BLACKEYE VARIETAL IMPROVEMENT

J.D. Ehlers, A.E. Hall, P.A. Roberts, W.C. Matthews, and B.L. Sanden

SUMMARY

Objectives of the UCR Blackeye Varietal Improvement project are to develop blackeye bean varieties and complementary management methods that increase grower profits through increased yield and grain quality, and decreased production costs. Thirty-two new blackeye breeding lines developed by the UC Riverside blackeye breeding program were evaluated in Preliminary Trials conducted at Kearney and Shafter Research and Extension Centers in 2000. From these trials, seventeen promising breeding lines were identified. Among these are lines UCR 00-515, UCR 00-516, and UCR 00-517 that have high grain yield potential and substantially larger seed size (>24 grams per 100 seed) than CB46 or CB27 (21 and 22 g/100 seeds, respectively in the 2000 Trials). They also have resistance to races 3 and 4 of Fusarium wilt, broad-based resistance to root-knot nematodes, and heat tolerance at flowering. The seed coat of all the selected lines is a brighter white than CB46. Line UCR 00-524 had high grain yields over the two locations and has very large seed with a bright white seed coat. Line UCR 00-CT15 has heat tolerance at flowering and chilling tolerance at emergence, and very large attractive seed. The results from Preliminary Trials 1 and 2 indicate progress is being made in developing new blackeye varieties with high yield potential, broad based resistance to root-knot nematodes and Fusarium wilt, and better seed quality than CB46 and CB27. We also evaluated 84 African x blackeye breeding lines, 8 wild cowpea x blackeye lines and 10 Italian germplasm accessions for resistance to lygus in 4 trials at Kearney. Lines 96-11-27, 96-11-38, 99-8-193, 99-8-260-1, 99-8-260-2, 99-8-279, 99-8-280-1, 99-8-320, 99-8-321 and 99-K2-35-2 were shown to have moderate pod set and/or grain-damage resistance to lygus. We developed 40 blackeye breeding lines with the strong broad-based resistance to root-knot nematodes derived from UCR 430. We observed a recovery-type resistance to cowpea aphid in several African lines, including IT93K-503-1. African x blackeye lines 99-8-209 and 99-8-321 and backcross lines developed from crosses of UCR 5038 and blackeyes also had strong recovery resistance to cowpea aphid. Several hundred selections were made from 1,000 F_3 — F_7 blackeye breeding lines at Riverside, Shafter and Kearney in 2000. These lines are being developed to have improved grain quality, yield potential, resistance to pests, heat tolerance at flowering and chilling tolerance at emergence. Persistent green blackeye breeding lines were developed that resemble California blackeyes in performance. A mild flavored sweet cowpea with 6% sucrose was received from Purdue University via Africa. Normal cowpeas have 2-3% sucrose. Genetic tests indicated that the trait is recessive and simply inherited. The sweet line was crossed and backcrossed to CB27 and CB46 in order to transfer the sweet trait to California blackeyes. Akara is a popular West African food made from cowpea that is a potential fast-food product in the US. Tests with several cowpea and blackeyes varieties conducted at the University of Georgia in 1999 and 2000 indicate that all-white line UCR 97-15-33 is well suited for making this product. We increased seed of this line to about 60 lbs. Six other all-white lines were identified as promising and enough seed of these was bulked for replicated field-testing in 2001.

INTRODUCTION

This project is developing improved blackeye bean varieties and complementary management systems that increase profitability through increased yield and grain quality, and decreased production costs. The specific ongoing objectives of this project include development of varieties with high yield, erect plant type, large grain with low seedcoat cracking that cans well, heat tolerance, and resistance to Fusarium wilt (races 3 and 4), early cut-out , root-knot nematodes, cowpea aphid and lygus bug. Several newer objectives include development of varieties with unique grain quality characteristics that could help expand the languishing markets for this crop, including cowpea varieties with all-white grain that are otherwise very similar in agronomic characteristics to California blackeyes, dry-harvested persistent-green blackeyes that resemble fresh-shelled blackeyes after soaking in water for several hours, and sweet blackeyes that have higher levels of sucrose and milder taste than normal blackeyes. Sweet blackeyes, with a sweeter and milder flavor, could help to expand consumption beyond the existing regional market of the southeastern US.

Progress continues to be made in breeding lygus resistant blackeyes. Lygus resistant blackeye varieties may become very important in the near future to maintain high bean quality and yield levels. Restrictions on the use of currently available insecticides are likely to increase, and few new insecticides for minor crops such as blackeyes may be available due to the high cost of pesticide registration.

STATUS OF THE NEW VARIETY CB27

California Blackeye No. 27 (CB27), which was developed by the UCR breeding program, was released as a new variety by the California Crop Improvement Association in 1999. A full description of the variety appeared in our 1999 Annual Report to the California Drybean Board and in the journal Crop Science (Crop Sci. (2000) 40: 854-855). Briefly, CB27 is an erect, compact blackeye that has seed with similar size and a brighter white seedcoat and less rounded appearance than CB46. CB27 has heat tolerance and broader-based resistance to Fusarium wilt and root-knot nematodes than CB46 (see Table 1). This is the first new blackeye variety available to California growers since the release of CB46 and CB88 about ten years ago. Plant Variety Protection (PVP) Title V was granted in 2000. With PVP Title V protection, only Certified Seed of this variety can be sold. A royalty of $0.04 per pound of Certified seed will be charged to in-state growers and a royalty of $0.20 per pound of Certified seed will be charged to out-of-state growers and for the home-garden seed trade. Growers will be able to save enough seed for their own plantings from year to year without royalty charges.

About 3,000 lbs of CB27 Foundation seed was produced at UC Davis in 1999 under the supervision of California Crop Improvement Association. This field was not rigorously rouged in part because lygus damage to floral buds and the consequent vegetative vigor of the crop made it difficult to detect off-type plants during the growing season. Several types of off-type seed were observed in the lot after harvesting. Concern was raised prior to planting this Foundation seed for production of Certified seed in 2000 that the purity might not be high enough to achieve Certification, but because of the perceived demand for seed of this variety, it was agreed that an attempt be made to produce Certified seed from this lot of Foundation seed. The Foundation Seed was planted in a grower s field near Shafter.

