UC Davis Grain Legume Improvement and Statewide Support Activities

2014-2015 Progress Report to the California Dry Bean Board

Lima Bean Breeding

Palkovic Antonia, Dohle Sarah, Gamiño Laura, Berny Jorge, Khuu Ninh, Mora Vanessa, Sison Karla, Long Rachael, Gepts Paul.

The Bean Breeding group at UC Davis is working in parallel to: 1.) Breed improved lima bean varieties for California growers; and 2.) Gain knowledge of lima bean genetics to expedite future breeding efforts. Our current focus is on increasing *Lygus* and nematode tolerance in both the large and the baby lima bean market classes. Given the 50% budget cut sustained by the Bean Breeding project for 2014-2015, we have focused mainly in lima beans on completing the selection of an improved Bush Large Lima variety, and initiating the development new lima bean varieties for the future, in the Baby and Large Lima classes.

Summary of 2014 Lima Bean Breeding Projects

1. Second year of field testing of Steve Temple's advanced Bush Large Lima (BLL) lines for *Lygus* tolerance and seed quality.
2. Seed increase of 9 of Steve Temple's advanced Bush Large Lima (BLL) lines to move towards the release of at least 1 new line in 2015-2016.
3. Field evaluation of *Lygus* tolerance in 23 varieties from the International Center of Tropical Agriculture (CIAT). *Lygus* resistant varieties are being crossed with California varieties to improve *Lygus* tolerance while maintaining good agronomic characteristics.
4. Field planting of backcross lines for *Lygus* and nematode resistance in large and baby lima bean varieties.
5. Field evaluation of Recombinant Inbred Lines (RILs) from parents UC 92 and UC Haskell to gain a better understanding of the genetic base of *Lygus* tolerance.
6. Additional activities.

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1. ***Lygus* Tolerance Yield Trials of Advanced Bush Large Limas** (funded by CDBAB, NSF, and UC Davis Plant Sciences) (A. Palkovic, S. Dohle, L. Gamiño, K. Sison, V. Mora, N. Khuu, and J. Berny)

The second year of a *Lygus* tolerance trial was planted at UC Davis Agronomy Field Headquarters to evaluate the *Lygus* tolerance of 12 advanced lines of bush large limas from Steve Temple's breeding program. The 12 advanced lines were planted along with 4 check varieties (Dopme 95, UC Haskell, UC 92, and 459-1). In 2014, we followed the same planting scheme as in 2013, planting entries in 20 foot, two-row plots with 30 inch spacing between rows using a randomized complete block design with four replicates and two treatments. In the 'No Spray' treatment block, the planting was not sprayed with any insecticides in order to allow *Lygus* pressure to build up in the plots. In the 'Spray' treatment block, the plants were sprayed twice for *Lygus* over the course of the field season. The first insecticide application was Warrior II on July 15, 2014 at a rate of 3.5oz/acre. The second insecticide application was Dimethoate 2.67, which was applied at a rate of 1pt/acre on August 20, 2014.

Harvest yields from each plot were weighed to evaluate whether any of the advanced lines appeared to have natural *Lygus*-tolerance. In the coming months, we also plan to visually evaluate a sub-sample of mature seeds from each of the plots for evidence of *Lygus* damage such as dimpling of the seed coat and/or discoloration of the seed due to *Lygus* stings.

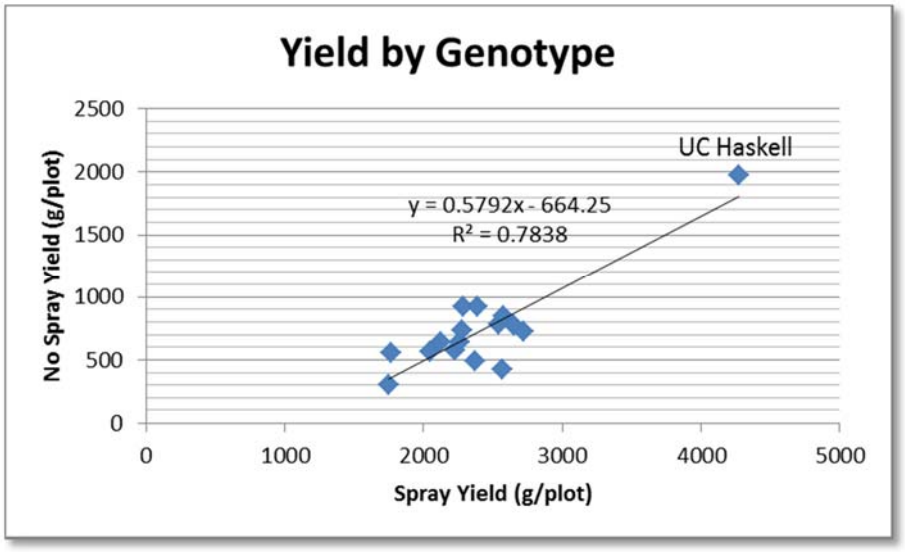
From an analysis of variance test performed on the 2014 harvest weights, there was no significant difference in yield amongst any of the BLL entries or checks, with the exception of the UC Haskell check, which, as a baby vine type, yielded significantly higher than any of the BLL genotypes.

