Modern Cowpea Breeding to Overcome Critical Production Constraints in Africa and the US.

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Abstract of Research Achievements and Impacts

Progress was made in three areas for the objective "Develop improved, pest resistant and drought tolerant cowpea varieties for target regions in sub-Saharan Africa and the US." Final testing and release of cowpea varieties: In California, Breeder and Foundation Seed of new 'blackeye' cowpea CB50 was increased, its release approved by UCR Variety Release Committee, and filing made for PVP and Variety Registration. Elite novel dry grain 'all-white' and 'dry green' cowpea lines were evaluated in three on-station trials for grain quality, yield, disease and insect resistance. In Burkina Faso, final yield testing of two new varieties were made in 5 provinces. In Senegal, on-farm tests were made and Foundation Seed produced to complete release of line ISRA-2065 with both thrips and aphid resistance for the wetter cowpea production zone. Advanced yield trials: These were conducted in Burkina Faso (2), Senegal (2) and California (3) on a total of 180 lines for release selection based on grain quality, yield, and disease and insect resistance data. Crosses for developing new breeding lines: crosses were made in Burkina Faso (7), Senegal (12) and California (21) to combine high yield, grain quality, and abiotic and biotic stress resistance traits. F1 and in some cases F2 seed were produced for use in population selection and recurrent backcrossing efforts. Under the Objective "Strengthen cowpea seed production and delivery systems in Angola, Burkina Faso and Senegal to ensure delivery of improved varieties" the following was achieved: In Burkina Faso, Breeder Seed of 10 improved varieties was grown in Pobe-Mengao, with anticipated yield of 100 kg seed of each entry. Foundation Seed of four varieties was produced at Saria and Pobe- Mengao, and preparations made for producing Foundation Seed of four varieties during the off-season under irrigation at three locations. In Senegal, Melakh and Yacine Foundation Seed was produced (50-100 kg per variety) to EWA seed producer network. In Thilmakha area, Senegal, Foundation Seed was distributed to two farmers for production of 1 ha each of Melakh and Yacine Certified Seed. Certified Seed production was also initiated in the Mekhe and Merina areas and farmer training for seed production conducted. Foundation Seed was provided to Producers Professional Training Center, Sangalkam and 1 ton of Melakh and Yacine seed was produced. Fields were visited by 44 producers representing 10 farmer organizations from 2 villages. In Angola, initial assessment of the infrastructure available for developing a viable seed production and distribution system was initiated, recognizing that no system exists currently. This effort is being coordinated with Dr. Beaver who is assessing the bean breeding and seed distribution setup.

Project Problem Statement and Justification

The primary project focus is to 1) increase productivity of African and U.S. cowpea producers through improved varieties that possess resistance or tolerance to the major abiotic and biotic stresses impacting production in these areas; 2) expand grower marketing opportunities by breeding cowpea varieties with desirable grain characteristics; 3) help ensure adequate seed of improved cowpea varieties; and 4) provide

training and capacity building in modern cowpea breeding to African researchers. This project addresses primary constraints under the Topical Areas of Inquiry for *Theme A* "reducing cowpea production costs and risks for enhanced profitability and competitiveness", and *Theme B* "increasing the utilization of cowpea grain, food products and ingredients so as to expand market opportunities and improve human health." Genomics and modern breeding methods will be used to improve cowpea for yield limiting constraints. By leveraging genomic resources developed under a complementary cowpea project, we will implement a comprehensive application of modern breeding protocols for cowpea. Until now cowpea, as an 'orphan crop', has lacked genomic resources for modern breeding despite its importance in African agriculture.

Increasing Cowpea Productivity. Low agricultural productivity is central to rural and urban poverty in Africa. On-farm cowpea yields in West Africa average 240 kg/ha even though potential yields (on-station and on-farm trials) are five to ten times greater. Drought, poor soil fertility, insect pests and diseases are major constraints. Cowpea varieties that yield more without purchased inputs especially benefit poor farmers, many being women who lack access to the most productive lands.

Productivity is central to increasing rural incomes irrespective of changes in cowpea acreage, because less land, labor, and capital are needed to produce the same amount of cowpeas. The resources can then be invested in other activities that help boost total family income. Productivity increases also help reduce prices to urban consumers since some farmer cost-savings can be passed through to consumers. Sustainable increases in cowpea productivity in Africa and the U.S. can be achieved by developing varieties with resistance to insects, nematodes and pathogens, drought tolerance, and ability to thrive under low soil fertility.

Increasing Marketing with Improved Varieties: New cowpea varieties must have features desired by consumers as well as farmers, including rain appearance, coupled with desirable cooking qualities and processing characteristics for specific products. Landrace grain types are often preferred locally, and if over-produced, prices offered to farmers can be low because of limited demand. Large white grains with rough seed-coat are preferred throughout West Africa and can be marketed over a wide area, buffering supply (and prices) in the region. Large white grains are also amenable to direct dry milling for use in value-added foods such as 'akara', 'moin-moin', and prototype value-added products. Development of adapted cowpea varieties with large white grain and resistance to pests would increase the marketing opportunities of cowpea farmers and traders in both Africa and the U.S. There is also considerable demand for large rough-brown seed type, especially in urban centers in Nigeria, but the standard rough-brown 'Ife Brown' is susceptible to pests and diseases. Other opportunities exist for new cowpea products based on the 'sweet' trait; sweeter and milder taste could help broaden cowpea consumption in the U.S. and Africa and to Latin America and elsewhere.

Increasing Seed Supply of Improved Varieties: Cowpea breeding by the CRSP, African NARS, and IITA (Senegal, Burkina Faso, Nigeria, and other countries) has led to improved cowpea varieties that are near release. However, only about 5% of the cowpea area in Africa is planted to improved varieties and their potential goes largely unrealized. Common bean research showed that rural African farmers will buy seed when it is available, suggesting that there is probably a market for cowpea seed as well.