We visited the field in August 2000 and observed many off-types plants. From the seed and plant types that were observed, it was clear that substantial out-crossing had occurred during an increase of breeder s seed at UCR in 1998. Seed from this planting did not meet the standards necessary for Certification.

TABLE 1: Pedigree*, Resistance/Tolerance Features of CB5, CB27, CB46, and Selected Promising New Breeding Lines Developed at UCR and Included in the 2000 Preliminary Trials

	FUSARIUM WILT		ROOT-KNOT NEMATODES			TOLERANCE		
			M. INCOGNITA					
ENTRY	RACE 3	RACE 4	AVIRUL	VIRULENT	*M .JAVANICA*	HEAT	CHILL	PEDIGREE
CB5	No	No	Yes	No	No	No	No	Calif. Blackeye/Iron// Calif. Blackeye^3
CB46	Yes	No	Yes	No	No	No	No	CB5/PI166146// CB5
CB27	Yes	Yes	Yes	Yes	Yes	Yes	No	(CB5/CB3)//[(Prima/ TVu4552)/UCD7977
PRELIM. 1								
UCR 00-541	Yes	Yes	Yes	Yes	Yes+	Yes	no	UCD9259//[(BES125/ UCD3589)/H8-8-9N]
UCR 00-516	Yes	Yes	Yes	Yes	Yes	Yes	No	CB27/UCD 9345
UCR 00-539	Yes	No	Yes	Yes	Yes	Yes	No	UCD90151//[(CB88/ Bambey21//CB88)/H8-14-N]
UCR 00-517	Yes	Yes	Yes	Yes	Yes+	Yes	No	CB27/UCD 9345
UCR 00-515	Yes	Yes	Yes	Yes	Yes	Yes	No	CB27/UCD 9345
UCR 00-509	Yes	Yes	Yes	Yes	Yes	Yes	No	(BES125/H8-9)/H8-8-9N
UCR 00-526	Yes	Yes	Yes	Yes	Yes+	No	No	CB27/UCD 9345
UCR 00-537	Yes	No	Yes	Yes	Yes	Yes	No	CB27/UCD 9345
UCR 00-520	Yes	Yes	Yes	Yes	Yes+	No	No	CB27/UCD 9345
PRELIM. 2								
UCR 00-524	Yes	Part.	Yes	No	No	Yes	No	CB27/UCD 9345
UCR 00-521	Yes	Part.	Yes	No	Less gall	No	No	CB27/UCD 9345
UCR 00-540	Yes	No	Yes	No	No	Yes	No	CB27/UCD 9345
UCR CT 15	Yes	No	Yes	No	No	Yes	Yes	[(Prima/TVu4552)/CB5]/ UCD7977//CB5
UCR 00-525	Yes	No	Yes	No	Less gall	No	No	CB27/UCD 9345
UCR CT 13	Yes	No	Yes	No	No	Yes	Yes	[(Prima/TVu4552)/CB5]/ UCD7977//CB5
UCR 00-514	Yes	Part.	Yes	No	Less gall	No	No	CB27/UCD 9345
UCR CT 25	Yes	No	Yes	No	No	Yes	Yes	[(Prima/TVu4552)/CB5]/ UCD7977//CB5

* Pedigree of UCD 7977 is CB5//CB5/PI166146.
avirul. = avirulent, effectively controlled by gene *Rk*
virulent = not effectively controlled by gene *Rk* alone
Yes+ = less root galling than CB27
Less gall = less galling than CB46, similar in galling to CB27 at Kearney *M. javanica* site in 2000.

About 12,000 lbs. of Foundation Seed was produced in 2000 at UC Shafter Research and Extension Center for production of Certified Seed in 2001. This field was planted from 300 lbs of purified breeders seed produced at UCR in 1999 that was initially derived from greenhouse grown single plants that had each been screened for resistance to aggressive strains of *M. incognita*. The Foundation seed field was carefully rogued by trained personnel and inspected and we did not observe any off-type seeds. As there will be no Registered seed class of CB27, Certified seed of CB27 should be available to growers in 2002.

We produced 1,000 lbs of Breeders seed of CB27 in an isolated field at UC Riverside in 2000. J. Ehlers and A. E. Hall rogued this field several times in mid-season. A sufficient amount of this breeder s seed will be provided to Foundation Seed Service for the production of Foundation seed in 2001.

Performance of Breeding Lines in Preliminary Trials

Thirty-two new blackeye breeding lines developed by the UC Riverside blackeye breeding program were evaluated in Preliminary Trials conducted at the Kearney and Shafter Research and Extension Centers in 2000. Because of the large number of entries, two trials each with 16 entries and CB46 and CB27 were conducted at each location. This year was the first time these entries had been tested in replicated yield plots. They represent new blackeye lines bred for combinations of desirable traits, including large seed size, resistance to Races 3 and 4 of Fusarium wilt, broad-based resistance to root-knot nematodes, heat tolerance at flowering and chilling tolerance at emergence. The pedigrees, resistances/tolerances of a subset of these lines that were selected for possible further testing are given in Table 1. Note that six of the promising lines have a resistance profile equivalent to CB27, that is, they possess broad-based resistance to root-knot nematodes and Fusarium wilt and heat tolerance. Three of the lines have chilling tolerance at emergence and heat tolerance (Table 1).

Each Preliminary Trial had three replications arranged in randomized complete blocks. All of the trials used a single-row, 30 bed system. Plots consisted of four rows, 20 feet long, with the center two rows being cut and threshed for yield determination. All of the trials were planted in late May and grown to accumulate two pod flushes with season durations of 113 days at Shafter and 118 days at Kearney (Table 2). Temik applied at layby before row closure was used to control pests. Temperatures during flowering in July were hot enough to cause damage to floral buds of heat-susceptible lines, and temperature-induced suppression of floral buds was observed on these lines.