Effect Tests					
Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Insecticide treatment	1	1	88152944	519.233	**<.0001**
Lima bean line	15	15	24919649	9.7853	**<.0001**
Line*treatment	15	15	2681130	1.0528	**0.4104**

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Ratio	
Model	31	119540893	3856158	22.7133	
Error	95	16128653	169775		Prob > F
C. Total	126	135669546			**<.0001**

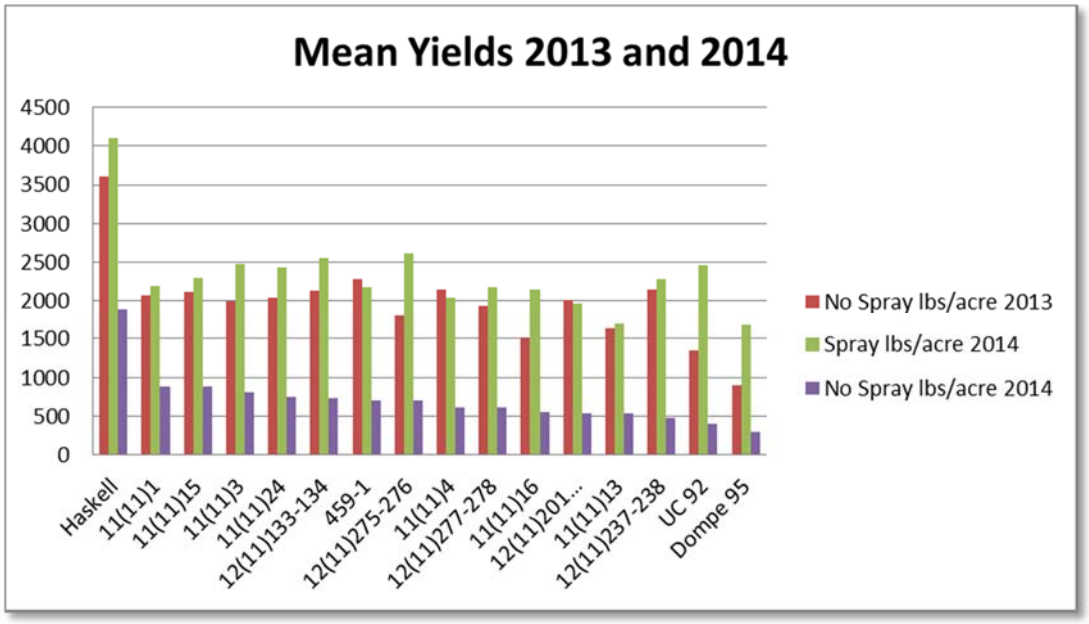
Mean Yield by Treatment in 2014			
Treatment	Least Sq Mean yields (g/plot)	Std Error	Mean
No Spray	741	52	732
Spray	2426	52	2437

Mean Yield by Genotype in 2014			
Genotype	L S Means (g/plot)	Std Error (g/plot)	LSMeans (lbs/acre)
Check: Haskell	3124	145	3000
12(11)275-276	1724	145	1656
11(11)3	1712	178	1644
12(11)133-134	1711	145	1643
11(11)24	1658	145	1592
11(11)15	1652	145	1586
11(11)1	1602	145	1538
Check: 459-1	1504	145	1444
Check: UC 92	1493	145	1434
12(11)277-278	1448	145	1391
12(11)237-238	1430	145	1374
11(11)16	1401	145	1345
11(11)4	1382	145	1327
12(11)201…	1305	145	1253
11(11)13	1163	132	1117
Check: Dompe 95	1029	157	988



This is consistent with past observations that UC Haskell has tolerance to *Lygus* (see our 2013-2014 report: Figure 1, p. 6). Our continued work on the UC Haskell – UC 92 Recombinant Inbred Line population (see Section 5) should eventually enable us to find a genetic locus that may explain UC Haskell's apparent tolerance to *Lygus* and we may then incorporate that genetic information into selecting new resistant varieties of BLL.

As can be seen in the graph below, insecticide treatments had a significant, positive effect on yield of all lines tested in 2014.



From the bar graph, we can also see that yields of last year's unsprayed plots were much higher than those from this year, but in 2013 we had no 'Spray' treatment. However, *Lygus* pressure was worse in general in 2014 compared to 2013.

