seeded Andean cultivar that might be suited for East Africa or Ecuador. Lower yielders under terminal drought were: Pinto UI 114, a cultivar susceptible to Mp, CNC2 , PR 9457-41, SEA 5, NGB 99007 and Negro Otomí.

These last two genotypes are shiny black seeded cultivars from the Mexican highlands, which were damaged by Mp. In order to test for the stability of response to drought and Mp, the same trial will be conducted at two sites in the lowlands of Veracruz in the fall-winter season 2001/2002 under terminal drought and will be inoculated with local isolates of Mp. In this second trial irrigation will be withheld earlier than in the previous experiment. Identified terminal drought and Mp tolerant tropical black seeded lines will be increased and made available to colleagues in the region while resistant lines without commercial value will be included in the crossing block to develop resistance genotypes for the lowlands.

Table 1. Maturity, 100-seed weight and seed yield of 10 top yielders under terminal drought of a group of 56 diverse bean genotypes grown under two moisture treatments[1] at Cotaxtla, Veracruz, Mexico 2001.

		Maturity DAS[2]		100 seed wt in g		Yield kg/ha^{-1}	
Genotype	Origin	Irrigated	Stressed	Irrigated	Stressed	Irrigated	Stressed
A 195	CIAT	77	73	49.4	43.9	1750	1815
BAT477	CIAT	73	69	24.6	19.5	1625	1691
G 21212	Colombia	77	70	23.9	22.3	1447	1691
NI/8025-35-1	INIFAP	77	67	19.8	17.3	2046	1559
Bambuí	EMBRAPA	75	68	19.4	16.0	1460	1552
NGO 99173	INIFAP	75	69	22.3	17.5	1868	1526
NI/8025-65-1	INIFAP	76	69	21.1	18.4	1750	1500
R. Nativa	UPR	74	67	25.9	25.0	1559	1493
NGO 99165	INIFAP	75	69	24.3	16.6	1934	1480
NGO 99176	INIFAP	76	69	23.2	20.0	1625	1473
Ave.(n=56)		77 a	70 b	22.6 a	18.8 b	1564 a	1262 b

[1] Plots irrigated during the whole cycle. Stressed, irrigation was withheld from 50% flowering onwards; [2] DAS = Days after sowing; [3] Different letters denote significant differences at P<0.01

Belinda Roman completed requirements for a M.S. degree in the Department of Agronomy and Soils of the University of Puerto Rico. A portion of her thesis research dealt with an evaluation of the performance of advanced lines from the cross 'DOR303 x Indeterminate Jamaica Red' in field trials planted in Puerto Rico during the summers of 1999 and 2000. Three lines were identified that had greater seed yield over both years than the heat tolerant parent Indeterminate Jamaica Red. The line PR9920-171 combined a mean seed yield of 1,600 kg/ha with resistance to bean golden yellow mosaic virus. This line will be evaluated in advanced line trials and will be considered for release in Puerto Rico as an improved cultivar. Narrow sense heritabilities for seed yield (kg ha^{-1}), number of pods/plant and number of seed per plant were intermediate in magnitude whereas heritability estimates for individual seed weight was large. Because additive genetic correlations between individual seed weight and seed weight/plant were positive and large (0.92* in 1999 and 0.89* in 2000), indirect selection using individual seed weights could have been used to identify superior yielding lines. The parents (Indeterminate Jamaica Red and DOR303), five of the highest yielding lines and five of the lowest yielding lines from the 1999 growing season were evaluated during the summer of 2000 for pollen viability. Percent pollen viability of the five most heat tolerant lines (85.0%) was significantly greater than the five most heat sensitive lines (68.6%). The pollen viability of the heat tolerant parent Indeterminate Jamaica Red (93.7%) was also significantly greater than the heat sensitive parent DOR 303 (67.4%).

CIAT researchers reported that G21212 has tolerance to low P soils. A large number of plants with black and small red seed were selected in Puerto Rico in F_2 nurseries from crosses between G21212 and BGYM resistant breeding lines and varieties.

SEA 5, San Cristobal 83, Negro Tacana and BAT 477 are sources of resistance to ashy stem blight. Resistance to this disease, which is caused by *Macrophomina phaseolina,* has been found to contribute to drought tolerance. A large number of plants were selected in F_2 nurseries from crosses between these lines and sources of resistance to BGYM. The F_3 lines from these crosses will be evaluated in Honduras in 2002.

The performance of a total of 139 lines from CIAT were evaluated at the Isabela Substation over two growing seasons. The trials included sources of disease resistance and tolerance to abiotic stress. A36, IPA 7,Negro Cotaxtla and Negro INIFAP produced the greatest mean yields (> 3,000 kg/ha) among the lines with adaptation to low soil fertility. SEA 4, SEA 5, SEA 9 were the highest yielding (> 3,000 kg/ha) sources of drought tolerance. The small red lines DICTA 113 (3,301 kg/ha) and DICTA 122 (3,508 kg/ha) produced the greatest overall yields. These lines will be included as parents in the 2002 crossing block.

I.A.1.b.(2)(j) Current status of research: In addition to greater disease resistance, cultivars developed by the lowland bean breeding team have been adopted by small farmers because of their superior performance under heat or drought stress or in soils with low fertility. These conditions are frequently encountered in the lowlands of Central America and the Caribbean.

The project has made excellent progress breeding heat tolerant small red beans cultivars for the lowlands of Central America. In addition, these lines are being used to improve the heat tolerance of other seed types. Nevertheless, we need to know more about the inheritance of this trait and to identify molecular markers to facilitate MAS. In collaboration with the MSU-Mexico team, CIAT and NBR programs from Profrijol, breeding for tolerance drought and low soil fertility has intensified. Sources of tolerance to low soil fertility identified by CIAT are being used in our small red and black bean breeding program. Some heat tolerant lines have shown good performance under drought.

Several drought trials were conducted this year to study the genetics of drought. The best heat, drought and low fertility sources are being recombined with disease resistant lines to develop small red and black bean cultivars with superior agronomic performance and greater consumer acceptance. The selection of bean lines with greater levels of tolerance to abiotic stress will intensify during the next five-year period of funding. Several populations already have been developed that should produce bean breeding lines with greater tolerance to terminal drought and heat. Dr. Jonathan Lynch, Penn State soil scientist, will strengthen the capacity of LAC researchers to select beans with greater tolerance to low soil fertility

I.A.1.b.(2)(k) Documented impact: Bean/Cowpea CRSP researchers participated in the development and release of BGYM resistant and heat tolerant bean cultivars such as 'Dorado' and 'Tio Canela 75' that has permitted small red bean production to expand to lower altitudes in Honduras and El Salvador.

The adoption of disease resistant small red bean cultivars has been enhanced because these lines have superior agronomic performance under drought, heat or low soil fertility. Small, low input bean producers in LAC frequently encounter these conditions. Adaptation to stress environments in combination with disease resistance, are the main criteria that farmers use to adopt an improved bean variety. As many as 40-50% of the farmers in some regions of LAC have adopted bean cultivars developed by the Bean/Cowpea CRSP. Greater levels of adoption in Central America and the Caribbean are observed in the lowland to medium altitudes (up to 1,200 masl). Higher altitudes tend to have lower rates of adoption. In general, official and non-governmental extension agencies have paid less attention to bean producers at higher altitudes, which limits the access of highland farmers to improved seed.

I.A.1.b.(3) Activity #3: Develop BGYM and white mold resistant transgenic plants
I.A.1.b.(3)(a) Priority: (2) High priority--Initial plants (T1 generation seeds/plants) will be available at Michigan State University for the Andean line JB178 for two constructs the mutant *rep* gene (amino acid mutant in the DNA-nicking domain) and the control (a *rep* gene with a nonfunctional start codon). Transgenic plants will need to be detected by PCR and then seed increased. (3) Could be postponed--This increased effort on bean transformation at the University of Wisconsin and University of Costa Rica could be postponed for a year, but this would cause a serious delay in the eventual time frame for production of transgenic beans and their evaluation for virus resistance.
I.A.1.b.(3)(b) U.S. researchers: Maxwell and Kelly
I.A.1.b.(3)(c) HC researchers: Ramirez
I.A.1.b.(3)(d) Methodology: The transformation team at UW-Madison, constructed a new transformation plasmid that contained the herbicide resistance gene, *bar*, and the antiviral mutated *rep* gene from BGYMV (trans-dominant interference strategy). A similar construct, except the mutated *rep* gene was from BGMV, had been used by Dr. Josias Faria and colleagues at CENERGEN, Brazilia to transform Olathe beans with resistance to BGMV.

Dr. J. Kelly's team at MSU abandoned the electro-transformation system and evaluated another technique developed by Trieu et al. (2000, Plant J. 22:531-541) for transformation *in planta* the model legume *Medicago truncatula*. The method was adopted from a successful system used to transform *Arabidopsis thaliana* that involved the vacuum infiltration of the flowering plants with a suspension of *Agrobacterium*. Trieu et al. (2000, Plant J. 22:531-541) generated genetically stable transformants using either the flower or seedling infiltration system in *M. truncatula*. We choose the flower infiltration system to attempt to transform bean (*Phaseolus vulgaris*) as Trieu et al. (2000 Plant J. 22:531-541) demonstrated the highest success rate (76%) with this method.

Dr. R. Allison's team continued to evaluate methods for testing the variables of the electro-transformation method.

Another antiviral strategy for broad-spectrum resistance to geminiviruses was funded by a USDA/NRI grant to Dr. D. P. Maxwell, UW-Madison. This new strategy involved a combinatorial chemistry approach for the selection of RNA and peptide ligands that would bind to conserved sequences of the geminiviral genome and thus, these peptides are anticipated to interfere with replication. If successful, this strategy will replace the trans-dominant interference strategy current being pursued.
I.A.1.b.(3)(e) Anticipated (1 year) results of activity: Ultimately, beans with greater resistance to BGYMV will be available for both Andean and Mesoamerican type germplasm as well as lima beans. Beans with greater white mold resistance will be developed. A more refined system for bean transformation will have been developed, which will have applications to many other aspects of bean improvement.
I.A.1.b.(3)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Researchers in the LAC region and the U.S. do not have a reliable system for transformation of beans. It will not be economically feasible to produce genetically modified organisms until a relatively cheap transformation system is developed. Long-term impact should be more sustainable and higher bean yields.	End of FY 01	Design and construction of improved transformation vector Evaluation of 30-40 germplasm lines for transformation potential T1 generation transgenic beans (one germplasm line) for at least two different constructs of the *rep* gene
	End of FY 01	Evaluation of T1/T2 generation transgenic beans for resistance to BGYMV in growth chambers Engineer two additional T1 generation transgenic bean lines for at least two different constructs of *rep* gene
	FY 02	Field evaluation of the first transgenic beans developed in FY 00 Evaluation of T1/T2 generation plants for resistance to BGYMV
	End of FY 03	Field evaluation of transgenic beans developed in FY 01

I.A.1.b.(3)(g) Budget:

Costa Rica (Ramirez)	$ 8,091
MSU (Kelly)	4,100
UWI	44,044
Total (Direct Costs only)	$56,235

I.A.1.b.(3)(h) Major changes: The team (Ms. Brooke Milde, Dr. M. K. Nakhla, Dr. Josias Faria and Dr. D. P. Maxwell) at UW-Madison was to use the electro-transformation technique being developed by Dr. Richard Allison at Michigan State University. However, because of difficulties with this technique, Dr. Maxwell decided to go with the biolistic method and to use the same approach as had been successfully used in Brazil by colleagues at CENERGEN, Brasilia. Thus, Francisco Aragão at CENERGEN supervised the construction of a particle gun and Dr. Josias Faria, CNAPF, Brazil brought the particle gun with him to Madison. Dr. Faria then did most of the bean transformation work at UW-Madison.

Dr. J. Kelly's team at MSU abandoned the electro-transformation system and evaluated another technique developed by Trieu et al. (2000, Plant J. 22:531-541) for transformation *in planta* the model legume *Medicago truncatula*.

I.A.1.b.(3)(i) Progress during past year: At UW-Madison, the particle gun was used to transform beans by forcing small particles coated with the antiviral/herbicide genes into the meristem tissue of the Olathe pinto bean. Early experiments at CNAPF by J. Faria test several cultivars of bean and found that the apical meristem of Olathe was most exposed and thus, thought to be easiest to transform. Over 9 months, the transformation team bombarded 2,400 meristems and generated 38 T0 plants that tested positive for herbicide (Basta) resistance and positive for the antiviral construct by PCR. These 38 plants yielded about

2,000 T1 seeds. Thirty-four T1 plants from one T0 plant (plant 6-1) were inoculated with BGYMV and 3 had delayed symptoms and tested positive for the antiviral insert by PCR and had tolerance to the herbicide. T2 seed were collected from these three plants. In another experiment, a total of 30 T1 plants were tested from 5 different T0 plants and all T1 plants were susceptible to BGYMV. Currently, the T2 seeds are being evaluated for the presence of the antiviral insert by PCR.

In Brazil, Dr. Faria has made crosses between the transgenic beans resistant to BGMV and commercial cultivars. Permission has been received to field test these transgenic beans in early 2002.

At MSU, Dr. Kelly's team reported: Given the genotypic specificity of *Agrobacterium* to infect, we choose a group of six bean genotypes that represented the two major gene pools and races of bean that differed in growth habit and exhibited early flowering characteristics (see table below). Since the plants were grown in flats for approximately six weeks or until the bean plants began to flower, we used genotypes that flowered earlier. One hundred and forty-four seeds of each genotype were planted. When the plants had produced flower buds and a few open flowers, the upper part of the plant was submerged in a container with a suspension of *Agrobacterium*. The flat was inverted and placed in a vacuum chamber and held for five minutes. After infiltration, the plants were covered with plastic film for 24 hours and then transplanted into six-inch pots. Seed was harvested from individual T_0 plants at maturity. For the transformation process, we used *Agrobacterium* strain 35S-TLG2b-T7 3300 MCS possessing the *bar* gene that conditions resistance to the herbicide Basta. Seed of individual T_0 plants were planted in flats and sprayed with Basta (0.4ml/l) to detect transformants. Since no transformants were observed after testing T_1 seed from individual T_0 plants, all the T_1 seed was sprayed in the event that the transformation event occurred in a single flower bud. No transformed plants were detected as all T_1 seedlings succumbed to the effect of the herbicide. In retrospect, the plantlets were severely stressed having to maintain them in 72-well inserts in flats until they flowered at around 40 days after planting. After vacuum infiltration with *Agrobacterium* many plants died and the survivors produced limited amounts of seeds (1-10 seeds). Given the large size of bean plants at flowering we couldn't work with this size of plant in the freeze drier used to vacuum infiltrate the plants. If we could have worked with non-stressed plants that produced more buds/flowers and seed, the opportunity to find transformants may have improved. Thus, there are no encouraging results for the transformation of beans with resistance to white mold.

At MSU Dr. Allison reports for his team: My laboratory continues to work towards a reliable method of transforming large seeded legumes with the electro-transformation method. The potential transformants of bean that were PCR positive the antiviral construct did not yielded a good Southern blot hybridization. The seeds have been transferred to another lab for further screening and, to date, that lab has no positive data concerning transformation. We recently concluded a series of *Phaseolus* and *Glycine* transformation attempts with a herbicide resistance gene and those plants are currently yielding seed (September 2001). We have conducted the necessary preliminary experiments to determine suitable concentrations of herbicide for screening potential transformants and those trials will be initiated next month. Meanwhile our transformation apparati and all of our greenhouse space is devoted to the end of the *Phaseolus* experiments and the beginning of cowpea transformation experiments. These are intended to introduce a viral gene from *Cowpea aphid borne mosaic virus* and the *gus* marker to cowpea. This research is in collaboration with Dr. Idah Sithole, University of Zimbabwe and her student Richard Mundembe. The research is sponsored by a grant to the Univ. of Zimbabwe from the Rockefeller Foundation. We are able to conduct a systematic approach to testing numerous variables. Our present limitation is greenhouse space as we have resorted to placing plants on the floor. So we remain optimistic that our transformation system will work. We are unable to predict its efficiency at this point. We have concentrated on three genera of large seeded legumes including the three varieties of *Phaseolus*. We are currently testing numerous variables and are working at our research facility's capacity: three greenhouse spaces and one walk-in growth chamber.

I.A.1.b.(3)(j) Current status of research: Transformation of beans appears to be possible with the biolistic method, however, efforts to confirm the transformation event by Southern blot analysis needs to be completed. At UW-Madison, the 2,000 T1 seeds will be germinated and T1 plants checked for the antiviral insert by PCR. T2 seed will be generated from all T1 plants that test positive for the antiviral insert. The promoter used (*nos* promoter) for the herbicide gene does not seems to give high herbicide resistance and if time permitted, a stronger promoter would be used to construct a new plasmid. The future of this project will dependent on funding from CRSP, since no other funds are available to support the continued evaluation of these T2 seeds. The research in Brazil is being funded by EMBRAPA and will continue.

I.A.1.b.(3) (k) Documented impact: Through a collaborative effort with Brazilian scientists, there is finally some very encouraging results for the transformation of beans with resistance to BGYMV. It is at least 2 years away from having T4 seeds for testing in the field in Puerto Rico.

I.A.2. Research area: Effective disease management strategies for the lowlands

I.A.2.a. Background: Diseases are major constraints to bean production in the lowland tropics. For example, results from economic studies conducted by PROFRIJOL indicated that web blight alone accounted for 19% of yield loss in Honduras and a loss of $7.1 million to the 1993 bean crop in El Salvador. In addition, diseases cause increased costs of production due to the application of pesticides. The application of pesticides, which in addition to additional out-of-pocket expenses for the grower, also poses environmental safety issues. When new disease resistant varieties are released, their success depends on having a management system that will maximize durability of the resistance.

Deployment of resistance genes to variable pathogens is dependent on knowledge of the pathogenic variability. In Honduras, all of the known rust resistance genes have been defeated by *U. appendiculatus* races present in any two-year period. Gene combinations need to be tested for resistance stability against an array of races found in Honduras over the past four years. Resistance to the web blight pathogen has been identified in Puerto Rico but this source needs to be tested against variants of the pathogen from the LAC region. Development of common bacterial blight resistance has been slow because of partial resistances (QTL) identified so far. Knowledge of the QTL/strain relationship of *Xanthomonas campestris* pv. *phaseoli* will be needed before QTL can be combined to strengthen and broaden resistance. Although resistance to the BGYMV has been identified, the reaction of sources of this resistance or breeding lines with the resistance to related geminiviruses (still to be characterized) need to be established.

I.A.2.b. Proposed research area workplan and subsequent annual progress report

I.A.2.b.(1) Activity #1: Identify and study variability of fungal (*Uromyces appendiculatus*, *Rhizoctonia solani, Phaeoisariopsis griseola and Colletotrichum lindemuthianum),* bacterial and viral pathogens.

I.A.2.b.(1)(a) Priority: (2) High priority

I.A.2.b.(1)(b) U.S. researchers: Steadman, Coyne, Maxwell

I.A.2.b.(1)(c) HC researchers: Godoy-Lutz, Doyle/Rosas, Ramirez

I.A.2.b.(1)(d) Methodology: Conduct mobile nurseries to monitor variability of virulence of the bean rust. Evaluate new techniques for screening beans for web blight reaction using isolates representing the genetic variation of the pathogen within the region. Begin to characterize fungal pathogens (rust, ALS, anthracnose and web blight) collected during field visits throughout Honduras and in the wild bean plant exploration in late 2001. We anticipate collaboration with other plant pathologists (C. Araya/anthracnose and G. Mahuku/ALS) in the LAC region. Use molecular techniques to characterize the web blight pathogen and study phylogenetic relationships. Research will be conducted to characterize QTL for resistance to common bacterial blight and to determine if specificity can be detected between particular QTL for resistance to common blight pathogen strains. RAPD molecular markers and scars will be used in backcross breeding program to pyramid QTL from different germplasm sources to enhance the resistance of great northern and pinto beans to CBB. A set of differential *Phaseolus vulgaris* lines will be developed to identify common blight pathogen races. Use molecular techniques to screen BGYMV resistant bean lines for and correlate with bean field reaction to BGYMV. Use molecular techniques to characterize geminiviruses, particularly the new bean-infecting geminivirus in Costa Rica and the web blight pathogen and study phylogenetic relationships. New PCR and DNA probes for detecting bean-infecting geminiviruses will be developed and technology transferred from WI University to HC in LAC.

New geminivirus methods: Specific PCR primer/pairs and DNA hybridization probes were developed for detection of the five major bean-infecting begomoviruses: Bean dwarf mosaic virus, Bean golden mosaic virus, Bean golden yellow mosaic virus, Bean Calico mosaic and Tomato yellow leaf curl virus. The specific methods are available from D. P. Maxwell, University of Wisconsin-Madison.

I.A.2.b.(1)(e) Anticipated (1 year) results of activity: There will be publications and presentations at scientific meetings that demonstrate a better understanding of the pathogen variability and new or improved strategies for the control of plant diseases. There will be improved screening and testing beans for disease resistance. There will be a more effective deployment of resistance genes and associated disease management strategies resulting in more durable disease resistance.

I.A.2.b.(1)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
The improved screening techniques will permit breeders to be more effective in the development of disease-resistant bean varieties. Deployment of resistance genes and related management practices should result in more durable disease resistance.	FY 00-02	Impact can be measured by the adoption of disease resistant varieties and sub-sequent reduction in disease severity and pesticide use. Manuscripts in referred journals describing improved disease screening techniques and inheritance studies of new sources of disease resistance

I.A.2.b.(1)(g) Budget:

Costa Rica (Ramirez)	$ 6,000
Dominican Republic	26,506
Honduras	12,000
UNL	21,601
UWI	2,000
Total (Direct Costs only)	$68,107

I.A.2.b.(1)(h) Major changes: The plant exploration grant from USDA was not activated in 2000-01 due to delays in finalizing the contract between USDA and UNL. As a result, no activity occurred on angular leaf spot and anthracnose diseases. These diseases were excepted to be collected from wild beans during the plant exploration and distributed to cooperators (CIAT, Costa Rica and USDA-ARS) for variability studies.

I.A.2.b.(1)(i) Progress during past year: Rust Pathogen: A combination of pathotypes that affect Mesoamerican as well as Andean bean genotypes have been identified by means of mobile nurseries in the San Juan Valley of the Dominican Republic. The planting of red mottled along with black seeded varieties have stimulated development of a diverse rust population in some areas of the Valley. Similarly, a shift in rust populations has been observed in the Arbonite Valley and Savane Zombi, bean growing areas in Haiti. Both Andean and Mersoamerican bean genotypes have shown susceptible reactions to rust.

Differential genotypes in the mobile nursery established in a field planted with a mixture of Arroyo Loro Negro (black) and an unknown black seeded genotype yielded a diverse reaction profile. Rust pathotypes detected in the sample overcame resistance genes Ur-5 and Ur-10 (Mex 309 and Resisto, respectively), and Ur-9 (PC-50), but not Ur-11 (PI-181996), an unknown gene present in BAC-6,and by a combination of Ur-3, Ur-6 and other genes from Beldak-RR-1. Other rust samples from red-mottled beans in DR fields have not changed for the past two years. With the increase of Arroyo Loro Negro (black) plantings for the export market, new virulent pathotypes may develop.

In Honduras, the Ur-6 gene was resistant to most pathotypes identified, but it was not enough to be a useful single resistance gene source. Some two gene combinations also did not provide resistance to all the pathotypes available in our collection. Three and four rust resistance gene combinations are being tested in breeding lines of small reds.

Some preliminary tests were done on East African (Tanzania) bean rust samples. Andean-specific pathotypes were common, indicating that the Ur-4 gene would not be effective. Ur-3 resistance gene was effective against the majority of pathotypes and when combined with Ur-5 and CNC sources provided resistance to all pathotypes. More sample tests are planned for the next phase of research.

Rust incidence and severity was low on the High Plains of the USA. However, in one field of a susceptible bean variety, a rust pathotype was found to produce susceptible reactions on resistant varieties of pinto and great northern beans. In one instance GN Weihing with two resistance genes was overcome. The threat of this and other pathotypes with increased virulence found the past three years is not known. There has been no evidence of resistance from the Ur-3 gene found in pinto 'Chase' being defeated in any commercial field in the region. Thus, the high virulence detected in our greenhouse tests probably is due to low populations within the overall rust pathogen populations and may or may not increase over time. Breeding lines with three and four rust resistance genes are in the advanced testing stage.

Web Blight Pathogen: Web blight (WB) is caused by aerial isolates of *Rhizoctonia solani* Kuhn (telemorph: *Thanatephorus cucumeris*). The disease is widespread in the LAC region and has caused yield losses up to US $7 million per year. Low to moderate levels of resistance to WB are only available in a few cultivars and breeding lines. Variability of the *R. solani* pathogen is not understood and thus has limited progress in breeding for disease resistance. Based on RFLP analysis of the internal transcribed spacers region ITS-5.8 S ribosomal DNA, we identified five genetically distinct *R. solani* subgroups. To confirm the extent of such variability we sequenced the amplified ITS region of 321 isolates from samples from 11 countries in the LAC region. Sequence results agree with the RFLP analysis. In addition, sequence comparisons and phylogenetic analysis identified more differences between aerial and soilborne *R. solani*. WB isolates from Honduras and Dominican Republic which produce microsclerotia deserve to be assigned a new subgroup, not previously described in the literature on taxonomy of *Rhizoctonia.* Taxonomist, Dr. Shiro Kuninaga at the Health Sciences University in Hokkaido, Japan will cooperate on future taxonomic studies on *Rhizoctonia*. Data from the sequence work was sent to the Genbank and posted in its database on the World Wide Web.

Common Bacterial Blight Pathogen: Breeding for resistance to common blight based on inoculation and selection for phenotypic reaction has been a slow and challenging process. However, use of molecular markers tightly linked to known plant resistance genes is expected to expedite and increase the precision of the selection process. The objective was to clone resistance genes and/or to find markers tightly linked to known resistance genes for breeding purposes using specific pathogen isolates. Phosphate-binding domain (P-loop) is conserved in 13 protein families, including the NSB-LRR type plant resistance gene class containing Kinase-1a domain (Traut WT, 1994). Degenerate primers based on conserved domains were used to pull out fragments with kinase-1a domain targeting plant resistance genes (Chen et al., 1998; Collins et al., 1998). Sequence analysis indicated that about 20 clones contain NBS-LRR type disease resistance signature at and around the conserved domains. Thirty-three common bean lines/cultivars, resistant to different diseases, including common bacterial blight (CBB) caused by *Xanthomonas campestri pv phaseolis* (*Xcp*), were inoculated with specific *Xcp* isolates. Then leaf samples were taken at different times. The mRNA was used in bulk for initial amplification of the kinase-1a containing fragments that were cloned subsequently. RFLP mapping of these fragments using the BAT93 x JALO EEP558 RIL population, which was used originally to create the integrated map of common bean indicated that this gene family was mostly conserved in four different chromosomes (B2, B3, B4, B7) and absent in three chromosomes (B8, B9, B10). Mapping also showed the distribution of this gene family in the genome, especially relative to known resistance genes. Detected linkages to disease resistance genes are expected to be useful in breeding for disease resistance.

There is no recognized set of differential common bean varieties and lines to detect races of Xcp. Some reports indicate the presence of races of CBB pathogens based on hypersensitive versus compatible reactions of isolates on common beans (M. Zapata, Univ. Puerto Rico) while others were only able to detect races on tepary bean lines (F. Opio, Uganda, and H. Zaiter, et al., NE) but not on common beans. Differential reactions to isolates of Xcp based on low versus high compatibility have been reported on common beans by several investigators (J. McElroy and D. Coyne, NE: F. Opio, Uganda; M. Schuster and D. Coyne, NE). Additional research is needed to clarify the reaction of common beans to Xcp. The objective of this research was to test a large number of diverse Xcp isolates (maintained in A. Vidaver's lab, UNL) from wide geographical areas against 34 germplasm sources (collected from several investigators) that expressed varying levels of resistance to CBB along with two well known susceptible germplasm sources, Pinto UI114 (ID, US) and PC-50 (DR).

In all experiments the multiple needle method of inoculation was used with 10^6 CFU/ml of Xcp when the first trifoliate leaf was fully expanded. CBB symptoms were rated 14 days after inoculation as symptoms or percent of the inoculated area with water soaking and necrosis. In the first replicated experiments the 34 resistant and two susceptible bean lines and buffer control were inoculated with 10 Xcp isolates. Two isolates each were selected at random from North America, South America, Caribbean, Africa and Europe. Based on the results of the first experiment 12 common bean lines that expressed differential reactions at the compatibility level were tested in a second replicated experiment with 30 different Xsp isolates, representing diverse regions but not used in previous experiments. The susceptible check varieties developed severe CBB symptoms (54-82%). Eight lines out of the 34 resistant lines tested showed promise as differential lines to detect races of Xcp based on the assumption that a combination of resistant ratings of no symptoms or low compatibility reactions (less than 5% CBB symptoms) versus high compatibility reaction (greater that 5% CBB symptoms). Twenty-one isolates had high virulence and nine had low virulence. Based on results of these two initial experiments, seven lines have promise for use as differentials to Xcp isolates based on low versus high compatibility reactions to a number of isolates. There were eight resistant lines based on the mean reactions over all isolates. A third experiment has been planted recently (October 2001) to test an additional 40 isolates on 10 of the lines tested in experiment two, along with XAN-159 and the susceptible check variety pinto UI114.

Geminivirus: Standard molecular techniques, polymerase chain reaction (PCR) and nucleic acid hybridization, were developed for the detection and identification of five bean-infecting begomoviruses. Three techniques were compared, modified and evaluated for optimal detection level of bean-infecting geminiviruses: multiplex PCR, non-radioactive nucleic acid hybridization, and DNA extraction methods. DNA extraction techniques were developed for high detection levels and for minimal reagents and steps for PCR and hybridization. The heat extraction method of a modified Dellaporta protocol was determined to be sufficient for PCR and hybridization detection; dry tissues may require additional treatment for PCR amplification. Specific PCR and hybridization probes were developed by identification of unique, conserved sequences for each virus. The designed specific PCR primers were optimal at a temperature of 61° C and able to detect picogram levels of DNA in both single and mixed infections. The Alk Phos Direct hybridization kit was found most effective for detection of viruses at 65° C and able to detect picogram levels of viral DNA. These techniques have widespread application to developing countries and will provide tools to evaluate the epidemiology and diversity of geminiviruses as well as assist resistance breeding, germplasm selection, and strategies for control. These methods were transferred to colleagues at the University of San Carlos, Guatemala City during two months by Ms. Jamie Potter.

These specific detection methods for the five bean-infecting geminiviruses were evaluated with tissue samples from both laboratory and field-collected plants from Florida, U.S., Mexico, Central America, the Caribbean, and Brazil. *Bean golden mosaic virus* was found in bean and soybean samples from Brazil; *Bean calico mosaic virus* was detected in bean samples from Los Mochis, Mexico; *Bean golden yellow mosaic* virus was found in bean samples from Guatemala, the Dominican Republic and Florida, US; and *Tomato yellow leaf curl virus* was detected in tomato samples from the Florida, US and Jamaica. *Bean dwarf mosaic virus* was not detected in any of the field samples tested. Several weed samples were also included and no bean-infecting geminivirus was detected in any of these samples from Jamaica, Dominican Republic and Guatemala. These detection methods will provide tools to assist in the understanding of the epidemiology and diversity of geminiviruses as well as facilitate resistance breeding, cultivar selection, and strategies for control.

Plants of beans showing a diversity of golden mosaic symptoms were collected in Costa Rica. DNA was purified by a modified Dellaporta method, and geminivirus detection was made by PCR with universal primers for DNA-A and DNA-B. PCR fragments were cloned and partially sequenced. In Costa Rica we have found 2 different geminiviruses, which produce yellow mosaic symptoms but these viruses are different than BGYMV. Some years ago a new geminivirus was found in bean sample #677, which was growing within a cucurbit plantation. This virus was partially characterized and studies showed that it was not widely distributed. During the 2000 survey of bean geminiviruses, we found other different geminiviruses widely distributed in western and northern Costa Rica associated with mosaic symptoms on bean plants. One sample #1152, had a hypervariable DNA-B size of 500 bp with primer pair 2039/CRc2, where as BGYMV has a PCR fragment size of about 650 bp. Both the "Top A" and "Top B" regions, which were obtained with universal PCR primers, were cloned and partially sequenced. Sequence analysis of the DNA-A showed that this new virus is in the squash leaf curl virus family and thus very unrelated to BGYMV. Bean calico mosaic virus is in this family, but this new bean-infecting geminivirus from #1152 is distinct from this Bean calico mosaic virus. It is important to know if this virus is in other parts of Costa Rica or Central America. We recently collected 100 beans samples form plants with mosaic symptoms from Southern Nicaragua. These samples will be analyzed by DNA hybridization with a specific probe from the 1152 virus.