Recently, effective models for production and dissemination of improved cowpea seed have evolved in Burkina Faso and Senegal, based on collectives (e.g. women farmer organizations) and for-profit seed cooperatives (NGO-established, but now largely self-sustaining). However, their limited scope reflects insufficient quantities of Breeder and Foundation Seed. We propose to help support increased production of Breeder Seed and work with producers of Foundation Seed to strengthen their production and marketing. Strengthening seed production and delivery at the early breeder-involved stages will promote availability of high quality planting seed.

Training and Capacity Building: The research under these topical areas will provide an excellent framework for training current and new African scientists and capacity building for Host Country Institutions (*Theme D* "increase the capacity, effectiveness and sustainability of agriculture research institutions which serve the cowpea sector in developing countries).

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

Objective 1: Develop improved, pest resistant and drought tolerant cowpea varieties for target regions in sub Saharan Africa and the US using modern plant breeding tools.

Approaches and Methods: Three main paths of work will be followed to achieve our research objective. We will complete final testing and release protocols of lines developed under the previous Bean/Cowpea CRSP of other germplasm in the development 'pipeline', and initiate new short- and long-term breeding strategies to develop high-yielding improved varieties.

Final Testing and Release of Varieties
Several advanced breeding lines have been developed under the previous Bean/Cowpea CRSP at UCR and in Burkina Faso and Senegal that are nearing release (Table 1). Limited experiment station and/or on-farm tests are needed to complete the final evaluation of these lines.

Table 1. Varietal candidate lines

Candidate Line	Developing Institution	Releasing Institution	Type	Steps Needed in Workplan Period
03Sh-50	UCR	UCR	Blackeye	Completion of Release, PVP Documentation
07-11-572	UCR	UCR	All-white	Experiment station tests. Breeder and Foundation seed increase
03-11-747	UCR	UCR	'Dry Green'	Experiment station tests. Breeder and Foundation seed increase
IT98K-205-8	IITA	INERA	White	Seed production and on-farm evaluations
Melakh	ISRA	INERA	White	Seed production and on-farm evaluations
KVx421-2J	INERA	INERA	White	Seed production and on-farm evaluations
ISRA2065	ISRA	ISRA	White	Final on-farm evaluation, Breeder and Foundation seed increase

In Burkina Faso and Senegal, final on-farm evaluations of four lines (Table 1) will be conducted, and the lines released by the end of workplan period. In Senegal, candidate ISRA 2065 will be compared to 'Melakh' in on-farm trials grown at five sites in the 'Peanut Basin' area of the country. Each on-farm trial will consist of plots ¼ ha in size. Also, 60 advanced lines will be evaluated in on-station trials at 3 locations (Bambey, Nioro, Louga). The trials will have 4 replications with each plots being four rows and 5 m length.

In Burkina Faso, the 3 varietal candidate lines will be grown in on-farm trials by 5 farmer groups at Pisela Village and at 10 other sites in Central and Northern Burkina Faso. Sites will be considered as

replications and each plot will be 300 m^2. In addition, six other new candidate varieties that have been developed at INERA will be evaluated in on-farm trials at the same 10 sites in Central and Northern Burkina Faso.

At UCR, breeder and foundation seed of 03Sh-50 was produced in 2007 in anticipation that this variety would be released in 2008. We will continue to work with at least two farmers and one cleaning warehouse (Cal Bean and Grain, Pixley, CA) by monitoring these fields from planting through sales of the product. The farmers will grow two 15-ha production-scale fields of 03Sh-50 and the standard cultivar CB46. The grain produced will be cleaned at Cal Bean and Grain and this warehouse will supply commercial 'clean-out' information. During the first six months, we will collate existing information from on-station and on-farm trials conducted between 2003 and 2007 with this variety, request formation of a UCR Variety Release Committee, and file for Plant Variety Protection and Variety Registration through the Crop Science Society of America. For 07-11-572 and 03-11-747 (or a related 'sister line'), a 'fast-track' release protocol will be followed to accommodate the needs of potential licensees for these varieties to be made available as quickly as possible. We will be able to do this because these varieties represent new grain types that do not have existing standard varieties with which they can be compared. In anticipation of release of these lines, Breeder and Foundation Seed of these lines will be produced by the end of the workplan period.

A set of five advanced blackeye lines have already been identified as potential blackeye cowpea varieties for the US. These will be included in advanced trials that will be conducted in trials conducted at two locations (Shafter and Kearney) during the workplan period. Each trial will have at least four replications with plots consisting of 4 rows, with rows 8m long. One or more of these varieties may be advanced to candidacy for release by the end of the workplan period.

We will initiate a new two-tiered breeding strategy to meet the immediate and longer term needs of farmers. The **Short-Term Strategy** will use improved and local varieties having both grain quality and agronomic features appreciated by farmers such as appearance, taste, cooking qualities, yield stability, appropriate plant type and maturity. Obvious defects in local and improved varieties will be improved by breeding in resistance to diseases and pests plus other traits, using a rapid recurrent backcrossing approach that will improve productivity and be accepted by farmers. During the first six months, selected varieties to be improved by this approach are given in Table 2.

Table 2. Lines to be improved by introgression of specific traits using backcrossing.

