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 under "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, new 'blackeye' cowpea CB50 was released in 2008 and 8,000 kg Certified Seed produced in 2008 was sold out for 2009 planting. The 2009 crop is being sold by several warehouses as a premium export class. Elite novel dry grain 'all-white' cowpea line evaluations in four on-station trials for grain quality, yield, disease and insect resistance were positive and a release will be attempted next year. In Burkina Faso, 5 tests of two new varieties confirmed improved yields (700-800 kg/ha) and strong farmer interest. In Senegal, 30 on-farm tests were made and Foundation Seed produced to complete release of line ISRA-2065 with thrips and aphid resistance. Advanced yield trials were conducted in the 2008 and 2009 seasons in Burkina Faso (4), Senegal (6) and California (7) on a total of 180 lines for release selection based on grain quality, yield, and disease and insect resistance. Crosses for developing new breeding lines were made in Burkina Faso (7), Senegal (12) and California (21) to combine high yield, grain quality, and abiotic and biotic stress resistance traits. Most crosses were advanced to F3-F4 stage in 2009. Under the seed production and delivery systems objective, the following was achieved: In Burkina Faso, Breeder Seed of 10 improved varieties (>100 kg/entry) was grown in Pobe-Mengao, Foundation Seed of 4 varieties was produced at Saria and Pobe-Mengao, and 2.5 MT of Foundation Seed of 4 varieties from off-season production was sold to Certified Seed producers. 40 lead farmers were trained as Certified Seed producers. In Senegal, 2 ha each of Melakh and Yacine Foundation Seed was produced at Bambey to supply EWA NGO seed producer network. In Thilmakha 1 ha each of Melakh and Yacine Certified Seed was produced by farmers in 2009. Certified Seed was also produced in the Mekhe and Merina areas and women and men farmer groups trained in seed production. From Foundation Seed provided to Producers Professional Training Center, Sangalkam 1 MT of Melakh and Yacine seed was produced in 2008 and a second generation in 2009, plus Certified Seed produced by 10 farmer organizations. A student from Angola started degree training in cowpea germplasm and breeding and will aid in Angola seed production and distribution system assessment.

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:

Completing varietal release protocols for 03Sh-50 and application for Plant Variety Protection (PVP): 03Sh-50 was released by the University of California, Riverside in May 2008 as California Blackeye 50 (CB50). PVP has been applied for and is pending approval (PVP Application 200800395). A variety registration manuscript was published in the Journal of Plant Registrations (Ehlers et al., 2009) and a seed sample supplied to the National Center for Genetic Resources Preservation (NCGRP) in Fort Collins. CB50 has been designated as US Plant Introduction (PI) 655235 by the NCGRP. Data from 15 reliable trials conducted over four years showed that the yield potential of CB50 is equivalent to CB46, but that the grain of CB50 is more attractive than CB46 due to whiter color and larger size. CB50 also has resistance to Fusarium wilt race 4 which CB46 does not. About 8,000 kg of Certified Seed was produced in 2008 and sold out for the 2009 planting season. This variety has received excellent 'Press' in local farm journals and the 2009 crop is being sold by several warehouses as a premium export class of this crop. We anticipate an expanded California production acreage of CB50 in 2010.

Selecting superior blackeye breeding lines from early and advanced generation nurseries: Breeding nurseries with early and late generation blackeye breeding lines were evaluated at Shafter, Kearney, and Riverside. About 200 single plant selections were made in 2008 for further development and evaluated in 2009, including progenies developed from crosses between CB50 and CB46, and other lines that are part of a breeding effort to develop later maturing blackeyes with one large single flush, and blackeyes with superior grain quality.

Developing lygus and aphid resistant blackeyes*:* In 2008 we conducted a large lygus resistance trial under unprotected (no insecticide) conditions at Kearney, with 30 entries including CB27, CB46, and CB50. The trial was harvested by hand-picking pods 90 days after sowing from a 5 foot section from the middle of the two middle rows of each 4-row plot. Three lines, 07KN-42, 07KN-46 and 07KN-74, had outstanding yields that were significantly greater than CB46. All three lines had similar percentage of grain damaged by lygus as CB46, ranging from 27.0 to 38.5% among the 4 lines, which were not statistically separable. Although the grain quality of 07KN-42 and 07KN-46 is not up to commercial blackeye standards, these lines both have very large seed which will simplify breeding large-seeded blackeyes when they are used as parents in crosses with California blackeyes. In 2009, the highest 14 performing lines were included in trials with both protected (insecticide treated) and unprotected plots in

two trials with different planting dates and good insect pressure. Data from the October harvest including seed damage assays have not been finalized.