The trials at Shafter had excellent stands and grew vigorously but suffered a form of cut-out toward the end of the season. The crop was cut on Sept. 15 and threshed on Oct. 17. At Kearney, stands and growth were excellent throughout the season. About 1 week after cutting on Sept. 19 at Kearney, approximately 1 of rain fell. This reduced grain quality slightly, but the crop dried satisfactorily and was threshed on Oct. 19.

Summary of Results of Preliminary Trial 1

Lines UCR 00-515, UCR 00-516, and UCR 00-517 have high grain yield potential and substantially larger seed size (>24 grams per 100 seed) than CB46 or CB27 (21 and 22 g/100 seeds, respectively) (Table 2) as well as heat tolerance, and broad-based resistance to root-knot nematodes and Fusarium wilt (Table 1). Lines UCR 00-539 and UCR 00-509 also have heat tolerance, broad-based resistance to root-knot nematodes and Fusarium wilt and high yield potential, but their seed is medium sized (22 and 23 g/100 seeds, respectively) similar to CB27 (22 g/100 seeds). The seed coat of all five lines is a brighter white than CB46, and the shape of the seed of these varieties is slightly elongated, similar to CB27. Line UCR 00-541 appears to have exceptional yield potential. This line produced the highest grain yields at both Kearney and Shafter (Table 2). At both locations, the yields were significantly higher than CB46 and CB27. UCR 00-541 is also heat tolerant and has broad based resistance to root-knot nematodes and Fusarium wilt. The individual seed size of this line is similar to CB46 (Table 2), but we have observed that the seed of this variety is occasionally blemished with a darkened patch on the seed coat. Because of this blemishing, UCR 00-541 may only be useful as a parent in the breeding program.

TABLE 2: Grain yields and individual seed weight of entries of the 2000 Preliminary Trials.

	SHAFTER	KEARNEY	MEAN	SHAFTER	KEARNEY	MEAN
	LB/AC			G/100 SEEDS		
UCR 00-541	4400	5470	4940	20.1	21.2	20.7
UCR 00-516	4200	4550	4380	24.3	24.2	24.3
UCR 00-539	4310	4370	4340	21.7	22.6	22.2
UCR 00-517	3850	4520	4190	24.3	24.5	24.4
UCR 00-515	4140	4080	4110	23.8	24.3	24.1
CB46	3780	4320	7080	20.0	21.4	20.7
UCR 00-509	4100	3990	4050	22.0	23.1	22.5
CB27	**3220**	**4080**	**3650**	**21.9**	**22.7**	**22.3**
UCR 00-526	3490	3790	3640	20.3	20.3	20.3
UCR 00-537	3880	3380	3630	23.6	24.9	24.2
UCR 00-520	**2950**	**4130**	**3510**	**20.4**	**22.2**	**21.3**
LSD (0.05)	**620**	**840**	**500**	**0.6**	**0.8**	**0.5**
CV (%)	**9**	**12**	**11**	**1.7**	**2.1**	**1.9**
PRELIM. TRIAL 2						
UCR 00-524	3650	5290	4470	25.4	26.3	25.9
UCR 00-521	3720	4450	4090	21.3	22.9	22.1
UCR 00-540	3450	4540	3990	22.7	23.1	22.9
CB46	3670	4270	3970	20.4	21.0	20.7
UCR CT-15	3300	4530	3910	25.2	26.4	25.8
CB27	3500	4200	3850	22.2	22.7	22.4
UCR 00-525	3140	3750	3450	22.2	23.0	22.6
UCR CT-13	2755	4130	3440	25.0	25.6	25.3
UCR 00-514	3120	3590	3350	21.3	21.4	21.4
UCR CT-25	2850	3480	3160	24.0	25.6	24.8
LSD (0.05)	**909**	**1221**	**734**	**1.2**	**1.5**	**0.9**
CV (%)	**16**	**17**	**17**	**3.0**	**3.6**	**3.3**

Kearney planted May 25, cut Sept. 19 (118 days)
Shafter planted May 26, cut Sept. 15 (113 days)

SUMMARY OF PRELIMINARY TRIAL 2

Line UCR 00-524 has very large seed with a bright white seed coat. It had high grain yields over the two locations, but especially at Kearney (Table 2). This line has a resistance profile similar to CB46 (Table 1), except that it is heat tolerant, while CB46 is not. Line UCR 00-CT15 has resistance to root-knot nematodes and Fusarium wilt the same as CB46 and equivalent yield potential. However, this line is superior to CB46 because it has heat tolerance at flowering and chilling tolerance at emergence, and very large attractive seed. The results from Preliminary Trials 1 and 2 indicate progress is being made in developing new blackeye varieties with high yield potential, broad based resistance to root-knot nematodes and Fusarium wilt, and better seed quality than CB46 and CB27.

Developing Lygus Resistant Blackeyes

Our strategy for developing lygus resistant blackeyes is to screen a large number of accessions and breeding lines that we are developing, attempting to find resistance that is strong enough to be practically useful to growers. At the first stage of the screening process, a large number of lines are grown with few replications in unprotected field nurseries with frequently placed check plots of CB46. The accessions or breeding lines are evaluated visually for ability to flower and set pods, and for level of lygus-damaged seed. This approach is used because of the large number of entries being evaluated, most of whom will be susceptible and discarded. Once a potential resistant line is identified in these initial screens, we attempt to confirm and quantify the resistance in more intensive field evaluations, such as the replicated yield trials described below that have protected and unprotected treatments.

Each year we also obtain new cowpea germplasm for screening from international and national institutes in Africa and other places. The accessions are first grown in a greenhouse to eliminate the possibility of introducing seed-borne viruses. Then they are screened in the field under unprotected conditions for the ability to flower, set pods, and produce seed with little lygus-induced feeding damage. In 2000, several large lygus resistance trials and screening nurseries were planted at Kearney and Riverside.