Recurrent Parent Line	**Institution**	**Trait being introgressed**	**Trait donor (non-recurrent) parent**
Yacine	ISRA	Macrophomena	IT93K-503-1
Yacine	ISRA	Flower thrips resistance	58-77
Yacine	ISRA	Striga	SuVita 2
Mouride	ISRA	Large grain	Montiero derived line
Melakh	ISRA	Striga resistance	IT97K-499-39
Melakh	ISRA	Green grain	UCR 03-11-747
KVx396-4-5-2D	INERA	Striga resistance, Large grain	IT81D-994
KVx396-4-5-2D	INERA	Green grain	UCR 03-11-747
IT98K-205-8	INERA	Large seed	Montiero derived line
CB5	UCR	Fusarium wilt	CB27
CB46	UCR	Green grain	UCR 03-11-747
CB46	UCR	Root-knot nematodes	IT84S-2049

During the workplan period crosses between the recurrent and non-recurrent parents will be made, plus the first and second backcrosses, followed by inbreeding the second backcross progenies to develop BC_2F_2 families. Early in the second workplan period, these progenies will be evaluated for trait expression, and a third backcross made onto selected individuals. Molecular markers for some of the target resistance traits emanating from the EST-derived SNP-marker genotyping effort under the GCP-TL1 cowpea project will be used to select progenies carrying required alleles at each BC generation before flowering. This will allow quick identification of individuals without phenotyping for another round of backcrossing.

The **Longer Term Strategy** is to pyramid resistance and grain quality factors in varieties desired by farmers using crosses between elite parents having complementary parental lines. To develop high performing, drought tolerant varieties we will use a 'two-stream' recurrent selection approach. One stream will include the six possible biparental crosses between highly drought tolerant lines SuVita 2, 58-57, TN88-63, IT93K-503-1. The F_1's will be made at UCR, then advanced to the F_2 generation and subjected to seedling screening for drought tolerance. A set of 100 drought-tolerant F_2 individuals will be identified and advanced to the F_3 for each population. By the end of the workplan period, the 100 F_3 lines of each population will be developed. They would then be selected again for drought tolerance at the seedling stage, and 50 F_4 lines selected at UCR. Two of the six populations of 50 F_4 lines would be distributed to each program (UCR, ISRA, and INERA) for drought tolerance phenotyping. A smaller subset of 10 lines would be selected from this evaluation, and reevaluated for drought tolerance at the F_5 generation. Individuals from the most drought tolerant lines will be used for crossing to the improved lines developed under the backcrossing program described earlier and in Table 2. Also in the workplan period, breeders in Senegal and Burkina Faso will choose a set of popular local cowpea varieties for targeted genetic improvement through MAS or MARS. These will be hybridized to sources of known thrips resistance and heat/drought tolerance. Using greenhouse and off-season nurseries, the F_1 and F_2 generations will be advanced as quickly as possible. Individuals selected with markers will be evaluated for trait expression to validate the usefulness of the markers in different genetic backgrounds.

Results, Achievements and Outputs of Research:

Final Testing and Release of Varieties:

At UC Riverside a combination of experiment station and on-farm test sites were used to conduct near final evaluations of the advanced lines for pre-release performance data and seed multiplication for release requirements. For the new 'blackeye' cowpea variety released in 2008 03Sh-50, 1.6 ha of 'Foundation to Foundation' seed was produced by the UC Foundation Seed Program, yielding about 6,500 lbs of 'new crop' Foundation Seed. 400 lbs of the 2007 Foundation seed crop was used to plant 3.2 ha for Certified Seed production on a grower's ranch. The crop was harvested recently and yielded approximately 9,000 kg of Certified Seed,A 15-ha production-scale field of 03Sh-50 and the standard cultivar CB46 were grown during the 2008 season. The grain produced is being cleaned at Cal Bean and Grain Cooperative, Pixley, CA and this warehouse will supply commercial 'clean-out' percentages and market demand information received from grain legume brokers and sales personnel.

Existing information from on-station and on-farm trials conducted between 2003 and 2007 with this variety was collated and submitted to the UCR Variety Release Committee who approved the release in May 2008. We worked with our campus Intellectual Property Office and their designated legal representatives to file for Plant Variety Protection (PVP). We are developing a Crop Science manuscript describing the new release registration and Variety Registration through the Crop Science Society of America.. The new variety is named 'California Blackeye 50' ('CB50'). Three kg seed was deposited with the USDA germplasm repository in October 2008 as part of the release requirement. In developing the 'fast-track' release requirements for the novel dry grain 'all-white' and 'dry green' cowpeas, the elite lines 07-11-572 and 03-11-747 and related 'sister lines' were evaluated in on-station trials in 2008 at Parlier (Kearney Center) and Shafter (UC Research and Extension Centers both located in the San

Joaquin Valley main production area) and at the UC Riverside station, in comparison with standard blackeye varieties CB46 and CB27During the spring of 2008, 5 kg of seed all-white breeding line 07-11-572 was planted on 0.4 ha the UC Riverside Coachella Valley Research Station to produce sufficient seed for a large-scale grower trial during the main summer season. 125 kg of seed was harvested and given to the grower who planted the seed on 5.3 ha on July 2. This trial was recently harvested (13,250 kg produced) and yielded approximately 2,500 kg/ha, which is comparable to California blackeye yields for this location and planting date. Grain samples of this variety have been shipped to a major US food company for evaluation for use in several products. Evaluations were made for grain quality, yield, disease (nematode and root-rot) and insect (lygus and aphid) tolerance and resistance. Harvest stage data from these trials is being collected at time of reporting. These field evaluations will be used to support release applications in 2009, when Breeder and Foundation Seed of these lines will be produced.

In Burkina Faso, field evaluations for final yield testing to support release of new varieties IT98K-205-8 and Melakh were made during the 2008 season. These are improved varieties obtained from the previous Bean/Cowpea CRSP collaborative activities. They are early (60 days to maturity), high yielding varieties that are adapted to the main cowpea growing area of Burkina Faso, and as such, represent an excellent opportunity to have immediate impact for cowpea farmers through INERA release. On-farm yield tests were conducted in 5 villages of 5 different provinces of the country. In each village, 3 farmers conducted the evaluation trial. At time of reporting the trials has been harvested at all the sites and yield and grain quality data are being processed. Hundreds of visitors from the farming community and cowpea sector have visited the trial. The positive responses to these evaluations indicated that cowpea farmers are ready to adopt these new varieties.