All-white and dry-green grain classes: Tests in 2008 and 2009 at two locations of the yield potential of the 'all-white' 07-11-572 advanced line determined that it has grain yields equivalent to CB46. A 'fast-track' release protocol is being followed to accommodate the needs of potential licensees for 07-11-572, so that this variety can be made available as quickly as possible. This is possible because the 'all-white' grain type of this is breeding line is new and unique, meaning it does not have existing standard varieties with which it can be compared and must compete with for release approval. However, in the same 2008 and 2009 field trials the grain yields of 'dry green blackeye' advanced breeding line 03-11-747 and its sister lines were relatively low, with observations of weaker root system development than normal in one location. For this 'dry green' market class further testing of new breeding lines developed from previous crosses will be done to identify more promising materials before release is considered. Now the high-throughput marker genotyping capability is developed, a promising planned approach to expedite selection will be employed next year by using marker-assisted backcross breeding to introgress the 'green genes' into a CB46 or CB50 genetic background, thus retaining the high yield potential and other component traits of CB46 (Table 2).

In Burkina Faso (INERA): Field evaluations for final yield testing to support release of new varieties IT98K-205-8 and Melakh were made during the 2008 and 2009 seasons. 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. Average yields in 2008 obtained were 700kg/ha for IT98K-205-8 and 800kg/ha for Melakh. The 2009 trials data are not yet completed. The two varieties were preferred because of Striga resistance and their earliness. Farmers started to harvest in some localities 55 days after planting. Hundreds of visitors from the farming community and cowpea sector visited the trials. The positive responses to these evaluations indicated that cowpea farmers are ready to adopt these new varieties.

In Senegal (ISRA): 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 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. Demonstration trials were conducted in the South zone of the peanut basin (Kaolack Nioe and Kaffrine) zone in 2009. Larger plot sizes of 1000 m^2 were used for each of the 2 varieties (Mélakh and ISRA-2065) tested. These demonstration trials were conducted in a total of 30 farms. These trials constitute the final activity for an official release.

Advanced yield trials:

In Burkina Faso (INERA): In Burkina Faso, two advanced yield trials were conducted at Saria and Pobe Mengao in both 2008 and 2009. A set of 23 improved insect tolerant lines were compared to a popular released variety (KVx 396-4-5-2D). The KVx 396-4-5-2D variety will be used in the recurrent backcrossing program. Each trial had a randomized block design with 3 replicates. The 2008 trial data allowed selection of the best performing lines and these have been harvested at the two sites in 2009 and performance data are being analyzed. The best performing lines will be re-tested in the 2010 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. Additionally, 20 lines with medium maturity were selected from the first trial based on 2008 performance and included in replicated yield trials in farmer fields. Two trials each were conducted in the Mekhe and Louga areas. Similarly, the same number of lines was selected based on grain size (100 grain-weight > 25g) from the second 2008 trial and tested under the same conditions. In both of these trials randomized complete block designs with 4 replications and plots size of 4 rows, 5m long were used.

In California: Evaluation of three 'new' advanced blackeye breeding lines for grain yield and quality, and agronomic characteristics was conducted at two locations: At the Shafter and Kearney (Parlier) UC Research and Extension Centers, replicated trials comparing yields and grain quality of CB46, CB50 and three 'new' blackeye breeding lines (Table 1) were conducted under double-flush production systems in 2008 and 2009. The experimental design both years was a Latin Square with 6 replications. In the 2008 trials with five lines analysis was completed in November 2008, the three best of the five lines were selected for testing in 2009. We conducted Fusarium wilt and root-knot nematode resistance screens of these lines in greenhouse and field plot tests to characterize their resistance profiles. These three lines (UCR P-191, UCR P-203 and UCR P-87) have resistance to both race 3 and race 4 of Fusarium wilt and resistance to *Meloidogyne incognita* root-knot nematode. Two of the lines, P-191 and P-203, also have greater resistance to *M. javanica* root-knot nematode, compared to CB46. New blackeye line P-87 showed both high yield potential and lower levels of 'skin checking' (seed-coat splitting) than CB46 in the 2008 trials (data not yet analyzed for the 2009 season). This line has resistance to race 3 and race 4 of Fusarium wilt, with medium sized seeds, and we plan to include this line in large plot tests in 2010 in a move toward release. Seed-coat splitting was also significantly lower on the three new breeding lines compared to CB46 in 2008; this is being assessed again in the grain harvested from the 2009 field trials. In 2008, percent 'split' seed-coat averaged 8.2, 5.7 and 5.6% for P-87, P-191, and P-203, respectively, compared to an average of 14.8% for CB46, in line with results from previous years.