I.A.2.b.(1)(j) Current status of research: The PCR-RFLP method has been successful in identifying genetic variability of isolates we have collected. We need to survey other areas where WB is causing major yield losses to determine the prevalent subgroups so that we will accurately know which germplasm and disease management practices need to be deployed at a particular site. Our methodology for accurate identification and management recommendations can be helpful to other CRSP collaborators in Africa who have identified WB as a widespread and economically important disease.

Ms. Jamie Potter will complete her M.Sc. Thesis in January 2002, and then the project will be finished except for publications.

Dr. Ramirez traveled to University of Wisconsin to continue the molecular characterization of this new geminivirus, #1152. Enough data will need to be collected to write a paper for publication in Plant Disease.

Mobile rust nurseries have been used each year for the last four years to monitor variation of the rust pathogen in the DR and NE. This nursery is expected to be used more in Honduras, Nicaragua and Guatemala and extended to E. Africa. Research on the molecular characterization of the WB pathogen began two years ago and will need two more years to complete. BCMV/BGYM resistant breeding lines will be recombined with high yielding blacks, whites and small red classes for eventual release in LAC (5 years). Work on conducting research to develop differentials for CBB started two and a half years ago and will require one more year to complete.

Jorge Gonzalez will complete his studies before April 2002.

I.A.2.b.(1)(k) Documented impact: With the application of the geminivirus methods, it was determined that a private snap bean breeder from the U.S. with field trials in Los Mochis, Mexico, was not selecting bean germplasm for resistance to BGYMV but to BcaMV. We expect research laboratories involved with identification of bean-infecting geminiviruses to use these PCR and DNA probes in the future. We have already had inquires from scientists from Honduras, Guatemala, Costa Rica and Cuba. Jamie Potter went to the University of San Carlos, Guatemala City and spent two months transferring this PCR and DNA hybridization technology to scientists there. She also participated in Biotechnology Course on Molecular Methods for Virus Detection as part of their new M.Sc. Program in Biotechnology. The discovery of the wide-spread distribution of bean-infecting geminivirus #1152 has great implications for breeding for virus disease resistance. Since this virus is in a totally different geminivirus family than BGYMV, it is critical to evaluate bean germplasm that has resistance or tolerance to BGYMV for its response to this new virus.

The results of the rust and web blight research will be used by breeders to incorporate resistance genes into breeding lines or varieties for the LAC region and US. Due to the nature of the rust pathogens, yearly monitoring is necessary to keep up with shifts in populations that can erode current resistance. The mobile rust nurseries containing rust differential lines were used to identify varieties and bean lines for release in the DR, Honduras and NE for resistance to rust and to monitor changes in the virulence of the rust pathogen against known genes and gene combinations. This nursery has been sent to Nicaragua and Guatemala for their use. Molecular characterization of WB polymorphic groups from the LAC region has revealed much more genetic variation than thought previously and has important implications in breeding and in selecting resistant lines. The black root disease of bean continues to be a problem to the production of black beans carrying the I gene in the DR and Haiti. Now germplasm with resistances to BGYM and BCM (bc-3) will allow bean production in Hispanola and Honduras. A novel and new approach was developed to develop probes for the actual genes for resistance to CBB. It is expected that these will be superior to all previously generated molecular markers because the probes are specific to the genes themselves.

I.A.3. Research area: Improved cropping systems for the lowlands

I.A.3.a. Background: Improved natural resource management and production technologies are needed to promote bean production in the LAC region. Relay intercropping of maize and beans using few inputs is the predominant cropping system in Central America. Results from on-farm trials show that intercropping maize and beans during the first growing season increases grain production, helps to reduce soil erosion and facilitates the management of weeds. Researchers in Africa have found that certain foliar diseases of beans are less severe when beans and maize are intercropped. Recommended soil and water conservation practices include the use of stone or live (vetiver and other grasses) contour barriers, the use of plant residue incorporated or as ground cover, inoculation with *Rhizobia*, incorporation of organic matter such as cow or chicken manure, and the use of leguminous green manure or cover crops. Results from on-farm trials also demonstrated that a significant increase in bean yields could be obtained using an improved, higher yielding variety with a moderate level of fertilizer and foliar fertilization. Seed treatment with fungicide, a common and inexpensive practice used by U.S. bean growers, should help improve germination and reduce seeding rates. In a competitive global economy, small to medium scale farmers in the LAC region need to reduce the cost of producing beans. Use of improved varieties and technologies will optimize benefits and reduce damages to the environment. On farm trials and field days are effective means to test varieties and technologies as well as transfer information to bean growers. NGOs can be used to reach a greater number of small-scale farmers. Foundation seed of improved varieties will be distributed to farmers to support artisan seed production and participatory activities in the region.

I.A.3.b. Proposed research area workplan and subsequent annual progress report

I.A.3.b.(1) Activity #1: Develop cropping systems for beans in the lowland tropics that integrate disease management practices and cultural practices that sustain productivity and preserve soil and water resources.
I.A.3.b.(1)(a) Priority: (2) High priority
I.A.3.b.(1)(b) U.S. researchers: Beaver, Steadman, Coyne
I.A.3.b.(1)(c) HC researchers: Rosas, Arnaud-Santana, Godoy-Lutz, Prophete
I.A.3.b.(1)(d) Methodology: On-farm trials and field days will be conducted in Honduras, El Salvador, Nicaragua, the Dominican Republic and Haiti to evaluate disease management practices and biofertilizers to exploit the benefits of symbiotic associations with Rhizobium and mycorrhiza effective strains. Project personnel will continue to collaborate with PROFRIJOL, the CIAT bean program, NGO's and universities in the evaluation of improved varieties, disease management strategies and more sustainable management practices. Plots will be established on farms to demonstrate different management options and for training. Field studies will continue to be conducted to determine the response of beans to mycorrhiza and *Rhizobium* inoculations.
I.A.3.b.(1)(e) Anticipated (1 year) results of activity: Disease management strategies and biofertilization practices will be developed that complement the disease resistance and abiotic

stress tolerance of recently released bean varieties. Bulletins containing recommended practices for bean production will be distributed to Honduran farmers and NGO technicians at training courses or when they purchase bean seed from Zamorano. Project personnel will use the on-farm trials to conduct field days that will include discussion of the benefits of disease management strategies and biofertilization practices.

I.A.3.b.(1)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
The on-farm trials have proven to be a very effective technique to permit farmers in Honduras to evaluate the performance of recently released varieties. This same approach will be used to evaluate disease management strategies and cultural practices that increase productivity and protect the environment. The cost effectiveness of producing beans in the Central America and Caribbean will be reduced.	FY 02	The performance of lines in the on-farm trials helps to measure the progress and potential impact of the bean breeding program and aids in the identification of new bean disease or pest problems. In the long term, disease management and improved cultural practices should lead to increased or more stable bean yields. Results from adoption and economic impact studies Presentation at scientific meetings Distribution of bulletins for farmers with recommended practices

I.A.3.b.(1)(g) Budget:

Dominican Republic	$10,000
Honduras (El Salvador & Nicaragua)	5,455
UPR (Haiti)	6,000
Total (Direct Costs only)	$21,455

I.A.3.b.(1)(h) Major changes: No major changes are expecting for year 2002. The project will continue collaborating with NBR programs, NGOs and LAC universities to conduct field plots to demonstrate recommended varieties and management practices. Foundation seed will be provided for validation and demonstration plots, or for supporting artisan seed production initiatives including production and postharvest practices for good quality seed. The project will continue to support the recovery of bean production in Central America, providing seed of improved varieties, training (short courses and in-service) and technical assistance when necessary.

The drought in Central America caused the loss of many on-farm trials planted during the 'primera' growing season. Farmers, national bean research programs and NGO's faced a seed shortage for the 'Postrera' planting season.

I.A.3.b.(1)(i) Progress during past year: Several field days were conducted in Central America in collaboration with the NBR programs and NGOs. Demonstration plots to promote improved varieties and recommended practices, including fertilization rates, disease management, mycorrhiza inoculation and others, were established in Honduras, El Salvador, Costa Rica and Nicaragua. Collaboration with bean researchers from the NBR programs, to carry out validation and demonstration plots of improved varieties and recommended practices has been very effective.

Honduras: Improved varieties, including Tio Canela 75, Dorado and Milenio, and recommended fertilization and disease management were compared with farmers' varieties and production practices at more than 50 locations in three provinces of the east-central region of Honduras (where more than 50% of beans are produced). Bean/Cowpea CRSP personnel participated in the two-year post-Mitch revitalization project supported by USAID/Honduras. Significant increases in yield were observed using improved varieties and some recommended technologies. Bean/Cowpea CRSP researchers were involved in the proposal preparation, and providing foundation seed, training and technical assistance. The project reached more than 5,000 families and collaborated with more than a dozen NGOs.

Several validation plots of improved varieties and cultural practices were established throughout Honduras. Nearly 20 COVA trials (including four promising bean breeding lines) and more than 100 farmer plots of Milenio were established in bean fields using the crop management practices of the farmer. Agronomic performance (yield, adaptation and disease resistance), seed type and cooking and consumption characteristics were evaluated in these trials and plots. The most common bean production practices included the use of landraces, and to a lesser extent improved varieties such as Tio Canela 75, Dorado, or Catrachita, low levels of fertilizers, low use of machinery (some animal traction) and rainfed production. Significant yield increases were obtained using improved varieties and additional fertilizer. More sustainable bean production has been obtained with improved varieties and soil management and water conservation practices.

Mycorrhiza inoculation has proven to be very effective to increase plant growth on nurseries and plantations of coffee, banana and plantain, fruit crops, forage and pastures, and several forest trees. This technology is being validated by Zamorano in Honduras and Nicaragua. The project is evaluating the benefit of mycorrhiza inoculant on bean productivity under abiotic stress conditions, including drought and low soil fertility. Preliminary greenhouse and field studies indicate significant increases in bean biomass, root length and density, and yield, associated with increases in water and nutrient absorption. Genotypic variation in the response to mycorrhiza inoculation was observed among several lines and cultivars. Additional field-testing is underway on research stations as well as in farmer fields.

Nicaragua: Several lines developed by the Bean/Cowpea CRSP were tested in regions of Nicaragua with different soil, temperature and precipitation regimens. Promising lines have been identified for each agroecological region; this group includes to Amadeus 77, MD 23-24, EAP 9020-14, MD 30-19, SRC1-1-18A and EAP 9504-30B, which are being validated on farmer fields using their own bean production practices.

Amadeus 77 is currently in the final stage of validation on farmer fields. An acceptance study on agronomic performance, cooking and tasting characteristics and market value is being conducted. Amadeus 77 is expected to be released in Nicaragua by the end of this year. The line CM 12225-14, was developed by Zamorano from an F_2 population received from CIAT (S. Singh); this line and later introduced to Nicaragua as part of the VIDAC-99, will be also released this year.

El Salvador: Amadeus 77 is being validated under farmer conditions to gather the necessary information for its release. This line was considered to be released early this year; however, the earthquakes and drought disasters that occurred during the past year have impeded the release process. Currently, an acceptance study of this variety including agronomic as well as socioeconomic aspects associated to bean production, is being conducted with more than 200 farmers and in collaboration with social scientists of the LAC team and PROFRIJOL is expected that Amadeus 77 will be released in El Salvador during the first semester of 2002. Although this line is well adapted to other bean production regions, it will be promoted for lowlands of El Salvador where severe yield reductions are caused by high temperatures and a high incidence of BGYM in the coastal region.

Costa Rica: Two small shiny red lines are currently being considered for release in the two major bean regions of Costa Rica, Brunca and North Huetar. The first region is predominantly small-scale bean production on the hillsides whereas farmers in the second region produce beans on a larger scale and are mechanized. Seed of these lines is currently being produced by PITTA, the research and technology transfer organization in Costa Rica, to have sufficient quantities for the validation and release process. It is expected that at least one of these lines will be released during year 2002. These lines were selected from trials conducted under low input conditions, and for their resistance to anthracnose and angular leaf spot.

Haiti: Although the small red bean is not a major bean market class in Haiti, Tio Canela 75 is becoming well accepted by farmers due to superior disease resistance and agronomic adaptation to drought and low fertility. In addition, culinary tests have shown that consumers favor the quality of this variety. Seed increase of Tio Canela 75 and Morales, a white seeded line released in Puerto Rico, is currently underway. Among the black bean lines selected by farmers under high incidence of BGYM, the project lines PR 9909-5, PR 9980-5, PR 9980-18 and EAP 9712-13 are included. Seed of these promising black lines is being increased in Haiti.

Dominican Republic: Integrated disease management practices that include a fallow period and synchronous period of planting in November continues to be promoted and has contributed to lower incidences of BGYMV, rust, and CBB, improved yields, lower pesticide use, and higher profits for bean producers in the Dominican Republic. Additional management practices to complement current practices for disease management were tested for the first time in the 2000-2001 growing season on the Arroyo Loro Research Station and/or in growers' fields. These experiments involved (a) crop rotation, (b) date of planting, (c) fertilization, (d) population density (row spacing) of varieties, and a (e) critical one time spray application for white fly control. Complete data will be provided after two seasons. Incidence of disease and pests in relation to crop growth and yield will be recorded in all experiments. These experiments are expected to reduce costs of inputs for farmers. Based on first year's data, the 1November 2000 planting date produced the highest yield while the 15 December 2000 planting produced no yield. The best whitefly control was obtained when a systemic pesticide was applied at 8-10 days after planting and a second spraying was applied 10 days later. The most effective rotation at this time was bean/sweet potato/bean.

A farmers association in the San Juan de la Maguana valley of the Dominican Republic sponsored a field day at the Arroyo Loro Research Station on January 12, 2001 to showcase the research contributions and training of the Bean/Cowpea CRSP project. Attendance by growers, ag-leaders and Ministry of Agriculture officials was excellent. Dr. Eladio Arnaud-Santana described ongoing research, the impact of the projects, and demonstrated a seed increase of JB-569; a new variety to be considered for release in 2002.

Dr. E. A. Santana continues to assist women farmers in the Dominican Republic and invites them to participate in the assessment of technologies and new varieties. Over 20 women, former WID trainees, came to the field day, and had an opportunity to describe to Dr. Carolyn Brooks, EEP reviewer, how the Bean/Cowpea CRSP has had a favorable impact on their lives and families.

Red mottled VICARIBE trials were planted in Damien, Haiti in December 2000 and in Salagnac, Haiti in July 2001. San Cristobal 83 and AFR 699 were the highest yielding lines (> 2,000 kg/ha) in the VICARIBE planted at Damien. In the absence of BGYM, the local landrace Salagnac 90-A yielded 1,772 kg/ha. The BGYM resistant line PR9909-5 (1,344 kg/ha) yielded as well as PC-50 (1,175 kg/ha).

Although the ECAR and VIDAC trials suffered from drought, many small red lines expressed impressive yield potential. The highest yielding small red lines were BCH 9738-14 (1,868 kg/ha) and EAP 9719-14 (1,823 kg/ha). Susceptibility to angular leaf spot and anthracnose appear to be the greatest weaknesses of small red breeding lines. SRC 1-1-18 from Zamorano and CM 12214-25 from CIAT were resistant to anthracnose in Haiti.

Twenty-seven black-seeded lines were evaluated in Damien, Haiti. This trial suffered more drought stress than the small red trials. In fact, the yield of Arroyo Loro Negro was only 651 kg/ha. One of the highest yielding lines PR9980-12, (1,342 kg/ha) was derived from a cross made in Puerto Rico between sources of BGYM and web blight resistance. Another promising line was 24-OP (1,414 kg/ha), a landrace variety from Brazil.

A seed increase of red mottled, pinto, small red and black lines was conducted at Damien. Once sufficient quantities of seed have been produced, the most promising lines will be tested on farms. A seed increase of five hectares of Arroyo Loro Negro was planted in Savane Zombi, which is 1,400 above sea level. Angular leaf spot reduced yields at this location. These results suggest that Arroyo Loro Negro should be recommended for lower altitudes in Haiti where yield loss caused by angular leaf spot is less common. It is important for black beans to be grown at higher altitudes to have resistance to both anthracnose and angular leaf spot.

In April 2001, Emmanuel Prophete attended a participatory plant breeding workshop which was sponsored by the Programa Colaborativo de Fitomejoramiento Participativo en Mesoamerica. Juan Carlos Rosas coordinated the workshop and James Beaver was invited to make several presentations concerning breeding methods.

Sixty-one new bean landrace varieties were collected in the northern and northeastern departments of Haiti. Another 166 lines from the Haitian bean landrace collection were planted at Damien in order to produce fresh seed. Lack of electricity remains a problem for the long-term storage of bean seed in Haiti.

I.A.3.b.(1)(j) Current status of research: Increased or more stable bean production in LAC and the U.S. requires improved bean cultivars, more sustainable cultural practices and integrated disease and pest management practices. Validation plots are conducted in collaboration with farmers to evaluate the performance of breeding lines and recently released varieties. Validation plots of crop management technologies are usually conducted using improved varieties and local cultivars to demonstrate the combined benefit of using improved cultivars and crop management practices. Larger demonstration plots are used for conducting field days with farmers or extensionists to promote improved varieties and recommended practices. NBR programs frequently conduct these activities and NGOs and the Bean/Cowpea CRSP personnel provides support with seed and technical assistance. Although, the traditional emphasis has been on agronomic performance (yield, adaptation and disease resistance), recent field days have given greater attention to seed type and consumer characteristics. A minimum set of data is taken on these characteristics. Often, a farmer and consumer acceptance study is part of this process. All this information is used to determine if a breeding line should be released as a cultivar.

Validation and demonstration plots, and field days were conducted last year in several countries Central American and Caribbean countries as part of the process to release new cultivars. It is expected that black bean lines developed by the Bean/Cowpea CRSP will be ready for validation by 2003. The project provides support to the NBR programs for seed production activities associated with validation trials, demonstration plots and dissemination of released varieties.

I.A.3.b.(1)(k) Documented impact: Consumer acceptance of small red beans is increasing in Haiti. Farmers from Leogane and Jacmel have expressed interest in obtaining seed of Tio Canela 75. They are impressed by its high yield potential, BGYM resistance and tolerance to drought. The CIAT/IICA project in Haiti is increasing seed of Tio Canela 75 and should have one ton of this variety available by November 2002.

The Haitian company Agrotecniques plans to produce 150 tons of the black-seeded variety Arroyo Loro Negro. Bean/Cowpea CRSP researchers, who participated in the development of Arroyo Loro Negro, had provided Agrotecniques with basic seed stocks of this variety after hurricane Georges.

The release of an improved bean cultivar can result in different kinds of benefits. Farmers using Tio Canela 75 have observed modest yield increases using traditional practices and greater yield increases when using additional fertilizer. Validation and demonstration plots along with field days are very effective ways to transfer improved varieties and management practices. Many farmers have significantly reduced pesticide use to control diseases such as BGYM (the white fly vector) after adopting resistant cultivars. Also, more effective management practices can be adopted by farmers to control pests (such as a reduced number of application of pesticide for pod borers) or weeds (such as timely hand weeding and post-emergence herbicide applications), which is facilitated by, erect plant architecture and the uniform, shorter flowering duration of improved cultivars.

I.A.4. Research area: Variety release and drought tolerance for the highlands

I.A.4.a. Background: Drought, due to insufficient or unpredictable rainfall, has been identified worldwide as a bean production problem exceeded in magnitude only by bean diseases. The majority of bean production in the world takes place under rainfed conditions. Mexico is the second largest bean producing and consuming nation, where 90% of the beans are produced under sporadic rainfall (200-400 mm) resulting in a low average yield of 450 kg/ha. Even these low yields vary greatly from year to year depending on the cycle of the weather in any particular season. Drought and disease production limitations, endemic to Mexico, are similar to production problems experienced elsewhere. Mexico is an ideal site to study drought because of the network of well-trained scientists in that country. Although the literature contains numerous studies that have been conducted on individual physiological parameters in other crops, there is a need to examine these parameters in bean genotypes to determine their importance in drought resistance. Likewise, there is a need to develop technologies that permit the examination and selection of a large number of genotypes typical of the numbers under test in a breeding program. The development of indirect selection criteria using molecular markers linked to key traits is a major focus of this drought research. The variable nature of drought stress (either alone or combined with high temperature) and type of drought (intermittent or terminal) require different strategies for control.

I.A.4.b. Proposed research area workplan and subsequent annual progress report

I.A.4.b.(1) Activity #1: Develop germplasm with enhanced drought adaptation for the lowlands and highlands.
I.A.4.b.(1)(a) Priority: (1) Essential
I.A.4.b.(1)(b) U.S. researchers: Kelly, Foster
I.A.4.b.(1)(c) HC researchers: Acosta, Rosas, Mkandawire
I.A.4.b.(1)(d) Methodology: RIL's will be developed from an inter-gene pool and from interracial crosses to exploit different drought adaptation traits and mechanisms. During FY 99, a drought nursery from Malawi and a bush core collection from CIAT was tested along

side new promising drought tolerant lines. In addition, select parental genotypes are being characterized for agronomic, physiological and molecular traits. During FY 01, the RILs will be evaluated in two highland and two lowland environments, one in Mexico and the other either in CA or in the Caribbean basin. Other research activities include the determination of the inheritance of traits related to drought adaptation other than yield and the development of screening techniques for drought resistance by utilizing secondary traits rather than yield. Molecular markers linked to specific drought adaptation traits will be used to develop cultivars with enhanced drought adaptation for the semiarid highlands.

I.A.4.b.(1)(e) Anticipated (1 year) results of activity: Lines with enhanced drought resistance in different seed classes (blacks and pintos). Breeding lines will be shared between scientists in Honduras, Ecuador and Malawi as well as with CIAT and PROFRIJOL. Improved selection methods for drought resistance will be developed. Breeding strategies to develop drought resistant cultivars will be improved. Improved bean germplasm will be exchanged within the LAC region (i.e., Honduras, Rosas) and with the East Africa CRSP project (Malawi, Mkandawire). Collaborative trials to evaluate drought tolerance will be conducted at multiple locations.

I.A.4.b.(1)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Breeding programs will be more effective in developing cultivars for drought-prone areas.	FY 00-02	A 5-10 percent yield increase in selected rainfed highland areas due to use of recently released drought-resistant cultivars (Pinto Villa) has been documented. Adoption and use of new strategies for the selection of breeding lines for drought Bean cultivars released with enhanced levels of drought tolerance

I.A.4.b.(1)(g) Budget:

Mexico	$17,000
MSU (Kelly)	12,000
Total (Direct Costs only)	$29,000

I.A.4.b.(1)(h) Major changes:

I.A.4.b.(1)(i) Progress during past year: Variety release and sustainable seed production for lowlands/biotech: Forty-nine bean genotypes were evaluated for the combined effect of terminal drought and resistance to Macrophomina phaseolina (Mp). Since many soils in the tropical lowlands are infested with Mp, resistance is a needed trait if a bean genotype is to perform well under conditions of terminal drought. In addition, damage by Mp can be antagonized by drought and heat stress. Two subsets of genotypes, one containing a diverse array of drought resistant lines (from different sources, 27) and 29 bred black seeded lines were evaluated. Genotypes were sown in January 2001, during the dry season, under two water treatments, irrigation and terminal drought at Cotaxtla, Veracruz. At sowing time, the seed in the entire experiment was inoculated with a local isolate of Mp. An 8x7 rectangular lattice design was utilized and four replicates were fully irrigated and four were subjected to terminal drought, where irrigation was withheld from flowering onwards. Due to unusual rainfall in March, terminal drought stress was mild. Based on the average from all genotypes, terminal drought significantly enhanced maturity by seven days and reduced the 100-seed weight by 17% and yield by 19% (Table 1). Among top yielders under stress was the Andean line A 195 and genotypes known for their resistance to Mp, such as Rosada Nativa (Puerto Rico), BAT 477 (CIAT), Bambuí (EMBRAPA, Brazil) and most of the superior bred lines that have Negro 8025, a tolerant cultivar, in their pedigree. A 195 is a large cream seeded Andean cultivar that might be suited for East Africa or Ecuador. Lower yielders under terminal drought were: Pinto UI 114, a cultivar susceptible to Mp, CNC2 , PR 9457-41, SEA 5, NGB 99007 and Negro Otomí. These last two genotypes are shiny black seeded cultivars from the Mexican highlands, which were damaged by Mp. In order to test for the stability of response to drought and Mp, the same trial will be conducted at two sites in the lowlands of Veracruz in the fall-winter season 2001/2002 under terminal drought and will be inoculated with local isolates of Mp. In this second trial irrigation will be withheld earlier than in the previous experiment. Identified terminal drought and Mp tolerant tropical black seeded lines will be increased and made available to colleagues in the region while resistant lines without commercial value will be included in the crossing block to develop resistance genotypes for the lowlands.

Table 1. Maturity, 100-seed weight and seed yield of 10 top yielders under terminal drought of a group of 56 diverse bean genotypes grown under two moisture treatments[1] at Cotaxtla, Veracruz, Mexico 2001.

		Maturity DAS[2]		100 seed wt in g		Yield kg/ha^{-1}	
Genotype	Origin	Irrigated	Stressed	Irrigated	Stressed	Irrigated	Stressed
A 195	CIAT	77	73	49.4	43.9	1750	1815
BAT477	CIAT	73	69	24.6	19.5	1625	1691
G 21212	Colombia	77	70	23.9	22.3	1447	1691
NI/8025-35-1	INIFAP	77	67	19.8	17.3	2046	1559
Bambuí	EMBRAPA	75	68	19.4	16.0	1460	1552
NGO 99173	INIFAP	75	69	22.3	17.5	1868	1526
NI/8025-65-1	INIFAP	76	69	21.1	18.4	1750	1500
R. Nativa	UPR	74	67	25.9	25.0	1559	1493
NGO 99165	INIFAP	75	69	24.3	16.6	1934	1480
NGO 99176	INIFAP	76	69	23.2	20.0	1625	1473
Ave.(n=56)		77 a	70 b	22.6 a	18.8 b	1564 a	1262 b

[1] Plots irrigated during the whole cycle. Stressed, irrigation was withheld from 50% flowering onwards; [2] DAS = Days after sowing; [3] Different letters denote significant differences at $P<0.01$

Field Evaluation of the Regional Black, Flor de Mayo and Pinto Bean Nurseries for the Semiarid Highlands of México: Activities during winter 2000 included the seed increase and generation advancement of 2304 recombinant breeding populations from early (F1 - F4) to more advanced generations (F7 - F10). A bean CORE Collection of about 506 genotypes was seed increased to renew bean germplasm. Winter bean nurseries included 237 F2 populations obtained from CIAT, 330 individual plant selections of different seed classes from the CEVAMEX breeding program, and 796 F6:7 improved breeding lines developed from crosses among elite bean cultivars from the semiarid highlands. 201 promising F6:8 bean-breeding lines were evaluated in three field nurseries at different locations across the highlands of Mexico. Nurseries included 50 black breeding lines, 56 different colored beans with emphasis on flor de mayo bean class and 95 pinto seeded lines. Nurseries were planted at different dates depending on the onset of the rainy season of locations at CE Valle del Guadiana and Flores Magón in Durango, CE Valle de Mexico (Santa Lucia), CE Zacatecas and Chihuahua. Results indicated that in the pinto class the cross Pinto Villa/Perry Marrow, with 13 recombinant lines was the best family with highest average seed yield (1801 kg/ha) across locations. This average yield was 19% higher than the check cultivar Pinto Villa and 31% higher than the experiment seed average. Flor de mayo nursery included recombinant breeding lines from six bean populations where the cross Pinto Bayacora/Flor de mayo Bajio with 32 promising lines. Seed yield was highest at Santa Lucia (2367 kg/ha) while seed yields at Chihuahua were the lowest (775 kg/ha). Seed yield of bean populations was similar to the location site average except for the cross Pinto Mestizo/AZPA 31 (824 kg/ha). Within the black seeded recombinant breeding lines, seed yield of the cross N. Sahuatoba/CNC were highest at Durango (1621 kg/ha) or 50% higher than the average seed yield (1071 kg/ha). Based on these results a series of lines were selected to be part of the regional yield trials for the semiarid highlands of México for the 2001-2002 period. 21 lines were of the flor de mayo class, 20 within the pinto class and only 14 were of the black bean class. These improved breeding lines were increased during winter 2000-01 at CE Valle del Fuerte, Los Mochis, Sinalo, México. Harvested seed was disease free and yield trials were planted during summer 2001 at twelve (12) locations across the highlands at Chihuahua, Zacatecas, Aguascalientes, Texcoco and Durango and lately at Cd. Obregon, Sonora. Data has been taken on phenological traits, reaction to diseases (rust, bacterial blight and anthracnose) and agronomic adaptation. Large plots were also planted at CE Valle del Guadiana for anticipated field performance and agronomic characterization of the best three breeding lines of each class.

New cultivars: This year two bred lines have been proposed for registration as new cultivars for the semiarid highlands of Mexico, 'Negro Vizcaya' and 'Flor de Mayo 2000' (BIC, 2001). The first variety is a black shiny seeded cultivar, while the second is pink seeded flor de mayo class. These cultivars were derived from crosses made at CIAT under a collaborative project with INIFAP. Experimental lines were extracted from those crosses and extensively tested in the semiarid highlands of Mexico under rainfed conditions with the support of the CRSP project since 1996. Under rainfed conditions in the sub-humid highlands, Flor de Mayo 2000 averaged 2078 kg ha^{-1} and outyielded the checks 'Flor de Mayo M38' and 'Flor de Mayo Bajío' by 4.2 to 55.6%, respectively. At the locations in the semiarid highlands, Flor de Mayo 2000 averaged 1719 kg ha^{-1} and was superior to 'Flor de Mayo Sol' and Flor de Mayo Bajío', the predominant cultivars in the region, by 5.3 to 32.3%, respectively. In the sub-humid highlands, Negro Vizcaya averaged 1817 kg ha^{-1} and outyielded the checks 'Negro Altiplano' and 'Negro Sahuatoba' by 19.5 to 46.5%, respectively. At the locations in the semi-arid highlands, Negro Vizcaya averaged 1517 kg ha^{-1} and was superior to 'Negro San Luis' and 'Negro Queretaro', the predominant landraces in the region, by 6.7 to 19.0 %, respectively. Foundation seed of those new cultivars have been multiplied and registration is being pursued before further seed increases are allowed.

New sources of drought resistance: In the search of new sources of drought resistance, a nursery that included best lines as identified in previous trials, was formed. Nursery included materials from: Malawi (MC6, DON 38 and DON 35), USA (97RS101, 97RS110, T39, Black Jack and B98311), CIAT': Core Collection (26 G genotypes), CIAT's low P nursery (A 774, VAX 1, FEB 190, FEB 192, G 1977 G 21212; SEA 5, SEA 10 and TLP 19); MD 23-24 from Honduras and seven genotypes from Mexico. A 7x7 lattice design with three replicates under each of two moisture treatments, irrigated and drought stressed was used. This trial was sown in the lowlands of Veracruz, in January 2001 and in the highlands in June at Texcoco, July at Sandovales, and in August at Calera, Zacatecas. In Texcoco and Calera irrigation was applied to enhance seed emergence. Besides the agronomic traits, crop cover, leaf chlorophyll and relative water content were measured in Cotaxtla. In addition cooking time and other quality related traits were recorded and are reported in a different section.

In Cotaxtla terminal stress was mild due to unusual rainfall in March. Average from all genotypes, terminal drought significantly enhanced maturity by five days and reduced the 100-seed weight by 9% and yield by 27% (Table 2). Two determinate cultivars, displayed superior yields under terminal drought stress: G 17427 (Fleet Wood) and ICA Quimbaya (data not shown). This last genotype is an Andean cultivar with a red mottled seed type that was recently released in Ecuador and that might be suitable for East Africa. Five top yielders under stress were: Pinto Zapata, 97RS110, 97RS101, SEA 10 and TLP 19. Other outstanding genotypes were G 17666 and G 18147 (from the CIAT's core collection), DON 38 introduced from Malawi, Bayo San Luis a landrace from the Mexican highlands and MD 23-24 from

Honduras. This trial has allowed for the identification of introduced promising genotypes in different seed classes and races that will be utilized in crosses in order to develop bred populations for both, lowlands and highlands.