In Senegal, the breeding line ISRA-2065 was developed under the previous Bean/Cowpea CRSP from a cross between the high-yielding CRSP cultivar 'Mouride' and aphid and thrips resistant local landrace accession '58-77', with the objective of developing a cultivar with the yield and stability of Mouride but with resistance to aphids and thrips. ISRA-2065 ISRA-2065 is as early as Melakh (60 days from planting to maturity) and has the same desirable grain quality. It has been tested extensively in the peanut basin of Senegal and additional on-farm assessments were made during 2008. This variety is being targeted for release in the wetter part of this cowpea production zone where flower thrips are especially damaging since it has stronger resistance to thrips than Melakh. On-farm tests in 2008 were conducted in collaboration with the NGO 'ANCAR' in the Kaolack (Nioro) area and with the NGO 'EWA' in the Southeastern region of Sedhiou. In this zone the tests were also coupled with Foundation Seed production in preparation for formal release.

Advanced yield trials:
In Burkina Faso, two advanced yield trials were conducted at Saria and Pobe Mengao. A set of 23 improved insect tolerant lines were compared to a popular released variety (KVx 396-4-5-2D) This variety will be used in the recurrent backcrossing program. Each trial had a randomized block design with 3 replicates. The trials have been harvested at the two sites and performance data are being analyzed. The best performing lines will be re-tested in the 2009 season at multiple sites in anticipation of decisions on release of one or more of the lines.

In Senegal (ISRA) two advanced yield trials were conducted at the Bambey and Thilmakha ISRA field stations. The first trial included 98 lines from the cross Nd. AW x Yacine and the two parents. The experimental design was a 10 x 10 lattice with 2 replications. Two-row plots 5 m long were used. The second trial included 54 lines from the following crosses: Mélakh x UCR 232; CB 27 x Mélakh; Mélakh x Monteiro derived lines, and ND. AW x Yacine. The control entries were Mouride, Mélakh, Yacine, and ISRA 2065. A randomized block design with 4 replications was used. Individual plots were 4 rows, 5 m long. The two center rows are being used for yield and agronomic characterization of each line, and harvest data are being collected at time of reporting.

In California, a set of five advanced blackeye lines previously identified as potential blackeye cowpea varieties for the US were evaluated during the 2008 season in advanced trials conducted at two locations (Parlier and Shafter). Each trial had six replications with plots consisting of 4 rows, with rows 8m long. The grain quality, yield and disease and insect resistance data will be finalized during the off-season. We anticipate that one or more of these varieties will be advanced to candidacy for release by the end of the current workplan period, following further field testing in 2009.

Crosses for developing new breeding lines:
In Burkina Faso, Dr. Drabo made all the planned crosses except those with Montiero as a trait donor parent. These are summarized in Table 3. The F1 generation seed will be advanced to F3 stage during the current workplan period. The Montiero crosses will be made during the 2008-2009 off-season during the current workplan period. The ultimate goal of the crosses is to increase seed size of the improved varieties for Burkina Faso since large seed size is one of the most important characteristics of preference in the sub-region. The range of crosses should allow selection of new larger seeded varieties carrying important insect, disease and Striga resistance traits. The national cowpea plan of action for Burkina Faso has stressed the Importance of exporting the surplus cowpea production to the neighboring countries that have deficits of more than 500,000 metric tons.

In Senegal, all the planned crosses were made by Dr. Cisse at ISRA except for Melakh x UCR 03-11-747 because of seed viability problems. This cross will be made during the period January-March 2009. The crosses are summarized in Table 4. For introgressing Striga resistance, Yacine was crossed with a more recent line (IT90K-76) instead of Suvita 2. Advanced lines from Melakh and Montiero derived genotypes with large seeds are in yield trials. The Mouride x Monteiro lines will introduce large grain quality into a drought and striga resistant background. Additional crosses were also made and included ISRA-2065, Yacine and Melakh each crossed with the Striga resistant lines IT82D-849 and IT90K-77, and 58-57 x Suvita which is part of the 'High x High' elite line long-term breeding strategy.

In California, Dr. Ehlers made the planned crosses at UC Riverside during the summer of 2008 for use in the recurrent back-crossing program (Table 4). Some of these were based on previous introgression crosses with the trait donors, whose best looking late backcross progeny were crossed with the recurrent CB5 and CB46 backgrounds. Small replicated plot field tests of the back-cross populations were made at on–station evaluation sites during the 2008 season to assess seed size and quality, and several promising lines were selected. A significant challenge is to select improved lines with acceptable grain size, especially in the CB46 x IT84S-2049 cross because the nematode resistance donor is a small-seeded African line.

Under the planned 'Longer Term Strategy' to pyramid resistance and grain quality factors in varieties desired by farmers using crosses between elite parents having complementary parental lines, several activities were initiated during the reporting period. To develop high performing, drought tolerant varieties we will use a 'two-stream' recurrent selection approach. For the first stream, five bi-parental crosses between highly drought tolerant lines SuVita 2, Mouride, IT97K-499-39, IT97K-556-6, IT84S-2246, and IT93K-503-1 were made during the spring of 2008 at UC Riverside. The resulting F1's were then advanced to the F2 generation during the summer in the greenhouse. 100 F2 individuals per cross are now being advanced in the greenhouse to create 100 F3 families that will be subjected to seedling screening for drought tolerance during 2009 (Table 6). Other sets of F2 populations between drought tolerant lines Mouride, IT93K-503-1, IT97K-499-39, IT98D-1399, and Ein El Ghazal (Sudan) and elite African breeding lines KVx61-1 and KVx544-6-151 (both from Burkina Faso), Apagbaala and Marfo-Tuya (both from Ghana), UCR 779 (Botswana), and IT82E-18, IT95K-1479, IT97K-819-45 and IT98K-558-1 were planted at the Coachella Valley Agricultural Research Station in mid-August under drip-irrigation and subjected to terminal drought conditions by withholding water just prior to flowering to the end of the crop cycle. Single plant selections from these F2 will be made based on visual performance

under drought. Thus we are on track for later generation selections being distributed to each program (UCR, ISRA, and INERA) for drought tolerance phenotyping and for use in crossing to the improved lines developed under the backcrossing program summarized in Tables 3-5.