Crosses for developing new breeding lines:

In Burkina Faso (INERA): Dr. Drabo made all the planned crosses, and these are summarized in Table 3. The F1 generation seed of each cross was advanced to F3 stage during the current reporting 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, Striga and nematode resistance traits, drawing on previous findings from the Bean/Cowpea CRSP project (Sawadogo et al., 2009). 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 (ISRA): In Senegal, all the planned crosses were made by Dr. Cisse at ISRA. 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 2009 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 with

IT98K-1111-1 for Macrophomina resistance. The 58-57 x Suvita cross, which is part of the 'High x High' elite line long-term breeding strategy was also made.

In California: The planned crosses were made at UC Riverside during the summer of 2008 for use in the recurrent back-crossing program (Table 5). 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 (completed in October 2008) to assess seed size and quality, and several promising lines were selected. In 2009 the selected lines were included in replicated trials at the Shafter and Kearney locations and plots have been harvested for yield and grain quality determinations but not yet analyzed. 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. We anticipate that our ability to make foreground and background selection decisions with the SNP-based marker genotyping will aid in breaking this and other negative linkages.

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 conducted during the reporting period. To develop high performing, drought tolerant varieties we are using 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 were then advanced in the greenhouse to obtain 100 F3 families in 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 (CVARS) in mid-August 2008 under drip-irrigation and subjected to terminal drought conditions by withholding water just prior to flowering until the end of the crop cycle. Single plant selections from these F2 were made based on visual performance under drought in November 2008. These selections were advanced in the greenhouse during winter-spring 2009, and the progenies were planted for the next round of selection and testing at CVARS in September 2009.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.

Marker-assisted backcrossing (MABC) is a breeding strategy that can markedly increase the rate of progress and the precision of backcross breeding outcomes. The new high-throughput SNP genotyping platform developed with leveraged funds under the GCP TL-1 cowpea project headed at UCR is ideally suited to the current task of introgressing key traits into locally adapted varieties via MABC (Muchero et al., 2009). We have begun to implement MABC during the latter half of 2009 by collecting leaf tissues of backcross progenies with the goal of identifying individuals carrying a majority of molecular markers associated with the genetic background of the recurrent parent, with the addition of the trait markers from the donor parent. The trait-marker associations have been identified through QTL mapping efforts that combined AFLP and SNP marker data with extensive phenotyping data for drought tolerance (Muchero et al., 2008, 2009a.b), insect resistance (Muchero et al, 2009c) and continuing efforts for root-knot nematode, Macrophomina, Fusarium, and other disease resistance traits. Genotyping through the platform will be conducted in late 2009 and early 2010 so selected progenies can be grown out during next year.

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. At least100 kg of seeds of each entry were 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 be 35 metric tonnes in the current year for Burkina Faso. Foundation Seed of varieties KVx 414-22-2 (2 ha), IT98K-205-8 (0.5 ha) and Melakh (0.5 ha) were produced during the off-season in October 2008 and February 2009 under irrigation at three identified sites. A total of 2.5 MT of seeds were produced and sold to the Certified Seed producers. Money obtained by selling the Foundation Seed was used for supporting 2009 seed production activities in attempts to establish a self-sustaining plant seed production and delivery system. 40 leader-farmers have been trained to produce and conserve Certified Seed in the 2010 rainy season.

In Senegal: With additional support of EWA, 2 ha each of Melakh and Yacine Foundation Seed was produced at the ISRA Bambey station. It is expected that at least 100 kg of each variety will be made available to the NGO. This network has several women seed producers as members. In the Thilmakha area, Foundation Seeds were distributed to two farmers and a women's group for production of 1 ha of Melakh and 1 ha of Yacine Certified Seeds during the 2009 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 conducted in collaboration with a farmers' union (UGPM) in Mekhe with 40 kg of Melakh and Yacine and in the Merina area on 1 ha each. In UGPM, the group is comprised of both women and men members while in Merina only women seed producers were included. Training of farmers during the 2009 season for seed production consisted of field selection, removal of off-types and diseased plants, and both harvest and post-harvest handling. Double bags will be provided to farmers for storage. The Producers Professional Training Center (CPFP) of Sangalkam (West of Thiès) has produced a second generation of Foundation Seed from the 2008 production in their facilities, while Certified Seed production was made by 10 farmer organizations from 2 villages.