In Texcoco, disease pressure has been high, mostly halo blight (Pseudomonas phaseolicola) on Andean genotypes, rust (Uromyces appendiculatus) on Pinto genotypes selected from the CIAT's Core Collection and common blight (Xanthomonas campestris) on tropical and USA genotypes. Anthracnose (Colletotrichum lindemuthianum) attacked several genotypes from different gene pools. Due to excess rain, the drought treatment was not established in this location and we will get data on yield potential.

In Sandovales, the main disease this season was common blight. Average from all genotypes seed yield under rainfed conditions (i.e. natural intermittent drought) was of 62 g/m^2; seed yield was increased by 44% with supplemental irrigation applied twice during the reproductive phase, 30 mm each time. Water was applied during dry spells after flowering. Higher yielding genotypes under limited rainfed conditions were G 13647 (117 g/m^2), G 2846 (landrace flor de mayo from Mexico; 117 g/m^2), Pinto Villa (106 g/m^2), G 842 (88 g/m^2)and G 1354 (88 g/m^2). Under rainfed plus supplemental irrigation best genotypes were G 13647 (229 g/m^2), G 22923 (186 g/m^2), Pinto Villa (161 g/m^2), G 2646, (158 g/m^2) and G 16054 (155 g/m^2). Of those genotypes, G 13647 and Pinto Villa were included in both groups.

In Zacatecas, the rainy season was delayed more than a month and rainfall was abundant in September and early October, thus some trials as well as commercial fields around the station are far from maturity. For the last two years, we have been studying the feasibility of using a simple "T" ruler to measure crop cover (CC) by determining the height and width of the crop across genotypes. The aim has been to relate CC to either biomass or seed yield under stress and non-stress conditions and in the near future determine its inheritance and usefulness as a practical indirect trait for selection. This year the calculated correlations between CC and seed yield varied from 0.5 to 0.6 under stress and irrigated conditions at both, Cotaxtla and Sandovales. We had noticed that when correlations are determined within the same growth habit, correlation values improve. Best genotypes will be included in the crossing block for both, lowlands and highlands. In the future, crosses between Durango and Nueva Granada races will be shared with the highland and lowland programs in Ecuador and East Africa.

Table 2. Maturity, seed yield and 100-seed weight of diverse bean genotypes grown under two moisture treatments[1] at Cotaxtla, Veracruz Mexico 2001.

		Maturity DAS[2]		100 seed wt in g		Yield kg/ha^{-1}	
Genotype	Origin	Irrigated	Stressed	Irrigated	Stressed	Irrigated	Stressed
P. Zapata	INIFAP	74	71	32.1	29.6	2232	2026
97RS110	MSU	73	70	35.9	32.8	1987	1982
97RS101	MSU	73	69	36.7	34.4	2092	1877
SEA 10	CIAT	72	71	29.5	28.8	2061	1816
TLP 19	CIAT	74	72	17.2	16.2	2074	1763
G17666	Nicaragua	70	68	15.6	18.0	1760	1754
G18147	Haiti	72	72	21.7	21.0	1868	1737
MD 23-24	UPR	74	71	20.4	18.9	2202	1737
B.S. Luis	Mexico	79	76	28.8	28.1	1969	1684
N. Veracruz	INIFAP	75	72	17.7	15.9	2228	1667
Ave(n=49)		77 a[3]	72 b	27.8 a	25.3 b	1764 a	1285 b

[1] Irrigated during the whole cycle. Stressed, irrigation was withheld from 50% flowering onwards
[2] DAS = Days after sowing
[3] Different letters denote significant differences at P<0.01

RILs development and characterization: In order to exploit different drought adaptation mechanisms, four sets of RIL's have been developed since 1998. A trial was sown in January 2001 with a set of 93 RILs, two parents and five checks to characterize their response to terminal drought stress in the lowlands of Veracruz, Mexico. This set of RIL's is in the F_{11} generation and were derived from the Negro INIFAP/Negro 8025 simple cross, both mesoamerican. A 10X10 lattice design was utilized and three replicates were fully irrigated and three were subjected to terminal drought stress where irrigation was withheld from flowering onwards. Average from all genotypes, terminal drought significantly enhanced maturity and reduced 100-seed weight and yield (Table 3), yield reduction due to terminal drought was 30%. Under both, irrigated and stressed conditions, there were RIL's that gave significantly higher yields than parents and checks (Table 3). Under stress parent Negro 8025 was superior to Negro INIFAP, while among the checks Negro Sahuatoba and T39 were superior to local cultivars, Negro Tacaná and Negro INIFAP. Results clearly show advance among the RILs in comparison to both parents and it was surprising to observe introduced bred cultivars from the highlands (Sahuatoba) and from abroad (T39) that were superior to local checks under terminal drought. The same trial was established during the summer at two highland locations, Texcoco and Sandovales. To date only data on flowering and disease reaction are available. Best RILs will be further tested in the lowlands of Mexico and made available to colleagues where the opaque black commercial class is important. The parents of this population of RILs are part of a broader study to identify molecular markers linked to drought response and were already characterized with microsatellites (45) and RAPDs (200) but no important differences were observed between them (Dice's similarity index = 0.87), thus further studies on this approach are not recommended in this population. Other three populations of RIL's are being evaluated in the same locations, but since they were derived from intergene pool crosses many lines are still showing segregation. Data on yield and other traits will be reported later.

Crossing block and segregating populations: During the last two years we continue to cross lines from the Nueva Granada race as sources of earliness, seed quality and rust resistance, i.e. Bayomex and Canario 60. Those are mostly combined with cultivars from the Durango and Jalisco races. In the case of drought most parents used in crosses are from the local Durango race (Pinto Zapata and Pinto Villa) and few parents from abroad have been utilized, one of them is ICA Palmar and few lowland adapted genotypes such as SEQ 12.

In 2000, populations were developed by crossing sources of resistance to root-rots, such as: Pinto Villa, N203, TLP 19, SEQ 12, landrace Negro Bola and G 12729 (wild). F4 families derived from those populations were planted at Texcoco in a naturally root-rot infested soil. Preliminary selections have been made among rows on the basis of plant vigor and later individual plants in selected rows will be scored and selected on the basis of root health and commercial seed class. Selection will be advanced during the winter season 2001-02 and F_6 lines will be available for testing in the next extension. At the moment we are conducting row and within row individual plant selections in 50 F_4 populations, as well as in 50 F_2 segregating populations, most of them derived from biparental and three way crosses. Those crosses are intended for line development for both, lowland and highland environments.

Uniform yield trials: Three nurseries, one of each commercial seed class: pinto, black and flor de mayo, were distributed for yield and disease evaluation across the Mexican Highlands. Trials were established under rainfed conditions at least in one location in the states of Chihuahua, Durango, Zacatecas, Aguascalientes and State of Mexico. No yield data is available. After harvesting attention will given seed yield and to other traits, for example, short cooking time, seed size, color and shape.

Table 3. Maturity, 100 seed weight and yield of five top RIL's, parents and checks under irrigation[1] and terminal drought at the lowlands of Veracruz, Mexico. 2001

	Maturity DAS[2]		Yield kg/ha^{-1}	
Genotype	Irrigated	Stressed	Irrigated	Stressed
NI/8025-47	78	70	1834	2334
NI/8025-49	78	69	2531	2169
NI/8025-4	77	66	2522	2055
NI/8025-94	77	68	2372	2055
NI/8025-23	76	69	2019	2037
NG 8025	77	69	1966	1913
Negro INIFAP	78	69	2328	1605
Negro Sahuatoba	78	69	2151	1948
T39	75	68	2134	1825
Negro Otomí	77	72	1208	1481
Negro Altiplano	76	70	2110	1402
Negro Tacaná	78	68	2204	1287
Ave.(n=100)	77 a[3]	70 b	2143 a	1567 b

[1] Plots irrigated during the whole cycle. Stressed, irrigation was withheld from 50% flowering onwards; [2] DAS = Days after sowing; [3] Different letters denote significant differences at $P<0.01$

I.A.5. Research area: Improved symbiotic nitrogen fixation of bean cultivars under low resource conditions.

I.A.5.a. Background: Nitrogen deficiency is a problem throughout the Latin American region with 50-75% of soils deficient in N. Fertilization is desirable, but often either outside the financial reach of subsistence farmers, or else impractical because weather conditions are likely to limit fertilizer uptake and efficient use. Nitrogen (N_2) fixation in beans is a desirable alternative, but the crop is often perceived as weak in this trait. Earlier studies within the Ecuador/Minnesota project have sought: (1) to identify and pyramid genes contributing to enhanced N_2 fixation in this crop, (2) to select bean varieties in Ecuador which were active in this trait and well adapted to Ecuadorian production conditions, (3) to improve both the availability and use of inoculant quality rhizobia for beans in Ecuador and Minnesota and (4) to research changing needs and methods of legume inoculation.

I.A.5.b. Proposed research area workplan and subsequent annual progress report

I.A.5.b.(1) Activity #1: Development and release of bean varieties or breeding lines having superior nitrogen-fixing ability.
I.A.5.b.(1)(a) Priority: (1) Essential
I.A.5.b.(1)(b) U.S. researchers: Graham, Bernal, Christiansen
I.A.5.b.(1)(c) HC researchers: Peralta, Ochoa, Murillo, Guala
I.A.5.b.(1)(d) Methodology: Lines chosen from the second cycle of recurrent selection for enhanced BNF, (Elisondo et al., 1999) outyielded all the original parental lines in trials at Becker, MN, and were superior to elite breeding lines evaluated at this low N location. Crosses have been made between the high N_2-fixing lines 19 and 34 identified by Elisondo-Barron, and the poor N_2 fixer 'Sanilac'. F_3 seed from these crosses is available, but further evaluation will depend on availability of a graduate student in 2001. RILs from the cross of DOR364 x BAT277 were also evaluated for differences in N_2 fixation at Becker in 1999. They are, currently being evaluated for marker differences at CIAT, with no further activity anticipated on our part.

From an initial 60 lines of Andean bean germplasm evaluated for N_2 fixation under low P fertility conditions in the glasshouse and in Ecuador, the lines E295 and ANT22 have been chosen for growth and yield at low P under conditions where they were dependent on N_2 fixation. Two CIAT lines G19833 and G19839, included in this study because of previous reports of low P tolerance were amongst the poorest of the lines studied. We attribute this to differences in methodology, and will contrast the selections using rock phosphate and dependence on BNF, and aluminum phosphate and N fertilized.

Evaluation for traits associated with low P tolerance is underway with evidence already of genotypic variation in rhizosphere acidification and alkaline phosphate production. Studies undertaken in 2000/2001 will complete evaluations of differences in root architecture, carbohydrate partitioning and organic acid production and characterization, then will contrast these lines in rhizoshere microbial populations and diversity, and for support of P-dissolving microorganisms in the rhizosphere. Ms Christiansen is expected to graduate by June, 2001.
I.A.5.b.(1)(e) Anticipated (1 year) results of activity: MesoAmerican and Andean bean lines with enhanced potential for nitrogen fixation under low input conditions. Molecular markers for biological nitrogen fixation. Undergraduate (Ecuador) and Graduate (Minnesota) training. Two Ph.D. degrees will be completed during this period. Publications and presentations that outline progress in research and encourage others into the field.
I.A.5.b.(1)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Increased bean seed yield and quality in the LAC region and in the U.S. Reduced dependence on fertilizer N addition and a more sustainable agriculture.	FY 00-02	Results from adoption and economic impact studies Decreased sale of fertilizer to produce beans

I.A.5.b.(1)(g) Budget:

Ecuador	$ 18,250
UMN	26,000
Total (Direct Costs only)	$ 44,250

I.A.5.b.(1)(h) Major changes:
I.A.5.b.(1)(i) Progress during past year: In the first phase of this project, lines chosen following two cycles of recurrent selection for enhanced BNF, (Elisondo et al., 1999) out yielded both parental lines and all elite varieties tested at the low N Becker site. The only lines showing almost comparable growth and yield were also selections for enhanced nitrogen fixation from the Honduras program. Gains in ability to fix nitrogen depended on effective parental selection and inoculant cultures, and required a low N soil for field testing. Evaluation of both biomass yield and seed yield at low N was needed to distinguish gains in nitrogen fixing ability from gains due to more effective N partitioning. With attention to these details, and to the period of crop growth, breeding for improved nitrogen fixation in beans was highly effective.

Because much of the earlier emphasis in BNF research has been with MesoAmerican bean types, studies begun at Minnesota in late 1999 moved to emphasize Andean bean types, and to evaluate their ability for nitrogen fixation at low P. Further, because most other studies have used an approach favoring genotypes with rapid root growth or uptake mechanisms, our studies stressed growth at low P in a support medium favoring genotypes better able to solubilise phosphate from low grade mineral and organic sources. One reason for this was concern with the effect of drought on genotypes having dense but superficial root systems.

Following an initial evaluation of 51 genotypes, eight selected genotypes of Andean *Phaseolus vulgaris* L., were inoculated with *Rhizobium* then grown at levels of rock phosphate designed to supply 5 and 140 mM phosphorus (P). Periodic harvests were made from 17-45 days after planting, and nodulation, N_2 fixation, and dry matter production were measured. Plant parts were analyzed for N, P, soluble carbohydrates and starch and final seed yields were also determined. These studies were reported in the FY2000 but detailed analysis had not been completed at that time. Strong correlations were evident between nodule P concentration and acetylene reduction activity (ARA); between stem starch concentration and mg N per plant. A strong correlation between N accumulation per mg P and plant growth supports the suggestion that the former parameter could be a good indicator for N_2-fixing ability at low P. These correlations are shown in Fig 1. In contrast, plant dry weight was negatively correlated with leaf P concentration. E295 and ANT22 were the best and G19833 the worst of the genotypes evaluated in terms of dry weight accumulation at low P. Some of the differences between these genotypes have already been reported (Annual report, 2000).

Because rhizosphere processes can affect phosphorus (P) availability for plants we further evaluated these three cultivars for differences in rhizosphere acidification, organic acid production, root phosphatase activity, nodule occupancy, and root hair number and length when grown at low P and dependent on N_2 fixation for growth. ANT22 maintained a lower rhizosphere pH than G19833 at low P, and N_2 fixation further reduced rhizosphere pH. No organic acid production was detected. G19833 also secreted significantly less phosphatase than E295 at low P when relying on N_2 fixation. At low P, ANT22 and E295 produced longer root hairs than G19833. Rhizosphere acidification, acid phosphatase activity and increased root hair length may contribute to low P tolerance in ANT22 and E295.

Each of these three cultivars was grown at 5 and 140uM P, then inoculated with soil suspension from an Andean bean soil. Nodules were harvested and the rhizobia they contained characterized using Box A1R PCR and clustered using the Bionumerics program. The 900 nodules sampled grouped into 10 clusters of which the two largest were both identified as *Rhizobium etli* . P level had a significant effect on the proportion of nodules containing strains from each cluster, with G19833 recovering significantly less rhizobia from cluster 1 under low P conditions (see Table 1). *R. etli* belonging to cluster 1 appear to be less competitive at low P than other rhizobia, a factor that could be important in strain selection. The study underscores the importance of evaluating beans for low P tolerance in several growth systems and soils.

Table 1. Distribution of nodule occupancy among three clusters determined by cluster analysis after DNA fingerprinting of nodule rhizobia. The three genotypes, ANT22, E295, and G19833 were grown at 5 and 140 μM P in soil solution adjusted by supply of rock phosphate. The small cluster group contains all strains that are not contained in the two major clusters.

		5 μM P			140 μM		5 μM P	140 μM P
	ANT22	E295	G19833	ANT22	E295	G19833	All	All
Cluster	48	47	29	55	50	56	124	161
Cluster	52	48	50	49	55	46	150	150
Cluster	50	55	71	43	45	48	176	136
Total	150	150	150	147	150	150	450	447
		$X^2 = 9.80$*			$X^2 = 1.46$ ns		$X^2 = 9.01$*	

150 nodules were analyzed from each genotype and P level. *and ns = significant at 5% and not significant.

Studies were also initiated on the effects of host cultivar on the population structure of microbial community structure in the rhizosphere as a function of P supply. DNA corresponding to the rRNA gene in soil microorganisms has been isolated from the rhizosphere, purified and subject to PCR, then denaturing gradient gel electrophoresis used to show differences in population structure. This approach shows promise, but studies had not been completed at the time Miss Christiansen had to leave for Bolivia after completion of her degree. Changes in microbial community structure have recently been reported in other crops and associated with biocontrol, and in enhanced tolerance to disease. It is likely that they could also affect P supply to the bean.

Varietal selection under low soil N conditions (Ecuador): Initial studies in Ecuador evaluated promising varietal materials under low N soil conditions and with rhizobial inoculation. They led to identification of lines suitable for inclusion in national program testing which combined good local adaptation, disease resistance and high N_2 fixation. Je.Ma is typical of these, and is now a widely-used local variety, and a valued parent in the crossing program. Currently there is no screening for nitrogen fixation *per se* but most varietal trials are inoculated and N application restricted.
I.A.5.b.(1)(k) Documented impact: Bean production in much of Ecuador is carried out under low input conditions with fertilizer N rarely used. Under these conditions yield increases in lines bred for enhanced nodulation and N_2 fixation are likely, and could be used to measure impact. Such gains will be confounded, however, by the greater disease resistance of the varieties with which we are now working, and the improved knowledge of farmers concerning when and how to apply pesticides . Farmer's in the PESAE-FAO food security program in Ecuador already note significantly lower cost of production, but the factors important in this are still to be determined.

I.A.5.b.(2) Activity #2: Improvement in available bean inoculant rhizobia, bean inoculant availability and inoculation methodologies.
I.A.5.b.(2)(a) Priority: (1) Essential
I.A.5.b.(2)(b) U.S. researchers: Graham and Tlusty
I.A.5.b.(2)(c) HC researchers: Guala, (until April), Bernal
I.A.5.b.(2)(d) Methodology: This project has emphasized host rather than strain evaluation and testing. However with response to bean inoculation now well documented in Ecuador, with farmers there more interested in legume inoculants, and with evidence of within country differences in cultivar specificity, attention to the practical questions of inoculation and to demonstration activities in specific areas continues to be important. Facility in addresssing these problems will be improved with the return of Gustavo Bernal to Ecuador in 2000-2001. In Minnesota better control of root rots (see below) and new inoculant formulations permitting heavier inoculation rates, are also opening the way for greater response to inoculation, and to improved farmer adoption.

An inoculant laboratory has now been established in Santa Catalina. Again, the return of Gustavo Bernal will permit expanded activities in this area. Projected activities include:
(1) inoculant provision for farmers in the different bean producing regions; (2) the development of quality control programs, including more detailed strain selection activities and screening of further peat deposits; (3) the extension of inoculant provision to include additional crops including soybean, clovers and peas; (4) collaboration with the root control program in Minnesota for evaluation of biocontrol/Rhizobium preparations for use with beans and (5) further studies to confirm the difference in symbiotic response of bean varieties from the Mesoamerican, northern Ecuadorean and Andean gene pools with rhizobia from each region of bean production.

In Minnesota, we have shown overlap in nodulation and N_2 fixation between beans and the rhizobia from some prairie legumes. This could be a factor affecting bean response and N_2 fixation in farmer's field. Bean seeds have been shown to carry Dalea rhizobia. Interaction between introduced and native rhizobia, and the extent to which this influences BNF in beans will be evaluated.

I.A.5.b.(2)(e) Anticipated (1 year) results of activity: Inoculant-quality rhizobia for *Phaseolus vulgaris* available and available for use by scientists and inoculant manufacturers. Strains and any regional preferences shown will be listed on our website.
Enhanced use of inoculants in both Minnesota and Ecuador, and better availability and understanding of the different formulations that can be used.

Improvement in the nitrogen nutrition of bean plants in both Ecuador and Minnesota, coupled to a decreased need for N fertilization.

Long-distance training opportunities in inoculant technology and use (see also 3.3).

I.A.5.b.(2)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Increased bean seed yield and quality in the region and in the U.S. Reduced dependence on fertilizer N, reduced N pollution in agriculture, development of more sustainable agricultural practices. Better informed research workers and collaborators	FY 00-02	Results of adoption and economic impact studies Lower fertilizer sales Improved water quality

I.A.5.b.(2)(g) Budget:

Ecuador	$15,000
Mexico	3,000
UMN	0
Total (Direct Costs only)	$18,000

I.A.5.b.(2)(h) Major changes:

I.A.5.b.(2)(i) Progress during past year: Field inoculation studies in Ecuador during the past several years have shown yield responses to inoculation. Demonstration plots and field days have been held, and 50% of farmers are adopting inoculation technology (FAO-PESAE, 2000). Recent emphasis in Ecuador has been to develop a small inoculant facility capable of supplying a full range of legume inoculants. This laboratory has been completed, and strains for a range of grain and pasture legumes collected. Much of the work with bean inoculants in Ecuador has been completed though wider strain testing is needed. FY 2001 was a bridging period until the return of Bernal. Support through a grant from PROMSA is facilitating additional studies on the identification of suitable local peat sources, inoculant quality and on strain selection for a number of species. The time since Bernal's return to INIAP (late in July) has been too short for reportable results.

In Minnesota, interest in bean inoculation has increased as a result of the joint biocontrol/*Rhizobium* inoculation studies. Substantial increases in crop yield as a result of inoculation with *R.tropici* UMR1899 have been reported. To build on these results additional financing for bean inoculation studies is being sought through the RAPID Response Program at the University of Minnesota. This will emphasize farmer education in improved inoculant formulations and their use, as well as applied research studies emphasizing strain selection and inoculant testing.

In FY2001, the major *Rhizobium* focus has been on the biodiversity and characteristics of the rhizobia associated with beans in the Staples, Verndale and Park Rapids production areas. In these areas antibiotic and fungicide seed treatments are commonly used, and inhibit nodulation and nitrogen fixation, without controlling root rot. The results obtained have been surprising from several perspectives:

- Since beans were grown by the Indians in Minnesota well before the arrival of settlers, and inoculation was rarely if ever used, we had anticipated that bean rhizobia found in this area would be Mesoamerican in origin, or derived from prairie rhizobia displaced from their normal host *Dalea* after settlement. As shown in FY2000, the rhizobia we recovered from these fields did not sort with any of the known species of rhizobia. Subsequently, when strains were evaluated using several different taxonomic criteria, the results we got varied with method of analysis. This is shown in Table 2.

Table 2. Influence of the method of evaluation on the apparent species identifications of the rhizobia recovered from beans growing in the Staples, Verndale and Park Rapids regions of Minnesota.

Strain	Box-PCR Group	No Strains	Species that organisms are most similar to, based on PCR	FAME	16S rRNA
PR30	1	3	None	R. etli	R. leguminosarum
S3	2	11	None	R. etli	R. leguminosarum
S20	3	3	None	R. leguminosarum	R. leguminosarum
V33	4	4	None	R. gallicum	R. etli
V34	5	7	R. etli	R. etli	R. leguminosarum
PR7	6	6	None	R. rhizogenes	R. tropici
S34	7	1	Rhizobium sp. (Dalea)	R. leguminosarum	R. leguminosarum

If we accept 16S rRNA data as having greatest precision in taxonomic grouping, then 71% of the strains tested would belong to *R.leguminosarum bv phaseoli.* This in contrast to studies from other parts of the world in which the frequency of this organism in natural populations of bean rhizobia rarely exceeds 20%.

- The frequent use of streptomycin and captan as seed treatments in the region, could have resulted in the selection of rhizobia that are more tolerant to captan and streptomycin. These studies are still to be completed, but initial indications are that some at least of the organisms we have recovered have higher than normal tolerance to the chemicals used as seed dressings. Studies to measure the inhibitory effect of such treatments on normal bean nodulation, and nodule distribution in the root system are underway and show striking effects of seed treatment on these nodulation parameters and on N_2 fixation.
- Because the rhizobia recovered from beans grown in the Staples, Verndale and Park Rapids region were not typical of those normally associated with beans, we undertook additional studies on their N_2- fixing ability with the locally-important variety Montcalm. We also determined the speed in nodulation of these strains as a surrogate for strain compatibility with this host. Surprisingly, a number of the strains were effective in symbiosis (see Fig 2) with a strong correlation evident between the plant dry weight of N_2 dependent Moncalm plants and the speed in nodulation of the rhizobia tested (See Fig 3). It is a common assumption that natural populations will tend toward inefficiency in nodulation and N_2 fixation, but this was not evident in the present study.

Because of the results obtained in the Minnesota studies, we are in the process of examining the diversity and ability for N_2 fixation of rhizobia associated with commercially-grown beans in other states (in many of which bean seed treatment is common). As a contrast, we are also studying organisms obtained from organic farms and historical gardens, and from México.

Progress during 2000 and 2001 in México: Five bean-nodulating Rhizobium strains along with three fertilizer rates and a treatment that combined Rhizobium plus micorriza were tested under irrigation and favorable rainfall environments in 2000 and 2001 (Table 4). A RCB design with four replicates was utilized. Plots consisted of three 5 m rows spaced 60 cm apart. Two trials with same treatments were established in the summer 2001 with two cultivars and in two planting dates at Texcoco, at the moment yield data is not available. Strain Rhi 652 was kindly provided by Oscar Acuña (UCR), while CE3 is a streptomycin resistant strain derived from Rhizobium etli type strain CFN42 from Celaya, Gto., Mexico. The other strains were derived from Rhi 652. During the growing season, at least once, the nodule occupancy was determined in two plants from the middle row per plot. Nodules were analyzed for antibiotic resistance and plasmid profiles (work done at Cuernavaca by the group of Dr. Jaime Mora, UNAM). Seed and plant nitrogen content from each plot was also determined. Yield was significantly different across environments and was similar among treatments (Table 3). Seed nitrogen content, i.e., protein content, was superior in the treatment with nitrogen fertilizer (100%) to the minus nitrogen (65%) and to the one of the Rhizobium strains. Best strain in seed N-content was Rhi 652 with protein contents above 85% as compared to the plus N check (data not shown). The yield obtained with inoculant was similar to the one obtained with nitrogen fertilizer across trials which suggests an efficient N fixing capacity by common bean in the favorable environment of Central Mexico. The use of Rhi 652 and other strains as inoculants in Central Mexico is very promising.

Table 3. Seed yield in kg/ha^{-1} of two bean cultivars grown under different Rhizobium strains and fertilizer rates at three locations in Mexico.

	Location and cultivar				
	Texcoco[2]	Juchitepec[3]	Cotaxtla, 2001		
Treatment[1]	NG 8025	NG 8025	PT. Zapata	NG 8025	Average
Rhi 652	3457	1298	2333	1759	2212
Rhi CE3	3436	1448	2111	1667	2165
Rhi HP652	3137	1472	2398	1676	2171
Rhi652/789	3329	1410	2194	1611	2136
Rhi HP310	2756	1386	2231	1870	2061
Rhi 652+Mc	3346	1503	2176	1574	2150
50-50-00	2837	1445	1815	1546	1911
00-50-00	3235	1568	2111	1704	2154
35-35-35	-	-	1917	1852	1884

[1] Rhi = Rhizobium strain; Mc = mycorrhiza; [2] irrigated; [3] Rainfed

1.A.5.b (3) (j) Current status of research: This research was initiated as part of the thesis requirements of Gustavo Bernal, and funded through a grant from LASPAU. When this grant terminated, funding was continued with support from the college and from an NSF grant to the US-PI. Bernal finished his thesis in May, 2001. This study will continue, with NSF support to better understand and relate strain movement and relate it to host inoculation needs. The project will integrate into extension CRSP activities in East Africa with minimal cost to the CRSP. NSF funding continues until 2004.

I.A.6. Research area: Development of disease resistant lines and management practices for bean production in the highlands of Ecuador and Mexico.

I.A.6.a. Background: Disease constraints, particularly rust, anthracnose and root rots present major problems for bean production in the highland regions of Mexico and Andean South America. If yields are to be advanced, and benefits from N_2 fixation realized it will have to be as part of a package that includes genetic improvement and development of integrated management practices for disease control in this crop. Prior to CRSP activities, there were essentially no improved varieties in use in Ecuador. Much remains to be done, though fortunately, many of the constraints important in Ecuador find similar expression in Minnesota, minimizing overlap. Initiatives previously undertaken in this area included: (1) evaluation and use of appropriate and adapted breeding lines from the CIAT bean program under field conditions in Ecuador and (2) with CIAT activities in the region reduced, the initiation of breeding activities at Santa Catalina that emphasize rust and anthracnose resistance, and high altitude adaptation. Inputs on strategy and approach have come from Drs. Singh, Voysest and Grafton.

I.A.6.b. Proposed research area workplan and subsequent annual progress report

I.A.6.b.(1) Activity # 1: Improved disease resistance and adaptation in bean varieties developed for Ecuador and Mexico.
I.A.6.b.(1)(a) Priority: Essential
I.A.6.b.(1)(b) U.S. researchers: Graham and Grafton
I.A.6.b.(1)(c) HC Researchers: Peralta, Murillo, Ochoa
I.A.6.b.(1)(d) Methodology: F_3 and F_4 seed from 2, 3, and four-way crosses involving the rust and anthracnose resistant and high N_2 fixing line J'ema and lines such as Paragachi, Catrachita and Imbabello which have greater local acceptance, are currently being planted in farmer's fields in Ecuador. All material is inoculated with Rhizobium. Selections will be made in April-June, 2000 on the basis of disease resistance, yield and N_2 fixation, adaptation and farmer acceptance, with participatory methods used to involve farmers in selection. Material identified will advance to larger scale tests field tests, and to national testing and varietal release trials at different sites in Ecuador.

Suggested parental lines from CIAT have been evaluated for disease resistance, adaptation and other traits in Ecuador, with a number selected for inclusion in the crossing block. These will continue to generate a flow of breeding materials for early generation disease resistance testing, and subsequent yield trials in different sites across the highland region.
I.A.6.b.(1)(e) Anticipated results of the activity: Improved varieties suitable in adaptation and disease resistance.

Increased bean yield and quality in the highland areas of Ecuador.

Reduced dependence on pesticide usage, and a more sustainable agriculture.
I.A.6.b.(1)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Enhanced use of improved varieties and corresponding decline in pesticide usage, increased yield and quality of beans in region, greater use in human nutrition and a more sustainable agriculture	FY 00-02	Results of adoption and economic impact studies

I.A.6.b.(1)(g) Budget:

Ecuador	$12,000
Mexico	3,000
MSU (Kelly)	4,000
UMN	0
Total (Direct Costs only)	$19,000

I.A.6.b.(1)(h) Major changes:

I.A.6.b.(1)(i) Progress during past year: Project activities in Ecuador have been affected by the poor conditions for indigenous farmers, and consequent rural strikes. This has made travel to experimental sites often difficult. Poor salaries at INIAP also led to the resignation of Marcelo Guala, while PROMSA grants to Pepe Ochoa and Angel Murillo (to pursue advanced degree training in the U.S. and Puerto Rico respectively), affected the manpower available for field studies.

Breeding for enhanced disease resistance in Andean bean varieties: Germplasm activities balance the generation of hybrid materials from the breeding program at Santa Catalina with the introduction and evaluation of promising bean lines from CIAT. In this system locally-generated F_1 seed is grown out under pressure from rust at the Tumbaco site, with individual plant selection practiced, and seed from selected plants seeded plant to row in the next cycle. Selected lines are then included in a series of yield and adaptation nurseries undertaken at different sites in northern Ecuador, before inclusion of the most outstanding materials in national yield trials. Evaluation of introduced CIAT lines parallels the testing of later generation (F_4- F_5) national materials. Activities in 2001 included:

- F_1 plants from crosses between lines selected for tolerance to rust, good yield and adaptation, and locally acceptable grain type and growing period were grown out under rust pressure at the Tumbaco site. 29 individual plant selections were made, and will be seeded plant to row in the next season of testing. A total of 28 F_3 populations from single and multiple crosses for disease resistance, adaptation and acceptable grain type were multiplied in the field prior to plot scale yield testing in the next cycle. Twelve F_4 populations generated in Ecuador y 10 F4 populations from CIAT were evaluated with 116 individual plant selections made.
  - A preliminary yield trial of 43 new lines from CIAT was conducted. Arme 3, is a promising locally bred line, with high yield potential.
  - A preliminary yield trial of 11 promising breeding lines was conducted. ARME3., MAM48 and Mil uno had the best performance.