Objective 2: Strengthen cowpea seed production and delivery systems in Angola, Burkina Faso and Senegal to ensure delivery of improved varieties.

Approaches and Methods: Cowpea seed production and delivery systems in Burkina Faso and Senegal will be strengthened to ensure delivery of improved varieties. Adoption of improved varieties is constrained by inadequate supply of Breeder and Foundation Seed, which in turn limits the Certified Seed that can be produced. Insufficient resources limit growing, harvesting and storing Breeder Seed increases, in turn limiting Foundation Seed and Certified Seed for farmers is due to the lack of Foundation seed coupled with the relatively low interest in cowpea by public and governmental organizations and private seed companies.

We will increase directly amounts of Breeder and Foundation Seed available to Certified Seed producers, help identify new Certified Seed producers, and strengthen and expand proven activities in Senegal and Burkina Faso through leveraged funding from NGOs and USAID Mission funding, if possible. We will work with the national extension services in Senegal (ANCAR), Burkina Faso, and Angola (SENSE) to reach the farmers' organizations in different communities. We will also seek to strengthen the small private seed producers, some of them already working on cowpea.

A strategy adopted by the newly created GCP/ICRISAT 'Legumes for Livelihoods' project that is on-going in Niger, Nigeria, Mali, Tanzania, and Mozambique for cowpea is to improve farmers' access to seed and enhance widespread adoption of improved cowpea varieties through the development and promotion of community seed production and promotion of local markets for seed. Their well-considered view is that no single agency can produce and provide the required quantities of high quality planting seed. Seed of improved varieties can be disseminated through rural retail networks based on government schools. In Senegal, Burkina Faso, and Angola, schools can act as a seed supply center in each village, with teachers trained on procedures for quality seed production. Several progressive farmers will be selected per village and given guidance in seed production and supplied with quality Foundation Seed for multiplication. They will become the source of improved seed for the entire village. From these efforts, local entrepreneurs may arise to form local seed companies. Strong linkages will be developed with PASS (Program for Africa's Seed Systems), WASNET (West African Seed Network) and other programs to derive synergy in promoting local seed enterprises.

In Burkina Faso, Breeder Seed will be produced in the off-season for five varieties (IT98K-205-8, Melakh, KVX421-2J, KVX414-22-2, Gorom Local) on 200 m^2 per variety. The seed will be produced at Bazega under irrigation. Foundation Seed production will be made to ensure an adequate capacity on each of the three INERA stations (Saria, Pobe, and Kamboinse). This activity will generate about 4 tonnes of Foundation Seed on 5 ha planting. This will address the estimated 20 % shortage of Foundation seed, kick-starting an expansion of the self-sustaining system seed production system. Training of farmers as Certified Seed producers will be done in three locations (ZandomaProvince and SenmatengaProvince in the north, and NayalaProvince in the center). At each location, 25 seed producers, a mix of women and men, will be trained. Foundation Seed will be provided and farmers will be trained in seed production, harvest and post-harvest handling, recognizing that this process differs from the production of cowpea for consumption.

In Senegal, availability of Foundation Seed has been identified as a bottleneck for adequate supply of seed to farmers. Foundation seed is used to produce the Certified Seed that is distributed to farmers for production planting. To overcome this, N. Cisse will produce ½ ha of Melakh and ½ ha of Yacine to

complement the Foundation Seed production by the ISRA seed unit at Bambey. This effort will help to identify the demand level for Foundation Seed and provide seed for establishing new Certified Seed growers in cowpea production areas where there is currently no formal Certified Seed production effort. To achieve new Certified Seed grower establishment, we will work with the national Extension Service (ANCAR) and farmer organizations at 3 locations (Thilmakha region, Merina district, Mekhe). At each location, Foundation Seed will be provided and farmers will be trained in seed production, harvest and post-harvest handling, recognizing that this process differs from the production of cowpea for consumption. Organizations who contact ISRA for Certified Seed will be directed to the new Certified Seed producers, to establish a supply and demand relationship that should become self-sustaining.

In Angola, we will conduct an initial assessment of the infrastructure available upon which to develop a viable seed production and distribution system, recognizing that no system exists currently. We will link with government and NGO institutions, including World Vision, Africare, CRS and ADRA-Angolana, to determine opportunities for initiating the cowpea seed system. We will provide guidelines and descriptions for Angolan nationals in multiplication of high quality seed of selected varieties for farmers. In parallel to this effort, the cowpea field evaluations will be conducted under Objective 1, with the aim of identifying candidate varieties among local landraces, and Bean/Cowpea CRSP (in Ghana, Senegal and/or Burkina Faso) and IITA varieties. One or more of these candidates will become the first varieties to be formally produced for farmers under the new seed system. We will plan to use the data from the primary season trials, planned for completion in March 2009, to make the variety selection and produce the first generation (G1) of Breeder seed by the end of the workplan period.