In Angola: Our initial assessment of the infrastructure available upon which to develop a viable seed production and distribution system has been based on communication within the project, recognizing that

no robust system exists currently. This effort is in conjunction with Dr. Beaver who visited Angola in summer 2009 for similar assessments of the bean breeding and seed distribution setup. We were unable to visit Angola during the reporting period, but are hopeful that our interactions with the new trainee Angola trainee Antonio David focusing on cowpea in the MS program at UPR will help develop new approaches with target cowpea varieties.

CAPACITY BUILDING

As reported under Section XII, supplemental funds approved in September 2008 through the CRSP Technical Committee and Director for Capacity Building were used in Senegal and Burkina as planned, and in Angola funds for the vehicle purchase are in the process of being invoiced. Approvals were granted in September 2009 of additional funds for the three Host Country partner Institutions in support of the cowpea breeding and genetic improvement programs. These pass-through funds will be contracted between UCR and the HC institutions at in the next two month, so expenditures of these funds can be made before the new cowpea growing season.

Under Training: MS Training (Breeding) - Angola (Univ. Puerto Rico). Mr. Antonio David, a student from Angola was identified for training in the MS Plant Breeding program through the University of Puerto Rico (UPR). After some delay, he started in the program at UCR in August 2009 for the Fall Semester. We are coordinating with Dr. James Beaver, who is providing local mentorship. Antonio David will work on Angola-based cowpea gemplasm characterization for the research component of the degree.

Degree Training:

MS Student 1:

First and Other Given Names: Antonio
Last Name: David
Citizenship Angola
Gender: Male
Degree Program for training: MS
Program Areas or Discipline: Plant Breeding/Genetics/Plant Pathology
Host Country Institution to Benefit from Training: Angola
University to provide training: University of Puerto Rico
If enrolled at a US university, will Trainee be a "Participant Trainee" as defined by USAID? Yes
Supervising CRSP PI: PA Roberts and HC PI
Start Date: August, 2009
Projected Completion Date September 2010
Type of CRSP Support (full, partial or indirect) Full
If providing Indirect Support, identify source(s) of leveraged funds:
Amount Budgeted in Workplan, if providing full or partial support:
Direct cost: $40,000
Indirect cost: None
U.S. or HC Institution to receive CRSP funding for training activity: UC-Riverside.

We have been working with several trainee applicants for the PhD program at UC Riverside, but have yet to have one accepted in and matching with the program. Currently 2 candidates are in the application process, with a start date in the PhD program of Winter Quarter 2010 (January 2010). Of these two, Madame Penda Sarr is an applicant from Senegal where she is working with HC PI Dr. Cisse and ISRA scientists with interest in Plant Pathology and cowpea breeding. She is coming to UCR in December for English training. The second candidate is Mr. Arsenio Daniel Ndeve, from Mozambique, who recently completed a MS degree in Denmark and is working with cowpea breeder Rogerio Chiulele, at Universidade Eduardo Mondlane. He is an excellent candidate for training in cowpea breeding and

pathology, building on the vigorous cowpea breeding program being established by R. Chiulele with assistance from IAMM and their research stations at Umbelezi and especially Chokwe, where the station manager is Celestina Jochua, HC PI for Jonathon Lynch's Pulse CRSP project in Mozambique.

Explanation for Changes

Under Objective - Training:
Difficulty has been encountered in communication with the HC PI for Angola. As a result, we have been unable to make an appropriate assessment of the seed system needs for cowpea in Angola. We will endeavor to complete this activity of Objective 3 during the coming year of the project period. We have, however, initiated the MS degree training of the Angola student (Antonio David) at University of Puerto Rico, and plan to engage him in developing this assessment of the Angola cowpea seed system.
We have been working with several trainee applicants for the PhD program at UC Riverside, but have yet to have one accepted in and matching with the program. Currently 2 candidates are in the application process, with a start date in the PhD program of Winter Quarter 2010 (January 2010). Of these two, Madame Penda Sarr is an applicant from Senegal where she is working with HC PI Dr. Cisse and ISRA scientists with interest in Plant Pathology and cowpea breeding. She is coming to UCR in December for English training. The second candidate is Mr. Arsenio Daniel Ndeve, from Mozambique, who recently completed a MS degree in Denmark and is working with cowpea breeder Rogerio Chiulele, at Universidade Eduardo Mondlane. He is an excellent candidate for training in cowpea breeding and pathology, building on the vigorous cowpea breeding program being established by R. Chiulele with assistance from IAMM and their research stations at Umbelezi and especially Chokwe, where the station manager is Celestina Jochua, HC PI for Jonathon Lynch's Pulse CRSP project in Mozambique.