At Kearney in 2000, we conducted four trials to evaluate progress in breeding for lygus resistance. Lygus Trial 1 evaluated eight lines under lygus protected and unprotected conditions. In Trials 2, 3, and 4 a total of 94 breeding lines were evaluated under unprotected conditions. In Trial 2, 18 lines (including ten Italian germplasm lines, 6 breeding lines developed from crosses between blackeyes x African cowpea lines, and CB46 and CB27 were evaluated in an unprotected nursery with four replicates that was planted May 25th. Experiment 3 had 57 blackeye x African cowpea breeding lines and four replicates, whereas Experiment 4 had 19 breeding lines and two replicates.

We invited Purdue University entomologist Richard L. Shade to help us evaluate our work on Lygus resistance, and he was able to visit us from Sept. 19-23, 2000, and evaluated our lygus resistance trials at the Kearney Research and Extension Center on Sept. 21st and 22nd.

Lygus Trial 1-Protected vs. Unprotected Replicated Yield Trial

Lygus Trial 1 had protected vs. unprotected treatments with eight entries that included CB46, one African x Blackeye line, and six wild x cultivated lines. We compared the grain yield and lygus-induced seed damage of these lines at Kearney. The seven breeding lines were chosen based on their performance in similar trials or from protected/unprotected trials or unprotected screening nurseries conducted in 1998 and 1999 at Kearney or Riverside. The trials were planted on May 25 and cut on Sept. 19th.

There were no significant differences in yield loss due to lygus among the entries tested (Table 3). However, several lines with relatively low losses due to lygus in previous years also had relatively low losses in 2000 compared to CB46. For example, wild x cultivated breeding line 96-11-27 had lygus caused yield losses of 14% and 13%, while CB46 had losses of 27 and 29% in 1999 and 2000, respectively.

TABLE 3: Protected and unprotected grain yield, yield loss due to lygus and percent damaged seed under unprotected conditions of CB46 and African x blackeye or wild x cultivated cowpea lines at Kearney in 2000 (Lygus Trial 1).

LINE	TYPE*	GRAIN YIELD		PERCENT LYGUS SEED		SEED SIZE	SEED COLOR/ * PATTERN*
		PROTECTED	UNPROTECTED	YIELD LOSS	DAMAGED SEED	G/100 SEEDS	
		LB/AC	LB/AC	%	%		
96-11-27	WxCA	2780	2430	13	12	15	B-W/ Holstein
96-11-38	WxCA	2660	2220	16	16	22	B-W/ Holstein
96-11-29	WxCA	2600	2100	19	16	15	B-W/ Holstein
99-8-232	AfxCA	3180	2530	20	20	21	Browneye
IT95M-43	WxCA	2442	1810	25	7	13	Brown
96-11-30	WxCA	2070	1550	26	14	15	B-W/ Holstein
96-11-37	WxCA	2750	2040	26	23	17	Blackeye
CB46	CA	4010	2950	27	22	21	Blackeye
Mean		2810	2200	21	16	17	
LSD (0.05)		295	278	NS	7	3	
CV (%)		11	16	35	32	4	

* WxC; WxCA = breeding line developed from wild cowpea x blackeye cross
** B-W/Holstein = black pigment covers about 75% of surface area on white background.

Significant differences were observed among the lines for percentage of lygus damaged seed in the unprotected plots. IT95M-43, a wild x cultivated line developed at the International Institute of Tropical Agriculture (IITA) had the least damaged seed (7%); CB46 had 22% of its seeds damaged by lygus (Table 3). Line 96-11-27 also had low seed damage due to lygus (12% damaged seed). Line 96-11-27 was evaluated along with CB46 in a similar trials conducted in 1999. In 1999, line 96-11-27 had 6 percent damaged seed, compared to 14 percent damaged seed for CB46. This line appears to possess a moderate level of seed damage resistance to lygus. Crosses have been made between this line and California blackeyes in order to develop larger seeded, blackeye lines with this resistance. Even a moderate level of protection should help improve overall grain quality under many production conditions.

SCREENING OF BREEDING LINES DEVELOPED FROM BLACKEYE X AFRICAN COWPEA HYBRIDS

History of the lines: In 1998, thirteen F_3 lines (out of 280) derived from crosses involving CB46 or CB27 and exotic African cowpea lines IT93K-273-2-1, IT92KD-370, IT86D-716, IT93K-129, or IT93K-2046 had been observed to have high pod set scores in an unprotected, lygus infested field at Kearney. Thirty-six single-plant selections were made from these lines and grown in an off-season nursery in Coachella during the spring of 1999. Several selections were made within each line to give a total of 120 F_5 lines. Thirty-three of the 36 F_4 families had enough seed for planting a screening nursery at Riverside in May. The 120 F_5 lines were evaluated in an unprotected two replicate nursery at Kearney, planted on July 2, and in a single replicate nursery at UCR that was planted on July 8. All of the nurseries had check rows of CB46 planted every fourth plot.

Both the early-planted F_4 and the late-planted F_5 tests at Riverside in 1999 did not experience sufficient lygus pressure for very effective evaluation of resistance, but careful notes on budding and flowering time were made. Selections were made between and within F_5 families based on agronomic type, seed quality, and podding intensity at UCR and all the seed of six lines was bulked for lygus resistance evaluation conducted in 2000 (see Lygus Trial 2 below). The F_5 lines in the late-planted Kearney trial in 1999 experienced a devastating aphid infestation that prevented collection of useful data on lygus damage, but interesting observations were made on cowpea aphid resistance in this set of lines (see Aphid Screening at Kearney section). The 80 selections that were made were advanced in the greenhouse during the winter to provide sufficient seed for replicated trials in 2000. In 2000 these lines were planted in one of four lygus screening trials at Kearney, depending on the availability of seed.

LYGUS TRIAL 2.

Trial 2 included six of the above African x blackeye lines, plus ten lines from an Italian germplasm collection that were identified in 1999 as potentially resistant, plus one African parental line, and CB46 and CB27. Trial 2 was unprotected from lygus, and had four replicates of two row plots that were 20 feet long. The trial was planted May 25th using bulked seed from the 1999 screening nursery at UCR as noted above. Richard L. Shade evaluated this trial for podset on Sept. 21, 2000. Two lines, 99-8-320 and 99-8-321, had podset scores significantly higher than CB46 and CB27 (Table 4). None of the Italian lines had high pod scores, indicating that the evaluations in 1999, based on single replicate evaluations, were not reliable.