Table 4. Lines from a preliminary yield trial of 43 promising introduced bean lines.

Line	Vigor	Pod-bearing	Rust	Days to harvest	Yield g/2,4m^2
AND1091	3	4	7	120	349
CAP25	4	5	5		362
DFA65	4	5	7	120	297
FOT74	3	6	7	106	196
FOT76	5	6	7	112	187
FOT77	3	5	5	107	192
POA17	3	6	7	107	203
POA18	4	5	7	120	628
YUNGUILLA	3	5	4	120	225
ARME2	3	4	4		470
ARME3	4	4	4	120	411

Table 5. Results from an advanced yield trial comparing 7 Ecuadorian bred red mottle bean lines and existing locally important varieties.

Identification	Vigor	Pod Load	Rust	Yield g/9.6m^2
AND279(MAM39XCAL143)F1 X(PVA800xAND277)F1)F1-1	3	4	2	1110
AND279(MAM39XCAL143)F1 X(PVA800xAND277)F1)F1-2	4	5	2	1242
ARME 4	3	3	4	1676
ARME 5	3	4	4	1699
(MAM48 x AFR 612)F1 x (PI150414 x PA 800a)F1-7	2	4	2	3218
ARME 2	3	4	3	1100
ARME 3	4	3	4	1728
AFR 612	3	3	2	1493
MIL UNO	3	4	3	3784
YUNGUILLA	3	4	3	1233
PARAGACHI	4	5	6	1241

Table 6. Results for 9 of 14 bean lines grown under conditions of severe drought and abnormally high air temperature during 2001.

Line	Days to flowering	Vigor	Pod Load	Rust	Yield kg/ha
CAP 25	58	3	4	3	1733
AND 1091	48	3	5	5	1837
FOT 77	47	3	5	7	1342
POA 17	45	3	5	6	1335
ARME 3	53	3	5	4	1391
ARME 4	51	3	4	2	1139
ARME 5	51	3	4	3	1304
YUNGUILLA	52	3	4	3	1616
PARAGACHI	53	3	4	6	1588

INIAP had intended to release ARME 3 as a new variety in late 2001. However under the conditions of a pronounced drought from May to October, and with air temperature as high as 33°C, ARME 3 showed significant seed dehiscence. Because of this it was decided to carry out one more season of testing. ACE1 and ACE2 also continue as candidates for varietal release.

Activities are also underway to improve anthracnosis evaluation and screening. Seed differentials are being accumulated, and a humidity chamber has been constructed for progeny evaluation. Anthracnose can be a major problem at elevation in the Andes, but disease severity varies markedly with season, necessitating an artificial screening system for the more efficient evaluation of progeny. 25 INIAP varieties, advanced lines and resistance sources are currently being tested using artificial inoculation. Samples of anthracnose infected leaves and seed have also been collected for race determinations.

In México, a two weeks hands-on training on bean breeding was given in the Mexican breeding program at Texcoco to a scientist from the coastal areas of Ecuador, M.Sc. Ricardo Guaman. In addition, the trainee was provided with two sets of bean genotypes: released cultivars and improved lines, mostly Andean genotypes of the preferred commercial types in the lowlands of Ecuador. Bean genotypes were chosen by the trainee after evaluating them in the local field trials. Collaboration will be further enhanced with the exchange of improved lines derived from intergene pool crosses or crosses within the Nueva Granada race, a race important in both countries, and in East Africa.
I.A.6.b.(1)(j) Current status of research: Activities in this phase of the project are proceeding as expected. Emphasis on early generation screening for rust resistance is efficient in generating new materials for rapid passage to on-farm trials. Interaction between INIAP, FAO-PESAE and farmers is effective in identifying preferred materials that are disease resistant.
I.A.6.b.(1)(k) Documented impact: Bean lines developed in collaboration with CIAT or originating in the INIAP breeding program continue to come on line. Most have good rust and often anthracnose resistance, and are of the maturity characteristics and market class preferred in Ecuador. Additional new varieties will be available for distribution within the next year, and again should result in significant on-farm yield improvements. In the interim, greater farmer awareness of the value of disease resistance, and better education on disease control, have significantly lowered farm costs. In the FAO-PESAE project, farmers describe a reduction in cost of production from \$120 ha^{-1} in 1998 to only \$20 ha^{-1} with the newer materials and better training in chemical usage.

I.A.6.b.(2) Activity #2: Integration of biological, chemical and management practices in the control of root pathogens in beans
I.A.6.b.(2)(a) Priority: (1) Essential
I.A.6.b.(2)(b) U.S. researchers: Estevez, Grafton, and Graham
I.A.6.b.(2)(c) HC researchers: Peralta, Ochoa
I.A.6.b.(2)(d) Methodology: Studies on the ecology of pathogens involved in the root rot complex, and on integrated systems of root rot control, undertaken as part of the thesis requirements for Consuelo Estevez, have been very successful. In 1999 approximately 200 tons of bean seed was commercially treated using biocontrol preparations identified in Ms Estevez' thesis research. The results from these studies have attracted considerable attention, including a commercial company from England (Biorhizogen) than will test and market Rhizobium/Biocontrol preparations. A consequence has been external support (Agriculture Response Fund \$135,888) for ongoing activities, with Ms Estevez accepting a two year postdoctoral position in Plant Pathology to undertake the research. The research anticipated will include biocontrol experiments with bean/Rhizobium inoculants across 9 sites in Minnesota; studies on tillage, compaction and biocontrol interaction in beans; studies on N fertilization and root disease and an examination of biodiversity of Fusarium solani in bean soils. Additionally, as indicated above, Biorhizogen will undertake Rhizobium/biocontrol experiments across multiple sites in the U.S., including Minnesota. These studies will compare two different bean rhizobia (including UMR1899) and two biocontrol agents, and use the granular formulation, that was first recommended in our prairie legume studies. Ms Estevez only recently decided to take the post-doctoral position, so discussions with INIAP will be necessary to ensure that anticipated extension of her thesis research to Ecuador still goes forward. As indicated above this could devolve on Gustavo Bernal, strengthening his position

in Ecuador, and facilitating collaborative activities with Ms Estevez. Dr. Grafton would also be a major contributor to activities both in Minnesota and North Dakota and in Ecuador.
I.A.6.b.(2)(e) Anticipated (1 year) results of activity: IPM techniques for the control of root pathogens.

Biocontrol organisms suited to integrated management applications.

Publications and presentations that outline progress in research and encourage others into the field.
I.A.6.b.(2)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Increased bean yield and quality in the highlands of Mexico and Ecuador, and in the U.S. Reduced dependence on pesticide usage, and more sustainable agricultural production. Enhanced root health permitting improved nodulation, N_2 fixation and N benefits to the host	FY 00-02	Results from adoption and economic impact studies

I.A.6.b.(2)(g) Budget:

Ecuador	$3,000
Mexico	3,000
MSU (Kelly)	3,915
UMN	0
Total (Direct Costs only)	$9,915

I.A.6.b.(2)(h) Major changes:
I.A.6.b.(2)(i) Progress during past year: Studies on the ecology of pathogens involved in the root rot complex, and on integrated systems of root rot control, undertaken as part of the thesis requirements for Consuelo Estevez de Jensen, have been very successful. In 1998, integrated root rot control in farmer's fields in northwestern Minnesota led to yield increases of more than 600 kg ha^1, with noticeable improvement in root health and nodulation also achieved. These results have attracted considerable attention in Minnesota and North Dakota, with widespread acceptance by farmers, and with seed-applied biocontrol treatments extensively promoted within the bean industry. In the 2000 planting season, alone, more than 280 tons of seed was treated with *Bacillus subtilis* GB03 in Minnesota, close to 25% of all the bean seed planted in the state. Further gains, more emphasis on the commercialization of inoculants, and increased farmer interest should continue to spread use of this methodology. Current activities in this area (funded through the University of Minnesota and AURI, and with Dr Estevez de Jensen in a Research Associate position with Profs. Percich and Kurle) continue toward an integrated approach to root rot control. A major study has been the interaction of moldboard and chisel plowing with seed treatment effects on root rot of dry bean and soybean. Dry bean and soybean seed were treated with *Bacillus subtilis* and *Rhizobium*, then sown into a Verndale sandy loam soil that had been either moldboard or chisel plowed. The experiments were located on an irrigated field with a history of severe root rot.

Stand counts were not affected by tillage practice or seed treatment, but both dry bean and soybean had greater plant height and dry weight at flowering in the moldboard plots. Dry bean and soybean root rot severity in both the moldboard and chisel plots were reduced by seed inoculation with *B. subtilis* and *Rhizobium.* Plots that were chisel plowed yielded more than those that were moldboard ploughed for both bean and soybean (1756 kg ha^{-1} chisel vs 1150 kg ha_{-}^{1} for bean; 5240 kg ha^{-1} vs 4873kg ha $^{-1}$ for soybean). Seed treatment with *Bacillus* and *Rhizobium* increased dry bean yields in both moldboard (1,049 to 1,252 kg/ha) and chisel ploughed systems (1,593 to 1,919 kg/ha), with cone penetrometer resistance values significantly greater in the chisel ploughed treatments.

In a second study various combinations of a peat based formulation containing *Bacillus subtilis* and *Rhizobium*, a standard seed treatment (SST) containing Captan, Streptomycin and Lorsban and an untreated control were compared in greenhouse and field evaluations. Two different *Bacillus subtilis* strains (GBO3 or MBI600) and two *Rhizobium* genotypes (*Rhizobium tropici* UMR1899 or *Rhizobium etli* RCR3622) were contrasted.

Under greenhouse conditions plants receiving chemical seed treatments were shorter and had greater symptom development than those treated with *Bacillus subtilis* GBO3 plus *Rhizobium etli* RCR3622. However, neither plant dry weight nor acetylene reduction activity was affected (Table 7). *Bacillus subtilis* MBI600 plus *Rhizobium* RCR3622 also reduced disease severity and increased root dry weight. A consequence of seed treatment with streptomycin and captan is that nodulation and the onset of N_2 fixation in even healthy plants is delayed, and overall N_2 fixation reduced with the plant able to fix much less nitrogen. Effects on nodule distribution are striking with the first 2-3 inches of root system completely devoid of nodules. Studies on the impacts of this are in the process of harvest.

Table 7. Effect of seed treatments on bean root rot, plant growth and nitrogen fixation in plants grown in the glasshouse.

Treatments	**Disease Severity (1-9)**	**Plant Dry Weight (g)**	**Root Dry Weight (g)**	**Acetylene Reduction (um/hour/plant)**
Untreated control	1 d	3.6 c	2.0 abcd	23 ab
Bacillus subtilis GB03 + *Rhizobium etli* RCR 3622	4 c	4.5 abc	2.7 a	34 a
Bacillus subtilis MBI600	4.2 b	5.0 a	2.2 abc	22 ab
Captan+Streptomycin+Lorsban + *B. subtilis* GB03	4.2 bc	3.9 abc	1.6 cd	23 ab
R. etli RCR 3622	4.5 bc	3.8 bc	1.6 bcd	24 ab
B. subtilis MBI600+*R. etli* RCR3622	4.5 bc	4.5 bc	2.2 abc	29 ab
B. subtilis MBI600+*R. tropici* UMR1899	5.0 b	4.2 abc	2.0 abcd	22 ab
B. subtilis GB03+*R. tropici* UMR1899	5.0 b	4.6 abc	2.4 ab	30 a
Rhizobium tropici UMR1899	5.0 b	3.8 bc	1.8 bcd	23 ab
B. subtilis GB03	5.0 b	4.4 abc	2.3 abc	26 ab
Captan+Streptomycin+Lorsban	6.2 a	4.1 abc	1.3 d	22 ab

Different letters within a column are significantly different by LSD 5%.

In the field study, there was a significant effect of biocontrol application on disease severity (Table 2), with even *Rhizobium tropici* UMR1899 inoculated alone reducing disease severity (Table 8). Bean yields for *B. subtilis* GBO3 plus *R. etli* RCR 3622 were significantly higher than those for the untreated control and the SST was ineffective.

Table 8. Effect of Biocontrol Agents, Rhizobium and a Chemical Seed Treatment on Bean Root Rot, Verndale, 2001.

Treatment	Emergence	Disease Severity (1-9)	Root Weight g plant $^{-1}$	Yield Kg ha^{-1}
B.subtilis GB03 + *R.etli* RCR 3622	223 a	3.8 c	6.1 a	1854a
B.subtilis MB1600	161 d	4.3 bc	5.1 abc	1452ab
R.etli RCR3622	188 bc	4.1 bc	3.1 d	1456ab
B.subtilis MB1600 + *R.etli* RCR3622	191 bc	4.4 bc	3.8 cd	1455ab
B.subtilis MB1600 + *R.tropici* UMR1899	191 bc	3.8 c	4.3 bcd	1627ab
B.subtilis GB03 + *R.tropici* UMR1899	219 a	4.0 bc	4.5 bcd	1591ab
R.tropici UMR 1899	176 c	4.2 bc	5.1 abc	1613ab
B.subtilis GB03	186 c	2.8 d	3.6 cd	1575ab
Untreated control	183 c	5.4 a	5.7 ab	1411b
Seed treated (C+S+L)	207 ab	4.7 ab	4.5 bcd	1349b

Because of concerns with the ineffectiveness of the SST there has been strong farmer interest in the use of biocontrol agents and a resurgence of interest in *Rhizobium* inoculants. It is estimated that 50% of farmers in this area of Minnesota used seed-applied biocontrol preparations in 2001, and commercial interest in the preparation of co-inoculated biocontrol and *Rhizobium* preparations continues to grow. Because of this we have sought additional rapid response funding to examine this process in greater detail.

A second series of field studies in which biocontrol organisms are applied to the soil rather than to seed, and which aim to prevent pathogen build up in straw residues have shown significant promise, but are still to be harvested.

Plans to implement parallel studies in Ecuador were delayed by the later than anticipated return of Gustavo Bernal to INIAP, but will continue. We also see this area as one of priority for testing in Tanzania.

In México in 2000, we reported on two experiments that were carried out with 15 genotypes that were chosen because of their known root-rot resistance: G 12729 (wild), PI 203958 (N203), Negro Puebla, Wisc. RRR, G 122, FR 266, Pinto Villa, Negro Durango, Negro 8025, BAT 477, Negro Cotaxtla 91, Negro INIFAP, Negro Tacaná and the susceptible cultivars Flor de Mayo Bajío and Canario 107. Here we report on the relationship between climatic parameters during the season and disease incidence and severity. R. solani was positively influenced by temperature (Table 5). The severity of Fusarium spp was highly correlated to the amount of rainfall during the cycle. The fluctuation observed on the attack of those fungi in the field during the growing season, seems to be related to the erratic climatic conditions of the Mexican highlands, Fusarium being favored by cool and wet weather, while the strongest attacks of Rhizoctonia seem to be related to warmer (dry) days.

Table 5. Spearman correlations between average root-rots incidence of 15 bean genotypes and climatic parameters registered during the growing cycle at Texcoco, Mexico in 1999.

	Disease severity		Disease Incidence	
Parameter	Fusarium	Rhizoctonia	Fusarium	Rhizoctonia
Max. temp. °C	-0.64 *	0.92 **	-0.84 **	0.71 **
Min. temp. °C	0.37	0.55 *	-0.01	0.80 **
Ave temp. °C	-0.04	0.84 **	-0.42	0.92 **
Rainfall mm	0.76 **	0.16	0.42	0.56 *

In 2001, additional emphasis was focused on the identification of root-rot tolerant genotypes from the Andean gene pool. For that several trials were established and genotypes scored for root-rots reaction in an infested soil at Texcoco, State of Mexico as follows:

- Trial with 36 snap bean genotypes, planted twice, early and late June, plot size of two rows 5 m in length, 0.6 m apart and four replicates;
- Trial that included 36 introduced genotypes from Puerto Rico, plots were single 5 m row 0.6 m apart and three replicates; those were selected from previous year trials VICARIBE Red Mottled and VICARIBE Red Kidney;
- An unreplicated trial with 100 determinate type I genotypes from the CIAT's core collection, plots were single 5 m row 0.6 m apart;
- An unreplicated trial with 15 genotypes from the breeding program at Puerto Rico (Beaver); and
- CIAT's low P trial that includes 49 genotypes. In each plot across trials, three plants were dug out and root systems observed for Fusarium spp incidence as well as for the formation of adventitious roots. This last trait is related to cultivar's tolerance.
- Moderately resistant genotypes to Fusarium spp were: a) Early Gallatin; b) Lime light and G12193 (Cajamarca 175, from Peru); c) line X057-1; d) line A 321, G 4540 (Rochela, from Colombia) and G 4459 (Nep 2, from MSU). Those tolerant cultivars will be further tested under controlled conditions in the greenhouse.

I.A.6.b.(2)(k) Documented impact: Several impacts of this activity were described above. They include seed treatment of a large proportion of the bean seed sown in Minnesota, and widespread adoption of biocontrol and combined biocontrol/Rhizobium technologies by industry.

I.A.6.b.(3) Activity #3: Identify soil conservation, management and fertilization strategies leading to reduced erosion and degradation of soil, and improved water conservation in the highland areas of the region.
I.A.6.b.(3)(a) Priority: (2) High priority
I.A.6.b.(3)(b) U.S. researchers: Graham and Allan
I.A.6.b.(3)(c) HC researchers: Peralta and Guala
I.A.6.b.(3)(d) Methodology: Soils in the Ecuadorian highlands are of high pH and often deficient in essential micronutrients. Because of their slope, soils losses estimated at as much as 500 tons per ha have been reported. Part of this problem is the inappropriate use of very high altitude or steeply sloped land in agriculture. Earlier studies in this project have: (1) shown almost universal zinc deficiency in the region, and a tendency toward iron deficiency, (2) demonstrated marked response to zinc chelate applied either as a foliar or soil amendment, (3) examined cultivar variation in response to low zinc levels in soil and (4) introduced additional fruit and pasture species on the more heavily sloping land, and demonstrated the value of contour plowing, and other means of erosion control.

Appropriate conservation and crop fertilization procedures are a major constraint to sustainable bean production in Ecuador, and throughout the highland region. In this research activity we will:

- Identify and promote conservation and management strategies that reduce soil erosion and water runoff in highland bean production.
- Validate micronutrient fertilization technologies in on-farm experimentation with farmers

I.A.6.b.(3)(e) Anticipated (1 year) results of activity: There will be more widespread use of conservation practices limiting soil losses; greater diversity of fruit trees and agroforestry species used in the region, with potential impacts on diet; more efficient water use and less water pollution; and widespread use and validation of micronutrient fertilization methodologies.

I.A.6.b.(3)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Increased or stabilized bean yields. Reduced erosion and water runoff. Greater awareness in the rural community of conservation needs.	FY 01-02	Results from adoption and economic impact studies

I.A.6.b.(3)(g) Budget:

Ecuador	$ 4,500
UMN	0
Total (Direct Costs only)	$ 4,500

I.A.6.b.(3)(h) Major changes:

I.A.6.b.(3)(i) Progress during past year: Activity during the year was minimal because of the unsettled local conditions and problems in transportation and movement.

I.B. Constraint #2: Limited Storage Options--No activities are planned for this year.

I.C. Constraint #3: Insufficient Research for Improved Nutrition and Product Development

I.C.1. Research area: Improved nutrition and product development

I.C.1.a. Background: Dry beans are an important source of nutrients for all nationalities, but particularly for consumers in developing countries. However, because of incomplete digestion, the true nutritional value of beans is not realized. In addition, indigestible starch contributes significantly to the flatulence problem associated with legume consumption.

Total dietary fiber, indigestible starch and protein, galactosyl sugars, prolonged cooking time and cooking methods are factors that limit the full nutritional potential of dry beans. Indigestible starch produces more intestinal gas per gram of bean flour than do the oligosaccharides; the genotype and processing method affect the digestibility of dry beans; beans processed in tin cans had lower amounts of indigestible starch than beans cooked with a pressure cooker or in a pot on the top of the stove; the higher indigestible starch associated with pressure cooking and stove top cooking may be the result of the longer cooking time at lower temperature associated with these cooking methods compared to canning the beans; cooking beans induced cell wall crystallization and decreased starch bioavailability. Following cell wall crystallization, the cotyledon cells became resistant to breakage even when finely milled with a Wiley or UDY cyclone mill. Heat induced cell wall crystallization during bean cooking is a primary barrier to starch digestibility. Cryogenic milling (-195C) with a 6700 SPEC freezer/mill was necessary to disrupt cell walls prior to cooking and achieve complete starch digestibility. Prolonged cooking time, flatulence, and reduced bioavailability of nutrients are just a few of the factors leading to a steady decline in per capita consumption in spite of the numerous positive attributes of dry beans.

Iron deficiency anemia is one of the major problems in developing countries; beans are an alternative low cost source of iron providing 3.6 to 5.7 mg of iron per 100g of beans.

However, the bioavailability is low and bean consumption cannot provide adequate amounts iron to prevent anemia. A dehydrated iron fortified bean based food product was developed. Acceptability studies indicated that the food was acceptable as a weaning food. We are developing additional bean based food products from mixtures of fermented beans and rice. We are also working to develop a bean-corn weaning food suitable for consumption in countries where corn is a staple in the diet. The next step is to see if the bean-based weaning foods can be produced economically on a commercial scale using industrial technology. Oligosaccharides, one of the seed components that causes flatulence and other gastrointestinal discomforts, can be reduced by fermenting the beans before formulating the food product. Fermentation might also increase the level of B vitamins in beans.

We are working to develop strategies to educate consumers on the health benefits of eating beans in order to increase bean consumption in both the U.S. and LAC countries where beans were once major components of the diets. Beans contain phytochemicals (non-nutrients) that have biological activity and that have been shown to reduce cancer. If beans provide sufficient amounts of anti-cancer phytochemicals to reduce cancer, this information could stimulate bean consumption and would be included in the consumer education information.

I.C.1.b. Proposed research area workplan and subsequent annual progress report

I.C.1.b.(1) Activity #1: Identify highland and lowland bean lines with superior seed quality traits and study the inheritance of seed quality traits.
I.C.1.b.(1)(a) Priority: (2) High priority
I.C.1.b.(1)(b) U.S. researchers: Hosfield
I.C.1.b.(1)(c) HC researchers: Perez and Acosta
I.C.1.b.(1)(d) Methodology: Search for bean lines from Ecuador, Malawi and the semiarid highlands of Mexico with high seed quality traits. Develop RIL's for different seed quality traits and attempt to identify genes and QTL's associated with superior seed quality.
I.C.1.b.(1)(e) Anticipated (1 year) results of activity: Donors of superior seed quality traits will be identified and germplasm exchanged within the LAC regional project, East Africa and CIAT.
I.C.1.b.(1)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Less fuel needed for cooking beans thus saving energy. Identification of sources of superior seed quality traits.	FY 01-02	Results from adoption and economic impact studies

I.C.1.b.(1)(g) Budget:

Mexico	$3,000
MSU (Hosfield)	0
Total (Direct Costs only)	$3,000

I.C.1.b.(1)(h) Major changes: We expanded this objective to include screening beans of the Central American small-red market class for cooking time. In FY 2000, we found after screening 37 dry bean accessions of interest to growers in the LAC region, that cultivars represented by the Central American small-red market class were the longest cooking beans compared to other market classes. Some red seeded genotypes took over two hours to cook to a degree of tenderness to which they were palatable. Since dry beans with red seed coats are preferred in Central America, we initiated a screening program to ascertain the range of variability for cooking time in small-red germplasm. We are searching for germplasm that cooks to eating softness in less than 60 minutes. We believe the increased scope of work in FY 2001 will be a major benefit to bean breeders of the region.

I.C.1.b.(1)(i) Progress during past year: Host Country (Mexico) Progress: The effect of mild terminal drought stress on the quality parameters of 49 bean genotypes harvested in Cotaxtla, Veracruz (7x7 trial) was determined. While stress significantly decreased seed weight, it increased seed protein content and cooking time. In the case of low cooking time genotypes, this group included genotypes from both the Nueva Granada and Mesoamerican races (Table 1). As for the content of solids in broth, an appreciated trait when preparing soupy bean dishes, those with higher content were the larger seeded ones. In the case of protein content, it varied from intermediate to low values and no trends on race adscription or seed size were observed. Seed of the same trial from Texcoco (subhumid highlands) and Sandovales (semiarid highlands) will be assessed for quality parameters. For inheritance studies the seed from the population of RILs described before will be utilized from the highland sites above mentioned.

Table 1. Extreme bean genotypes for protein content, cooking time and solids in broth under terminal drought stress, seed harvested at Cotaxtla, Veracruz, 2001.

Genotype	% Protein content	Genotype	Cooking time min.	Genotype	% Solids in broth
	High		**High**		**High**
SEA 5	22.6	G 13637	169	97RS101	0.54
G 3386	22.3	G 2494	160	Quimbaya	0.48
G 4285	22.1	G 842	158	G 19012	0.44
G 801	21.9	G 3386	154	G 22923	0.43
G 1354	21.0	Black Jack	149	G 28460	0.43
	Low		**Low**		**Low**
NG INIFAP	18.0	DON 35	67	TLP 19	0.22
G 17427	17.9	G 4258	78	DON 35	0.21
Pinto Villa	17.5	G 4523	81	G 2494	0.20
G 1688	17.0	Negro Dgo.	87	G 6762	0.19
MC6	16.9	G 21137	88	G 17427	0.17

U.S. Institution (Michigan State University) progress: We initiated a study to ascertain the range in variability for cooking time in dry beans representing the Central American small-red market class. Seed lots of thirty-nine accessions consisting of native cultivars and improved lines were obtained from the Escuela Agricola Panamericana (EAP) in Tegucigalpa, Honduras. Since we desired freshly harvested seed to eliminate storage effects from bean cookability, the seed lots were taken from the winter crop and did not reach us until August 2001. Because of the delay in obtaining the seed, screening didn't begin until late August, consequently, no data are available for this report.

Table 2. Small-red cultivars and promising breeding lines obtained from Honduras for screening for cooking time.

No.	Identification	Origin
	Native	
1	Chingo R	Curso FM (La Vega 1)
2	Concha Rosada	Curso FM (La Vega 1)
3	Cuarentano	Curso FM (La Vega 1)
4	Cuarenteño	Curso FM (La Vega 1)
5	Danli 46	Curso FM (La Vega 1)
6	Desarrural IR	Curso FM (La Vega 1)
7	Esteli 150	Curso FM (La Vega 1)
8	Paraisito	Curso FM (La Vega 1)
9	Rojo de Seda	Curso FM (La Vega 1)
10	Rojo Nacional	PIF 01-05
11	Saca Pobres	Curso FM (La Vega 1)
	Improved	
1	BCH 9733-8C	Inc. La Vega 1
2	Catrachita	Curso FM (La Vega 1)
3	DICTA 113	Curso FM (La Vega 1)
4	DICTA 122	Curso FM (La Vega 1)
5	DICZA 9801	Inc. Zona III (38B)
6	Don Silvio RR	Curso FM (La Vega 1)
7	DORADO	Curso FM (La Vega 1)
8	EAP 9503-32A	Inc. La Vega 1
9	EAP 9503-32B	ECAR 2001
10	EAP 9503-38	ECAR 2001
11	EAP 9504-30B	ECAR 2001
12	EAP 9504-3A	ECAR 2001
13	EAP 9508-48	ECAR 2001
14	EAP 9509-29	ECAR 2001
15	EAP 9510-1	ECAR 2001
16	EAP 9510-28	ECAR 2001
17	EAP 9510-77	Curso FM (La Vega 1)
18	MD 23-24	Curso FM (La Vega 1)
19	MD 30-37	Curso FM (La Vega 1)
20	Milenio	Curso FM (La Vega 1)
21	PRF 9653-16B-1	ECAR 2001
22	PRF 9653-16B-3	ECAR 2001
23	PRF 9653-4-1	ECAR 2001
24	PRF 9657-53-14	ECAR 2001
25	PRF 9659-35-8	ECAR 2001
26	PRF 9707-36	Inc. Zona III (38A)
27	PTC 9557-10	ECAR 2001
28	Tio Canela - 75	Curso FM (La Vega 1)

I.C.1.b.(1)(j) Current status of research: Studies on seed quality traits including rate of water uptake, cooking time, and protein content were begun in 1997. Host Country (Mexico) researchers have been successful in identifying dry bean lines with fairly rapid cooking times (60-80 minutes) with moderate to high protein levels. This work bodes well for increasing the

efficiency of food preparation of beans and saving fuel energy in their cooking. High protein lines increases the amount of dietary nutrients per 1 g of beans consumed. We have completed the final phase of cooking time screening of selected genotypes by the U.S. component [Michigan State University (MSU)]. We screened 37 accessions from the program of Dr. James Beaver (University of Puerto Rico Project). These accessions were representative of several market classes, and all were of considerable interest to growers in Central America and the Caribbean. No screening for protein content or other seed quality traits was performed by the U.S. component of this B/C CRSP. The U.S. Principal Investigator will discontinue cooking time and seed quality trait screening and evaluation with the termination of the current grant, i.e., April 2002. The U.S. P.I. of the nutrition utilization component of this CRSP will integrate all future cooking time evaluations as part of routine screening procedures for cultivar development by MSU and USDA/ARS.
I.C.1.b.(1)(k) Documented impact: The negative relationship between water absorption during soaking and cooking time of beans was corroborated by RAPD markers. Breeders can now select fast cooking genotypes from slow cooking ones with a high degree of assurance using water absorption as a prediction of cooking time. Selection based on the water absorption of a breeding line as an indirect estimation of its cooking time is rapid and saves resources.

I.C.1.b.(2) Activity #2: Continued research to identify and quantify bean seed physico-chemical factors amenable to change by food processing and/or genetics; use knowledge of physico-chemical factors to develop new products.
I.C.1.b.(2)(a) Priority: (1) Essential
I.C.1.b.(2)(b) U.S. researchers: Nielsen, Mason and Hosfield
I.C.1.b.(2)(c) HC researchers: Bonilla
I.C.1.b.(2)(d) Methodology: Chemical analyses to identify Total Dietary Fiber (TDF), phytates, and tannins**.** Study different processing systems to improve digestibility (enzyme, fermentation). Study vitamin stability in fermented products**.** Develop bean-corn weaning food and determine its nutritional quality and acceptability.
I.C.1.b.(2)(e) Anticipated (1 year) results of activity: Establish the effect of cooking and processing methods on TDF and tannins. New bean products with higher nutritional value will be developed.
I.C.1.b.(2)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
New knowledge will provide baseline data from which additional research can proceed Interest of private industry to commercialize products	FY 02	Manuscript in refereed journal describing results of research Adoption of processing technologies that produce new bean-based products

I.C.1.b.(2)(g) Budget:

Costa Rica (Bonilla)	$21,000
MSU (Hosfield)	3,000
Purdue (Nielsen/Mason)	9,805
Total (Direct Costs only)	$33,805

I.C.1.b.(2)(h) Major changes: Work on a bean-corn fermented weaning food and vitamin stability in fermented products was completed at the end of the previous year, and work was not continued on these. Having evaluated the data on fermented bean-based weaning foods, it was decided that fermentation did not offer enough nutritional advantages to justify the additional cost of production. After further evaluation of the literature and our own information, it was decided that our future focus should be on bean-based food products that would be attractive to more members of a

family and a broader age range, than was the weaning food. Considering the increasing consumption, popularity, and wide availability of snack foods, work was started on utilization of beans in nutritious granola bars and bean-corn chips.
I.C.1.b.(2)(i) Progress during past year: The new M.S. graduate student working on this project learned various chemical and physical assays that will be used on the bean-based products developed. Also, facilities were prepared for storage of dry beans to intentionally make beans hard-to-cook. Red and black beans are now being held under control conditions to maintain “control” beans and under adverse conditions to create “hard-to-cook” beans. These control and hard-to-cook beans will be used in the food products being developed and tested.

Various food companies that process beans or snack foods were contacted to obtain input about bean-based snack foods. This information contributed to our decision to pursue the development of granola bars and corn chips that contain dry beans. Formulations will be tested comparing the use of control dry beans and hard-to-cook dry beans.

To pursue the development of bean-corn chips, we discussed for several months the possibility of working jointly with a small company in California that processes bean products. However, for several reasons, that company is not able to work with us at this time, but instead gave us contacts to pursue once we have completed work on formulation and processing. Therefore, we are working on our own now on this effort with the bean-corn chips.