Networking and Linkages with Stakeholders

We are working closely with national and international cowpea breeders and other scientists, including Drs. Ousmane Boukar, Christian Fatokun, and Sata Muranaka, 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. 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. We have provided Dr. Julie Lauren of the Dry Pulse CRSP project with advice about and seed of 35 cowpea varieties for her project in Kenya. We are also working with Dr. Jim Beaver at the University of Puerto Rico on training a CRSP student from Angola. Dr. Ehlers represented the project team and made three presentations in a bean and cowpea breeders' workshop in Honduras in August 2009, coordinated by Dr. Jim Beaver, PI of the Pulse CRSP bean breeding project. Under the CGIAR-GCP funded project Tropical Legumes 1, we are leading the cowpea improvement Objective and interact with a large international network of tropical legumes researchers.

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 Louga, Mekhe and Merina regions. Support for the amount of 2500 USD was received from the Network of farmers organization (RESOPP) which EWA has helped establish. A Memorandum of Understanding was signed in 2008 between RESOPP-EWA and ISRA for the production of Melakh and Yacine Foundation Seed; the program is established to last five years. In June 2009, The Kirkhouse Trust started supporting activities on marker assisted backcrossing for Striga resistance, by providing $20,000 annually for 3 years.

Dr. Bahiru Duguma, the Pulse CRSP oversight officer, accompanied Drs. Roberts, Ehlers and Drabo on a research field-site visit to Burkina Faso in September 2009. We visited key cowpea research and production areas in Kamboinse, Koudougou, and Pobe-Mengao. This was a valuable sharing experinece about cowpea breeding research, seed systems work, and the vision and expectations of the USAID program supporting the CRSP.

Leveraged Funds

Name of PI receiving leveraged funds: Phillip Roberts
Description of leveraged Project: Functional Genetic Analysis of Drought Tolerance Genes in Cowpea Through Virus Induced Gene Silencin
Dollar Amount: $30,000
Funding Source: USDA

Name of PI receiving leveraged funds: Phillip Roberts
Description of leveraged Project: : Improving Cowpea Productivity for Marginal Environments in sub-Saharan Africa
Dollar Amount: $1,952,008
Funding Source: CGIAR-GCP

Name of PI receiving leveraged funds: Jeff Ehlers
Description of leveraged Project: : Improving Drought Phenotyping in Cowpea
Dollar Amount: $243,811
Funding Source: CGIAR-GCP

Name of PI receiving leveraged funds: Jeff Ehlers
Description of leveraged Project: Evaluation of UCR SNP Cowpea Genotyping Platform for Fingerprinting Wild Cowpea
Dollar Amount: $30,000
Funding Source: USDA
Name of PI receiving leveraged funds: Phillip Roberts
Description of leveraged Project: California Blackeye varietal improvement
Dollar Amount: $19,960
Funding Source: CalDBAB

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. Ndiaga Cisse was promoted as director of the ISRA/CNRA Bambey Research Station in 2009.

Following are descriptive statements concerning leveraged funding awards:
California Dry Bean Advisory Board and its Blackeye Varietal Council (funds currently and typically set at $18,000 – 20,000 per year) funded for cowpea breeding in
California. This is a continuing, longterm research arrangement in support of the UC Riverside cowpea breeding program.