Results, Achievements and Outputs of Research:

In Burkina Faso, in order to satisfy the demand for Certified Seed production, Breeder Seed of ten improved cowpea varieties was produced at the northern location of Pobe-Mengao during the 2008 season. The varieties were KVx 396-4-4, KVx 396-4-5-2D, KVx 414-22-2, KVx 421-2J, KVx 771-10, KVx 775-33-2, Gorom Local, Melakh, KVx 745-11P, and IT98K-205-8. Will harvesting and cleanout is ongoing at time of reporting, we anticipate that at least 100 kg of seed of each entry will be obtained. One hectare of Foundation Seed for each of four varieties (KVx 61-1, KVx 396-4-4, KVx 396-4-5-2D, KVx 745-11P) was produced at Saria and Pobe- Mengao. The objective was to complement the national Foundation Seed demand, estimated to be35 metric tonnes this year for Burkina Faso. Planting preparations have been made for Foundation Seed of varieties KVx 414-22-2 (2 ha), IT98K-205-8 (0.5 ha) and Melakh (0.5 ha) that will be produced during the off-season in October 2008 and February 2009 under irrigation at three identified sites. Money obtained by selling the Foundation Seed will be used for supporting next year's seed production activities in attempts to establish a self-sustaining plant seed production and delivery system. Plans and materials are in preparation for training at least 40 leader-farmers to produce and conserve Certified Seed in the next year before the 2009 rainy season.

In Senegal, with additional support of EWA, 1 ha each of Melakh and Yacine Foundation Seed was produced at the ISRA Bambey station. An agreement was made to provide 50 kg seed of each variety to EWA network of seed producers, but it is expected that at least twice this amount will be made available to the NGO based on the 2008 yield. This network has several women seed producers as members. In the Thilmakha area, Foundation Seeds were distributed to two farmers for production of 1 ha of Melakh and 1 ha of Yacine Certified Seeds during the 2008 season. These lead-farmers were part of the mini-kit on-farm testing network established under the previous Bean/Cowpea CRSP and they were familiar with the improved production practices promoted by ISRA. Certified Seed production was also initiated in the Mekhe and Merina areas on 1 ha each. In both areas a women seed producer was included. Training of farmers during the 2008 season for seed production consisted of field selection, rouging of off-types and diseased plants, and both harvest and post-harvest handling. Double bags will be provided to farmers for storage. Foundation seeds were also provided to the Producers Professional Training Center (CPFP) of Sangalkam (West of Thiès) for production of 1ha each of Melakh and Yacine. About 1 metric tonne of

seeds was obtained. The fields were visited during the season by 44 producers composed of women and men, representing 10 farmer organizations from 2 villages.

In Angola, we are conducting an initial assessment of the infrastructure available upon which to develop a viable seed production and distribution system, recognizing that no system exists currently. This effort is in conjunction with Dr. Beaver who is visiting Angola in November for similar assessments of the bean breeding and seed distribution setup.

Explanation for Changes

The following provides explanation for the non-achievement of benchmark indicators:
Under Objective 1 Breeding: Germplasm assembly and seed increase in Angola. There was considerable delay between UCR and MSU in finalizing the main sub-contract for the project. This in turn caused delay in the execution of the sub-agreement between UCR and IIA. Unfortunately, unlike the other HCs under this project, IIA had little capability to initiate the work without funding. Nevertheless, the assembly of cowpea germplasm has made good progress, but the seed increase will be made during the next cropping season, in early 2009.

Angola (Univ. PR) started.

Under Training: MS Training (Breeding) -
Difficulty was encountered in identifying an appropriate Angolan student for this program. The initial student identified will not now participate in the project training through UPR. However, an excellent alternative student has been identified and is now processing his application through UPR. Because of the delay, the revised plan is for the student (Mr. Antonio David) to come to UCR during the 2009 summer to work with the cowpea research and breeding program, before starting the MS degree training at UPR in Fall Semester 2009.

Networking and Linkages with Stakeholders

We are working closely with national and international cowpea breeders and other scientists, including Drs. Ousmane Boukar and Christian Fatokun, Senior Scientists and Cowpea Breeders at IITA, Dr. Mohammed Ishiyaku of the IAR in Nigeria, Rogerio Chiulele at Eduardo Mondlane University in Maputo, Mozambique, Michael Timko at University of Virginia and Larry Murdock at Purdue Univ. In June 2008 we sent seed of 150 cowpea accessions and breeding lines to Eduardo Mondlane University. We are working closely with the California Dry Bean Advisory Board and its Blackeye Council on research priorities of the industry. We are working with Inland Empire Foods, an important legume processor based in Riverside, on developing Akara (or 'Bean Tots') for inclusion into the California school program and with another major US manufacturer on utilization of several products that our varieties are well suited to as described in the results section above. We are also collaborating with Dr. Julie Lauren of the Dry Pulse CRSP project and provided seed of 35 cowpea varieties for her project in June 2008. We are also working with Dr. Jim Beaver at the University of Puerto Rico on training a CRSP student from Angola. We have been interacting with Dr. Emmanuel Prophete in Haiti and will be sending him seed of several cowpea varieties for trials he plans to conduct in there.

In Burkina Faso, we are working with AFRICARE, a NGO financed by USAID to ensure food security. Our collaborative work aims to develop new Striga resistant varieties adapted to intercropping. A collaboration with LVIA, a NGO financed by the EU and Italy, aims to train farmers for cowpea certified seed production and conservation. With Association FERT, a French NGO whose aim is to improve cowpea production in the northern part of the country, we have initiated on-farm tests of improved varieties and we are helping them to produce Certified Seed. Linkages have also been made

with five farmer organizations: “Song Taaba” at Donsin near Ouagadougou; “Six S” at Pobe Mengao; Producteurs de semences de Diouroum; Producteurs de Semences at Pobe Mengao; and Producteurs Semenciers Songd Woaga at Saria. In Senegal, collaboration was established with the extension service ANCAR in the Kaolack region and with the PADER project of EWA in the southern region of Sedhiou, for on-farm testing of the advanced breeding line ISRA-2065. EWA, ANCAR-Thiès and CPFP of Sangalkam were involved in seed production in the Mekhe and Merina regions.