Regarding the granola bars that contain beans, formulations for both a baked and a "chewy" bar have been tested, with focus now on the chewy type. The most successful formulation to present is a bean-containing product that, according to U.S. nutrition labeling regulations, could have nutritional claims for protein, fiber, and folic acid contents, be considered a low-fat product, as compared to a control granola bar that could only have no nutritional content claims. Those products are ready to be subjected to sensory evaluation, to obtain information for any necessary modification in the formulations and further testing.
I.C.1.b.(2)(j) Progress during past year: The bean-containing granola bar will be subjected to sensory evaluation at Purdue Univ., and will be tested for select chemical and physical properties. Plans will be made to do sensory testing of the product during the next year using children and adults in rural villages in Honduras. Products made using control beans will be compared to those made using hard-to-cook beans, for both the granola bars and the bean-corn chips.

Considerable work remains on the bean-corn chips, but the plan is to test various formulations and processing conditions, then eventually subject a prototype product to sensory evaluation and select chemical and physical tests.

Some new instruments and techniques recently available to us at Purdue Univ. will be considered for use in testing the chemical and physical differences between the control beans and hard-to-cook beans being used in the food products. This information will be helpful in understanding any effects hard-to-cook beans have in the food products.
I.C.1.b.(2)(k) Documented impact: None to present.

I.C.1.b.(3) Activity #3: Continue to develop and implement commercialization strategies for bean based food products and assess the economics of manufacturing the developed bean-based food products.
I.C.1.b.(3)(a) Priority: (1) Essential
I.C.1.b.(3)(b) U.S. researchers: Nielsen
I.C.1.b.(3)(c) HC researchers: Bonilla

I.C.1.b.(3)(d) Methodology: Develop a campaign to educate people on the important contribution of beans to a healthy diet

I.C.1.b.(3)(e) Anticipated (1 year) results of activity: A public relations campaign formulated and underway and a company that is willing to commercialize products; show that the food product can be produced economically.

I.C.1.b.(3)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Greater awareness of the health benefits of eating beans	FY 01-02	Number of people showing renewed interest in bean consumption. Greater than 60% of responses of target group are positive.
Commercial bean-based food product available for sale	FY 01-02	Adoption of bean-based food by industry.

I.C.1.b.(3)(g) Budget:

Costa Rica (Bonilla) $16,000

Total (Direct Costs only) $16,000

I.C.1.b.(3)(h) Major changes: None

I.C.1.b.(3)(i) Progress during past year- Educational Campaign: During this last year, the educational campaign took place in the chosen pilot community, Sabanilla de Montes de Oca, a urban community. The campaigning took place from the second week of September until the second week of December 2000 and from the first week of February until the last week of April, 2001. Due to the Christmas festivities and schools' vacation, the program was not kept through mid December and January. Several activities were part of the campaign:

Interpersonal Campaign-Activities addressed to the community:

- Fair- The fair included the following events: health-related activities performed by the Caja Costarricense de Seguro Social (Social Medical System of Costa Rica), nutritional evaluation, bean nutritional information and preparation of bean dishes, educational talks, and expositions. There was great participation from the Technical School Instituto Nacional de Aprendizaje (INA). Their chef students cooked dishes from the bean booklet wrote last year. The public had a chance to taste the different products and was interested in buying the book. Part of the economical support came also from the private sector, through a bean broker group called Empresa Pedro Oller, S.A. The media, local and national, was present at the fair, and later, they were allowed to have national coverage.
- Supermarket Intervention: This activity took place in three of the biggest supermarkets, Mas x Menos, Pali and Super Cindy. The clients received bean information and tasted different bean dishes.
- Activities Addressed to Children: Eighteen talks about the nutritional value of beans were given, bean dish preparations with two groups, poster designed by children from three different elementary schools and theater workshops with children from one school.
- Activities Addressed to Support Personnel and Community Leaders: Two activities were performed with the health personnel, one was a group session with the two EBAIS (Primary Basic Health Attention) that serve the Sabanilla Community. The other activity was a round table called "Nutrition in the Prevention and Treatment of Chronic Diseases and Cancer." School kitchen and snack concessions had three sessions.

Massive Campaign-activities addressed to mothers were: six posters were placed in strategic places–churches, supermarkets, pharmacies and small stores; the bean cooking books were distributed; a total of 24,000 brochures were sent to the mothers of the Sananilla community and a theater workshop was conducted with children from one school. Activities addressed to children were six different posters were placed in three different schools.

Activities Addressed to the General Population: The community fair created interest from the media about bean consumption. As it can be seen in the following table, there was a lot of media coverage after the bean fair and the messages reached almost the entire population.

Table 1. Messages about beans given in different medias

Media	Program Name	Times[1]	Persons/Day[2]	Consumer
TELEVISION				
Channel 6	Noticias Repretel	3		Adult population
Channel 7	Telenoticias	1	326000	Adult population
	Buen dia	5	36000	Housewives
	Cocinando con Tia Florita	1	20000	Housewives
Channel 15	Baul de Girasoles	1		Professionals metropolitan area
RADIO				
Radio Periodicos Reloj	Cinco minutos con la Caja	5	6700	Housewives
Radio Santa Clara		2	100000	Farmers, housewives and workers of the rural San Carlos area
Radio Rolando Angulo	Entrevista con Rolando Angulo	2	9000	Adult population
NEWSPAPERS				
Al Dia	suplemento Siempre al Dia	4	500000	Adult population
La Nacion	Suplemento Viva	2	550000	Adult population
	Suplemento En Forma	1		Adult population
Prensa Libre		1	24000	Adult population
Periodico Universidad		1		Students, university staff
Girasol		1	2000	Professionals from the Metropolitan area

[1] Number of times that there was a presentation about the fair and beans.
[2] Empty cells, we did not have information about how many persons viewed the program.

Evaluation of the campaign: As a final graduation project, a student has monitored the campaign process. The data has been collected and is currently being analyzed. In addition, a three step evaluation process was started in April 2001. These steps are:

- Planning
- Data collection
- Data processing and analyzing

As a result of the campaign, the broker group Pedro Oller S.A. is interested in a nationwide bean campaign.

Bean Products Commercialization: There has been a constant effort to find a group that will produce and commercialize the fortified bean product. However, we have not been successful in such an enterprise. The Banco Centroamericano de Integracion Economica (BCIE), Central American Bank for Economic Integration, gave a $20,000 grant to amplify the market studies done several years ago to the general population. The previous market study was directed to mothers with children younger than three years of age.
I.C.1.b.(2)(j) Current Status of Research: The following chemical analyses: protein, fat, iron, potassium and fiber are being performed. The shelf life of the bean pate is being evaluated. After the shelf life evaluation, sensory evaluation and chemical analyses will be performed.
I.C.1.b.(2)(k) Documented impact: We do not have any documented impact so far.

I.C.1.b.(4) Activity #4: Determine if consuming beans reduces colon cancer.
I.C.1.b.(4)(a) Priority: High
I.C.1.b.(4)(b) U.S. researchers: Bennink
I.C.1.b.(4)(c) HC researchers: None
I.C.1.b.(4)(d) Methodology: Navy and black beans will be cooked, dried, ground and used to prepare nutritionally adequate diets for rats. Weanling rats will be injected with a carcinogen that induces colon cancer and then fed a control diet, a navy bean based diet or a black bean based diet for eight months. It is hypothesized that more of the rats fed the bean based diets will be cancer free compared to rats fed the control diet. Also, the number of tumors will be less and the tumors will be smaller in rats fed beans.
I.C.1.b.(4)(e) Anticipated (1 year) results of activity: Tumor incidence, multiplicity, and burden will be determined. Annual progress report.
I.C.1.b.(4)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
New information regarding nutritional value of beans	FY 00-02	Manuscript in refereed journal describing results of research

I.C.1.b.(4)(g) Budget:
MSU (Hosfield for Bennink) $21,605
Total (Direct Costs only) $21,605

I.C.1.b.(4)(h) Major changes: The research was conducted as proposed.
I.C.1.b.(4)(i) Progress during past year: The objective of this study was to determine if consumption of black beans and/or navy beans would reduce chemically-induced colon tumorigenesis in rats. Rats were fed diets based on either black beans or navy beans. Cooked-dried beans comprised 75% of the bean diets while casein was the protein source in the control diet. The diets were formulated to contain equivalent amounts of digestible protein, minerals, vitamins, fat, fiber and energy. All essential amino acids were present in sufficient amounts After feeding the diets for 1 month, colon cancer was initiated by injecting azoxymethane. Thirty weeks later the rats were killed and all lesions were processed for histological examination.

Eating black and navy beans had a profound impact on colon tumorigenesis in laboratory rats. Eating black beans decreased tumor incidence by 54% and eating navy beans reduced tumor incidence by 59%. Similarly, tumor multiplicity (number of tumors/tumor bearing rat) was decreased by 50% and 55% by feeding on black and navy beans, respectively. These results suggest that eating beans can help to prevent colon cancer. However, this type of research cannot identify the active anti-cancer component(s) in beans or the mechanism of action. The rate and extent of bean starch digestion may play a role in the anti-cancer action of beans. Foods that produce a low glycemic index, such as beans, produce lower plasma glucose levels, which tend to lower the secretion of insulin. There are data to suggest that hyperinsulinemia stimulates growth of colon tumors. Therefore, reduced insulin secretion which is known to occur with bean consumption may be associated with the observed reduction in colon tumorigenesis. Greater secretions of insulin may have stimulated food intake in the control group. The control group ate more and gained 29-39% more adipose tissue than the rats fed the black bean or the navy bean diet. The association of greater body fat and greater colon tumor incidence in the control rats is compatible with the observations that excess weight and obesity in adult humans increases the risk of colon cancer.

Beans contain considerable amounts of resistant starch (starch that is not digested in the small intestine) as well as high amounts of soluble and insoluble fibers. The fiber was expected to carry the resistant starch towards the distal colon where most of the colon tumors develop. Fermentation of resistant starch and fiber could produce butyrate which has anti-cancer actions in cell culture. Rats eating bean diets had significantly more resistant starch entering the colon and 9 times more butyrate in the distal colon.

Beans also contain potentially bioactive microconstituents such as phenolic compounds, protease inhibitors, phytic acid, phytosterols, and saponins — all of which have been associated with anti-cancer activity. While these phytochemicals may be partially responsible for the observed decrease in colon cancer incidence, it is not possible from this study to determine their relative importance. Nevertheless, the large differences in anthocyanin and tannin content between black and navy beans and the similar inhibition of colon cancer by both beans strongly suggest that the reduction in colon tumorigenesis was not related to anthocyanin or tannin.

I.C.1.b.(4)(k) Documented impact: None to present

I.D. Constraint #4: Socioeconomic Research Insufficiently Integrated with Production and Utilization Research

I.D.1. Research area: Adoption and impact studies.

I.D.1.a. Background: Previous research in this area has focused on the following areas.

Farm Record keeping: Accurate data are required to assess the profitability of improved agricultural technologies, including improved varieties and management practices. Record keeping studies have been implemented in the Dominican Republic (2 years), Guatemala (1 year) , Honduras (2 years), Mexico (2 years), Nicaragua (1 year) , and Puerto Rico (1 year). These studies have provided insights on the profitability of bean production in the respective countries. In Puerto Rico, an additional year of record keeping data will be collected in order to further document the profitability of recently released varieties.

Bean Seed Production and Marketing: Throughout the LAC region, seed availability has been identified as a critical constraint to increasing farmers' yields and profits. In Honduras, previous research (1999) analyzed the impact of Zamorano's efforts to produce and distribute improved bean seed in response to the acute shortage following Hurricane Mitch. In Honduras, building on lessons learned from the previous study, a new initiative will be implemented--in collaboration with a NGO--to organize an association of farmer research committees and assist its member groups to establish small seed enterprises. Under this initiative, Zamorano will provide training and technical assistance in seed production, storage, marketing, marketing, and Record keeping to up to 50 farmer research committees. In Haiti, following a hurricane in 1999, CRSP scientists in the Dominican Republic sold 20 mt of seed (Arroyo Loro Negro) a private input supply firm. This seed was multiplied by Agrotechnique and is being sold to farmers through its network of input distributors. In summer 2000, data will be collected (in collaboration with the Ministry of Agriculture and an NGO, O.R.E) to assess the performance of private bean seed marketing in Haiti and to analyze the impact of this initiative on farmers' yields/profits. These data will be analyzed in fall 2000. In Guatemala, a pilot study will be implemented under which an input dealer will collaborate in marketing seed of an improved bean variety–similar to what has been done in Haiti. This study will assess the potential for private been seed marketing in Guatemala.

Bean Processing Industry: Processing beans into value-added products has the potential to increase the demand for locally-produced beans and generate foreign exchange through the export of these products. Previously, a pilot study of the bean processing industry was carried out in Honduras (1995) and a similar study is being implemented in Costa Rica.

In summer 2000, a study of Guatemala's bean processing industry will be implemented to document the status of the country's bean processing sector, identify constraints to future expansion, and strategies for relaxing these constraints. These data will be analyzed in fall 2000.

Impact Studies: Studies to assess the level of farmer adoption of improved bean varieties and to estimate the financial/economic rate of return to investments in agricultural research (ROR) are required to determine the extent to which these research investments have benefitted farmers and consumers and to inform breeders regarding future research priorities. Previously, an adoption study was carried out in Honduras (1995) and a ROR study was implemented in the Dominican Republic (1998).

In Honduras, the recently-released variety, *Tio Canela-75,*, has been widely adopted by farmers throughout the principal bean-producing regions of the country. In collaboration with PROFRIJOL and Zamorano, a ROR study will be carried out to quantify the rate of adoption and impact of this variety. In Mexico, several improved bean varieties have been widely adopted throughout the semiarid regions of Durango, Chihuahua, and Zacatecas. A ROR study will be implemented to document the impact of these varieties. In Mexico, the government is implementing a variety of reforms designed to liberalize its agricultural sector. A key component of this effort--PROCAMPO–which was introduced in 1994, provides direct income support to farmers growing 9 commodities (including beans), in lieu of input subsidies/price support for specific commodities. Because government will no longer intervene in input/output markets, farmers are expected to reallocate their crop hectares in response to market forces. As this program is new and such a program has never been tested in a developing country, there exists considerable of uncertainty regarding it's long-run impact on the regional pattern of crop production, efficiency, welfare, and total production. This study will assess the recent and future impact of PROCAMPO—focusing on the implications of these changes on regional bean production patterns, total bean output, the country's demand for beans imported from the US--and draw implications for the CRSP's future research focus.

I.D.1.b. Proposed research area workplan and subsequent annual progress report

I.D.1.b.(1) Activity #1: Implement a farm record keeping study in Puerto Rico--Cost of production data will be collected from approximately 30 farmers in several municipalities. These data will be analyzed to estimate the profitability of bean production under commercial management.
I.D.1.b.(1)(a) Priority: (1) Essential
I.D.1.b.(1)(b) U.S. researchers: Bernsten, Beaver
I.D.1.b.(1)(c) HC researchers: Maymi
I.D.1.b.(1)(d) Methodology: Select a representative sample of commercial growing beans. Monitor farm inputs use (labor, agrochemicals, equipment), prices, and production. Record technical problems farmers faced during the growing season. Estimate the costs of production, profits, and returns to labor. Carry out sensitivity analysis to identify the most important factors affecting profits, including alternative yield and output prices assumptions.
I.D.1.b.(1)(e) Anticipated (1 year) results of activity: Report documenting: (a) the profitability of recommended technologies under commercial conditions, (b) constraints farmers face in using the recommended technologies, and (c) modifications needed to improve the technology. The report will be distributed to policymakers, extension services, country scientists, and government officials.
I.D.1.b.(1)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Documentation of: (a) the profitability of improved varieties compared to traditional varieties, and (b) change in input use/crop management practices associated with higher profits	2001	Net returns/ha, input use/ha and environmentally beneficial changes in input use such as lower rates of insecticide application

I.D.1.b.(1)(g) Budget:

MSU (Bernsten)	$5,000
Total (Direct Costs only)	$5,000

I.D.1.b.(1)(h) Major changes: In Puerto Rico, due to budget constraints the budget was reduced to $4,000. As funds from USAID were received late in the fiscal year, this delayed the distribution of the seed for the on-farm trials.

While not in the original workplan, an additional recordkeeping study was carried out in Honduras, as it was felt that such a study was needed to assess the performance on improved bean varieties in a resource-poor environment.
I.D.1.b.(1)(i) Progress during past year-- Recordkeeping in Puerto Rico: The bean planting season in PR is during the Fall, so the crop is still in the field. In September, seed of the white bean cultivar 'Morales" was distributed by local extension agents to 10 farmers in northwestern Puerto Rico. Extensionists received instructions concerning the type of information that farmers should collect. James Beaver and Luis Meijia Maymi plan to visit farms during the month of November to identify technical problems that farmers may encounter during the growing season.

Recordkeeping Analysis for Yorito: In Honduras, beans are grown during the *primera* (June to August) and *postrera* (September-December) season. During the 2000 *primera* season, farm record keeping data were collected from 19 farmers by five *paratécnicos* (advanced farmers with no-formal agricultural education), who were supervised by Zamorano's bean program staff (Aracely Castro). The 20 farmers were distributed across 3 villages (6 to 7 per village) in the Yorito municipality of the Yoro Department (north-central Honduras). All of the respondents farmers on resource-poor hillsides, ranging from fields with an intermediate to steep slope. Ten participants were selected to represent farmers who used a low level of technology and 10 were selected to represent farmers who used an intermediate level of technology. Most farmers grew beans intercropped with maize in the primera, and monocropped beans in the postrera.

Primera: Among the *primera* sample, field size averaged 1.18 ha. (range, 0.17 ha to 2.45 ha). Their effective bean area (adjusted for inter-cropping) averaged 0.43 ha (range, 0.17 ha to 0.70ha). Of the 13 farmers in the sample (farmers for which a complete set of data were available), 6 farmers grew beans intercropped with maize and the remaining 7 planted beans monocrop. Monocropped farmers' variable costs (cash costs and family labor, valued at its opportunity cost, but excluding the cost of land) averaged L 2,158/ha ($US 130.82), with a range of L 459/ha to L 5,367/ha. Farmer average yield was 346 kg/ha (range = 0 kg/ha to 1038 kg/ha). The farmers sold their bean crop for an average price of L 8.10/kg ($US 0.49/kg), although the price ranged from L 4.46/kg to L 12.21/kg. Farmers' gross margins (gross revenue minus variable costs) averaged L 518.60/ha ($US 31.43), with a range of L -1,427/ha to L 5,212/ha. Mean costs/kg (mean of individual farmers' variable cost/kg) averaged L 9.02/kg (US$ 0.55/kg). In contrast, average cost/kg (mean variable costs for total sample, divided by mean yield for the sample) averaged L 6.24/kg ($US 0.38/kg). ($US 1 = L 16.50). During primera, the average yield of traditional variety (366 kgs/ha) was higher than that of modern variety (329 kgs/ha), while the unit average cost per kg of modern variety (L 9.40/kg) was higher than that of traditional variety (L 8.41/kg). Yields were lower than expected, partly due to a lack of rainfall during the growing season–as indicated by yields as low s 0 kg/ha.

Postrera: Among the *postrera* sample, field size averaged 0.99ha. (range, 0.17 ha to 2.45 ha). The effective bean area averaged 0.41 ha (range, 0.17 ha to 0.72ha). Of the 16 farmers in the sample, 3 farmers grew beans intercropped with maize and the remaining 13 planted beans monocrop. Monocropped farmers' variable costs (cash costs and family labor, valued at its opportunity cost, but excluding the cost of land) averaged L 1,627/ha ($US 98.63), with a range of L 800 to L 3,549/ha. Farmer average yield was 365.50 kg/ha (range = 129.81 kg/ha to 973.59 kg/ha). The farmers sold their bean crop for an average price of L 9.24/kg ($US 0.99), although the price ranged from L 5.94/kg to L 14.52/kg. Farmers' gross margins (gross revenue minus variable costs) averaged L 1,800/ha ($US 109), with a range of L 560/ha to L 5,922/ha. Mean costs/kg (mean of individual farmers' variable cost/kg) averaged L 5.12/kg (US$ 0.31). In contrast, average cost/kg (mean variable costs for total sample, divided by mean yield for the sample) averaged L 4.45/kg ($US 0.27). ($US 1 = L 16.5). During *postrera*, modern variety had higher yield and unit cost than traditional variety. The average yield and average unit cost for modern variety was 488.96 kg/ha (range, 173.08 kg/ha to 973.59 kg/ha) and L 6.27/kg (range, L 3.47/kg to L 8.42/kg), respectively. The average yield and average unit cost for traditional variety are 309.36 kg/ha (range, 129.81 kg/ha to 713.97 kg/ha) and L 4.62/kg (range, L 1.48/kg to L 11.55/kg), respectively. The average gross margin is higher for modern variety (L 2640/ha) than traditional variety (L 1419/ha). While farmer's yields were close to the expected means, the improved varieties likely gave higher yields due to their greater disease resistance.

I.D.1.b.(1)(j) Current status of research: Data will be collected and analyzed after the November-December harvest. After the second year of data are collected, costs of production, profits, and returns to labor will be estimated. The results of the cost of production study will be published in the "Technology Package for Bean Production in Puerto Rico" and presented at the annual meeting of the Puerto Rican Society for Agricultural Science. The on-farm trials and cost of production study will be promoted as a possible alternative for evaluating the potential value of crop cultivars developed by the University of Puerto Rico Agricultural Experiment Station.

Honduras: These data were analyzed using a spreadsheet. They will be further analyzed using using SPSS. In addition, future analysis will explore in greater depth the distribution of yields across villages in a effort to more fully identify why some farmers' yields were so low.

Future Recordkeeping Studies: During the past 5 years, RK data have been collected in several countries. While analysis of these data has provided feedback to scientists regarding the on-farm performance of new varieties/technologies, collecting these data requires interviewing each farmer every 2-3 weeks–making it relatively expensive to collect RK data. Currently a M.Sc. student is analyzing all of the RK data sets in order to determine which data varies from farmer-to-farmer/season-to-season. This analysis will serve to identify which data must be collected in the future from each farmers and which data can be "approximated" (i.e., estimated from previously collected data). Bases on this analysis, it is anticipated that in the future (next 5-year extension) it will be possible to limit RK data collection to a small subset of "critical" data–thereby reducing data collection costs/farmer, and making it possible to increase the sample size. In addition, in the future, we will select/stratify farmers into groups who use more similar technologies, in order to reduce variability that makes it difficult to document statistically significant yield differences between farmers using traditional vs. improved varieties.

I.D.1.b.)1)(k) Documented impact: The research documents the performance of improved varieties in Puerto Rico and the performance of improved varieties in a limited-resource/hillside environment in Honduras.

I.D.1.b.(2) Activity #2: Develop bean seed production and marketing enterprises in Honduras--This initiative, which will be implemented in collaboration with a local NGO (IPCA), will create an association of research committees which will work with up to 50 local-level research committees in 5 provinces to assist these committees to develop the capacity to produce and market improves bean seed varieties.

I.D.1.b.(2)(a) Priority: (1) Essential

I.D.1.b.(2)(b) U.S. researchers: Bernsten

I.D.1.b.(2)(c) HC researchers: Rosas

I.D.1.b.(2)(d) Methodology: Train NGO staff in seed production/storage technologies (including seed conservation), how to process/market bean seed, and farm record keeping. Work with NGOs/farmer-research committees to assess the demand for bean seed, identify the best locations/seasons to grow a seed crop, and identify alternative marketing channels.

Collect record keeping data required estimate the profitability of seed production and marketing.

I.D.1.b.(2)(e) Anticipated (1 year) results of activity: Report documenting:
(a) the profitability of seed production, (b) problems faced in developing seed enterprises, and (c) modifications needed to improve the success of these enterprises. The report will be distributed to policymakers, extension services, country scientists, and government officials.

I.D.1.b.(2)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Establishment of profitable seed production/marketing enterprises that relax the country's existing bean seed constraint	2002	Number of seed enterprises established, mt. of seed produced and marketed, and the profitability of these enterprises

I.D.1.b.(2)(g) Budget:

MSU (Bernsten)	$13,700
Total (Direct Costs only)	$13,700

I.D.1.b.(2)(h) Major changes: No major changes.

I.D.1.b.(2)(i) Progress during past year: Background: An initiative for developing a national association of local research committees (CIALs) that would group more than 50 CIALs already existing throughout Honduran is being implemented by IPCA, a local NGO, assisted by CIAT's participatory research program (PRGA). Once the association of CIALs (ASOCIAL) is now legally organized. The project will assist them by providing foundation seed, training and technical assistance to develop the capacity to produce and market improved bean seed varieties among their associates and to farmers from other communities as well. The organization process of the ASOCIAL has taken more time than expected--the ASOCIAL will be expected to be functioning in 2002.

During the past two years, the project has provided assistance to the agricultural sector revitalization (post-Hurricane Mitch) project supported by USAID by providing more than 500 mt of seed of Tio Canela-75 to over 4,000 farmers in the east central region of Honduras. In addition, more than 200 mt of bean seed (mainly Tio Canela 75) have been distributed for the *postrera* planting of 2001 to more than 1,000 farmers, as part of a drought relief project recently implemented also under the support of USAID. The seed were distributed in collaboration with collaborating NGOs active in Honduras. Training on seed production, processing, and storage technologies had been provided to farmers and NGO´s technical personnel under these projects.

Past Year's Activities: The project supported several artisan seed production activities in Honduras during the past year, and continue to do so. These seed activities are conducted by farmers organized in CIALs (in collaboration with the IPCA project) and other type of small farmer organizations (in collaboration with other organizations). Relatively significant amounts of foundation seed (1-2 quintals/group) have been provided to CIALs from El Paraíso, Santa Barbara; El Palmichal, Comayagua; Cafetales, Yorito; Sabana de San Pedro, Yoro and Jutiapa, Atlántida. These distributions included seed of commercial varieties (Tio Canela 75, Dorado and Milenio), as well as seed of locally-released varieties under participatory research activities (DICZA 9801 and PRF 9707-36). These participatory activities are focused on strong farmer inputs in the process of evaluation and selection. Foundation seed of Tio Canela and Dorado has also been provided to other farmer groups, assisted by several NGO´s, such as Concern Worldwide and CONSULUPE (FAO/EEC), in the North of Francisco Morazan and in Yoro. Several training courses/workshops on seed production, post-harvest management technologies, and seed processing have been given to farmers and technicians.

The project is currently collaborating with CURLA, the Atlantic coast branch of the national university, providing assistance to a seed bank initiative in the Rio Cangrejal watershed at the North Atlantic coast of Honduras. One ton of seed of Tio Canela was provided for planting to farmer members of the seed bank organization. Under the seed bank system, farmers have to return twice the amount of seed that they have received for planting, to maintain a seed stock for the members and communities involved. Training on seed production and post-harvest management was provided to technical personnel of CURLA and EuroHonduras Consulting (the NGO working with these farmer groups). The project will be assisting these two organizations in strengthening the seed bank using adequate seed stocks, seed production management and post-harvest technology. Two heat tolerant lines (Amadeus 77 and EAP 9504-30B), previously selected by these farmers using participatory research approaches, are being tested in 30 small farms throughout the Rio Cangrejal watershed. Foundation seed from Tio Canela 75 and/or one of the two heat tolerant lines to be selected by farmers, will be increased at Zamorano and later provided to the seed bank organization for distribution among their members for the *primera* planting of 2002. At the seed bank facilities (metal silos), farmers can store their own seed at a very low price. However, the seed bank needs to improve their processing and storage facilities. In addition, an artisan method for drying physiologically mature plants under high humidity conditions is being tested with local farmers to improve their harvest process; the method would help to quicken plant threshing and reach the desirable seed moisture content for storage in shorter time and lesser risks. This solar method, which is used extensively in the southern Brunca region of Costa Rica, requires to only purchase transparent plastic sheets to cover the bean plant piles that sits over a bed of palm leaves or similar material to isolate the piles from wet surfaces or running water when it rains.

The project will continue collaborating with Zamorano´s Proemprezah project providing foundation seed and technical assistance. Proemprezah has been working with farmer associations to produce and marketing beans. El Plan, one of the bean production microenterprises produces and sells high quality Tio Canela 75 beans in the markets of Tegucigalpa and San Pedro Sula (major cities of Honduras), using 5 lb labeled packages with a brand name "El buen gusto" (the good taste). Currently, the association is interested in starting to produce beans using Amadeus 77, a new project variety that has better seed coat color (light red) and larger seed size (28 g/100 seeds) than Tio Canela 75; farmers expect to obtain better prices with this variety.

Foundation seed of Amadeus 77 has been provided to the NBR programs of El Salvador, Nicaragua and Honduras, for the process of validating and estimating the farmer and consumer acceptance prior to the commercial release in these countries.
I.D.1.b.(2)(j) Current status of research: The project will provide technical assistance to the seed bank organization from the Cangrejal watershed, at the Honduran North coast, to strength the system. Foundation seed of improved varieties will be provided to renovate seed stocks at least every two years to insure good quality seed. Assistance to improve the seed bank processing and storage facilities will be provided. Training on bean harvest and processing at the farm and in the seed bank facilities will be provided. Seed of selected new varieties and landraces will be increased. The collaboration with Proemprezah will continue; foundation seed and technical assistance will be provided to the farmer associations involved. The project will continue to be involved in seed production and distribution activities being conducted by individual CIALs in collaboration with IPCA. Once the ASOCIAL is organized and functioning, the project will get involved with this organization and provide similar support. On the other hand, the project will continue to collaborate with other NGOs and assist artisan production initiatives in the region. The project will continue to be part of emergency relief based on seed production and distribution, such as those supported recently by USAID.
I.D.1.b.(2)(k) Documented impact: The impact of this research is documented by the significant number of NGOs/farmer groups with whom the project has been assisting and the large quantities of bean seed that has been distributed to farmers.

I.D.1.b.(3) Activity #3: Pilot private sector seed distribution in Guatemala--Identify a private sector input dealer interested in distributing bean seed to small farmers, and assist this firm to obtain seed of an improved variety and package it in small quantities for commercial sale to small farmers**.**
I.D.1.b.(3)(a) Priority: (1) Essential
I.D.1.b.(3)(b) U.S. researchers: Bernsten
I.D.1.b.(3)(c) HC researchers: Viana
I.D.1.b.(3)(d) Methodology: Carry out a rapid appraisal to determine the structure of the seed market and the demand for improved seed among small farmers.

Identify an input dealer interested in marketing bean seed in small packages, identify the appropriate package size, and assist the firm to obtain seed.

Collect data from the participating input firm and its distributors to assess the strengths/weaknesses of this initiative and strategies for improving seed distribution to small farmers.

I.D.1.b.(3)(e) Anticipated (1 year) results of activity: Report documenting: (1) the quantity of seed distributed and the dealer assessment of the strengths/weaknesses of this initiative, and (2) suggestions for improving seed distribution to small farmers. The report will be distributed to policymakers, extension service, country scientists, and government officials.

I.D.1.b.(3)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Assessment of potential to utilize private sector input dealers to market improved varieties to small farmers	2001	Quantity of seed distributed, input dealer's assessment of the potential for marketing bean seed to small farmers

I.D.1.b.(3)(g) Budget:

MSU (Bernsten)	$1,000
Total (Direct Costs only)	$1,000

I.D.1.b.(3)(h) Major changes: This activity was dropped from the workplan due to budget constraints. However, an expanded version of this activity will be carried out in Honduras and Nicaragua during the next phase of the CRSP.

I.D.1.b.(3)(i) Current status of research: None

I.D.1.b.(3)(k) Documented impact: None

I.D.1.b.(4) Activity #4: Private sector seed marketing in Haiti--Assess the effectiveness of a private sector (Agrotechnique) initiative to multiply and market bean seed to small farmers

I.D.1.b.(4)(a) Priority: (1) Essential

I.D.1.b.(4)(b) U.S. researchers: Bernsten, Shields, Beaver

I.D.1.b.(4)(c) HC researchers: Prophete

I.D.1.b.(4)(d) Methodology: Carry out a rapid appraisal to describe the bean subsector, including seed marketing strategies.

Select a sample of 20-30 of Agrotechnique's 1,000 input dealer and collect survey data from these dealers to document the quantity of seed sold, farmers' demand for and assessment of the seed, strengths/weaknesses of this initiative, and strategies for improving seed distribution to small farmers.

Survey a sample of 3-4 farmers who bought seed from each input dealer to assess the yield performance of the seed bought and their assessment of its advantages/disadvantages.