The CGIAR Generation Challenge Program (GCP) Tropical Legumes I Project funded for 3 years (May 2007-April 2010) with expectation for extension of funded research (4-year extension for Phase 2 of project being applied for). The cowpea component of this project is lead by UC Riverside (Ehlers, Roberts, and Close) and includes collaborative funded cowpea breeding and research with the cowpea breeding programs in Burkina Faso (with PI I. Drabo), Cameroon (PI O. Boukar) and Senegal (PI N. Cisse), and IITA (PI, C. Fatokun and O. Boukar). This project funded at nearly $1.9M is developing cowpea genomic resources, including cDNAs, BACs, ESTs and SNP genotyping for genetic and physical mapping, and development of high-throughput marker genotyping for major traits. Traits targeted are insect resistance, especially flower Thrips, nematode and disease resistance, and drought and heat tolerance. The more upstream genomics and marker work funded under this project provides an excellent leveraging for CRSP activities described here to be used for more application (downstream) breeding.

A second GCP project funded to UC Riverside (Ehlers, Roberts, and Close) for $450,000 (January 2008 to December 2010), focuses on development of phenotyping protocols for cowpea drought tolerance, with work in the West Africa partner countries, California and Texas. This provides direct leveraging opportunities for the drought tolerance efforts.

A Southwest Consortium on Plant Genetics and Water Resources project (funded via USDA-CSREES) for $30,000 per year for two years was recently approved for 2010 and 2011 to develop a virus-induced gene silencing (VIGS) system for gene functional analysis in cowpea. Target test traits are drought tolerance candidate genes, although the system when established will be valuable for analysis of other important trait determinants.

The Pulse CRSP funds will also be leveraged with opportunity funds within the Host Countries via NGOs and national sources through presentation of the CRSP effort and the associated opportunities for participatory funding.

At INERA, for our cowpea work we are getting: - $30 000 from GCP/TL1 project (Improving tropical legume productivity for marginal environments in sub-Saharan Africa) and $22420 from GCP commissioned project for cowpea drought resistance.

At ISRA, support for the amount of 2500 USD was received from the Network of farmers organization (RESOPP) which EWA has help established. A Memorandum of Understanding was signed between RESOPP-EWA and ISRA for the production of 50 kg each of Melakh and Yacine foundation seeds. The program is established to last five years. The Kirkhouse Trust has started supporting from June 2009 activities on marker assisted backcrossing for Striga resistance. 20,000 USD will be provided annually for 3 years.

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 (Certified Seed producers).

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 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	Brown	Seed production and on-farm evaluations
ISRA2065	ISRA	ISRA	White	Final on-farm evaluation, Breeder and Foundation seed increase

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

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	Increased 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	Macrophomina
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, indicating status following advancement in 2008 and 2009.

Recurrent Parent Line	**Trait donor (non-recurrent) parent**	**Trait being introgressed**	**Current Generation (October 2009)**
CB5	CB27	Fusarium wilt	BC2F6
CB46	UCR 03-11-747	Green grain	BC4F8
CB46	IT84S-2049	Root-knot nematodes	BC6F7
CB46	Montiero (Brazil)	Large grain size	BC3F8
CB46	Bambey 21(Senegal)	All-white grain	BC4F8
CB46	IT97K-556-6 & UCR 779	Aphid resistance	BC1F5
CB46	IT93K-2046	Lygus resistance	BC3F7

Table 6. Crosses made and advanced to F3-F4 generation that will provide progenies for selection of drought and pest tolerant cultivars.

Cross	Type	Current Status (October 2009)
SuVita2/Mouride	Elite Drought Tol. x Elite Drought Tol.	F3 – F4 in field at CVARS now
IT93K-503-1/IT84S-2246	Elite Drought Tol. x Elite Drought Tol.	F4 at CVARS
Mouride /IT84S-2246	Elite Drought Tol. x Elite Drought Tol.	F4 at CVARS
IT97K-499-39/IT93K-503-1	Elite Drought Tol. x Elite Drought Tol.	F3 – F4 in CVARS now
IT97K-503-1/IT97K-556-6	Elite Drought Tol. x Elite Drought Tol.	F3 – F4 in field at CVARS now
Mouride/Apagbaala	Elite Drought x Elite Heat Tolerant	F3 – F4 in field at CVARS now
KVx61-1/Mouride	Elite x Elite Drought Tolerant	F3 – F4 in field at CVARS now
IT93K-503-1/UCR 779	Elite Drought Tolerant x Drought Tolerant and aphid resistant landrace	F3 – F4 in field at CVARS now
Apagbaala/IT82E-18	Elite Heat Tolerant x Elite	F3 – F4 in field at CVARS now
IT97K-819-45/Ein El Ghazal	Elite x Elite Drought Tolerant	F3 – F4 in field at CVARS now
Ein El Ghazal/KVx544-6-151	Elite Drought Tolerant x Elite	F3 – F4 in field at CVARS now
IT98K-558-1/Mouride	Elite x Elite Drought Tolerant	F3 – F4 in field at CVARS now
Apagbaala/IT98K-558-1	Elite Heat Tolerant x Elite	F3 – F4 in field at CVARS now
IT95K-1479/Mouride	Elite x Elite Drought Tolerant	F3 – F4 in field at CVARS now

CVARS – Coachella Valley Agricultural Research Station, Thermal, California desert location off-season nursery.