TABLE 4. Average Pod Set Scores (0-9 scale; 9=full apparent podset) of Ten Italian Germplasm Lines (designated by UCR prefix), Six African x Blackeye Breeding Lines, Two African Parental Lines, and CB46 and CB27 over 4 reps (Lygus Trial 2).

LINE	MEAN	TYP/ORIGIN	RELATED LINE AND PODSET SCORE IN LYGUS TRIAL 3 OR 4
CB46	5.8	Variety/UCD	
CB27	3.0	Variety/UCR	
IT92K-370	5.7	African breeding line/IITA Nigeria	
IT93K-2046	3.8	African breeding line/IITA Nigeria	
99-8-320	7.3	African x blackeye line/UCR	
99-8-321	7.0	African x blackeye line/UCR	99-8-321-2=7.3 99-8-321-1=5.0 (Trial 4)
99-8-338	4.8	African x blackeye line/UCR	99-8-338-2=4.8 99-8-338-1=6.0 (Trial 4)
UCR 5494	5.8	Accession/Italy	
99-8-209	5.8	African x blackeye line/UCR	99-8-209-1=5.8 99-8-209-2=4.8 99-8-209-3=3.8
UCR 5372	5.3	Accession/Italy	
99-8-228	8.0	African x blackeye line/UCR	99-8-228-1=3.0 (Trial 4)
UCR 5373	4.8	Accession/Italy	
UCR 5376	4.5	Accession/Italy	
99-8-241	4.3	African x blackeye line/UCR	99-8-241-1=4.3 99-8-241-3=4.0 (Trial 4)
UCR 5377	4.0	Accession/Italy	
UCR 5375	4.0	Accession/Italy	
UCR 5404	3.3	Accession/Italy	
UCR 5400	3.0	Accession/Italy	
UCR 5362	2.5	Accession/Italy	
UCR 5399	1.3	Accession/Italy	
LSD (0.05)	1.3		
CV (%)	15		

Lygus Trials 3 and 4

We evaluated 57 lines developed from crosses between African and California blackeye lines (with CB27 and IT93K-2046 as checks) in Trial 3. This trial, planted June 25th, had two row plots, 20 in length and four replicates. Another 19 entries was planted at the same time using similar sized 2 row plots but had only 2 replicates due to insufficient seed (Trial 4). Richard Shade and Jeff Ehlers evaluated these trials jointly for podset on Sept. 22, 2000.

Lines 99-8-193, 99-8-260-1, 99-8-260-2, 99-8-279, 99-8-280-1, 99-8-320, and 99-8-321-2 had average pod set scores significantly greater than CB27 (Table 5). Of these, 99-8-260-1, 99-8-260-2 and 99-8-280-1 had high unprotected grain yields, roughly equivalent to CB27, and significantly lower seed damage due to lygus (Table 5). Line 99-8-279 had low yields but also had the lowest seed damage due to lygus.

Table 5: Average pod set scores (0-9 scale; 9=full apparent pod set), unprotected grain yields, and seed damage of the eight highest scoring African x blackeye breeding lines (out of 57 total lines), and CB27 over 4 reps (Lygus Trial 3).

Line	Pod Set	Yield	Lygus Damaged Grain	Seed Weight
		lb/ac	%	g/100 seeds
CB27	5.0	1530	30	25
99-8-280-1	7.8	1800	15	20
99-8-193	7.3	1160	26	24
99-8-321-2	7.3	1400	20	20
99-8-279	7.3	1250	9	18
99-8-260-1	7.0	1550	18	18
99-8-260-2	7.0	1690	22	18
99-8-281	6.8	1300	14	18
99-K2-217	6.8	1340	16	23
LSD(0.05)	1.1	NS	7	2
CV(%)	11	30	26	7

In Lygus Trial 4, line 99-K2-35-3 had a pod set score of 7.00 and unprotected yield of 1740 lb/ac compared to a pod set score of 5.5 and unprotected yield of 1530 lb/ac for CB46. However, 99-K2-35-3 had 28% of its seed damaged by lygus, compared to 30% for CB27

It was encouraging to note that both 99-8-321 and 99-8-321-2 (developed from a single plant selection from 99-8-321) had high podset scores in Lygus Trials 2 and 3 respectively (Tables 4 and 5). In general, there was very good consistency of podset scores between related lines in Lygus Trials 2 and 3, despite a months difference in planting date, suggesting a certain robustness of the results (Table 4).

Screening and Development of Breeding Lines Using Wild Cowpea Germplasm

Wild cowpeas are a potential source of insect resistance genes, but are themselves difficult to evaluate for resistance to lygus because of their photoperiod sensitivity, slow growth and development, and morphological characteristics that differ substantially from blackeyes. We have developed breeding lines derived from three-way crosses between blackeyes and wild cowpeas [(wild cowpea x blackeye) x blackeye] that are similar to blackeyes and continue to screen these for lygus resistance. Several of these lines have a moderate level of lygus resistance and several of these lines were backcrossed to blackeyes in 1999.

Hybrids were made between CB27 and CB46 and lygus resistant wild x cultivated lines 96-11-27, 96-11-29, 96-11-38 and eight wild cowpea (*Vigna unguiculata* ssp. *dekintiana* var. *rhomboidiae*) lines in 1999. F_2 seed of these crosses was planted during the spring 2000 at the Coachella Valley Agricultural Research Station and selections made in June. About 90 F_3 selections were planted at UCR under unprotected conditions and 38 selections made for further evaluation in 2001. It should be possible to develop advanced breeding lines with both resistance to lygus and blackeye agronomic characteristics using selection within and between these lines.