I.D.1.b.(4)(e) Anticipated (1 year) results of activity: Report documenting:
(a) the bean subsector, quantity of seed distributed, and the dealers'/farmers' assessment of the strengths/weaknesses of this initiative, and (b) guidelines for improving seed distribution to small farmers. The report will be distributed to policymakers, extension service, country scientists, and government officials.

I.D.1.b.(4)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Assessment of the performance of private seed marketing and recommendations for improving its performance	2001	Quantity of seed distributed, input dealers'/ farmers' assessment of the strengths/weaknesses of the initiative, and farmers' assessment of the varieties

I.D.1.b.(4)(g) Budget:

MSU (Bernsten) (fieldwork carried out in summer 2000, data to be analyzed in Fall 2000)	$4,842
Total (Direct Costs only)	$4,842

I.D.1.b.(4)(h) Major changes: None

I.D.1.b.(4)(i) Progress during past year: Background: In 1998 hurricane Georges ravaged the Caribbean, leaving farmers in many areas of Haiti without seed for planting in the upcoming seasons. As part of efforts to help restock farmers, Haiti's seed parastatal (CIPDSA) ordered 20 mt. of Arroyo Loro Negro (ALN), a black bean variety, from the B/C CRSP in the Dominican Republic for distribution in Haiti. After the anticipated funding for this program fell through, Agrotechnique (AT)--a private Haitian agricultural input dealer--purchased the ALN stock and multiplied the seed under contract with Haitian farmers. The study was undertaken to: a) describe the bean subsector, b) document the evolving bean seed production/marketing system, and c) assess the impact of ATs' distribution scheme on increasing the availability of improved bean seeds to resource-poor farmers.

Conduct: Fieldwork was carried out during summer 2000 (7 weeks), in collaboration with the Haitian Ministry of Agriculture's Research Centers at Damien and Levy Farm, CIPDSA, AT, and IICA-Haiti. A farmer-survey was conducted in two bean-producing environments of southwest Haiti: the irrigated plains of Les Cayes and the mountain areas surrounding Camp Perrin and Beaumont. In addition to interviewing 70 bean farmers (Les Cayes area, one-half irrigated and on-half mountain farmers) and 14 bean-seed growers (Beaumont and Les Cayes area), key informant interviews were conducted with representatives of the Ministry of Agriculture, CIPDSA, AT, and ORE--a Camp Perrin-based Haitian NGO that conducts agricultural research, produces bean and maize seed, and provides extension services to farmers in the region.

Key Findings: During the past 3 years (1997-99), Haiti's harvested bean area (FAO estimate) has averaged 58,075 has. Approximately 11% of the bean area is mono-cropped in irrigated fields and about 89% is grown as a rainfed crop in the mountains. The main irrigated bean areas are the Les Cayes plains (southwest), Cul-de-Sac (south-central), and the Saint-Marc/Artibonite Valley (north). While beans are grown in the mountains throughout the country, the main production areas are Beaumont/Camp Perrin (southwest) and the Kenscoff area (southeast). During the past 3 years, total bean production has averaged 40,200 mts. National yields have averaged 693 kgs/ha.

Haiti's bean seasons vary by location/environment. For example, in the southwest, irrigated beans are grown in Oct-Dec and Dec-Mar. In the dry mountains, beans are grown in during Feb-April; whereas in the wet mountains they are grown in Oct-Dec and Feb-April and in some years during July-Sept.

Bean production systems vary greatly between irrigated and mountain areas, although both irrigated and mountain farmers typically plant the same black bean varieties. Irrigated farmer typically rotate monocropped beans with sorghum, corn, or vegetables, apply purchased inputs (fertilizer, insecticide), and market most of their harvest. In contrast, mountain farmers intercrop beans with sorghum/corn, apply few purchased inputs, and retain most of their harvest for self-consumption. Farmers surveyed in the irrigated plains reported seed-to-harvest ratio of approximately 1:15, while many farmers in the mountains reported ratios as low at 1:2.

Each season, most farmers travel to regional grain markets to purchase fresh bean seed, which is available throughout the year due to differences in planting times in the mountains vs. the plains. Bean seed prices vary greatly over the year. For example, the price of black beans in the Camp Perrin market varied by approximately 120% between August 1998 and June 2000, a period during which there was significant inflation and political unrest in Haiti.

National bean grain/seed markets are relatively well integrated. A rapid reconnaissance conducted in the Camp Perrin bean market in August revealed that marketing channels reach all areas of the country. For example, in August 2000 freshly harvested beans from St. Marc, a community more than 300 km away, were being sold in the Camp Perrin market below the price of locally-grown black beans. Truck drivers interviewed during this reconnaissance reported that they commonly transported beans into Camp Perrin during the middle of growing seasons and from Camp Perrin to other regions after the local harvest.

Haiti has a long history of free or highly-subsidized been seed distribution (via CIPDSA and NGOs). In addition, 1 private firm sells a local unimproved bean variety and ORE multiplies/sells bean seed. However, no improved varieties have been available until AT entry into the seed market. AT, a long established firm, has marketed inputs (corn seed, fertilizer, insecticides, , machinery), but prior to 1999 it did not sell bean seed. After carrying out field trials on ALN with seed provided by Emmanuel Prophete, AT recognized the superior yield potential of this variety and decided to add ALN to its product line—with the expectation that farmers who purchased ALN would also purchase other inputs.

In 1999,_AT contracted about 40 small farmers in the Beaumont area to multiply ALN–producing 100 mt. of good quality seed. AT paid its seed growers a maximum premium price (depending on its quality) of HG 63/marmit (2.8kgs)–which was 10-25% above the local grain price. AT sold its seed for HG 123/marmit (2.8 kgs)–15-20% above AT's total seed production costs (e.g., payment to growers and cost of sorting, bagging, shipping). In 1999, AT sold 10 mt. to CIPDSA, who distributed the seed to farmers in northcentral Haiti at a subsidized price (about 50% of its acquisition price). In addition, AT sold seed to various aid organizations/ NGOs and retained some of its seed for future multiplication. Impressed with the strong demand ALN, Agrotechnique plans to produce 200 mt. of ALN seed for sale in the Oct-Dec 2000 planting season.

ORE also uses small farmer-growers to multiply 2 bean seed varieties: Lore 87, selected by ORE from a landrace and Tamazulapa, an old CIAT line. In Jan-Mar ORE sold seed for multiplication to it's growers for HG 60/marmit (2.8 kgs) and purchased their crop at HG 45/marmit–about 1-2 HG/marmit above the local grain price. ORE sold this seed to local farmers for HG 60/marmit and at a slightly higher price to CIPDSA/NGOs.

As ALN was not distributed to farmers in the survey area (southwest), it was only possible to assess its performance, based on information obtained from AT's seed growers. These farmers reported that they liked ALN because of its high germination rate and drought resistance. While AT's field trials have demonstrated ALN's superior yield, the seed growers felt that their yields were lower than anticipated due to late seed delivery. While farmers who planted ALN reported no disease problems, some irrigated farmer growing traditional varieties reported losing 100% of their crop to BGMV.

Initial analysis of the survey data (Les Cayes and Beaumont areas) indicates a strong demand for bean seed. The poor mountainside farmers demand seed because they sell their bean crop soon after harvest and need replacement seed for subsequent plantings. Because bean farmers in the irrigated plains are much more likely to be affected by BGMV, they use more chemical inputs. Thus, they have a demand for disease-free seed with a high germination rate and for varieties responsive to chemical fertilizer. In addition, AT applies Gaucho to ALN as a seed dressing, which provided some protection against whitefly/BGMV damage.

Key Insights: The study found that: 1) farmers in the southwest who planted improved bean varieties (multiplied by ORE) obtained their seed through village-level farmer organizations or NGOs, 2) AT's and ORE's seed multiplication programs represent a more effective vehicle for transferring technology to farmers than the national extension program, which is virtually nonexistent, 3) AT and ORE have successfully utilized small farmer to grow bean seed, 4) the "market" demand for improved seed has not yet been established, given that farmers are being supplied seed at a subsidized price (less than cost of production), with the difference between the cost/sales price covered by CIPDSA/NGOs, although AT believes that given AT's yield potential, farmers would be willing to pay full price, 5) while the interdependence between the irrigated/mountain areas enable farmers to obtain fresh seed of traditional varieties throughout the year, this represent a constraint to future effort to introduce environment-specific varieties with superior potential in irrigates areas/the mountains.
I.D.1.b.(4)(j) Current status of research: Fieldwork for the study was carried out in Summer 2000. The study has been completed and submitted as a M.Sc. thesis.
I.D.1.b.(4)(k) Documented impact: The study documented the potential for private sector seed production by utilizing small farmers to multiply seed under the supervision of a private input supply firm, which then marketed the improved seed primarily to NGOs for distribution to bean farmers. Also, the study documented the superior performance of Arroyo Loro Negro in Haiti–an improved variety bred by the Bean/Cowpea CRSP program in the Dominican Republic.

I.D.1.b.(5) Activity #5: Bean processing in Guatemala--Document the status of the bean processing industry in Guatemala, identify the potential for bean-based value-added products, and identify factors that limit further expansion
I.D.1.b.(5)(a) Priority: (1) Essential
I.D.1.b.(5)(b) U.S. researchers: Bernsten
I.D.1.b.(5)(c) HC researchers: Estrada-Valle, Viana
I.D.1.b.(5)(d) Methodology: Carry out a rapid appraisal to describe the bean subsector, focusing on bean processing enterprises.

Carry out key informant interviews with managers of principal bean processing firms to collect data on products produced, processes utilized, capacity, production, varietal preferences, sources of raw materials, target markets (domestic/export), problems encountered (production/marketing), and constraints to increasing type and volume of value-added products
I.D.1.b.(5)(e) Anticipated (1 year) results of activity: A report documenting:
(a) the bean subsector in Guatemala, (b) the status of the bean-processing industry, (c) constraints to expanding the production of value-added bean products, (d) new information to bean breeders, regarding industry's assessment of the consumer acceptability and processing quality of available bean varieties, and desired improvements; (e) research/initiatives needed to relax the identified constraints and thereby improve the quantity and expand the variety of bean-based products produced. The report will be distributed to policymakers, extension service, country scientists, and government officials.
I.D.1.b.(5)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Assessment of the potential to increase the production of value-added bean products	2001	New information about the potential for value-added products

I.D.1.b.(5)(g) Budget:

MSU (Bernsten) (fieldwork carried out in summer 2000, data to be analyzed in Fall 2000)	$5,103
Total (Direct Costs only)	$5,103

I.D.1.b.(5)(h) Major changes: None

I.D.1.b.(5)(i) Progress during past year: Background: Since the early 1980s, total bean production in Guatemala has been decreasing due to a decline in cultivated area and yields (MAGA, 1998, PRONACOM, 1999). Since 1984, domestic production has decreased by 4.9% annually while population has been growing by 2.7% (FAO, 1999). While this implies a 30% reduction in domestic per capita availability, a recent study (USAC, 1998) shows that per capita consumption has not decreased to this extent–indicating that commercial bean production has been supplemented by small farmers whose production is not included in official data (fields < 0.5 ha.).

Nevertheless, the decline in national bean production is an important concern to the government and the processing industry. In 2005, Guatemala and other Central American countries will lift tariff barriers, as a condition for the creation of the Free Trade Area of the Americas (FTAA). Once this point is reached, agricultural competitiveness will play an increasingly important role in determining the survival of the bean subsector. The study was undertaken to: a) document the current state of the bean processing industry, including its potential and constraints to expansion, b) analyze the existing problems of coordination between producers and processors, and c) propose recommendations for relaxing the identified constraints at the micro, sectoral and macro level.

Conduct: Fieldwork was carried out in the Departments of Jutiapa, Jalapa, Chiquimula and Guatemala, during July 2000. First, key informant interviews were carried out with staff of the Ministries of Agriculture and Economy (MAGA), the Central Bank, the Institute for Agricultural Science and Technology (ICTA), the Directorate for Foreign Trade Policy, and other governmental institutions to collect secondary data required to describe the subsector. Second, to collect primary data require to gain better insights about the production and marketing of dry beans, the researcher interviewed the technical teams of the Ministry of Agriculture in the study area, conducted 2 one-day workshops with 47 representatives of 9 bean farmers' organizations, and visited several villages to observe the assembly process and to interview bean traders. Finally, to gain insights regarding the bean subsector's structure and dynamics--from the processing industry's viewpoint–the general managers, plant managers, and sales personnel of 4 bean bagging/canning firms were interviewed.

Key Findings: Since the early 1970s, ICTA, has developed 28 improved varieties, some with outstanding levels of disease tolerance. However, due to weak linkages between technology generation and transfer, most farmers do not plant improved varieties--resulting in significant losses due to disease and pest damage, especially BGMV. According to PROFRIJOL, in 1996 only 49% of the dry bean area was planted to improved varieties. In an effort to better server farmers, the government reorganized the way it delivers technical assistance to farmers. Currently, technical assistance emphasizes local empowerment and decentralized decision-making in order to better address region-specific constraints. Under this system, department-level agricultural committees--composed of representatives of all farmers' organizations in the region--establish priorities. Then, these priorities are presented to MAGA, which allocates funds to private firms who provide technical assistance to farmers.

While market information (wholesale and retail prices, based on well-defined quality standards) is available to farmers at MAGA's departmental-level offices, the diffusion of this information is inadequate--given that typically farmers mus travel for 4 or more hours to the MAGA office to obtain market information. Thus, representatives of farmers' organizations are encouraging the government to broadcast market information via AM radio.

The relationships between staple crop producers and the financial sector is extraordinarily weak. Uncertainty--due to weather, market prices, and marketing opportunities possibilities--has discouraged commercial banks from financing agricultural activities. Despite the efforts of the National Bank for Rural Development, commercial financing supports only 3.16% of national bean production. The structure of financial services has had a major impact on marketing channels and conditions. In a large percentage of cases, village-level trader fulfill the credit gap by providing advances in-kind and in-cash to small- and medium-size farmers–acting as a substitute for not only banks, but also for traditional private lenders.

The bean marketing in the study area reflects a pattern, which is consistent with the financial determinants previously mentioned. About 70% of the marketed output is channeled through village assemblers/traders; 9% through cooperatives, and 21% though farmers' associations.

The bean canning industry, whose total output is estimated at 7,500 mt, consists of 4 firms–the largest being a subsidiary of a U.S.. multinational, Riviana Foods. All of these firms also can other products such as fruits, juices, and vegetables. While Guatemala's canning industry has grown at an annual rate of 12%/year for the last 5 years, canned bean output has grown by 4%/year.

Rapid growth in the canning industry has been strongly influenced by 10 factors: 1) political stability–for the last 6 years, Guatemala has had one of the most stable economies of Central America, 2) the country's exchange–which makes local products competitive in world markets, 3) Guatemala a qualified labor force, 4) improvements during the past 5 years in roads, power, and telecommunications, 5) non-restrictive governmental regulations (health/sanitation standards, fiscal regulations, 6) attractive governmental incentives that promote industrial production and export, 7) a growing domestic demand for canned beans, due to rising personal income and increased participation of women in the labor market, 8) a growing international demand for ethnic foods, 9) the presence of 35 million Central Americans and Mexicans in the U.S., and 10) the increasing popularity of Mexican-type foods in the U.S.

On the other hand, the bean-processing industry faces 2 major constrains: 1) it is highly dependent on imported beans, which makes it vulnerable to international price volatility, and 2) domestic bean production is declining, due to lack of incentives to farmers (low profit margins, due to low yields, high costs, and limited access to credit).

Currently, about 92% of Guatemala's bean imports are imported by the processing industry. Industry representatives reported that they did not procure their supplies locally because of: 1) lower prices in international spot markets (65% of cases), 2) a lack of product homogeneity (20% of cases), and 3) difficulty obtaining timely delivery (15% of cases). Currently, bean-processing firms import low-quality beans from countries that harvest mechanically (U.S., Canada, Chile, and Argentina) at discounted prices. Since these firms produce refried beans, the percentage of splits is not a relevant issue. Thus, despite a 20% import tariff on beans, these firms can procure beans on the international market at a lower cost than if they had purchased beans locally. However, bean wholesalers/retailers are unable to purchase low-priced beans on the international market since local bean consumers are particularly stringent in terms of quality and importing high quality beans is prohibitive, given the 20% import tariff. Interestingly, the processing industry exports a large share of its output to the U.S., where it is sold at ethnic shops that cater to Central American immigrants who are willing to pay a price premium for refried beans that are “produced” in Guatemala.

Despite the governmental efforts for stimulating vertical coordination within the bean subsector, the processing industry has not yet identified incentives that would induce them to participate in such initiative, which has seriously constrained the expectations of small bean growers.

Key Insights: The study found that: 1) commercial bean production has decreased, due to a lack of incentives to farmers and a high incidence of diseases, partly due to low adoption of improved varieties; 2) the bean-processing industry has been growing at a sustained rate and the industry is expected to continue to grow in the coming years; 3) the country’s supportive institutional and regulatory framework has promoted the growth of the industry; 4) the domestic and international demand for canned beans is growing; 5) a lack of coordination among farmers and the processing industry can be explained by the relative advantage for processors to purchase/import from spot markets in the U.S., Canada , and South America, instead of procuring beans locally; 6) a lack of coordination between processors and farmers has contribute to the decline in domestic production, which is manifested in a decrease of commercial production and an increase in production for household consumption, and 7) as tariffs decline with full implementation of the FTAA (2005), Guatemalan bean farmers will face increased competition for both the domestic bean market (whole beans and the processed bean market). Thus, priority must be given to increasing domestic bean yields and reducing production costs.
I.D.1.b.(5)(j) Current status of research: Fieldwork for the study was carried out in Summer 2000. The study was completed in Spring 2001 and has been submitted as a M.Sc. thesis.
I.D.1.b.(5)(k) Documented impact: The study documented the status of the bean subsector and growth in the country’s bean processing industry. Furthermore, it found that rather than procuring their bean stocks locally, most of these stocks were imported because imported beans (splits) were less expensive than local beans–a result that suggests that unless cost of production can be reduced, imports will account for a growing market share in Central American countries.

I.D.1.b.(6) Activity #6: Economic impact of bean research in Honduras--Estimate the rate of return (ROR) to bean research (*Tio Canela-75*) in Honduras
I.D.1.b.(6)(a) Priority: (1) Essential
I.D.1.b.(6)(b) U.S. researchers: Bernsten, Mather
I.D.1.b.(6)(c) HC researchers: Viana, Rosas
I.D.1.b.(6)(d) Methodology: Collect secondary data required to document the bean subsector.

Collect administrative data required to estimate the research investments associate with the development of *Tio Canela-75.*

Select a sample of bean farmers in the main bean production areas, carry out a survey to estimate the rate of adoption and yield performance of *Tio Canela-75*--compared to their previous varieties--and to determine farmers’ assessment of it’s strengths/weaknesses.

Estimate the ex-post financial/economic ROR to research investments associated with the development of *Tio Canela-75*.
I.D.1.b.(6)(e) Anticipated (1 year) results of activity: A report documenting:

(a) the bean subsector in Honduras, (b) the level of farmer-adoption of *Tio Canela-75*, (c) the financial/economic ROR to research investments to develop *Tio Canela-75*, and (d) farmers' assessment of the strengths and weaknesses of *Tio Canela-75*. The report will be distributed to policymakers, extension service, country scientists, and government officials.

I.D.1.b.(6)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Documentation of the ROR to bean research and implications for future bean research	2002	Adoption rate, financial and economic ROR

I.D.1.b.(6)(g) Budget:

MSU (Bernsten) (PROFRIJOL will contribute $2,000)	$7,854
Total (Direct costs only)	$7,854

I.D.1.b.(6)(h) Major changes: None

I.D.1.b.(6)(i) Progress during past year: Background: Since 1987, six improved bean varieties have been released in Honduras, including Catrachita (1987), Dorado (1990), Don Silvio (1993), DICTA 113 (mid -1990s), Tio Canela (1996), and DICTA 122 (1997). Each of these varieties was developed by Zamorano (the Department of Agronomy at the *Escuela Agricola Panamericana*) and/or DICTA (the National Bean Program), in collaboration with the Bean/Cowpea CRSP, PROFRIJOL, and CIAT.

In January 2001, the CRSP and PROFRIJOL jointly funded a survey of bean farmers (N=210) in the same two regions of Honduras which were surveyed in 1994. The survey was designed to generate data for an *ex post* economic impact assessment of bean research in Honduras, as well as to provide Zamorano and DICTA with information concerning the socioeconomic characteristics of adopters, the relative farm-level prices of different varieties, farmers' knowledge of improved varieties, and farmers' opinions regarding various agronomic, market, and consumption aspects of the improved and traditional varieties they use. The survey targeted the Midwest (El Paraiso and Francisco Morazan) and Northeast (Olancho) regions of Honduras, which together account for about half of national bean production. In each of the three departments, 70 farmers were selected randomly using 1994 Agricultural Census information to randomly select 10 villages in each department, and then generating bean farmer lists in the selected villages with which to select farmers at random.

Varietal Adoption: According to preliminary analysis of the survey data, in the 2000 *primera* season (June to August), 41.4% of the respondents planted an improved variety; 24.3 percent planted Dorado, 8.6% Tio Canela, 5.2 % Catrachita, and 3.3% Don Silvio. In the 2000 *postrera* season (September to December), 44.4 percent of respondents planted an improved variety; 24.8% planted Dorado, 11%Tio Canela, 3.8% Catrachita, and 4.8% Don Silvio. The pattern of varietal choice over time will be conducted, using both formal adoption and disadoption analysis as well as analysis of the reasons that farmers gave for varietal change. Preliminary analysis indicates that about 32% of the respondents have disadopted Dorado, while 11% have disadopted Tio Canela. While some of the disadopters of Dorado switched to Tio Canela, the majority of disadopters of MVs in general appear to have revert to a TV due to better market prices for TVs relative to MVs.

Yield: The mean area planted to bean for *primera* 2000 (N=168) was 1.53 ha, while the mean yield was 652 kg/ha (s.d. 446 kg/ha). The mean yield of respondents who grew Tio Canela in this season (N=18) was 869 kg/ha (s.d. 637 kg/ha), the mean yield for Dorado

(N=50) was 723 kg/ha (s.d. 430 kg/ha), and the mean yield for traditional varieties (N=112) was 632 kg/ha (s.d. 419 kg/ha). The mean area planted to bean for *postrera* 2000 (N=200) was 2.05 ha, while the mean yield was 447 kg/ha (s.d. 379 kg/ha). The mean yield of respondents who grew Tio Canela in this season (N=23) was 555 kg/ha (s.d. 500 kg/ha), the mean yield for Dorado (N=52) was 378 kg/ha (s.d. 351 kg/ha), and the mean yield for traditional varieties (N=200) was 498 kg/ha (s.d. 404 kg/ha).

Given the high yield variance in our sample for both TVs and MVs, there is no statistical difference (5% confidence level) between TV and MV yields when testing for yield difference season by season–although the yield differences are statistically significant at the 80% level. Regardless, multi-variate regression is needed to control for important factors besides variety which influence yield such as farmer socioeconomic characteristics, fertilizer use, altitude, regional rainfall, etc. This analysis is in progress.

Farmer Seed Source: The source of survey respondents' seed in *postrera* 2000 was from previous harvest (53%), neighbors (26%), traders (5%), and Zamorano (1%). Those who used saved seed in 2000 had used the same recycled germplasm an average of 5 seasons (2.5 years). The original source of the respondents' 3 principal varieties used was neighbors (48%), traders (10%), DICTA/Dept of Natural Resources (5%), CIAT Seeds of Hope project (4%), Zamorano (2%), and the local market (2%).

History of Improved Varietal Use : *Dorado*-- Ninety-five percent of the respondents had heard of Dorado, while 61% had planted it. Of those who had not planted it, 30% said they did not plant it because of its low market price relative to traditional varieties, 20% didn't know enough about it, and 20% said that seed was not available. Of those who have planted Dorado, 47% are still planting it. The 53% who tried Dorado but stopped planting it cited low market price (53%), unavailability of seed (9%), and low yield (7%), as reasons why they abandoned the variety.

Tio Canela-- Seventy-seven percent of the respondents had heard of Tio Canela, while 23.8% had planted it. Of those who had not planted it, 30% said they did not plant because they did not know enough about the variety, 31% said seed was not available, and 12% cited a low market price for the variety, relative to traditional varieties. Of those who have planted Tio Canela, 53% are still planting it. The 47% who tried Tio Canela but stopped planting it cited low market price (32%), unavailability of seed (16 %), disease susceptibility (10%), or long crop cycle (10%) as reasons why they abandoned the variety.

The seed source and varietal use results indicate that the Honduran bean seed system is highly underdeveloped, and will remain a significant constraint for the diffusion of improved bean varieties. Many farmers are not adopting improved varieties simply because they have either not heard of them or cannot access the seed.

Farm-level Prices: For the *primera* 2000, the mean farm-level price for the respondents was $US 0.46/kg (N=151). The mean respondent price for Dorado was $US 0.38/kg (N=41), for Tio Canela was $US 0.53/kg (N=12), and for the four main traditional varieties was $US 0.56/kg (N=55). For the *postrera* 2000, the mean farm-level price for the respondents was $US 0.51/kg (N=149). The mean price for Dorado was $US 0.45/kg (N=27), for Tio Canela was $US 0.47/kg (N=10), and for the four main traditional varieties was $US 0.54/kg (N=54). While more analysis is forthcoming, these mean prices do not appear to be influenced greatly by post-harvest storage, as 60% of respondents in primera sold their beans at harvest, and 85% had sold within a month of harvest. In the postrera, 70% of respondents sold at harvest, and 85% within a month of harvest. The location of each farmer's sale is not

also likely to affect price greatly as 90% of all respondents sold their beans in the field, at their home or in the nearest village, while 5% sold in a local market. Regional differences in price are expected and will be investigated.
I.D.1.b.(6)(j) Current status or research: Fieldwork for the study was carried out in January-February 2001. The data will be analyzed in greater detail during Fall 2001 and reported in an invited paper at the CIMMYT/CGIAR-sponsored impact of agricultural research conference to be held in Costa Rica in February 2002. This paper will include an estimate of the rate of return to bean research.
I.D.1.b.(6)(k) Documented impact: The study documented the adoption of improved bean varieties in Honduras and constraints to greater adoption–including grain quality/color and the weakness of Honduras' seed production and distribution system.

I.D.1.b.(7) Activity #7: Economic impact of bean research in Mexico--Estimate the rate of return (ROR) to bean research in the Highlands of Mexico
I.D.1.b.(7)(a) Priority: (1) Essential
I.D.1.b.(7)(b) U.S. researchers: Bernsten, Kelly
I.D.1.b.(7)(c) HC researchers: González, Acosta
I.D.1.b.(7)(d) Methodology: (1) Collect secondary data required to document the structure of the bean subsector, (2) Collect administrative data required to estimate the research investments associate with the development of recently released improved varieties, (3) Utilize administrative date and farmer-group interviews to estimate the rate of adoption and yield performance of recently released improved varieties in Durango, Zacatecas, and Chihuahua, compared to farmers' previous varieties, and to determine farmers' assessment of their strengths/weaknesses, (4) Estimate the ex-post financial/economic ROR to research investments associated with the development of recently released bean varieties.
I.D.1.b.(7)(e) Anticipated (1 year) results of activity: Progress Report only.
I.D.1.b.(7)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Documentation of the ROR to bean research and implications for future research	2002	Adoption rate, financial and economic ROR

I.D.1.b.(7)(g) Budget:

MSU (Bernsten)	$9,500
(Additional support from CONACYT)	
Total (Direct Costs only)	$9,500

I.D.1.b.(7)(h) Major changes: None
I.D.1.b.(7)(i) Progress during past year: The objectives of the study are to describe the dry bean subsector in Mexico , assess the rate of adoption of bean varieties that have been released INIFAP-B/C CRSP, and determine the economic impact (rate of return) to investments in bean research.

The methodology that is being used includes: a) a rapid appraisal of the bean subsector (collecting secondary data, conducting interviews with key informants including INIFAP scientists, extension service personnel, bean processors, groups of farmers), and b) formal surveys of bean farmers.

Mexico's three main bean-producing states are Durango, Chihuahua, and Zacatecas. To assess adoption rate and the impact of modern varieties on yields, farmer surveys will be carried out. In Durango, a random sample of 100 farmers will be interviewed by Gonzalez using a detailed questionnaire. The Durango respondents will be distributed across the main bean-producing counties in the state, in proportion to the number of bean farmers in the state (total N=100; Cuencame, N=40; Guadalupe Victoria, N=30;, and Panuco de Coronado, N=30). In Chihuahua (total N=200; Namiquipa, N=75; Cuauhtemoc, N=65; and Guerrero, N=60) and Zacatecas (total N=200; Fresnillo, N=90; Rio Grande, N=60; and Sombrerete, N=50), a random sample of bean farmers (distributed in proportion to the number of bean farmers in the states will be contacted by high school students and asked to complete "short" questionnaire (equivalent to a mail survey).

To assess the costs associate with the development of improved bean varieties, research cost data will be collected from INIFAP staff.

As fieldwork for this study was initiate in early September 2001, it is too early to report any results. However, the following varieties were distributed as certified seed in summer 2000: Durango (Pinto Mestizo, Pinto Bayacora, Negro Altiplano and Negro Sahuatoba); Chihuahua (Pinto Mestizo, Pinto Villa, and Negro Altiplano) and Zacatecas (Pinto Villa, Flor de Mayo Sol, and Negro Zacatecas).

I.D.1.b.(7)(j) Current status of research: The fieldwork is ongoing. Data collection will be completed in January 2002. These data will be analyzed in Spring 2002 and Gonzalez will complete his dissertation in August 2002.

I.D.1.b.(7)(k) Documented Impact: None

I.D.1.b.(8) Activity #8: The role of direct support programs for farmers in the transition to an open agricultural economy in Mexico--Assess recent changes in government support (PROCAMPO program) to Mexican bean farmers and project the future impact on these changes on bean production patterns and the county's import requirements for U.S. beans

I.D.1.b.(8)(a) Priority: (1) Essential

I.D.1.b.(8)(b) U.S. researchers: Bernsten, Mather, Kelly

I.D.1.b.(8)(c) HC researchers: Acosta

I.D.1.b.(8)(d) Methodology: Utilize secondary data/key informant interviews to document the structure of PROCAMPO.

Analyze crop hectarage data to assess recent shifts in area planted among the 9 crops targeted by PROCAMPO.

Conduct key informant interviews with policymakers, farm leaders and bean producers to assess recent changes in crop production and to determine their assessment regarding future changes.

Estimate the relative profitability of bean production (and other key crops), both before and after the introduction of PROCAMPO.

Develop a model to project future change in regional crop production and imports, focusing on beans, and the efficiency and welfare impacts of these changes.

I.D.1.b.(8)(e) Anticipated (1 year) results of activity: Progress Report only

I.D.1.b.(8)(f) Anticipated impact to which this activity will contribute, time frame and indicators:

IMPACT	TIME FRAME	INDICATOR
Projections regarding future regional shifts in bean production will guide breeders decisions as to the characteristics of varieties required in the future. Projections regarding future bean import requirements will inform US producers regarding future export markets in Mexico. Insights gained regarding the efficiency/ welfare impacts of PROCAMPO will guide the design of future agricultural policies.	2002	Projections of future regional crop production, total bean production, and national import requirements. Estimates of the efficiency/ equity impacts of PROCAMPO.