2. Seed Increase of Advanced Bush Large Limas at UC Davis Agronomy Field Headquarters (funded by CDBAB, NSF, and UC Davis Plant Sciences) (A. Palkovic, S. Dohle)

We continue to evaluate advanced Bush Large Lima lines for high yield and *Lygus* tolerance while simultaneously increasing the seed stocks of promising lines in order to streamline the process of getting new varieties on the market. Our goal is to release one BLL line in 2015-2016, based on the accumulated data for yield (Westley, UC Davis), *Lygus* (UC Davis), and nematode (Kearney Agricultural Center; see 2013-2014 report: Table 7, p. 10). With this goal in mind in 2014, we increased our seed stocks of 9 of the most promising BLL lines from Steve Temple's breeding program. The seed increase was planted on about a half-acre of ground at UCD Agronomy Field Headquarters using a precision Monosem planter. All lines were planted in 270' strips of 4 rows creating one block, with the exception of 11(11)24 and 11(11)3, which were only planted in 2 rows each due to a shortage of seed. These 9 lines were planted on May 23rd and 24th, 2014, and were harvested between September 30th and October 16th 2014. The weights listed below represent the seed we now have in storage from this seed increase, which has not yet been picked for dirt or stones.

Bulk seed weights of advanced lines of Bush Large Lima seed increase in 2014

	Amount of breeder's seed available		Yield[#]	
Line Name	lbs	kgs	Lbs/acre	Kg/ha
11(11)24	74*	33*	2467	2763
11(11)15	118	54	1967	2203
12(11)277-278	124	56	2067	2315
12(11)201…	120	55	2000	2240
11(11)3	68*	31*	2267	2539
11(11)16	144	65	2400	2688
12(11)237-238	146	66	2433	2725
12(11)275-276	150	68	2500	2800
11(11)13	108	49	1800	2016

[#] From single, unreplicated plots, and harvested over a long window of time (indicative only)

* Production from 2 rows, whereas other entries were grown on 4 rows

3. Broadening the genetic basis of California lima bean cultivars: Evaluation of new germplasm from the CIAT Collection for *Lygus* Seed-damage Tolerance, year 2 (funded by CDBAB, NSF, and UC Davis Plant Sciences) (A. Palkovic, S. Dohle, N. Khuu)

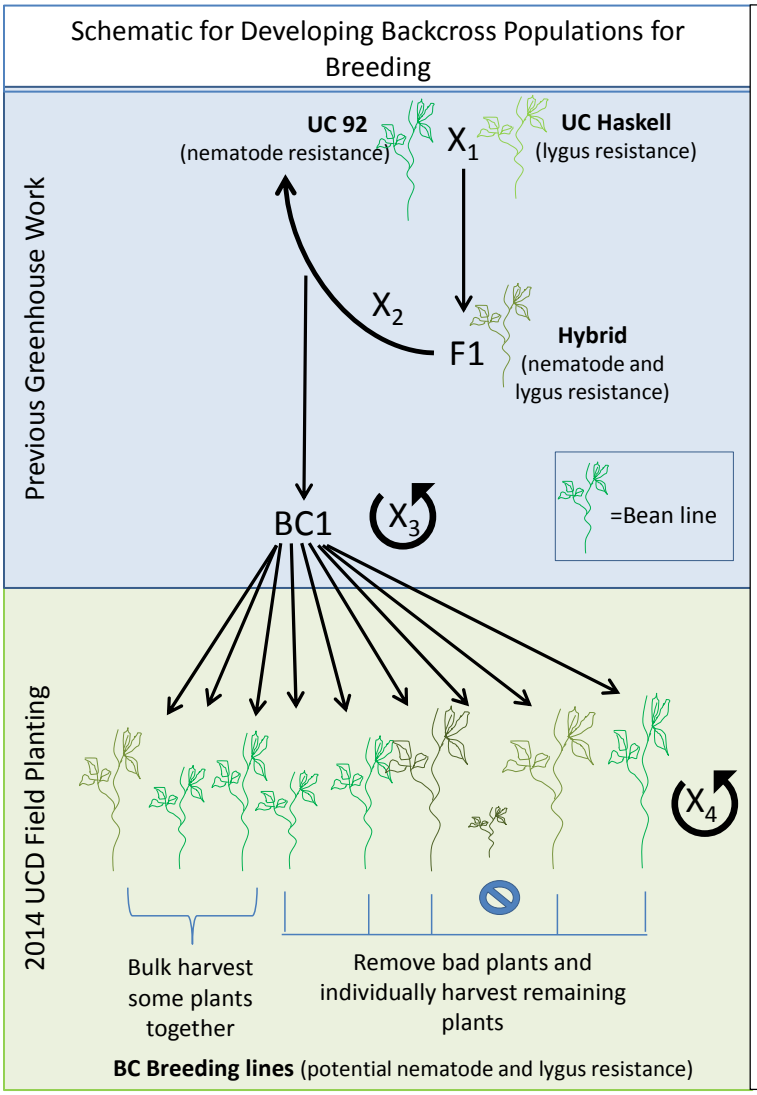
Of the 250 Lima lines that were obtained from the Lima Bean World Collection housed at CIAT in Cali, Colombia in 2012, 26 lines produced seed at UC Davis in 2012. These 26 lines were increased again in 2013, and in 2014, we had enough seed to plant 23 lines in the field for further *Lygus* tolerance evaluation. The 23 CIAT lines were planted in four replicates with four checks and two treatments (Sprayed against *Lygus* and Not Sprayed). The harvested seed from the 2014 season has not yet been evaluated for *Lygus* tolerance, but *Lygus* damage to the seeds will be visually evaluated and seed appearance will be assessed and compared to last year's results within the next few months before the May 2015 planting.