We evaluated 32 and 10 lines at UCR and Kearney, respectively, from wild x cultivated crosses made at the International Institute of Tropical Agriculture (IITA) and possess resistance to flower thrips. Another 28 and 7 lines were evaluated at UCR and Kearney, respectively, that were developed at UCR from early generation progenies of crosses between cultivated cowpeas and *Vigna unguiculata* ssp *dekintiana* var. *rhomboidiae* wild cowpeas received from IITA. We made 50 selections from the wild x cultivated lines evaluated at UCR. These will be re-evaluated in 2001.\

NEW POTENTIAL SOURCES OF RESISTANCE SCREENED OTHERS WERE RECEIVED AND MULTIPLIED

At Kearney, we screened 113 new cowpea breeding lines from the International Institute of Tropical Agriculture (IITA) under unprotected conditions. Only one line, IT84S-2135, appeared to have some level of resistance.

In July, 2000, we received a new set of 100 cowpea lines from the breeding program of IITA, including 20 lines that have shown resistance to insects in Africa and are entries of a insect resistance no-spray Cowpea International Trial. To ensure viruses are not introduced into California, the lines were planted in a greenhouse during the late summer and the seed successfully multiplied for lygus resistance screening in 2001.

DEVELOPMENT OF BLACKEYES WITH UNIQUE GRAIN TYPES TO EXPAND MARKETS

Blackeye productivity (sacks/acre) in California has doubled in the last 40 years thanks to improved farming practices and new varieties, but total blackeye production in the state has remained static and per capita consumption in the US has declined significantly during this period, despite marketing efforts to boost sales. Varieties with new grain types but having similar agronomic and yield potential as California blackeye varieties, could help in the development of new products and markets for California blackeye growers.

DEVELOPMENT OF ALL-WHITE COWPEAS FOR VALUE-ADDED PRODUCTS.

Cowpea is processed into many traditional West African foods, such as akara , that are delicious yet virtually unknown outside this region. Such foods could find wide acceptance by US consumers as snack or convenience foods or fast-foods . Akara is similar to a hush puppy but with a lighter texture. It is usually seasoned with chile pepper and other species and is very tasty. Traditionally akara is prepared from cowpeas that are soaked, dehulled, and milled wet. If the milled product is not used immediately, expensive or laborious drying or refrigeration is necessary for its preservation. Dry milling of whole grain cowpea would be much more efficient than wet milling and produce an easily storable product. This would make possible the development of ready to cook cowpea flour mixes for akara production or for use in other products such as bean chips, or as protein-rich supplements for breads or other cereal products. Unlike blackeyes, an all-white cowpea would produce a all-white flour that would be preferred for most products. Cowpea batters have several unique properties of interest to food scientists, including the ability to retain air when whipped.

All-white lines have been developed at UCR that are very similar to California blackeyes in terms of their agronomic type and yield potential. Should a market develop for cowpea flour or other products where the presence of a dark-pigmented eye is a disadvantage, this line will be ready to fill this need. In early 1999, a sample of grain of all-white line 97-15-33 was sent to the University of Georgia as part of a comparative study of different cowpeas for suitability in making akara . Akara is a popular West African food made from cowpea that is a potential fast-food product in the US. Tests with several cowpea and blackeyes varieties conducted at the University of Georgia in 1999 and 2000 indicate that all-white line UCR 97-15-33 is well suited for making this product. The pedigree of this line is [(Bambey 21/CB88//CB88)/ H8-8-3]/UCD 90151.

In 2000, we evaluated 90 large white F_6 to F_8 breeding lines at UCR. Sixty-four single plant selections were made and six lines were bulked so as to obtain enough seed of these lines for replicated yield tests to be conducted in 2001. The pedigree of the six lines is [[(Bambey 21/CB88//CB88)/ H8-8-3]/UCD 90151]/CB46.

DRY OR PERSISTENT-GREEN BLACKEYES.

The UC Riverside program is developing persistent-green California blackeye-type varieties for potential use in the frozen products. The grain of these varieties resembles fresh-shell blackeyes after soaking in water for several hours. Because the green color bleaches to white after prolonged expose to sunlight in the field, double-flush production practices, wherein growers accumulate two flushes of pods over 120 to 140 days, will not be possible. In other aspects, however, production, harvesting and storage practices would be as for traditional blackeye cowpeas that are now produced in California. The development of cowpea cultivars with a persistent green seed color has been the subject of considerable interest among food processors, especially freezers, because the grain of such cultivars can be harvested at the dry seed stage of maturity without loss of their green color. The retention of the green color is important because the choice of harvesting method for frozen cowpeas is often a compromise between cost and product quality. Harvesting dry cowpeas can be done efficiently and with minimal losses compared to mechanized harvest of mature-green cowpeas. Also, the crop does not need to be processed immediately and may be stored until it is convenient to freeze it. Several hours prior to freezing, the precise amount of grain needed would be soaked in water. This product would have low production and storage costs similar to other dry-grain legume crops yet the product would be used in high-priced vegetable-type applications. Compared to other frozen vegetable products that are harvested fresh and have high production, harvesting and storage costs, the relatively low costs of rehydrated cowpeas should encourage processors to use this ingredient in frozen vegetable blends and other applications. The market potential could be significant, especially if marketing efforts are made in nontraditional cowpea eating regions. Traditionally, because of proximity to market and the nature of fresh-frozen product, this industry was located in the southeastern US. However, with the advent of dry harvesting, California would be a more favorable production environment for this product because we can produce a much higher quality dry grain product due to lower insect pressure and lower rainfall and humidity than the southeastern US.

Several new persistent-green cowpea varieties, including Bettergreen and Charleston Greenpack , have recently been developed by the USDA Vegetable Laboratory in Charleston, SC that are adapted to the southeastern US. However, in California, they can be expected to yield substantially less than California blackeyes. The persistent green trait revolutionized the lima bean industry, and the quick acceptance of the green cotyledon cowpea cultivars Bettergreen and Charleston Greenpack by the freezing industry in the southeastern US indicates that the trait could have a significant impact on the cowpea industry in California as most processing horticultural cultivars are now harvested at the dry seed stage of maturity. Two recessive genes, *gc* for green cotyledon, and *gt* for green testae (seedcoat) condition a deep green color while the presence of one or another of these genes results in a light green color. Apparently, these genes prevent the normal breakdown of chlorophyll that occurs as seeds reach maturity. Dry persistent-green grain that we have stored in sacks out of sunlight has retained its green color for more than two years. Apparently there are no negative effects of this trait on yield or other agronomic characters. Advanced persistent-green breeding lines have been developed at UCR after two cycles of backcrossing to California blackeyes. These will be ready for yield testing in multi-location trials in 2002.