Literature Cited

Ehlers, J. D., B.L. Sanden, C.A. Frate, A.E. Hall, and P.A. Roberts. 2009. Registration of 'California Blackeye 50' Cowpea. *Journal of Crop Registrations* 3:236-240.

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Sawadogo, A., B. Thio, S. Kiemde, I. Drabo, C. Dabire, J. Ouedraogo, T. R. Mullens, J.D. Ehlers, and P.A. Roberts. 2009. Distribution and prevalence of parasitic nematodes of cowpea (*Vigna unguiculata*) in Burkina Faso. *Journal of Nematology* 41 (1): (In press).

Capacity Building Activities: P1-UCR-1

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)

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: 08/09
Project Completion Date: 06/11
Training Status: Active
Type of CRSP Support (full, partial or indirect): Full (Category 1)

First and Other Given Names: Marti
Last Name: Portorff
Citizenship: US
Gender: Female
Degree: Ph.D.
Discipline: Plant Genetics/Pathology
Host Country Institution to Benefit from Training:
Training Location: UC-Riverside
Supervising CRSP PI: Roberts, Phillip
Start Date: 10/08
Project Completion Date: 09/12
Training Status: Active
Type of CRSP Support (full, partial or indirect): Partial (Category 2b)

Dry Grain Pulses CRSP
Report on the Achievement of "Semi-Annual Indicators of Progress"
(For the Period: April 1, 2009 -- September 30, 2009)

This form should be completed by the U.S. Lead PI and submitted to the MO by October 1, 2009

Project Title: **Modern Cowpea Breeding to Overcome Critical Production Constraints in Africa and the US.**

	Abbreviated name of institutions											
	UCR			ISRA			INERA			IIA		
	Target	Achieved		Target	Achieved		Target	Achieved		Target	Achieved	
Benchmark Indicators by Objectives	10/1/09	Y	N*	10/1/09	Y	N*	10/1/09	Y	N*	10/1/09	Y	N*
	(Tick mark the Yes or No column for identified benchmarks by institution)											
Objective 1 Breeding												
Varietal identification and release	x	x		x	x							
Germplasm assembly and seed increase												
Germplasm Screening												
Varietal candidate screening - Angola										x	x	
Germplasm Development												
Cross Improved varieties												
Make BC1F1 and BC2F1												
Inbreed BC2F1 to BC2F2	x	x										
Make F1 elite x elite												
Advance F1 To F2,												
Develop F3 lines	x	x		x	x		x	x				
Objective 2 -Improve Seed Systems												
Breeder's Seed Production												
Foundation Seed Production												
Certified Seed Producer Training							x	x				
Assess seed system needs - Angola	x		x							x		x
Objective 3 - Training												
MS Training (Breeding) - Angola (Univ. PR) started												
PhD Training (Breeding - HPR) - started												
Training in MAS with SNP-based markers	x	x										
Breeding Guide	x	x										

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

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

Philip A. Roberts

Signature

######
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	1
Number of men	0	0	1	0
Short-term Training: Number of individuals who have received short-term training				
Number of women	0	0	3	3
Number of men	0	0	4	2
Technologies and Policies				
Number of technologies and management practices under research	1	2	13	18
Number of technologies and management practices under field testing	5	5	5	7
Number of technologies and management practices made available for transfer			5	4
Number of policy studies undertaken	0	0	0	0
Beneficiaries:				
Number of rural households benefiting directly	0	0	>2,000	>3,000
Number of agricultural firms/enterprises benefiting	0	0	8	9
Number of producer and/or community-based organizations receiving technical assistance	8	7	10	13
Number of women organizations receiving technical assistance	4	4	6	6
Number of HC partner organizations/institutions benefiting	3	4	3	3
Developmental outcomes:				
Number of additional hectares under improved technologies or management practices	0	0	>11,600	>19,000

Number of public-private sector partnerships formed as a result of USAID assistance 0