In addition, four F1 hybrid lines from greenhouse crosses between California cultivars and CIAT lines were planted this summer in order to evaluate plant spacing for making breeding selections in the field as well as to advance a generation of seeds when greenhouse space was limited. The F2 seeds harvested from this planting will be evaluated in summer 2015 and the best progenies may be backcrossed to California lines to increase their similarity to California varieties while adding pest tolerance or other agronomic traits of interest.

Crosses between California lima bean cultivars and adapted, introduced lima bean lines			
Female Parent	Male Parent	Origin of Male Parent	Description of Male parent
UC Haskell	G25290A	Guatemala	Cream and black seed, climbing habit
UC92	G25290A	Guatemala	Cream and black seed, climbing habit
UC92	G25626 (Hopi15)	USA	White rounded seed, climbing habit
UC92	G27360	Mexico	White and Black rounded seed, climbing habit

4. **Developing backcross (BC) lines for breeding program (funded by CDBAB, NSF, UC Davis Plant Sciences) (S. Dohle, N. Khuu)**

The objective of creating backcross (BC) lines for breeding is to add traits of interest to already improved varieties of beans while maintaining their high yield and seed quality. Backcrossing involves doing additional rounds of crosses or mating to an original parent. This enables us to increase the amount of similarities the new varieties will have to the former elite lines plus adds new traits like *Lygus* and nematode tolerance.



X_1 California lines were crossed to each other creating F1 hybrid seeds that contain 50% of their DNA from each parent.

X_2 The F1 plants were crossed back to the female parent. This created backcross (BC) seeds with ~75% female parent DNA and ~25% male parent DNA.

X_3 The BC seeds, planted in the greenhouse, self-fertilize. Each seed has a unique combination of parental DNA.

X_4 The seeds of these BC greenhouse plants were planted in the UCD fields in the summer of 2014 and self-fertilized for another generation.

Summer 2014: Low performing plants were discarded. About 250 plants were harvested individually and the remainder was bulk harvested with the family they were planted with.

In the summer of 2014, we planted six 250' rows of backcross F2 (BC_1F2) lima bean plants. The majority of our backcross populations are between a bush large lima type, UC 92, which has some tolerance to nematodes (*Meloidogyne incognita*, but not *M. javanica*), and a vine baby lima type, UC Haskell, which has tolerance to *Lygus*. Besides being current California varieties, these are also the parents that are being used for our recombinant inbred studies (see section 5). We chose these parents so that our continuing research on molecular marker development

can be directly applied to California adapted varieties. With our backcross populations we are trying to develop new breeding lines of both large and baby seeded types with combined tolerance to both nematode and *Lygus*.

To develop the backcrosses, UC 92 and UC Haskell were crossed and the progeny was verified as being hybrids through molecular marker analysis. Hybrid pollen was then used to backcross to the original parent. The current generation has a lot of variation to choose from to develop future improved varieties. Some of these backcrosses may yield both bush and vine types with both seed classes.

The back cross seeds were planted in the field this year to advance a generation, remove the lowest performing phenotypes from the program and to learn about logistics for advancing breeding populations in the field so we can continue to make our program more efficient.

The backcrossed seeds were planted with 1’ to 5’ between them. At five feet, it is relatively easy to maintain separation between plants for selections but this requires much more field space. Manually separating plants that are planted closer is exceedingly challenging. From our plantings this year we did negative selections and discarded very low yielding plants. Where possible, single plants were harvested and their seeds kept together. This was done for about 250 plants from the UC 92-UC Haskell crosses. These families (progenies) will be planted in summer 2015. They should begin to show more similar characteristics within themselves and more different characteristics between families.

Backcross plants which were too close to harvest separately due to a shortage of time, space and labor, were harvested in bulk with their parent family. These populations have great potential to produce improved lima bean varieties of both market classes for California growers, with the potential for both nematode and *Lygus* tolerance.

5. **Field Evaluation of Recombinant Inbred Lines to Study Lima Bean Genetics (funded by CDBAB, NSF, and UC Davis Plant Sciences) (S. Dohle, A. Palkovic, N. Khuu, K. Sison, V. Mora)**

Figure 1. Graduate student (and leader of the RI population development) Sarah Dohle and undergraduate intern Ninh Khuu during harvest in fall 2014.

Objective: We developed Recombinant Inbred Lines (RILs) for genetic and phenotypic studies of lima beans as an investment to accelerate the future breeding program. RILs are a set of plant lines with unique genetics containing a mix of the two known parental DNAs obtained by cross-breeding. They are used to compare patterns of physical characteristics or traits (phenotypes) of the plants in the field with patterns in their DNA sequence (genotypes). By analyzing these patterns we are able to discover areas of the DNA associated with traits of interest. They can also be replanted in different seasons, years, and locations.