I.D.1.b.(8)(g) Budget:

MSU (Bernsten)	<u>$24,372</u>
Total (Direct Costs only)	$24,372

I.D.1.b.(8)(h) Major changes: Due to evolving research priorities, the similarity between this study and Gonzales' research (Economic Impact of Bean Research in México), and the new priorities identified for the new five-year extension which will analyze regional bean trade patterns, this study was dropped from the workplan. Funds to support this study were reallocated to Gonzalez, who will explore some of the issues identified in this study.
I.D.1.b.(9)(i) Progress during past year: None
I.D.1.b.(9)(j) Current status of research: It will be addressed in next phase.
I.D.1.b.(9)(k) Documented impact: None

I.E. Constraint #5: Insufficient Cadre of Trained Personnel

I.E.1. Research area: Degree training

I.E.1.a. Activity #1: Training to be completed this year

I.E.1.a.(1) Name of student: Maurice Yabba
Gender: M
Nationality: U.S., St. Croix
Degree: Ph.D.
Discipline: Plant Physiology
Name of major professor: Eunice Foster
Thesis title: Common Bean (*Phaseolus vulgaris* L.) Yield, Root Growth and N Fixation Response to Moisture Deficits.
Educational institution: Michigan State University
Date training began: 09/98
Date training ended: 07/01
CRSP funding: Partial
Budget: $0 (MSU/Kelly)

I.E.1.a.(2) Name of student: Carlos German Muñoz
Gender: M
Nationality: Colombian
Degree: M.S.
Discipline: Plant Breeding and Genetics
Name of major professor: James Beaver
Thesis title: Inheritance of resistance to BGYMV in common bean

Educational institution: University of Puerto Rico
Date training began: 08/98
Expected date of completion: 12/01
CRSP funding: Indirect
Budget: $0 (UPR)

I.E.1.a.(3) Name of student: Consuelo Estevez de Jensen
Gender: F
Nationality: Ecuador
Degree: Ph.D., degree awarded October 31, 2000, currently a research associate in plant pathology
Discipline: Plant Pathology
Name of major professor: J. Percich and R. Meronuck
Thesis title: Etiology and Control of Dry Bean Root Rot in Minnesota
Educational institution: University of Minnesota
Date training began: 08/96
CRSP funding: Indirect
Budget: $0 (Ecuador)

I.E.1.a.(4) Name of student: Belinda Roman
Gender: F
Nationality: U.S.
Degree: M.S.
Discipline: Plant Breeding and Genetics
Name of major professor: James Beaver
Thesis title: Inheritance of Heat Tolerance
Educational institution: University of Puerto Rico
Date training began: 01/99
Anticipated completion date: 06/01
CRSP funding: Indirect
Budget: $0 (UPR)

I.E.1.a.(5) Name of student: Judy Kolkman
Gender: F
Nationality: Canadian
Degree: Ph.D.
Discipline: Plant Breeding and Genetics
Name of major professor: James Kelly
Thesis title: Identification and Molecular Characterization of White Mold Resistance in Common Bean
Educational institution: Michigan State University
Date training began: 01/96
Anticipated completion date: 06/00
CRSP funding: Indirect
Budget: $0 (MSU/Kelly)

I.E.1.a.(6) Name of student: Gustavo Bernal
Gender: M
Nationality: Ecuadorian
Degree: Ph.D., degree awarded May 28, 2001
Discipline: Soil Microbiology
Name of major professor: Peter Graham

Thesis title: Diversity of Bean Rhizobia Associated with *Phaseolus vulgaris*
Educational institution: University of Minnesota
Date training began: 09/97
Anticipated completion date: 02/01
CRSP funding: Indirect
Budget: $0 (Ecuador)

I.E.1.a.(7) Name of student: Irene Christiansen
Gender: F
Nationality: Danish
Degree: Ph.D., degree awarded June 15, 2001
Discipline: Soil Science
Name of major professor: Peter Graham
Thesis title: Phosphorus Utilization and Nitrogen Fixation in Andean Bean Germplasm
Educational institution: University of Minnesota
Date training began: 08/97
Anticipated completion date: 06/01
CRSP funding: Indirect
Budget: $0 (UMN)

I.E.1.a.(8) Name of student: Monica Parreño
Gender: F
Nationality: Ecuadoran
Degree: B.S.
Discipline: Science and Agricultural Production
Major professor: Juan Carlos Rosas
Thesis title: Molecular markers for angular leaf spot
Educational institution: EAP
Date training began: 05/01
Anticipated completion date: 04/02
CRSP funding: Partial
Budget: $2,000 (Honduras)

I.E.1.a.(9) Name of student: Elisa Erazo
Gender: F
Nationality: Honduran
Degree: B.S.
Discipline: Science and Agricultural Production
Major professor: Juan Carlos Rosas
Thesis title: Molecular markers for MAS (virus) on beans
Educational institution: EAP
Date training began: 01/01
Anticipated completion date: 12/01
CRSP funding: Partial
Budget: $3,000 (Honduras)

I.E.1.a.(10) Name of student: Dulis Duron
Gender: M
Nationality: Honduran
Degree: B.S.
Discipline: Science and Agricultural Production
Major professor: Juan Carlos Rosas

Thesis title: Mycorrhiza inoculation on beans
Educational institution: EAP
Date training began: 01/01
Anticipated completion date: 12/01
CRSP funding: None
Budget: $O

I.E.1.a.(11) Name of student: Gonzalo Montaño
Gender: M
Nationality: Bolivian
Degree: B.S.
Discipline: Science and Agricultural Production
Major professor: Juan Carlos Rosas
Thesis title: Mycorrhiza inoculation on beans
Educational institution: EAP
Date training began: 01/01
Anticipated completion date: 12/01
CRSP funding: None
Budget: $O

I.E.1.a.(12) Name of student: Kevin Soto
Gender: M
Nationality: Ecuadoran
Degree: B.S.
Discipline: Science and Agricultural Production
Major professor: Juan Carlos Rosas
Thesis title: Drought tolerance on beans
Educational institution: EAP
Date training began: 01/01
Anticipated completion date: 12/01
CRSP funding: Partial
Budget: $3,000 (Honduras)

I.E.1.a.(13) Name of student: Grabriela Díaz
Gender: F
Nationality: Chilean
Degree: B.S.
Discipline: Science and Agricultural Production
Major professor: Juan Carlos Rosas
Thesis title: Inheritance of angular leaf spot
Educational institution: EAP
Date training began: 01/00
Anticipated completion date: 12/01
CRSP funding: None
Budget: $0

I.E.1.a.(14) Name of student: Daniel Sosa
Gender: M
Nationality: Honduran
Degree: B.S.
Discipline: Science and Agricultural Production
Major professor: Juan Carlos Rosas

Thesis title: Management of angular leaf spot
Educational institution: EAP
Date training began: 01/00
Anticipated completion date: 12/01
CRSP funding: None
Budget: $0

I.E.1.a.(15) Name of student: Carlos Barrera
Gender: M
Nationality: Colombian
Degree: B.S.
Discipline: Science and Agricultural Production
Major professor: Juan Carlos Rosas
Thesis title: Resistance to common blight
Educational institution: EAP
Date training began: 01/00
Anticipated completion date: 12/01
CRSP funding: None
Budget: $0

I.E.1.a.(16) Name of student: Carlos Coello
Gender: M
Nationality: Ecuador
Degree: B.S.
Discipline: Agronomy
Major professor: Juan Carlos Rosas
Thesis title: Participatory bean breeding
Educational institution: EAP
Date training began: 05/00
Anticipated completion date: 04/01
CRSP funding: Partial
Budget: $3,000 (Honduras)(Direct Costs only)

I.E.1.a.(17) Name of student: Laura Hangen
Gender: F
Nationality: Costa Rican
Degree: M.S.
Discipline: Nutrition
Major professor: Maurice R. Bennink
Thesis title: Consumption of Black Beans and Navy Beans Reduced Azoxymethane Induced Colon Cancer in Rats
Educational institution: Michigan State University
Date training began: 01/99
Anticipated completion date: 04/01
CRSP funding: Total
Budget: $14,000
Status: Laura is back in Costa Rica and working part time as a lecturer in the nutrition department at the University of Costa Rica.

I.E.1.b. Activity #2: Continuing training

I.E.1.b.(1) Name of student: Horacio Gonzales
Gender: M
Nationality: Mexico
Degree: Ph.D.
Discipline: Agricultural Economics
Name of major professor: Rick Bernsten
Thesis title: Economic Analysis of the Impact of the Bean/Cowpea CRSP in the Semiarid Highlands of the North Central Region of Mexico
Educational institution: Michigan State University
Date training began: 09/98
Anticipated completion date: 9/02
CRSP funding: Dissertation field research only
Budget: $0 (MSU/RF)

I.E.1.b.(2) Name of student: Jorgé González
Gender: M
Nationality: Bolivian
Degree: Ph.D.
Discipline: Plant Breeding and Genetics
Major professor: Dermot Coyne
Thesis title: Inheritance, Heritability and Mapping of QTL for Resistance to Leafhopper in Common Beans.
Educational institution: University of Nebraska-Lincoln
Date training began: 08/98
Anticipated completion date: 12/01
CRSP funding: Total
Budget: $15,000 (DR)(Direct Costs only)

I.E.1.b.(3) Name of student: Luis Duran
Gender: M
Nationality: U.S.
Degree: M.S.
Discipline: Agronomy
Educational institution: University of Puerto Rico
Date training proposed to begin: 08/99
Date training anticipated to end: 12/01
CRSP funding: Indirect
Budget: $0 (UPR)

I.E.1.b.(4) Name of student: David Mather
Gender: M
Nationality: U.S.
Degree: Ph.D.
Discipline: Agricultural Economics
Name of major professor: Rick Bernsten
Thesis title: Yet to be finalized
Educational institution: Michigan State University
Date training began: 8/96
Anticipated completion date: 6/03
CRSP funding: Assistantship: 10-12/001 (0.5); 1-9/01 (0.25)
Budget: $ 12,218 (MSU/RF)

I.E.1.b.(5) Name of student: Juan Estrada-Valle
Gender: M
Nationality: Guatemala
Degree: M.Sc.
Discipline: Agricultural Economics
Name of major professor: Rick Bernsten
Thesis title: A Subsector Overview of the Guatemalan Bean Industry: Constraints and Opportunities for Vertical Coordination and Sustainable Growth
Educational institution: Michigan State University
Date training began: 8/99
Anticipated completion date: 12/01
CRSP funding: Assistantship: 10-12/01 (0.5)
Budget: $5,780 (MSU/RF)

I.E.1.b.(6) Name of student: Will Shield
Gender: M
Nationality: U.S.
Degree: M.Sc.
Discipline: Agricultural Economics
Name of major professor: Rick Bernsten
Thesis title: An Analysis of the Bean Subsector in Haiti and Private Sector Production and Distribution of Improved Seed
Educational institution: Michigan State University
Date training began: 8/98
Anticipated completion date: 12/01
CRSP funding: Assistantship: 10-12/01 (0.25)
Budget: $3,590 (MSU/RF)

I.E.1.c. Activity #3: Proposed new training

I.E.1.c.(1) Name of student: Juan Manuel Osorno
Gender: M
Nationality: Colombia
Degree: M.S.
Discipline: Agronomy
Educational institution: University of Puerto Rico
Date training proposed to begin: 08/00
Date training anticipated to end: 08/02
CRSP funding: Total
Priority: (2) High priority
Budget: $12,000 (UPR)(Direct Costs only)

I.E.1.c.(2) Name of student: Robyn Engleright
Gender: F
Nationality: U.S.
Degree: M.S.
Discipline: Plant Breeding and Genetics
Educational institution: Michigan State University
Date training proposed to begin: 09/99
Date training anticipated to end: 09/02
CRSP funding: Indirect
Priority: (2) High priority

Budget: $0 (MSU/Hosfield)

I.E.1.c.(3) Name of student: Mark Frahm
Gender: M
Nationality: U.S.
Degree: M.S.
Discipline: Plant Breeding and Genetics
Educational institution: Michigan State University
Date training proposed to begin: 10/99
Date training anticipated to end: 12/01
CRSP funding: Total
Priority: (2) High priority
Budget: $20,000 (MSU/Kelly)(Direct Costs only)

I.E.1.c.(4) Name of student: Veronica Vallejo
Gender: F
Nationality: U.S.
Degree: M.S.
Discipline: Plant Breeding and Genetics
Educational institution: Michigan State University
Date training proposed to begin: 10/99
Date training anticipated to end: 12/01
CRSP funding: Indirect
Priority: (2) High priority
Budget: $0 (MSU/Kelly)

I.E.1.c.(5) Name of student: Giselle Mauer
Gender: Female
Nationality: U.S.
Degree: M.S.
Discipline: Food Science
Educational institution: Purdue University
Date training proposed to begin: 07/00
Date training anticipated to end: 07/02
CRSP funding: Total
Priority: (1) Essential
Budget: $16,000 (Purdue)(Direct Costs only)

I.E.1.c.(6) Name of student: Belinda Roman
Gender: F
Nationality: U.S. Puerto Rico
Degree: Ph.D.
Discipline: Plant Breeding and Genetics
Name of major professor: James Kelly
Educational institution: Michigan State University
Date training began: 08/01
Anticipated completion date: 08/04
CRSP funding: Indirect
Priority: (2) High priority
Budget: $0 (MSU/Kelly)

I.E.1.c.(7) Name of student: Emmalea Garver
Gender: F
Nationality: U.S.
Degree: M.S.
Discipline: Plant Breeding and Genetics
Name of major professor: James Kelly
Educational institution: Michigan State University
Date training began: 08/01
Anticipated completion date: 08/03
CRSP funding: Indirect
Priority: (2) High priority
Budget: $0 (MSU/Kelly)

I.E.1.c.(8) Name of student: Geraradine Mukeshimana
Gender: F
Nationality: Rwanda
Degree: M.S.
Discipline: Plant Breeding and Genetics
Name of major professor: James Kelly
Educational institution: Michigan State University
Date training began: 08/01
Anticipated completion date: 09/04
CRSP funding: Indirect
Priority: (2) High priority
Budget: $0 (MSU/Kelly)

I.E.2. Research area: Non-degree training

The project continues to support baccalaureate students engaged in research projects in Ecuador, but up-to-date details were not collected because of the hospitalization of the U.S. PI.

I.E.2.a. Activity #1: Service to and upgrade of the Rhizobium website (http://www.Rhizobium.umn.edu) and monitoring of its impact
Priority: High priority
U.S. Researchers: Graham and Swenson
Methodology: Ongoing upgrades to the website.

Continued service to Question and Answer Service via EMAIL.
The number of trained personnel in the field of soil biology and N_2 fixation is low, and opportunities for adequate graduate training in this area difficult. To diffuse information we have developed a web site in Spanish and English that provides up-to-the-moment information on nodulation and N_2 fixation, and is a point of contact for questions and concerns. To date this has been utilized by more than 30,000 students, professors and research workers from more than 65 countries. These include numerous countries from our target area including Mexico, Venezuela, Brazil, Uruguay, Colombia and Ecuador. The website has generated via EMAIL perhaps 300 specific research and application queries on nodulation and N_2 fixation, again including many from countries in Latin America.
Anticipated (1 year) results: Response to the web site, and the opportunity to ask questions has been very strong, including a number website generated contacts from Latin America and Europe.
Output:
Budget: $2,000 (UMN)(Direct Costs only)

Progress during past year: Hits on this website since its inception in 1998 now exceed 400,000. We have stopped keeping detailed statistics but email contacts with the U.S. PI continue. This includes providing ongoing advice to graduate students in Argentina, Botswana, Colombia, Peru and Hungary. The English version of the site has been completely overhauled, and now includes a list serve for exchange of information.

I.E.2.a. Activity #2: Publication of a special issue of *Field Crops Research* dedicated to the 20 years of the Bean/Cowpea CRSP.
U.S. Researchers: Hall, Coyne and Graham (co-editors)
Progress during past year: At the suggestion of the U.S. PI, *Field Crops Research* as agreed to publish a special issue that reviews progress in the Bean/Cowpea CRSP since its inception. This is to be co-edited by Hall et al using referees from FCR organized by the U.S. PI. Ten papers have been agreed upon, and all lead authors contacted. Each has agreed to coordinate their respective chapters, and in particular to insure integration of U.S. and HC research results.
Major changes: This activity was not included in the original workplan but it was approved and endorsed by the TC.
Budget: None

I.E.2.b. Activity #2: Long-distance education in nitrogen fixation and soil biology
Priority: High priority
Methodology: Despite emphasis on education in the CRSP, training opportunities in the US are expensive and limited. Long-distance education provides the opportunity to give training in the student's home country. The Universidad Tecnologica Equinoccial in Quito is being funded through PROMSA to develop a master's degree in Biotechnology. We intend using this opportunity, and recently developed course websites in soil biology and soil science at Minnesota to facilitate long distance education in course materials and technique.
Anticipated (1 year) results: Students in Ecuador will use long-distance education for courses in soil biology and soil science.
Output:
Budget: $3,000 (UMN)(Direct Costs only)

I.E.2.c. Activity #3: Training in Marker-Assisted Selection (MAS) and English
Name of student: Aracely Castro
Gender: F
Nationality: Honduras
Non-degree training: Molecular biology in MAS (and English training for pursuing a Ph.D. degree at a later period)
Discipline: Molecular techniques
Educational institution: Michigan State University or U. Wisconsin
Date training proposed to begin: 05/01
Date training anticipated to end: 07/01
CRSP funding: Partial
Budget: $3,500 (Honduras)(Direct Costs only)

I.F. Constraint #6: Insufficient Extension--Not separated in workplan

I.G. Constraint #7: Insufficient Research-Extension Collaboration--Not separated in workplan

II. ACTIVITIES DURING YEAR FROM CRSP SUPPLEMENTAL FUNDS NOT INCLUDED IN WORKPLAN

No activities were undertaken in FY 2000 that depended on supplemental support not considered in the workplan.

The supplemental funding provided during FY 2001 was for travel by Grafton and Graham to Tanzania for activities associated with future development of BNF and breeding activities in that country. For various reasons it has not been possible to make the trip. Dr. Widders has agreed to encumber these funds for travel when the political climate improves.

II.A. Activity #1: Travel expenses for Ing. Emmanuel Prophete to visit Zamorano in December, 2000. He will participate in the evaluation of small red and black-seeded breeding lines and learn how the EAP has cooperated with NGO's to disseminate seed and conduct on-farm trials.
Background/justification: Zamorano has been successful in using participatory plant breeding techniques and on-farm testing in collaboration with NGO's to disseminate recently released bean varieties. The purpose of the trip to Honduras was to attend a participatory plant breeding workshop and to evaluate small red and black-seeded bean breeding lines.
U.S. researchers: James Beaver
HC researchers: Emmanuel Prophete and Juan Carlos Rosas
Methodology: N/A
Anticipated (1 year) results of activity: One year
Anticipated impact to which this activity will contribute, time frame and indicators:
IMPACT: Mr. Prophete will gain a better understanding of participatory bean breeding techniques. In addition, he expects to learn how EAP researchers were able to collaborate with NGOs to disseminate seed and conduct on-farm trials of bean breeding lines.
TIME FRAME: One year
INDICATOR: Increased adoption of bean breeding lines developed by the Bean/Cowpea CRSP
Budget: $1,750
Progress during past year: Emmanuel Prophete, James Beaver and Juan Carlos Rosas attended the participatory plant breeding workshop which as held in Zamorano from 23-25 April 2001. The workshop had more than 20 participants from eight different LAC countries. Many of the participants are actively involved in participatory plant breeding programs for maize and/or beans. Juan Carlos Rosas Rosas and James Beaver made several presentations describing breeding methods for cross and self-pollinated crops. Emmanuel Prophete, Juan Carlos Rosas and James Beaver spend the day following the workshop reviewing bean research activities at Zamorano.
Current status: During FY02, Emmanuel Prophete plans to increase on-farm testing of promising bean breeding lines. Participation on the workshop should provide him with a better understanding how to plan and coordinate on-farm trials.

II.A. Activity #2: Participation in Pathology Meetings
Background/justification: Funding allocated to attend meetings that allow interaction with scientists, present CRSP research results and plan future collaborative research. Meetings include PCCMCA in San Jose, Costa Rica (JRS), Caribbean Division American Phytopathological Society in Santo Domingo (JRS) and Phytopathological Society of Republic of China and International Rhizoctonia Symposium Taiwan (GG).
U.S. researchers: James R. Steadman
HC researchers: Graciela Godoy-Lutz
IMPACT: Graciela Godoy was given financial assistance from the symposium organizing committee and the CRSP supplied the rest. She was the only LAC scientist invited or in

attendance at this meeting. Her contacts have resulted in prestige for the CRSP research and future research collaboration on the web blight pathogen.

James Steadman's trips resulted in an understanding of interaction of the B/C CRSP and CIAT for inclusion in the new 5-year project (this resulted from an important meeting between CRSP PIs and most of CIAT's bean team). Research results on bean rust (such as the mobile nursery) and other diseases were available for Nicaragua, El Salvador and Guatemala. Collaboration with Costa Rica was also planned. A graduate student in plant pathology was recruited for the next phase of our LAC project.
TIME FRAME: August 2000 - April 2001
INDICATOR: See impact.
Budget: $5,400
Progress during past year: Attended meetings.
Current status: Completed.

II.B. Activity #2: Expenses for shipment of seed of the white-seeded line 'Morales' from Puerto Rico to Haiti
Background/justification: Farmers in certain regions of Haiti produce white beans but local white-seeded landrace varieties are susceptible to bean golden yellow mosaic virus (BGYMV). Morales was selected in Puerto Rico for resistance to this virus.
U.S. researchers: James Beaver
HC researchers: Emmanuel Prophete
Methodology: During the first year, a small amount of seed of Morales will be shipped to Haiti. The seed of this white-seeded bean variety will be multiplied in Haiti.
Anticipated (1 year) results of activity: Two years
Anticipated impact to which this activity will contribute, time frame and indicators:
IMPACT: Increased white bean production in Haiti
TIME FRAME: Two years
INDICATOR: Farmers in Haiti continue to plant Morales and bean golden yellow mosaic virus does not infect their fields.
Budget: $500
Progress during past year: A 50 kg bag of seed of 'Morales' was shipped to the Dominican Republic in October 2000. Ing. Alfredo Mena, IICA Representative in Haiti, assisted in the transfer of the seed to Haiti. During the past year, seed of Morales was increased in Haiti on experiment stations.
Current status: During FY02, seed of Morales will be distributed to farmers for on-farm trials. Farmers will be able to harvest the seed of Morales for use on their farms and for sale to their neighbors.

II.C. Activity #3: Travel expenses for Dr. James Beaver to strengthen collaboration with bean researchers in Haiti
Background/justification:
U.S. researchers: James Beaver
HC researchers: Emmanuel Prophete
Methodology: N/A
Anticipated (1 year) results of activity: One year
Anticipated impact to which this activity will contribute, time frame and indicators:
IMPACT: Enhanced bean research capacity in Haiti
TIME FRAME: One year
INDICATOR: The identification of promising bean lines for on-farm trials
Budget: $2,000

Progress during past year: In January 2001, James Beaver traveled with PROFRIJOL researchers to visit bean research programs in Puerto Rico, the Dominican Republic and Haiti. Abelardo Viana (PROFRIJOL Coordinator), Julio Cesar Nin and Emmanuel Prophete participated in the tour. The group spent one day in Puerto Rico evaluating bean lines planted at the Isabela Substation. The group spent two days in the Dominican Republic at the Arroyo Loro Research Station where they were able to meet with Graciela Godoy and Eladio Arnaud. The final stop of the tour was Haiti where the group evaluated lines in Damien. The group also had an opportunity to meet with Alferdo Mena, IICA Representative in Haiti. Mr. Mena encouraged the group to prepare a proposal to support bean research in Haiti.
Current status: The trip provided an opportunity to evaluate the same bean breeding lines at three locations in the Caribbean. In Puerto Rico, excessive rainfall had favored the development of common bacterial blight. In the Dominican Republic, rust and powdery mildew were the most common bean diseases. In Haiti, the breeding lines had moderate levels of drought stress. Results from these trials were used to identify promising bean lines for on-farm trials in Haiti and the Dominican Republic. Abelardo Viana and I provided Emmanuel Prophete with written lists of suggestions for a proposal which would strengthen bean research in Haiti.

II.D. Activity #4: (1)Travel expenses for a MSU graduate student to travel to Honduras from January to April, 2000 to conduct a drought trial. ($1,400), (2) Travel expenses for Dr. James Kelly to travel to Honduras to review graduate student research ($1,050)
Background/justification:
U.S. researchers: James Kelly,
HC researchers: Juan Carlos Rosas, Aracely Castro
Methodology: CRSP supplemental funds have been used to strengthen collaboration between the bean breeding programs of Michigan State University (MSU) and the Programa de Investigaciones en Frijol (PIF) in Zamorano, Honduras. The MSU dry bean breeding program developed two black bean populations with resistance to terminal drought specifically to meet lowland LAC regional needs in preferred seed types. This project was a new endeavor to expand drought research in Mexico to meet a major constraint to bean production in the tropical lowland areas. Drought resistance for this project was derived from materials identified previously through CRSP funded research on intermittent drought occurring in the Mexican highlands. The collaboration of the MSU and Mexico CRSP projects identified a drought resistant line, T-3016, which was crossed to Michigan black beans to transfer drought resistance from Durango to Mesoamerican seed types. Drought resistance in Mesoamerican seed types is needed in the lowland tropical areas, since small seeded beans are preferred. The need to expand research activities to other LAC region motivated the crosses of previously identified drought resistant Michigan black bean, B98311, to tropical black bean breeding lines, TLP-19 and VAX5. TLP-19 and VAX5 offer disease resistance to Macrophomina and CBB, respectively.
Anticipated (1 year) results of activity: one year
Anticipated impact to which this activity will contribute, time frame and indicators:
IMPACT: Selection of bean breeding lines for the lowlands with enhanced levels of drought tolerance
TIME FRAME: one year
INDICATOR:
Budget: $2,450
Progress during past year: A total of 150 recombinant inbred lines (RIL) were developed from the two black bean populations. RILs were increased to the F_6 generation in Michigan in 2000 and the two RIL populations, parents and checks were planted in completely randomized designs during the dry summer season in Honduras. Moisture-stressed and non-stressed treatments were used to assess the genetic differences between genotypes. Furrow irrigation and overhead sprayers were used for irrigation. Drought stress was initiated at the beginning of flowering. The plots in the drought treatment received approximately 300 mm of water,

while the irrigated plots received approximately 500 mm of water. The drought stress was most visible in the yield means. A five-fold difference in mean yield was recorded between the irrigated (1517 kg/ha) and drought (275 kg/ha) treatments. The drought intensity index (DII=0.82) was severe as a DII of 1.0 indicates a total loss of production due to drought. Therefore, a significant stress treatment was created, allowing for the identification of drought resistant lines.

Throughout the experiment, agronomic field notes and disease ratings for *Macrophomina phaseolina* were recorded. Measurements of yield under stress and non-stress were recorded to calculate geometric mean (GM) between treatments. New sources of drought resistance were identified in this experiment. Twenty-three drought resistant RILs out-performed local checks, parental genotypes and drought resistant varieties under moisture-stressed and irrigated treatments (Tables1, 2). Comparing GM values, the most resistant RIL, L88-63, yielded 150% more than the local check, Tio Canela-75, and 73% more than the highest yielding drought resistant check, Rio Tibagi. It also yielded 60% more than its drought resistant parent, B98311. The other drought resistant checks, BAT 477 and SEA 5, ranked 81st and 43rd, respectively out of 160 genotypes. These RIL populations were constructed in order to identify a drought resistant line that would meet the needs of the LAC region. Although these populations are adapted to the lowland environment of Central America, additional adaptation tests need to be carried out in other locations. Confirmation of drought resistance is being evaluated in Michigan in field trials in 2001 using the most resistant (top 10%) and susceptible (bottom 10%) RILs. Remnant seed of both populations is presently at PIF and seed has been sent to INIFAP, Mexico and CIAT bean breeding programs for further testing.
Current status: The research project required a collaborative effort between the graduate student, Mark Frahm from MSU and Dr. J. C. Rosas to conduct research with these populations in Zamorano, Honduras. In addition to the research, the collaboration entailed exchange of germplasm, transfer of techniques, assistance in field labor, and international research experience for Mark Frahm. Mr. Frahm was able to assist in the teaching of a plant breeding class taught by Dr. J. C. Rosas and the corresponding lab practical taught by J. A. Castro. He graded quizzes, reviewed material before exams, and presented lectures during laboratory classes. Not only was Mr. Frahm able to improve his communicative abilities in Spanish through classroom interaction, he was able to teach PIF research assistants a new technique of pollination that can save time and increase production. The PIF research assistants contributed to the terminal drought experiment through planting, pest and weed control and harvesting. During March 2001, Dr Kelly visited Zamorano to inspect the research work and meet EAP personnel including Dr. Rosas to discuss current and future research on drought resistance.

II.E. Activity #5: Travel for Dr. Dianne Runovarra to attend a MILPA meeting in Mexico in October The goal is to increase grower participation in breeding and seed multiplication
Background/justification:
U.S. researchers:
HC researchers:
Methodology:
Anticipated (1 year) results of activity:
Anticipated impact to which this activity will contribute, time frame and indicators:
IMPACT:
TIME FRAME:
INDICATOR:
Budget: $1,500
Progress during past year:

Current status: Mexico/MSU Activities during FY2000.

II.F. Activity #6: Continued research to develop processing technologies that will yield new bean-based products.
Background/justification: Travel for Dr. Josie Jackson, University of West Indies, to network with Dr. Ana Bonilla; Dr. Jackson has expertise in community nutrition.
U.S. researchers: George L. Hosfield, Maurice Bennink
HC researchers: Ana Bonilla
Methodology: N/A
Anticipated (1 year) results of activity: Form collaborative linkages
Anticipated impact to which this activity will contribute, time frame and indicators:
IMPACT: Expand existing HC research program to include community health initiative to promote and evaluate weaning food product developed in Costa Rica.
TIME FRAME: 1 year
INDICATOR: Collaborative interactions
Budget: $8,600 for travel
Progress during past year: Travel to Costa Rica completed
Current status: Dr. Jackson will be a collaborator with Drs. Bennink and Bonilla on New Five-Year Continuing Grant (2002-2007).

III. EVALUATION OF FUNDING/FISCAL MANAGEMENT IN FY 2001

No major problems were experience in FY 2000, though there were consistent delays in processing reimbursement checks for INIAP through Sponsored Projects Administration, and the U.S. PI sent an ordinate amount of time writing e-mails that would serve to protect administrative backsides.

III.A. Constraints Related to Level of, Delay in Receiving, or Reporting of CRSP Funds: At UW-Madison, a request to purchase the particle gun has been in the process for action for over 18 months. Since CRSP/USAID did not take action in a timely manner, the particle gun from Brazil was purchased, otherwise, our project activities would have terminated. There was an opportunity to support Dr. J. Faria from Brazil during this current budget year and Dr. Maxwell decided to go ahead and run the budget into overdraft. Because of the assistance of Dr. Faria, we now have 38 T0 transgenic beans, which generated over 2,000 T1 seeds. In Costa Rica as in other undeveloped countries, the importation of perishable reagents is very expensive and unreliable. An office of Louisiana State University has imported for our Institute in Costa Rica these types of reagents. Unfortunately, they are not able to do it any more. This is a major constraint for this group.

During the past year, Ms. Jawaly Ortiz assumed responsibility for preparing fiscal reports for the University of Puerto Rico. Her valuable assistance permitted the preparation of documents on a timely basis.

The level of funding was insufficient to take advantage of some opportunities and needs in the LAC region. Nevertheless, the project was able to maintain a good level of interaction in countries such as El Salvador and Nicaragua. The project needs additional sources to have a stronger presence in countries such as Haiti. The participation of the UPR and Zamorano researchers in PROFRIJOL bean research network is key to the success of the breeding program. No major problems were encountered on receiving and reporting of CRSP funds.

Ecuador: There were no major concerns or delays affecting receipt of reporting of CRSP funds in 2001.

As is often the case, delays in receiving USAID funding was a problem again this year.

The USAID makes budget allocations for projects twice each year. The first allocation is 7/12 of the annual budget for a project and covers the period of time from October 1 to April. The second allocation, 5/12 of the annual budget, covers the period from April to September 30.

Since the beginning of the current project, the second or 5/12 of the allocations to the Bean/Cowpea CRSP Management Entity have been increasingly delayed beyond the point where the PIs can effectively manage the projects. This past fiscal year (FY01) the second USAID allocation wasn't made until August. The discontinuity in flow of budget dollars places an undue hardship on everyone associated with a project.

In regards to the Costa Rica MSU project, this past year there have been unseemingly delays in getting reimbursements to Dr. Bonilla. This has created an undue level of angst not conducive to an effective project performance and achievement.