Leveraged Funds

Name of PI receiving leveraged funds: Jeff Ehlers
Description of leveraged Project: Drought phenotyping for cowpea
Dollar Amount: $445,000
Funding Source: CGIAR-GCP

Name of PI receiving leveraged funds: Jeff Ehlers
Description of leveraged Project: Improve tropical legumes for Africa
Dollar Amount: $1,952,008
Funding Source: CGIAR-GCP

Name of PI receiving leveraged funds: Phillip Roberts
Description of leveraged Project: Blackeye cowpea varietal improvement
Dollar Amount: $19,900
Funding Source: CDBAB

Name of PI receiving leveraged funds: Phillip Roberts
Description of leveraged Project: Cowpea collection aphid and nematode resistance screening
Dollar Amount: $16,001
Funding Source: USDA

Name of PI receiving leveraged funds: Ndiaga Cisse
Description of leveraged Project: Cowpea Foundation Seed production
Dollar Amount: $2,500
Funding Source: RESOPP-EWA

List of Scholarly Activities and Accomplishments

Dr. Issa Drabo, INERA, Burkina Faso, was awarded on October 5, 2008 “Chevalier de l’Ordre des Palmes Academiques” for his outstanding work on cowpea in Burkina Faso by the Minister of Higher Education and Research on behalf of the Chief of State.

Dr. Jeff Ehlers, UC-Riverside, was awarded the UC-Riverside campus “Distinguished Research Award (Non-Senate) for 2007-2008” in recognition of his research work on cowpea genetic improvement.

Contribution of Project to Target USAID Performance Indicators

No information provided.

Contribution to Gender Equity Goal

Among the target beneficiaries of the project work, the activities in Burkina Faso and Senegal resulted in eight producer/community based organizations being recipients of technical assistance during the report period, which are comprised of women and men. More specifically, four women organizations received technical assistance in Senegal and Burkina Faso, as planned. The technical assistance was focused on seed system processes under Objective 2, for growing, harvest handling and storing cowpea planting seed.

Progress Report on Activities Funded Through Supplemental Funds

During the reporting period, supplemental funds were approved through the CRSP Technical Committee and Director for Capacity Building in the three Host Country partner Institutions. The approvals were made in support of the cowpea breeding and genetic improvement programs as follows:

1. ISRA, Senegal: $30,000 to the Institut Senegalais de Recherches Agricole (ISRA), Bambey Research Station, in support of the purchase of a vehicle that will enhance the capacity of ISRA's cowpea breeding program to serve the needs of stakeholders of cowpea value chains in Senegal.

2. INERA, Burkina Faso: $11,000 to the Institut de l'Environnement et du Recherches Agricoles (INERA) in support of vehicle repair, the purchase of a weather station and training that will enhance the capacity of INERA's cowpea breeding program to serve the needs of stakeholders of cowpea value chains in Burkina Faso.

3. IIA, Angola: $33,600 to the Instituto de Investigacao Agronomica (IIA), Huambo Research Station, in support of the purchase of a vehicle and laboratory equipment that will enhance IIA's research capacity to serve the stakeholders of bean and cowpea value chains in Angola.

The contract for these supplemental awards were not processed during the reporting period, and will be reported on for progress during the October 1, 2008 to September 30, 2009 year under the current workplan period.

Tables/Figures Cited in the Report

Table 3: Crosses (High x High) made with Burkina Faso breeding lines.

Recurrent parent	Traits being introgressed	Donor parents
KVx 745-11P	Medium seed size white and rough	KVx 414-22-2 derived lines and KVx 775-33-2
KVx 396-4-5-2D	Striga resistance and seed size	Kvx 414-22-2 derived lines and KVx 775-33-2
KVx775-33-2	Increased seed size	Montiero
KVx 414-22-2	Increased seed size Striga and virus resistance	KVx 414-22-2 derived lines and Montiero
KVx 414-22-2	Increesed seed size and virus resistance	KVx 775-33-2
KVx 771-10	Striga and insect resistance	IT86D-716 and Moussa Local
KVx 775-33-2	Virulent race of Striga resistance	IT93K-693-2

Table 4. Senegal varieties being improved by introgression of specific traits by backcrossing.

Recurrent Parent Line	Trait donor (non-recurrent) parent	Institution	Trait being introgressed
Yacine	IT93K-503-1	ISRA	Macrophomena
Yacine	58-77	ISRA	Flower thrips resistance
Yacine	SuVita 2 (substituted IT90K-76)	ISRA	Striga
Mouride	Montiero derived line	ISRA	Large grain
Melakh	IT97K-499-39	ISRA	Striga resistance
Melakh	UCR 03-11-747	ISRA	Green grain

Table 5. California blackeye lines being improved by introgression of specific traits using backcrossing at UCR. BC1 to BC6 lines have been generated by 2008 and previous crosses.

Recurrent Parent Line	Trait donor (non-recurrent) parent	Trait being introgressed	Generation
CB5	CB27	Fusarium wilt	BC2F5
CB46	UCR 03-11-747	Green grain	BC4F5
CB46	IT84S-2049	Root-knot nematodes	BC6F6
CB46	Montiero (Brazil)	Large grain size	BC3F6
CB46	Bambey 21(Senegal)	All-white grain	BC4F6
CB46	IT97K-556-6 & UCR 779	Aphid resistance	BC1F4
CB46	IT93K-2046	Lygus resistance	BC3F6

Table 6. List of crosses made and advanced to F2 generation that will provide progenies for selection of drought and pest tolerant cultivars.