We will use the RILs to focus our field breeding efforts on lines that contain preferable DNA based on genetic analysis done in the lab. Lab analysis is done more rapidly and with fewer resources than field evaluation. This helps us to concentrate our field analysis and resources on lima bean lines with the highest probability of improvement while quickly culling lines which are likely to be low performers. This is the first RIL population of this large a size (n ~ 230) in the world to be developed for lima bean breeding research.

Creating RILs: We created our RIL population using the same parental lines as those that we are using for our backcross breeding lines: UC 92 and UC Haskell (see Section 4). We chose these parents to create the RILs for two important reasons. The parents are adapted California varieties with desirable tolerance traits; the information we learn from their RIL progeny can directly relate to our active breeding program. The parents also have a divergent evolutionary history which gives them different genetic backgrounds. It is important when looking for genetic patterns associated with field traits that there is enough variation in the DNA and in the phenotypes of the plants to make the association clearly identifiable. UC 92 is a Bush Large Lima with tolerance to nematodes (*Meloidogyne incognita* http://www.ipm.ucdavis.edu/PMG/r52200111.html and http://info.ucanr.org/dry_beans/1997/92.pdf) and was bred from Andean lima beans. UC Haskell is a Vine Baby Lima, which has shown *Lygus* tolerance and was bred from Mesoamerican lima beans.

These RILs were made by crossing UC 92 to UC Haskell and then self-fertilizing for 5-6 generations. Reciprocal crosses were made to use both parents as females so that maternally inherited DNA from both parents would be included in this research. To make lines for planting in the summer of 2014, it took three years of advancing generations by self-fertilization in the greenhouse and a seed increase at the USDA winter bean nursery in Puerto Rico to speed up the process (see 2013-2014 Report: Fig. 4, p. 12). We were able to evaluate 230 RILs at UC Davis this year.

2014 Field Planting: The main objective of planting this summer was to evaluate the RILs for *Lygus* tolerance. *Lygus* tolerance is assumed if there is little or no reduction in yield in in the absence of insecticide treatment. In addition to yield, we also tracked other phenotypic traits such as plant growth habits and development.

We hand-planted 1,945 single-row five-foot plots on 30" beds with the help of ten volunteers over two days. We planted 4 replicates of each of the 230 Lima RILs plus the parents and other checks in two sections of the field at UCD. One section received two insecticide treatments for *Lygus*: Warrior II was applied on July 15 at 3.5oz/acre, and Dimethoate 2.67 was applied on August 20 at 1pt/acre. The second section received no insecticide treatments. Netting of *Lygus* was done periodically throughout the season to verify insect pressure.

Post-planting, we tracked germination, flowering time, growth habit, maturity, plant height, inflorescence position and yield. Yield is our most important measure for *Lygus* tolerance. We hypothesize that lines which maintain yield without insecticide spray have some common genetic base for tolerance. There may also be patterns of tolerance associated with plant development such as plant architecture (vine vs. bush) and flowering time, both of which may contribute to more or less hospitable environments for *Lygus*.

Harvesting small plots of lima beans for yield is challenging. It is important to have a thorough harvest and not miss any pods within a plot but also to not have seeds from different plots contaminate each other by being stuck in the harvest equipment. Vine-type plants did not dry down enough in the field despite an application of the defoliant paraquat, to allow for adequate threshing with our small low-contamination bean threshers. For this reason, many of our plots were hand harvested. Plots which were too high yielding for hand harvest were put in large sacks and dried indoors for 1-8 weeks once winter rains began. The bottleneck caused by our current harvesting equipment being ill-suited to harvesting research-sized plots of lima beans may have an effect on yield data because the processing time for all 1,945 plots took three months.

Figure 2. Antonia Palkovic working with a volunteer to bag remaining bean plots for removal before rain.