III.B. Leveraged Funds: At UW-Madison, $20,000 was obtained on Hatch support for development of the PCR and hybridization detection methods for bean-infecting geminiviruses. Other support for Ms. Jamie Potter to travel to Guatemala and Cuba to transfer technology on molecular methods for detection of bean-infecting geminiviruses were $1,500 in gift from the Spitze Land Grant Award to D. P. Maxwell, Graduate Women in Science Ruth Dickie Grant-In-Aid ($500) for Guatemala, LACIS NAVE 2001 Short-Term Research Grant ($1100) for Guatemala, and the UW-Plant Pathology Departmental Travel Award ($400) for Cuba. A USDA/NRI grant on combinatorial approach for resistance in geminiviruses was received for $75,000. Funds for a Middle East Research Collaboration/USAID grant for $1.6 million is being funded for research on breeding for resistance to *Tomato yellow leaf curl geminivirus* in tomatoes. This grant is the result of Dr. Maxwell's efforts on geminiviruses and the contacts he has made in the Middle East, initially because of a CRSP sponsored visit to Cairo in 1990. The German agency of cooperation (DAAD) gave a complete fellowship to 2 students form Central America to work in CRSP project in Costa Rica with Dra. Pilar Ramírez.

During the past year, the University of Puerto Rico and the University of Florida received a grant from the USDA/CSREES Tropical/Subtropical Agriculture Program. The project is entitled, "Development of Common Beans with Web Blight Resistance through Interspecific Hybridization." The annual budget of the three-year project is $35,000.

Zamorano and the University of Puerto Rico received a very modest level of funding from PROFRIJOL (funded by the Swiss Development Corporation) for the development and testing of breeding lines for LAC and the distribution of breeding nurseries and trials. In addition, Zamorano and the UPR participate in the annual meeting of PROFRIJOL which permits interaction with CIAT scientists and national bean research program personnel. The NBR program members of the PROFRIJOL network contribute with research time, transportation, seed production and distribution costs.

Funds for conducting participatory plant breeding (PPB) activities in Honduras was received from the Participatory Research and Gender Analyses (PRGA)/CGIAR Program. The Norwegian Development Fund provided additional funding for collaboration on PPB activities in Nicaragua and Costa Rica. These funds are provided to Zamorano through the Collaborative Program for Particpatory Plant Breeding in the Mesoamerican region. The Participatory Research Project for Central America (IPCA in Spanish), funded by IDRC, contributed in project activities on PPB, validation trials and artisan seed production in Yorito and Santa Barbara, Honduras.

During 2000-01, Zamorano distributed seed of improved varieties to more than 5,000 farmers of the east-central region of Honduras, along with training and technical assistance on bean production, post-harvest management and seed processing. This was conducted in collaboration with more than 12 NGOs, under the agricultural sector revitalization project funded by USAID/Honduras. NGOs contributions included time from extension personnel and transportation. Farmer contributions included field plots, time and labor, seed of local varieties and inputs.

Ecuador: The project continued to be effective in the amount of funds it was able to leverage in 2001, and the way that all activities could be interrelated. Funds awarded in 2000 that continued in 2001 included:

- NSF Biocomplexity Project $2.956 million, second of five years
- MNDoT Prairie legume project $80,456, second of three years
- Promsa Ecuador $45,000 Inoculant Production. Initiated after return of G. Bernal
- Rapid Agriculture Response Fund $135,888, second of three years

Additional funding to Dr. Estevez de Jensen that was leveraged in 2001 included:

- Integrated Strategies to Control Bean Root Rot in Minnesota, Northarvest Bean Growers Association, two year total $47,371
- Crop Residue Management and other Strategies to Control Bean Root Rot in Minnesota, Central Regional Partnership, two year total $47,357
- Alleviating Soil-Related Physical and Pathological Stresses in Irrigated Dry Bean Production in Central Minnesota, Rapid Agricultural Response Fund, two year total $178,888. The U.S. PI in collaboration with Drs. Estevez de Jensen, Jurle and others has also applied for Rapid Response Funds to leverage inoculation studies in North-Central and North-Western Minnesota.

Dominican Republic

Sources	Amounts	Uses	Impacts
Min. Agr (SEA)	US $40,000 US $200,000	Salaries Equipment/Facilities	Enables LAC research to be conducted
CEDAF	US $1,000	For project's car insurance	Enables local travel to research trials.
Association of Ag. Producers San Juan Valley	US $500	Field Day	On-farm tests and other CRSP activities report to growers.

Other Funds: Nebraska

Sources	Amounts	Uses	Impacts
Nebraska Dry Bean Commission	$17,497	Bean Breeding	Release of disease resistant Pinto Chase and GN Weihing varieties
Nebraska Dry Bean Commission	$6,200	Detection of rust pathogen variation	To determine rust races pathotypes in High Plains region of US
USDA Regional Research Funds	$22,000	To conduct cooperative research in US bean-producing areas.	Developing new genetic knowledge on beans and detection of disease resistant germplasm
USDA- plant exploration	$15,500	Disease resistance	To collect wild beans and associated pathogens in Honduras
Dept. of Hort. & Agron. - UNL	$15,780	Support graduate student	Molecular genetics of resistance to common blight.

$15,000 from USDA-ARS to conduct cooking time studies of 28 Central American red beans obtained from the Esquela Agrícola Panamericana (EAP) in Honduras.

III.C. Other Funds: At UW-Madison, Dr. Maxwell manages a $1.9 million USAID grant on virus-indexing methods for plant quarantine and certification programs for the Middle East. This grant was a result of contacts made because of his geminivirus research program. The PCR methods developed on this CRSP project are a part of the virus-indexing grant. Also, a $1.5 million USAID/MERC grant on breeding for resistance to geminiviruses in tomatoes for the Middle East is expected to start in December 2001.

Funds generated from selling foundation seed at Zamorano has been used to renovate vehicles and equipment. Funds are also obtained from the sale of technical bulletins and manuals.

Funds donated to the Rhizobium Research Laboratory for consultant and other activities totaled $5,250.

IV. PUBLICATIONS, PRESENTATIONS AND AWARDS IN FY 2001

IV.A. Refereed Publications:

Acosta- Gallegos, J. A., F. J. Ibarra-Perez, R. Rosales-Serna, B. Cazares-Enriqez, P. Fernandez-Hernandez, A. Castillo-Rosales and J. D. Kelly. 2001. Registration of 'Bayacora' Pinto Bean. Crop Science 41:1645-1646.

Acosta- Gallegos, J. A., F. J. Ibarra-Perez, R. Rosales-Serna, A. Castillo-Rosales and J. D. Kelly. 2001. Registration of 'Negro Sahuatoba' Opaque Black Bean. Crop Science 41:1646-1647.

Acosta- Gallegos, J. A., F. J. Ibarra-Perez, R. Rosales-Serna, A. Castillo-Rosales, B. Cazares-Enriqez, P. Fernandez-Hernandez and J. D. Kelly. 2001. Registration of 'Negro Altiplano' Common Bean. Crop Science 41:1650.

Acosta- Gallegos, J. A., F. J. Ibarra-Perez, R. Rosales-Serna, P. Fernandez-Hernandez, A. Castillo-Rosales and J. D. Kelly. 2001. Registration of 'Mestizo' Pinto Bean. Crop Science 41: 1650-1651.

Alleyne, A. T., J. Fenton, J. R. Steadman, K. M. Eskridge and L. A. Sutton. 2001. Changing Virulence Patterns of *Uromyces appendiculatus* to Bean Cultivar Pinto Olathe from 1981 to 1992 in Nebraska. Phytopathology 91(6):52. (Abstract)

Bernal, G. and P. H. Graham. 2001. Diversity in the Rhizobia Associated with *Phaseolus vulgaris* L. in Ecuador, and Comparisons with Mexican Bean Rhizobia. Canadian Journal of Microbiology 47:526-534.

Boosalis, M. G., J. R. Steadman, K. Powers and B. Higgins. 2001. New Methods for producing, Recovering, Storing and Delivering Ascospores of *Sclerotinia sclerotiorium* and other Fungal Propagules. Phytopathology 91(6):5175. (Abstract)

Christiansen, I. and P. H. Graham. In press. Variation in Di-Nitrogen Fixation among Andean Bean (*Phaseolus vulgaris* L.) Genotypes Grown at Low and High Levels of P Supply. Field Crops Research.

Coyne, D. P., S. O. Park, J. R. Steadman and P. W. Skroch. 2001. Breeding, Genetics and Mapping of QTL for Architectural Avoidance and Physiological Resistance to White Mold in Common Bean. Proceedings of Sclerotinia 2001–The XI International Sclerotinia Workshop, York, England: Central Science Laboratory, July 8-12, p. 93-94. (Abstract)

Ergun, M., E. T. Paparozzi, D. P. Coyne, D. Smith, S. Kachman and D. S. Nuland. 2001. Testing the Effects of Moisture on Seedcoat Color of Pinto Dry Beans. HortScience 36:302-304.

Estevez de Jensen, C., J. A. Percich and P. H. Graham. In press. Dry Bean Root Rot Control with *Bacillus subtilis* in Minnesota. Field Crops Research.

Fall, A. L., P. F. Byrne, G. Jung, D. P. Coyne, M. A. Brick and H. F. Schwartz. 2001. Detection and Mapping of a Major Locus for Fusarium Wilt Resistance in Common Bean. Crop Science 41:1494-1498.

Fauquet, C. M., D. P. Maxwell, B. Gronenborn and J. Stanley. 2000. Revised Proposal for Naming Geminiviruses. Archives Virology 145:1743-1761.

Godoy-Lutz, G., J. R. Steadman, K. Powers and B. Higgins. 2001. Genetic Relationship among Isolates of the Web Blight Pathogen on Common Bean Based on PCR-RFLP and Sequence Analysis of the ITS-2 DNA Region. Phytopathology 91(6):5199. (Abstract)

Gonzales, J. W., D. P. Coyne, D. T. Lindgren, K. Eskridge, J. Steadman and G. Jung. 2001. Inheritance and Heritability of Leafhopper Resistance in Common Beans (*Phaseolus vulgaris* L.) Hort Science 36:456. (Abstract)

Grafton, K. F., J. B. Rasmussen, J. R. Steadman and C. Donahue. 2001. Potential New Sources of Resistance to White Mold in the *Phaseolus* Core Collections. Proceedings of Sclerotinia 2001–The XI International Sclerotinia Workshop, York, England: Central Science Lab, July 8-12, p. 153-154. (Abstract)

Graham, P. H. 2001. Nitrogen Fixation. In R. Robinson (ed.) Plant Science for Students. McMillan Publisher, New York, p. 91-95.

Graham, P. H. and C. P. Vance. In press. Symbiotic Nitrogen Fixation in Soil. In G. Bitton (ed.) Encyclopedia of Environmental Microbiology. Wiley, New York.

Hosfield, G. L. and J. S. Beaver. 2001. Variability for Cooking Time in Dry Bean. HortScience 36:455-456. (Abstract)

Kannan, S., S. Nielsen and A. Mason. In press. Protein Digestibility-Corrected Amino Acid Scores for Bean and Bean-Rice Protein-Based Infant Weaning Food Products. Journal of Agricultural Food Chemistry.

Kannan, S., S. Nielsen, A. P. Rodriguez-Burger and A. Mason. In press. Iron and Zinc Bioavailability in Rats Red Intrinsically Labeled Bean and Bean-Rice Infant Weaning Food Products. Journal of Agricultural Food Chemistry.

Kelly, J. D., G. L. Hosfield, G. V. Varner, M. A. Uebersax and J. Taylor. 2001. Registration of 'Jaguar' Black Bean. Crop Science 41:1647.

Lee, T. J. 2001. Development of Transgenic Tomatoes Conferring Early Resistance to Bacterial Wilt and Approaches for Transformation of Common Bean through an Agrobacterium–Mediated Method. Ph.D. Thesis, University of Nebraska-Lincoln, NE, p. 1-138.

Macchiavelli, R. and J. S. Beaver. 2001. Effect of Number of Seed Bulked and Population Size on Genetic Variability When Using the Multiple-Seed Procedure of SSD. Crop Science 41:1513-1516.

Melotto, M. and J. D. Kelly. 2001. Fine Mapping of the *Co-4* Locus of Common Bean Reveals a Resistance Gene Candidate, *COK-4*, that Encodes for a Protein Kinase. Theoretical Applied Genetics103:508-517.

Mutlu, N., D. P. Coyne and K. S. Gill. 2001. Cloning, Sequencing and Mapping of P-Loop Containing Genes for Disease Resistance in *Phaseolus vulgaris* L. HortScience 36:562-563. (Abstract)

Mutlu, N., D. P. Coyne, J. R. Steadman, J. Reiser and L. Sutton. 2001. Progress in Backcross Breeding with RAPD Molecular Markers to Pyramid QTLs for Resistance to Common Bacterial Blight in Pinto and Great Northern Beans. HortScience 36:450. (Abstract)

Park, S. O., D. P. Coyne, J. R. Steadman and P. W. Skroch. 2001. Mapping of QTL for Resistance to White Mold Diseases in Common Bean. Crop Science 41:1253-1262.

Rosales- Serna, R., R. Ochoa Márquez y J. A. Acosta-Gallegos. 2001. Adaptación fenológica y rendimiento de grano del frijol en el altiplano de México. Agrociencia (submitted).

Rosas, J. C. In press. Exeriencias en la aplicacion de metodologias participativas para el mejoramiento genetico del frijol comun en Centro America. Agronomia Mesoamericana 12(2):000-000.

Rosas, J. C., A. Castro and E. Flores. 2000. Mejoramiento genetico del frijol rojo y negro Mesoamericano para Centro America y El Caribe. Agronomia Mesoamericana 11(2):37-46.

Schneider, K. A., K. F. Grafton and J. D. Kelly. 2001. QTL Analysis of Resistance to Fusarium Root Rot in Bean. Crop Science 41:535-542.

Steadman, J. R., G. Godoy-Lutz and J. C. Rosas. 2001. Monitoring Pathogens Variability in Bean Rust with a Mobile Nursery. Phytopathology 91(6):5200. (Abstract)

Steadman, J. R., J. Kolkman and K. M. Eskridge. 2001. Search for Resistance to *Sclerotinia sclerotiorum* in Common Bean–Screening and Sources. Proceedings of Sclerotinia 2001–The XI International Sclerotinia Workshop, York, England: Central Science Lab, July 8-12, p. 63-64. (Abstract)

Yuen, G. Y., J. R. Steadman, D. T. Lingren, D. Schaff and C. Jochum. 2001. Bean Rust Biological Control Using Bacterial Agents. Crop Protection 20:395-402.

IV.B. Non-Refereed Publications:

Acosta-Gallegos, J. A., F. J. Ibarra-Pérez, B. Cázares Enriquez, A. Castillo-Rosales, R. Rosales-Serna, J. D. Kelly and S. P. Singh. 2001. Notice of Naming and Release of Flor de Mayo 2000, a New Mid-Season, Disease Resistant, Drought Adapted flor-de-mayo Cultivar for the Highlands of Mexico. Annual Report of the Bean Improvement Cooperative 44:195-196.

Acosta-Gallegos, J. A., F.J. Ibarra-Pérez, B. Cázares Enriquez, A. Castillo-Rosales, R. Rosales-Serna, J. D. Kelly and S. P. Singh. 2001. Notice of Naming and Release of Negro Vizcaya, a New Mid-Season, Disease Resistant, Shiny Black Bean, Drought Adapted Cultivar for the Highlands of Mexico. Annual Report of the Bean Improvement Cooperative 44:193-194.

Ariyarathne, H. M., D. P. Coyne, A. K. Vidaver and K. M. Eskridge. 2001. Pathogenic Variation in *Pseudomonas syringae* pv *phaseolicola* Strains on Common Beans. Annual Report of the Bean Improvement Cooperative 44:129-130.

Awale, H. E. and J. D. Kelly. 2001. Development of SCAR Markers Linked to the $Co\text{-}4^2$ Gene in Common Bean. Annual Report of the Bean Improvement Cooperative 44:119-120.

Burgos, P. A., Y. Mora, J. Acosta, J. Castellanos, O. Acuña, H. Peralta, and J. Mora. 2001. Response of *Phaseolus vulgaris* L. Cultivars to Inoculation with High Efficiency Rhizobium Strains in Experimental Fields in Mexico: Effect of Different Irrigation Systems. Plant and Soil (submitted).

Campo-Arana, R. and R. Echavez-Badel. 2001. Morphological, Physiological and Biochemical Characteristics of *Macrophomina phaseolina* Isolates Collected in Puerto Rico and the Dominican Republic. Annual Report of the Bean Improvement Cooperative 44:127-128.

Coyne, D. P. 2001. Growers Take Another Look at Great Northern Weihing Demand for Larger White Beans Evident in Markets. The Bean Bag 19(1), Summer.

Estevez de Jensen, C. J. E. Kurle and J. A. Percich. 2001. Management of Dry Bean Root Rot in Minnesota. Northarvest Bean Grower, p. 6-7.

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Estevez de Jensen, C., J. A. Percich and P. Graham. 2001. The Performance of a Co-Formulation of *Bacillus subtilis* plus *Rhizobium* and their Effect on Dry Bean Root Rot in Minnesota. Annual Report of the Bean Improvement Cooperative, p. 44, 81.

Estrada-Valle, J. 2001. A Subsector Overview of the Guatemalan Bean Industry: Constraints and Opportunities for Vertical Coordination and Sustained Growth. M.Sc. Thesis, Department of Agricultural Economics, Michigan State University.

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Vallejo, V. and J. D. Kelly. 2001. Development of SCAR Markers Linked to the Co-5 Locus in Common Bean. Annual Report of the Bean Improvement Cooperative 44:121-122.

IV.C. Presentations:

Acosta Gallegos, J. 2001. "Como acercarse a la ciencia"– 'Getting Closer to Science'. A workshop directed to students and young researchers in the Universidad Autónoma de Chapingo at Texcoco, State of Mexico, October 19.

Arnaud-Santana, E. 2000. The History and Development of Plant Pathology in the Dominican Republic in the XX Century. Paper presented at the Annual Meeting of the Caribbean Division of the American Phytopathological Society, Santo Domingo, October 31-November 3.

Beaver, J. S. 2001. Breeding Common Beans for Central America and the Caribbean. Invited paper presented at the First Convention of the Puerto Rico Seed Research Association, Ponce, Puerto Rico, September 14.

Beaver, J. S., G. Godoy-Lutz, J. C. Rosas and J. R. Steadman. 2001. Estraregias para seleccionar frijol con mayores niveles de resistencia a la mustia hilachosa. Paper presented at the Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales (PCCMCA), San Jose, Costa Rica, April 2-6.

Coyne, D. P. 2001. Co-Author of Three Posters and One Oral Presentation at the Annual Meeting of the American Society of Horticultural Science, Sacramento, CA, July 22-25.

Estevez de Jensen, C., J. E. Kurle and J. A. Percich. 2001. The Effect of Chisel and Moldboard Tillage on Dry Bean and Soybean Root Rot Caused by *Fusarium solani* f sp. *phaseoli* and *Rhizoctonia solani* in Minnesota. Phytopathology 91:S27. (Abstract)

Faria, J. C. and D. P. Maxwell. 2001. Bean Transformation: Perseverance. Workshop on Applications of Biotechnology for Cowpea Improvement for Africa, Dakar, Sénégal, January.

Godoy-Lutz, G. 2000. Variabilidad Genetica de Aisilameintos del Patogeno de la *Mustia Hilachosa* del Frijol Basada en PCR-RFLPY Sequencia de la Region ITS-2 DNA. Paper presented at the Annual Meeting of the Caribbean Division of the American Phytopathological Society, Santo Domingo, October 31-November 3.

Graham, P. H. and D. A. Allan. 2001. Can Soil Organisms Improve Agricultural Competitiveness and Sustainability? Paper presented to the Brazilian Congress of Soil Science, Londrina, Brazil, August.

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Hosfield, G. and J. Beaver. 2001. Cooking Time in Dry Bean and Its Relationship to Water Absorption. Paper presented at the Annual Meeting of the American Society for Horticulture Science, Sacramento, CA, July 22-25.

Kelly, J. D. and J. R. Kolkman. 2001. QTL Analysis of Resistance to White Mold in Common Bean. Presented a poster at Sclerotinia 2001 Workshop in York, U.K. July 8-12.

Kelly, J. D., Melotto, M. and Esteban, E. 2000. Integrado la biotecnolgia con los metods clasicos en la mejora de la judia. Invited to give the keynote address at the Seminario de Mejora Genetica Vegetal Meeting in Lugo, Spain, November 22-24.

Kurle, J. E., C. Estevez de Jensen and J. A. Percich. 2001. Tillage Effects of Root Rot Severity and Seed Yield in Soybean and Dry Bean. Agronomy Abstracts.

Maxwell, D. P. 2001. Geminiviruses: Passport to the World. Antigo, WI. Featured speaker for the Wisconsin Certified Potato Growers Association Annual Meeting, March.

_______. 2001. Diversity of Begomoviruses and their Management. Symposium speaker at the Caribbean Division of the American Phytopathological Society Meeting, Cuba, June.

Maxwell, D. P., N. K. Nakhla, J. L. Potter, L. Mejia, J. Karkashian, P. Ramirez and M. M. Roca de Doyle. 2001. Diversity of Tomato-Infecting Geminiviruses and Implications for Management. Tomato Breeders Round table, Antigua, Guatemala, March.

Mejia, L. and J. L. Potter. 2001. General Detection Methods for Whitefly-Transmitted Geminiviruses and Applications for Management. ICTA, Guatemala City, March 30.

Miklas P. N. and J. D. Kelly. 2000. Marker-Assisted Selection for Enhanced Disease Resistance in Common Bean. Chosen for oral presentation at the Durable Disease Resistance Conference held in Wageningen, Holland, November 29- December 1.

Nakhla, M. K. and D. P. Maxwell. 2000. Detection Methods and Management Strategies for Geminiviruses. University of Tunisia, Tunis, November.

Potter, J. L. 2001. Introduction to Whitefly-Transmitted Geminiviruses. Workshop on Molecular and Serological Methods for Detection of Plant Viruses. San Carlos University, Guatemala City, April 25-27.

________. 2001. Introduction to PCR and DNA Hybridization: Primer Design, Extraction Methods, Agarose Gel Electrophoresis. Workshop on Molecular and Serological Methods for Detection of Plant Viruses. San Carlos University, Guatemala City, April 25-27.

________. 2001. Caribbean Division of the American Phytopathological Society Meeting, Cuba, June (First place poster award).

________. 2000. Evaluation of Molecular Methods for Detection of Bean-Infecting Geminiviruses. Department of Plant Pathology, University of Wisconsin-Madison, October.

Ramirez, P. and D. P. Maxwell. 2001. Why Should We Identify Geminiviruses? Central American Whitefly Meeting held in conjunction with the Caribbean Division of the American Phytopathological Society Meeting, Cuba, June.

Rosas, J. C. 2001. Experiencias en la aplicacion de metodologias participativas para el mejoramiento genetico del frijol comun en Centro America. Proceedings of the Annual Meeting of the Collaborative Program for Participatory Plant Breeding in the Mesoamerican Region, Managua, Nicaragua, May 28-30.

________. 2001. Experiencias en la aplicacion de metodologias participativas para el mejoramiento genetico del frijol comun en Centro America. Proceedings of the XLVII Annual Meeting of the PCCMCA (Cooperative Program for the Improvement of Crops and Animals), San Jose, Costa Rica, April 2-6.

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________. 2000. Participatory Methodologies for the Genetic Improvement of Common Beans in Honduras. Proceedings fo the III International Seminar and Small Grants Workshop, PRGA/CGIAR, Nairobi, Kenya, November 5-11.

Rosas, J. C. and A. Castro. 2001. Presentations at the Short Course on Bean and Maize Breeding for Central America, Zamorano, Honduras, April 23-25.

Steadman, J. 2001. Co-Authored papers presented at the following meetings: One paper at American Phytopathological Society (APS) Meeting, Salt Lake City, UT, August 25-29; One paper at APS-North Central Division, Santo Domingo, DR, November 1-4.

Steadman, J., J. Beaver, G. Godoy-Lutz and J. C. Rosas. 2001. Uso de un Vivero Movil Como Guia para Desplegar Genes de Resistencia a la Roya Frijol Comun and Estrategras para Seleccion Frijol Comun con Mayores Niveles de Resistencia a la *Mustia hilachosa*. Presented two talks at the PCCMCA Meeting, San Jose, Costa Rica, April 2-6.

Steadman, J., G. Godoy-Lutz, J. C. Rosas and J. S. Beaver. 2001. Uso de un vivero movil para guiar el uso de resistencia de la roya de frijol. Paper presented at the Annual Meeting of the Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales (PCCMCA), San Jose, Costa Rica, April 2-6.

IV.D. Awards and Recognitions:

Dr. Jorge Acosta was awarded the Level III (Highest level) Distinction of the National System for Researchers in Mexico. He along with Dr. J. Castellanos (former CRSP researcher) are the only two agronomists to hold this distinction in Mexico. Dr. F. Ibarra was also awarded Level I of the National System for Researchers in Mexico.

Dr. Acosta was nominated by the Director in chief of INIFAP to the position of Director and Editor in Chief of the Official INIFAP Journal Agricultura Tecnia en México.

Dr. Eladio Arnaud-Santana, PI, was appointed Director of the Centro Sur de Investigaciones Agropecuárias y Forestales (CESIAF), DR. The Center will oversee research in five provinces of the South West part of the country. CESIAF is one of the Centers under the Instituto de Investigaciones Agropecuárias y Forestales (IDIAF), a new research institution created from the former Research Department of Secretaria de Estado de Agricultura.

Gustavo Ramon Bernal was awarded the Ph.D. degree for his thesis entitled, "The Diversity and Symbiotic Promiscuity of the Rhizobia Associated with *Phaseolus vulgaris* L. in its Ecuadorian and Mexican Centers of Origin."

Irene Christiansen was awarded the Ph.D. degree for her thesis entitled, "Variation in Di-Nitrogen Fixation among Andean Bean (*Phaseolus vulgaris* L.) Genotypes Grown at Low and High Levels of P Supply."

Dr. Dermot P. Coyne, PI, UNL, in 2001 received (1) the First Frazier–Zaumeyer Distinguished Lecture Award from the National Bean Improvement Cooperative, (2) the Outstanding Achievement Award from the Nebraska Dry Bean Commission, (3) a Career Award from the Nebraska Dry Bean Growers Association, (4) appointed Member of Fellows Screening Committee American Society of Horticultural Science and Screening Committee for Award of Merit, Gamma Signa Delta, UNL, NE and (5) Forty Year Service Award and Certificate–Citation in recognition for service on retirement, UNL, NE.

Consuelo Estevez de Jensen was awarded the Ph.D. degree for her thesis entitled, "Biocontrol of Kidney Bean Root Rot in Minnesota."

Dr. Graciela Godoy-Lutz received U.S. $2,000 award from PROFRIJOL to produce a video-documentary on Management of Common Bacterial Blight of Dry Beans. This video will be used as a tool to teach farmers in the bean growing countries of the LAC region.

Peter Graham was invited to give two keynote addresses to the Brazilian Congress of Soil Science, Londrina, Brazil in August, 2001.

Peter Graham continues as Editor in Chief for the Americas and Africa of Field Crops Research.

D. P. Maxwell received a citation from the governor of the State of Wisconsin upon his retirement in July 2001, from the University of Wisconsin-Madison.

J. L. Potter, M.Sc. student at UW-Madison, received the first place poster award for a graduate student at the Caribbean Division of the American Phytopathological Society, Cuba, June 2001, on her research on detection methods for bean-infecting begomoviruses.

J. Carlos Rosas received a Distinguished Achievement Award at the Biennial Meeting of the Bean Improvement Cooperative held in Fargo, ND, October 2001.

Invited Seminars and Talks:
Arnaud-Santana, E. Prospects for Growing Black Beans in the Dominican Republic for Export to Venezuela and Neighboring Islands. Spoke at a National Legume Crops Forum, Santo Domingo, DR.

________. 2001. Desalinization of Soils of Neyba. Public Lecture on the new Research Institute IDIAF, Bani, July 6, and gave a talk on the occasion of the opening of new offices of IDIAF, Azua, DR, May 17.

Coyne, D. 2000. An Overview of Breeding and Genetics of Dry Beans and Squash. Agronomy and Horticulture Highlights Conference, Cornhusker Hotel, Lincoln, NE, December 5.

________. 2000. Breeding for and Genetics of Disease Resistance of Crop Plants in Global Setting. Presented keynote address at the Annual Awards Banquet of Gamma Sigma Delta, University of Nebraska, Lincoln, NE, November 19.

________. 2001. Breeding for and Genetics of Disease Resistance of Crop Plants in Global Setting. Breeding and Genetics Seminar, Department of Animal Science, University of Nebraska, Lincoln, NE, February 6.

Steadman, J. 2001. Oral presentation at Sclerotinia Workshop, York, England, July.

Bean Field Day and Video Conference:
Arnaud-Santana, E. 2001. Spoke at the Bean Field Day organized by the San Juan Bean Growers Association, Arroyo Loro Experimental Station (EEAL), DR, January 12.

Coyne, D. and J. R. Steadman. 2000 and 2001. Each gave separate talks on progress in their dry bean research at the Nebraska Dry Bean Growers Annual Field Tour at the Panhandle Research and Extension Center, Scottsbluff, NE, August 7, 2001 and also presented research reports to the Nebraska Dry Bean Commission via video conferencing from Lincoln to Scottsbluff, November 12, 2000.

Workshops:
Coyne, D. P. 2001. Presented a poster and J. R. Steadman gave a paper and had four posters at the XI International Sclerotinia Workshop, Central Science Lab, York, England, July 8-12.

V. IDEAS FOR STRENGTHENING PROJECT

The UPR and Zamorano bean breeders are responsible for the improvement of the major bean market classes consumed in the lowlands of LAC. Continued interaction with a regional bean research network is needed to disseminate technologies developed by the Bean/Cowpea CRSP. Funds provided by the Swiss Development Corporation to PROFRIJOL are expected to be significantly reduced in the next few years. The Bean/Cowpea CRSP should assist the LAC bean research network to identify alternative sources of support. The Bean/Cowpea CRSP should invest some resources during the next period of funding to help maintain the bean research network. Funds are needed to support regional performance trials and participation in an annual meeting to review progress and plan collaborative activities. Key collaborators among NBR programs, LAC universities or NGOs, need to be maintained for specific germplasm screening, testing of breeding lines and dissemination of cultivars.

The collaboration with CIAT and other non-CRSP researchers should be increased. Collaboration should emphasize areas that have been proven difficult to achieve rapid progress, such as breeding for tolerance to drought and low fertility. Research efforts should be complementary. An annual visit of at least one LAC researcher to CIAT headquarters is recommended to review progress and develop future collaboration.

Honduras has taken leadership in participatory research and recent initiatives have been developed in the region (Costa Rica and Nicaragua). These types of initiatives could be beneficial to improve our knowledge of farmer and consumer demands for technologies, and to expand the project benefits to a wider range of stakeholders. Training in participatory research methodologies needs to be provided to those working directly with farmers (i.e. NGO´s or extension agents).

In Honduras, farmer and NGO demand for seed of improved varieties and training and technical assistance on crop management, seed production and post-harvest management continues to be strong. These activities should be continued during the next period of funding. Artisan and formal seed production initiatives in the region should continue to be supported by the project.

The project should strive to keep paperwork to a minimum. Most Bean/Cowpea CRSP researchers have a minimum of support staff. Administrative tasks related to the Bean/Cowpea CRSP often take time away from research.

The Minnesota/Ecuador project will continue to emphasize long distance education. This will involve collaboration with interested colleagues in course development and offering in third world countries, development of a Bean University site that will bring together information on beans, and continued upgrading to the RRL site.

The DR personnel, Drs. Eladio Arnaud-Santana (breeding) and Dr. Graciela Godoy-Lutz (plant pathology) and Haitian Emanuel Prophete (agronomist) are well positioned to assist CIAT in its effort to improve bean production in Haiti. They have already assisted the private and public sectors in Haiti by providing seeds of new lines, recently released varieties, technical bulletins, information on a production system to limit BGYMV, training of personnel, and evaluation and storage of the Haitian bean germplasm collection. CIAT needs to collaborate more with the CRSP project in Africa and LAC to realize gain through complementation of expertise and resources. CIAT should capitalize on expertise within the CRSP in the DR during the new five-year project and provide some funding to DR personnel on genetics of resistance and variation of the pathogens causing rust, CBB, WB and WM have global values as well as value to the U.S.

More effort needs to be made to identify NGOs and foundations (national/international) who might provide funds to support some phases of the project in particular countries. The CRSP is now receiving benefits from 20 years' activity in the DR with support from the Secretary of Agriculture and local growers.

Key U.S. senators (e.g., Hagel in Nebraska) who value international aid and cooperation need to be briefed about the gain from the investment in the CRSP at home and overseas.