Cross	Type	Current Status
SuVita2/Mouride	Elite Drought Tol. x Elite Drought Tol.	F2 – F3 in greenhouse now
IT93K-503-1/IT84S-2246	Elite Drought Tol. x Elite Drought Tol.	F2 – F3 in greenhouse now
Mouride /IT84S-2246	Elite Drought Tol. x Elite Drought Tol.	F2 – F3 in greenhouse now
IT97K-499-39/IT93K-503-1	Elite Drought Tol. x Elite Drought Tol.	F2 – F3 in greenhouse now
IT97K-503-1/IT97K-556-6	Elite Drought Tol. x Elite Drought Tol.	F2 – F3 in greenhouse now
Mouride/Apagbaala	Elite Drought x Elite Heat Tolerant	F2 – F3 in field at Coachella now
KVx61-1/Mouride	Elite x Elite Drought Tolerant	F2 – F3 in field at Coachella now
IT93K-503-1/UCR 779	Elite Drought Tolerant x Drought Tolerant and aphid resistant landrace	F2 – F3 in field at Coachella now
Apagbaala/IT82E-18	Elite Heat Tolerant x Elite	F2 – F3 in field at Coachella now
IT97K-819-45/Ein El Ghazal	Elite x Elite Drought Tolerant	F2 – F3 in field at Coachella now
Ein El Ghazal/KVx544-6-151	Elite Drought Tolerant x Elite	F2 – F3 in field at Coachella now
IT98K-558-1/Mouride	Elite x Elite Drought Tolerant	F2 – F3 in field at Coachella now
Apagbaala/IT98K-558-1	Elite Heat Tolerant x Elite	F2 – F3 in field at Coachella now
IT95K-1479/Mouride	Elite x Elite Drought Tolerant	F2 – F3 in field at Coachella now

Literature Cited

No information provided.

Capacity Building Activities: P1-UCR-1

Degree Training:

Student #1

First and Other Given Names:	Manuel
Last Name:	Costa
Citizenship:	Angola
Gender:	Male
Degree:	M.S.
Discipline:	Plant Breeding/Genetics/Plant Pathology
Host Country Institution to Benefit from Training:	Angola
Training Location:	University of Puerto Rico
Supervising CRSP PI:	Roberts, Phillip
Start Date:	10/08
Project Completion Date:	09/10
Training Status:	
Type of CRSP Support (full, partial or indirect):	Full (Category 1)

Student #2

First and Other Given Names: TBD
Last Name: TBD
Citizenship: African
Gender: Female
Degree: Ph.D.
Discipline: Plant Breeding/Genetics/Plant Pathology
Host Country Institution to Benefit from Training:
Training Location: University of Ghana, Legon and UCR
Supervising CRSP PI: Roberts, Phillip
Start Date: 10/08
Project Completion Date: 10/12
Training Status:
Type of CRSP Support (full, partial or indirect): Partial (Category 2b)

Student #3

First and Other Given Names:	Antonio
Last Name:	David
Citizenship:	Angola
Gender:	Male
Degree:	M.S.
Discipline:	Plant Breeding
Host Country Institution to Benefit from Training:	Angola
Training Location:	UPR
Supervising CRSP PI:	Roberts, Phillip
Start Date:	04/09
Project Completion Date:	06/11
Training Status:	Delayed
Type of CRSP Support (full, partial or indirect):	Full (Category 1)

Dry Grain Pulses CRSP

Report on the Achievement of "Semi-Annual Indicators of Progress"

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

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

Project Title: ı Cowpea Breeding to Overcome Critical Production Constraints in Africa and

	Abbreviated name of institutions											
	UCR			ISRA			INERA			IIA		
	Target	Achieved		Target	Achieved		Target	Achieved		Target	Achieved	
Benchmark Indicators by Objectives	10/1/08	Y	N *	10/1/08	Y	N *	10/1/08	Y	N *	10/1/08	Y	N *
	(Tick mark the Yes or No column for identified benchmarks by institution)											
Objective 1 Breeding												
Varietal identification and release												
Germplasm assembly and seed increase										x		x
Germplasm Screening												
Varietal candidate screening - Angola												
Germplasm Development												
Cross Improved varieties	x	x										
Make BC1F1 and BC2F1												
Inbreed BC2F1 to BC2F2												
Make F1 elite x elite	x	x		x	x		x	x				
Advance F1 To F2,												
Develop F3 lines												
Objective 2 -Improve Seed Systems												
Breeder's Seed Production				x	x		x	x				
Foundation Seed Production												
Certified Seed Producer Training												
Assess seed system needs - Angola												
Objective 3 - Training												
MS Training (Breeding) - Angola (Univ. PR) started	x		x									
PhD Training (Breeding - HPR) - started												
Training in MAS with SNP-based markers												
Breeding Guide												

Name of the PI reporting on benchmarks by institution	P. A. Roberts	N. Cisse	I. Drabo	A. Chicapa

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

Philip A. Roberts

Signature

9/30/08

Date

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

Dry Grain Pulses CRSP
Research, Training and Outreach Workplans
(April 1, 2008 – September 30, 2009)

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

Modern Cowpea Breeding to Overcome Critical Production Constraints in Africa and the US.
Lead U.S. PI and University: Philip A. Roberts, University of California, Riverside
Host Country(s): Angola, Burkina Faso, Senegal

Output Indicators	2008 Target (Apr 1-Sept 30, 2008)	2008 Actual (Apr 1-Sept 30, 2008)	2009 Target (Oct 1 2008-Sept 30, 2009)	2009 Actual (Oct 1 2008-Sept 30, 2009)
Degree Training: Number of individuals who have received degree training				
Number of women	0	0	1	
Number of men	0	0	1	
Short-term Training: Number of individuals who have received short-term training				
Number of women	0	0	3	
Number of men	0	0	4	
Technologies and Policies				
Number of technologies and management practices under research	1	2	13	
Number of technologies and management practices under field testing	5	5	5	
Number of *technologies* and management practices made available for transfer			5	
Number of policy studies undertaken	0	0	0	
Beneficiaries:				
Number of rural households benefiting directly	0	0	>2,000	
Number of agricultural firms/enterprises benefiting	0	0	8	
Number of producer and/or community-based organizations receiving technical assistance	8	7	10	
Number of women organizations receiving technical assistance	4	4	6	
Number of HC partner organizations/institutions benefiting	3	4	3	
Developmental outcomes:				
Number of additional hectares under improved technologies or management practices	0	0	>11,600	