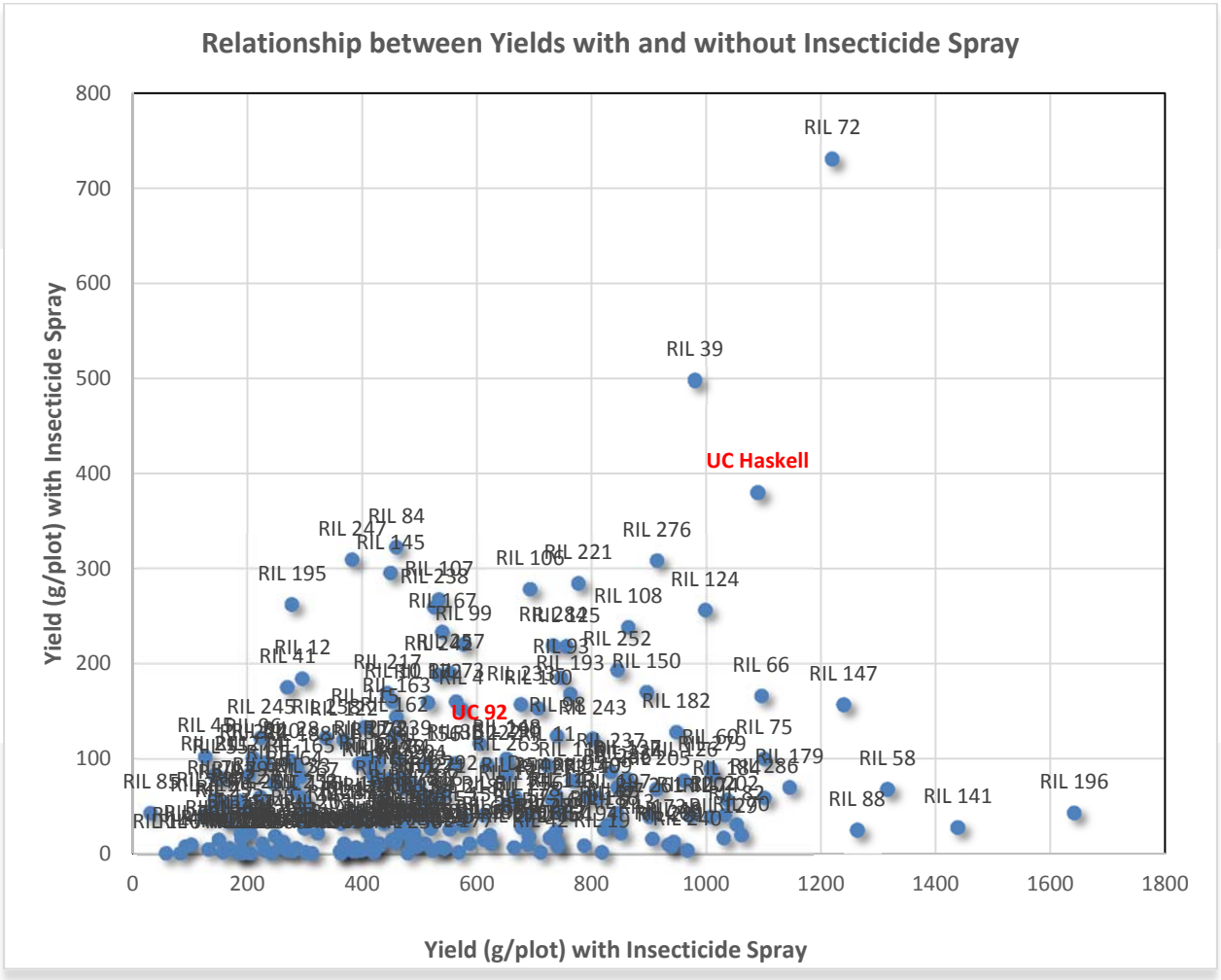
We cleaned the last samples at the end of January 2015 and are currently doing analysis of data. We measured yield of plots and compared lines which were sprayed and not sprayed. Those lines which show less reduction in yield without spray may have inherited some *Lygus* tolerance. We have only done preliminary analysis on our data, but there does appear to be a significant effect on *Lygus* tolerance based on genotype.

Preliminary yield results show a statistically significant relationship between yield and RIL genotype. It is important to keep in mind that this data is only from one season of planting and must be verified by additional plantings, but it looks very promising.

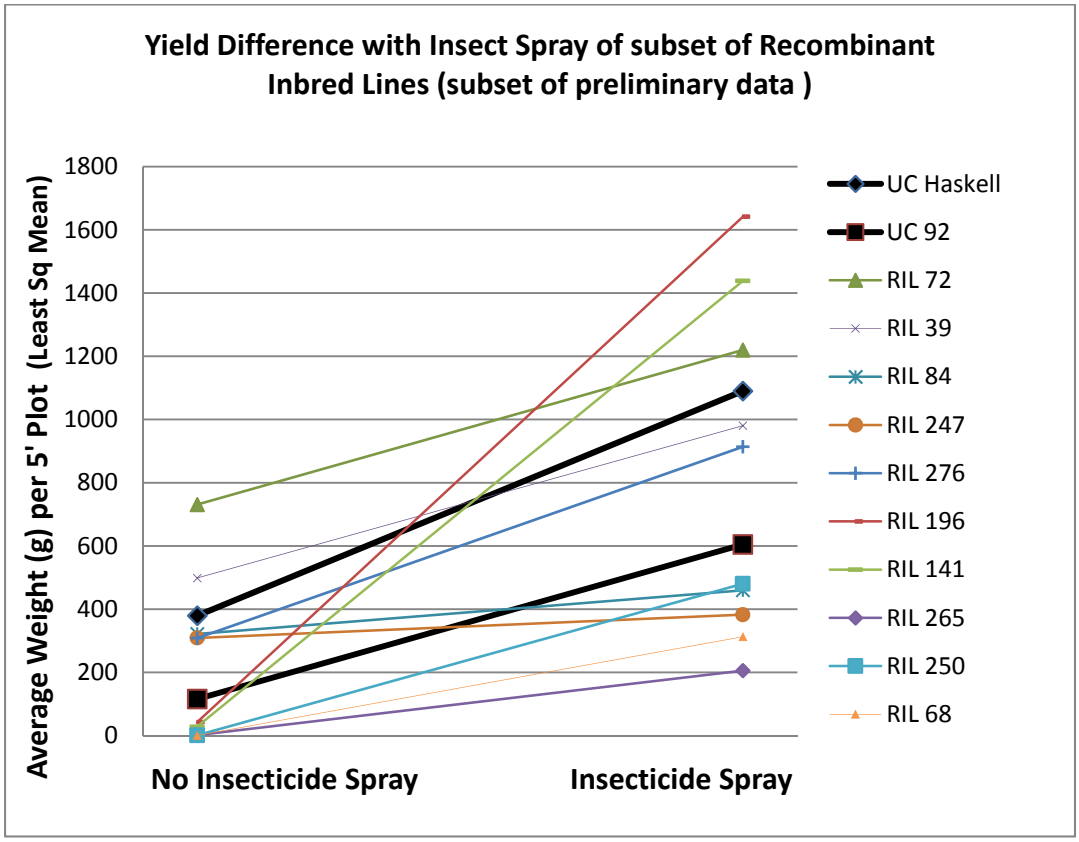
Analysis of Variance					
Source	Degrees of Freedom	Sum of Squares	Mean Square	F Ratio	
Model	459	153755963	334980	14.428	
Error	1032	23960256	23217		Prob > F
C. Total	1491	177716219			**<.0001**