THE SWEET TRAIT TO IMPROVE THE FLAVOR AND MARKETABILITY OF BLACKEYES.

Breeding line 24-125B is a sweet tasting cowpea developed by the breeding program of the Research Institute for Agricultural Development (IRAD)/Purdue University Bean/Cowpea Collaborative Research Program (CRSP) that is based in Maroua, Cameroon. Cameroonian farmers who had been brought to the IRAD/Purdue University CRSP project plots as part of a farmer assisted selection process noted that this breeding line tasted sweet or good . For over three years, Cameroonian farmers consistently chose this line as one of their favorites. Subsequent analysis of the sugar content of dry seeds of this line by Purdue University researchers revealed that this line has a sugar content of about 6% compared to sugar content of about 2% for normal cowpea varieties. Purdue researchers also conducted a triangular taste panel test in the U.S. comparing cooked samples of 24-125B with its non-sweet sister line 24-125A. In this test, two samples of the non-sweet line 24-125A and one sample of the sweet line were placed before a panelist. The tasters, who were generally unfamiliar with cowpeas, chose the sweet cowpea over its non-sweet sister line more than 80% of the time. Unfortunately, line 24-125B is photoperiod sensitive (will not flower during the long days of summer), and has unattractive small seed. The sweet trait is being rapidly bred at UC Riverside into cultivars adapted to California. With crossing to CB27, which has higher than normal sugar content (at about 3%), and with selective breeding it may be possible to develop blackeyes with even higher sugar content that is present in line 24-125B.

The discovery of the sweet trait opens up the possibility of developing new products and markets for California blackeyes . One possibility is the development of sweet versions of blackeyes. Another possibility is the development of new green + sweet market classes. One type might resemble garden peas having grains that are sweet, round-shaped and persistent-green in color. These may be used in frozen vegetable regional/ethnic (southern, oriental) blends. Sweet line 24-125B has been crossed to CB27, CB46 and to advanced persistent green breeding lines. F_1 and F_2 data collected thus far indicates that sweetness is completely recessive and likely to be simply inherited. As such, it should be straightforward to breed this trait into California blackeyes. Following an additional cycle of backcrossing to blackeyes and crosses of the sweet line to persistent green breeding lines, we will develop adapted sweet and sweet-green cowpeas for consumer evaluation and agronomic testing.

DEVELOPMENT OF NEW BLACKEYE GERMPLASM

Progress continues to be made towards the development of varieties with a combination of high yield, erect plant type, large grain, heat tolerance at flowering and chilling tolerance at emergence, resistance to early cut-out and broad-based resistance to root-knot nematodes and races 3 and 4 of Fusarium wilt.

In 2000, we identified promising blackeye lines from an evaluation of 100 F_6 and F_7 lines that were grown in one or two-row observation plots at Kearney, Shafter and Riverside. Single plant selections were made from these lines based on visual assessment of seed quality and agronomic characteristics. Other advanced generation progenies were evaluated for resistance to early cut-out in a field that typically exhibits early cut-out and selections were made. Selected lines may be bulked in 2001 for replicated yield tests in 2002.

We also evaluated and made selections from more than 1000 F_3—F_5 progeny rows at Riverside and Kearney in 2000. Parents of these breeding lines were chosen for their complimentary characteristics consistent with the objectives of our breeding program. A special effort has been made to select for attractive large seed with strong, non-cracking and bright white seedcoats, and progress was made in this area.

Breeding varieties that achieve high yield levels in fewer days by producing one large flush can make substantial increases in efficiency. Plantings of CB46 can be harvested 95 days after an early planting in May with yields up to 30-35 sacks/ac. A second flush of pods producing an additional of 20 sacks/ac can be obtained by allowing the crop to grow about 40 days more, if the crop does not cut-out . A ten-day to two week sleep period proceeds the second pod flush. This wastes valuable season at a time when growing conditions are favorable. We are developing blackeyes that should be able to yield 50 sacks/ac in 120 days. These varieties would flower about one week later than CB46 and produce a single large and extended pod flush.

INCORPORATING BROAD-BASED NEMATODE RESISTANCE INTO BLACKEYES.

Varietal resistance to nematodes is the only control strategy that is economically feasible for blackeyes. Resistant varieties reduce damage to the crop itself and are valuable as components of crop rotations because they can reduce nematode populations in the soil.

In 2000, the breeding program continued to select improved blackeyes that have the strong broad-based nematode resistance gene (Rk^2) from the African cowpea accession UCR 430 (IT84S-2049). Dr. Phil Roberts identified this important source of resistance several years ago as a result of work funded by the Blackeye Council. In our 1999 report, we detailed the origin and development of breeding lines being developed with the UCR 430 form of resistance. In the spring of 2000, we evaluated 60 F_6 families for resistance to nematodes in growth pouches. Thirty-nine families appeared to be fixed for resistance, while 6 were segregating and 15 were fixed for susceptibility. Resistant individuals from segregating families were propagated from the pouches in the greenhouse, and then planted in the field at UCR or during a late summer planting at Coachella. Remnant seed of the fixed F_6 families was planted in breeding nurseries at UCR, Kearney and Shafter in May for further evaluation and selection. Promising F_7 families will be bulked to obtain sufficient seed for yield testing in 2002 and evaluated in the field for resistance to *M. javanica*. It should be possible to develop a new blackeye variety with the UCR 430 type nematode resistance from these selections following several seasons of replicated multi-location testing (see P.A. Roberts et al. report in this volume also).