Effect Tests					
Source	Nparm	Degrees of Freedom	Sum of Squares	F Ratio	Prob > F
Treatment: Spray or No Spray	1	1	75406668	3247.865	**<.0001**
RIL/Entry number	229	229	38344478	7.212	**<.0001**
Treatment*RIL/Entry number	229	229	29791456	5.6033	**<.0001**

The ideal RIL for a breeding program is one which combines high yield under low *Lygus* pressure with a minimal reduction in yield under high *Lygus* pressure. The standard to beat is UC Haskell with a yield of 1090 g/plot with insecticide treatment vs. 380 g/plot without (i.e., a reduction of 65%). As shown by the following graph, some RI lines are close to or better than this standard. However, this analysis is the result of a single location and year, and thus will have to be replicated.



The chart below shows data for ten of the 230 lines to demonstrate how yield is generally reduced without insecticide application. However it is evident that some RILs have less of a change in yield than others, which may indicate *Lygus* tolerance. The Bold lines are the parents UC 92 and UC Haskell. Some of the RILs have both higher and lower yields than both parents. This event is known as transgressive segregation when progeny exhibit more extreme phenotypes than the parents. Those RILs which show little or no reduction in yield without spray, even if their maximum yield is not exceptional, may be insect resistant (for example, RIL 247 and RIL 68 in the below graph). We want to find the genetic basis of this resistance and combine this with the high yielding varieties.



Future Work with RILs: We collected leaf tissue from all 230 lines growing in the field. This tissue will be used for DNA extraction (funding pending) and genetic evaluation. Five intact pods were also collected from each plot which can be used to evaluate pod and seed characteristics. Seeds that were harvested this year will be used for a second season of planting and field phenotyping at UCD in 2015 using larger 20-foot plots. Larger plots will allow for more mechanized planting and harvesting than the 5-foot plots permitted, and harvest contamination will be a smaller portion of each plot. Larger plots also have the benefit of being

less sensitive to small variations in environment and management. However, the larger plots will take up approximately 2.5 times more field space next season.

These RILs have the potential to improve our breeding program for years to come. Because UC 92 is one of the parents and has exhibited nematode resistance, this RIL population may be used to study the genetic basis for nematode resistance. In addition to *Lygus* and nematode resistance, these RILs may be used to study other environmental stresses such as drought tolerance, and in general have the ability to aid in streamlining our breeding program for years to come.

Figure 3. Moving the last bags of RIL material to the dryer on January 9th 2015. We finally finished running the bagged plants through our belt thrasher (seen here) on January 22nd, 2015.

6. Additional Activities

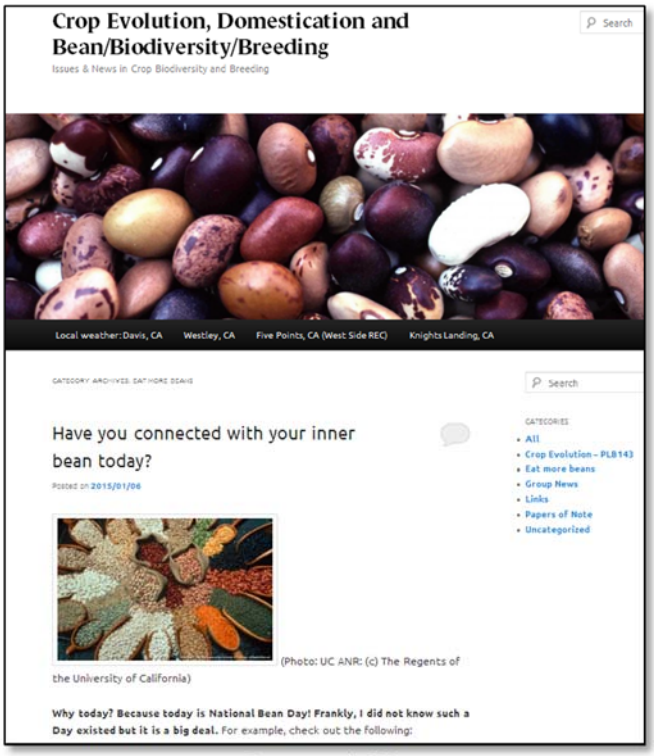
Assistance to UCR team: Assistance was provided to the UCR team for planting at Kearney Agricultural Center.