We also evaluated another 60 advanced blackeye breeding lines for resistance to *M. javanica* in the field by visually rating root galling at Kearney. These progenies were also planted in the breeding nurseries at Shafter, Kearney and Riverside for agronomic evaluation and selection. They were developed from crosses in which CB27 was crossed to other blackeye lines with *Rk*-type resistance as is found in CB46. Twenty of the lines were rated as having nematode resistance equal or better than CB27 (see P.A. Roberts et al. report in this volume).

DEVELOPMENT OF NEW BREEDING LINES WITH UCR 430 RESISTANCE

Large-seeded breeding lines 98-8-622-1 and 98-8-622-2 have resistance to root-knot nematodes derived from UCR 430. They were developed from a cross of N294 and cut-out resistant breeding line UCR 58, and also have resistance to races 3 and 4 of Fusarium wilt, and resistance to early cut-out. In 1999, crosses were made between CB27 or CB46 and breeding lines 98-8-622-1 or 98-8-622-1 and F_2 seed produced in the greenhouse. During the spring of 2000, the F_2 seed was planted at CVARS and 65 selections made. These F_3 families were planted in a field that exhibits strong early cut-out at UCR during the summer of 2000. Forty-four selections were made based on resistance to early cut-out, seed quality and agronomic characteristics. Cultivars could be developed from these early generation lines that have the unique combination of large, bright white seed, resistance to early cut-out, broad-based resistance to root-knot nematodes (derived from UCR 430) and Fusarium wilt, heat tolerance, and high yield that are needed for a new variety for California.

TRANSFER OF APHID RESISTANCE INTO BLACKEYES

Seedling and field screening in 1996 led to the identification of UCR 5038 as a source of strong resistance to cowpea aphid. This accession is a cultigroup *sesquipedialis* (yardlong) type of cowpea with small red seeds and will require several backcrosses to California blackeyes to obtain a variety that combines this aphid resistance with the agronomic traits of California blackeyes. In 1997 we made crosses between UCR 5038, and CB46 and H8-8-27, backcrossed the F_1 s to California blackeyes, screened the BC_1F_1 s and completed a second round of this procedure to obtain resistant BC_2F_1 plants. We continued this backcrossing procedure in 1998 and completed two cycles of backcrossing. After the last backcross was made, the resulting plants were screened and two of the most resistant plants were allowed to self. Twenty-five BC_3F_2 plants were grown greenhouse during the spring of 1999 and allowed to self to produce 25 BC_3F_3 lines. These lines were planted in an unprotected aphid resistance-screening nursery at Riverside with two replicates per line. Aphid pressure was light early in the season so to create an infestation, one completely infested branch of CB46 was placed at the beginning of each row. Despite this heavy inoculation, many parts of the field remained free of aphids. Scoring of the nursery was done by noting which lines did not allow establishment of aphids. Single plant selections were made from the lines in which the aphids did not become established and these were evaluated in aphid resistance nurseries at Kearney and UCR in 2000.

APHID SCREENING NURSERY AT KEARNEY IN 2000

We evaluated 10 of the backcross lines described above that were derived from crosses with UCR 5038, six lygus resistant breeding lines that had showed strong resistance to aphids in a 1999 lygus trial at Kearney, seven African accessions, along with CB27, IT93K-2046 and UCR 5038 as controls. This nursery became heavily infested with cowpea aphid about 30 days after planting. We scored the initial infestation level and recovery potential of each line on a score of 0-5. All lines became heavily infested, but distinct differences in the ability to recover and fend -off the attack was seen (Table 6). African breeding line IT93K-503-1, followed by African x blackeye breeding lines 99-8-209 and 99-8-321 and African breeding line IT93K-2046 had strong recovery and could possess an inducible form of resistance. These lines will be re-evaluated in large replicated plots in 2001.

TABLE 6: Initial cowpea aphid damage and regrowth from infestation scores from the 2000 aphid-screening nursery at Kearney. Lines considered to have a useful level of resistance are in bold.

ENTRY	INITIAL	REGROWTH	FINAL RECOVERY	
CB27	4	1	1	
UCR 5038	**4**	**3**	**4**	**(Parent/Yardlong Accession)**
IT93K-2046	**4**	**3**	**5**	**(IITA Accession)**
IT93K-503-1	**4**	**4**	**5**	**(IITA Accession)**
IT93KD-425-1	4	0	2	(IITA Accession)
IT89KD-288	4	2	4	(IITA Accession)
IT93KD-425-1	4	0	1	(IITA Accession)
IT92KD-370	4	1	2	(IITA Accession)
UCR 730	4	2	4	(Botswana Accession)
UCR 779	**4**	**3**	**4**	**(Botswana Accession)**
UCR 1340	**4**	**2**	**4**	**(India Accession)**
Melakh	5	0	0	(Senegal Accession)
98-8-13-1	5	0	1	(Backcross line with UCR 5038 source)
99-8-13-2	4	1	2	(Backcross line with UCR 5038 source)
99-8-13-3	4	1	2	(Backcross line with UCR 5038 source)
99-8-15-1	3	2	2	(Backcross line with UCR 5038 source)
99-8-15-2	4	2	4	(Backcross line with UCR 5038 source)
99-8-33-1	4	1	2	(Backcross line with UCR 5038 source)
99-8-43-1	4	2	4	(Backcross line with UCR 5038 source)
SpCV 8-1	3	0	0	(Backcross line with UCR 5038 source)
SpCV 8-2	**4**	**3**	**4**	**(Backcross line with UCR 5038 source)**
SpCV 12-1	**4**	**3**	**4**	**(Backcross line with UCR 5038 source)**
99-8-209	**4**	**3**	**5**	**(Blackeye x IITA lygus resistant line)**
99-8-228	4	0	0	(Blackeye x IITA lygus resistant line)
99-8-241	4	2	2	(Blackeye x IITA lygus resistant line)
99-8-320	4	2	5	(Blackeye x IITA lygus resistant line)
99-8-321	**4**	**3**	**5**	**(Blackeye x IITA lygus resistant line)**
99-8-338	4	2	2	(Blackeye x IITA lygus resistant line)

(Initial damage-5=dead, 0- no damage; regrowth-5=nearly fully recovered, 0= no recovery).

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