Bean Blog: UC Davis undergraduate student volunteers, Karla Sison and Vanessa More, created a bean blog to share their experience working with the bean breeding program. They also created a few short bean team videos for public enjoyment. Their Bean Team blog has logged over 800 unique visitors and more than 1,000 views in the approximate four months since they began the blog in September 2014.

- Bean team blog**:** http://beanteam.weebly.com/
- Video about bean field work: https://www.youtube.com/watch?v=jRDuI9dfkTs
- Video about final threshing: https://www.youtube.com/watch?v=WpfVRPq7SPE

Figure 4. Members of the lima bean breeding team. From l to r: Vanessa Mora, Karla Sison, Sarah Dohle, Antonia Palkovic

Group blog: P. Gepts is writing blog entries for the bean breeding group, including news about the breeding group, reports on scientific findings, and summaries of interesting research papers about breeding, in general, and beans, in particular: https://cedb.wordpress.com/



Appendix A. Yeild Results from RILs Section 5: Least Sq. Means Table. Highlighted cells show a reduction in yield without insecticide spray equal to or less than UC Haskell at 65%, which may indicate *Lygus* tolerance.

Line	Yield g/plot Least Sq Mean No Spray	Yield g/plot Least Sq Mean Spray	Std Error No Spray	Std Error Spray	Reduction in Yield No Spray
RIL 2	2	158	88	88	99%
RIL 3	27	520	76	76	95%
RIL 4	152	573	88	88	74%
RIL 5	7	259	152	88	97%
RIL 6	41	612	76	76	93%
RIL 7	1	84	108	76	99%
RIL 10	160	453	76	76	65%
RIL 11	93	723	88	88	87%
RIL 12	184	296	76	76	38%
RIL 14	45	742	76	108	94%
RIL 15	30	576	88	76	95%
RIL 17	52	652	108	88	92%
RIL 18	15	453	76	88	97%
RIL 19	2	818	88	88	100%
RIL 24	19	249	108	76	92%
RIL 25	20	623	152	76	97%
RIL 28	98	276	76	88	64%
RIL 30	57	437	76	88	87%
RIL 32	95	395	76	88	76%
RIL 33	59	296	88	88	80%
RIL 34	80	469	88	108	83%
RIL 35	95	562	88	76	83%
RIL 36	21	466	76	76	95%
RIL 39	498	980	76	76	49%
RIL 41	175	270	88	88	35%
RIL 42	2	711	152	76	100%
RIL 43	68	499	108	88	86%
RIL 44	41	515	88	108	92%
RIL 45	102	127	76	88	19%
RIL 47	31	828	88	76	96%
RIL 48	13	943	76	88	99%
RIL 49	37	160	76	76	77%
RIL 51	74	247	76	88	70%

RIL 53	26	553	76	76	95%
RIL 55	80	153	76	108	48%
RIL 57	28	678	76	76	96%
RIL 58	68	1316	88	88	95%
RIL 60	90	1007	76	76	91%
RIL 61	6	170	152	88	96%
RIL 62	7	258	108	76	97%
RIL 63	14	416	108	76	97%
RIL 64	68	282	76	76	76%
RIL 65	15	613	108	76	98%
RIL 66	166	1096	88	88	85%
RIL 67	10	742	76	76	99%
RIL 68	1	313	108	88	100%
RIL 69	60	223	76	88	73%
RIL 70	20	1061	76	76	98%
RIL 71	57	144	76	88	60%
RIL 72	731	1220	76	88	40%
RIL 73	160	564	88	88	72%
RIL 74	39	1008	88	88	96%
RIL 75	100	1101	76	88	91%
RIL 76	10	103	88	88	90%
RIL 77	18	691	76	88	97%
RIL 78	97	429	88	88	78%
RIL 79	56	187	88	108	70%
RIL 80	5	133	108	76	96%
RIL 82	31	1053	76	88	97%
RIL 83	53	163	76	88	67%
RIL 84	322	460	88	108	30%
RIL 85	43	32	108	88	-35%
RIL 86	7	537	88	76	99%
RIL 87	34	842	76	76	96%
RIL 88	25	1263	76	88	98%
RIL 89	5	405	152	76	99%
RIL 90	6	544	88	76	99%
RIL 93	185	747	108	76	75%
RIL 94	2	421	88	88	100%
RIL 96	101	210	76	76	52%
RIL 98	124	740	76	76	83%
RIL 99	220	577	88	76	62%
RIL 100	153	707	76	76	78%
RIL 102	77	424	88	88	82%
RIL 103	13	263	108	88	95%

RIL 104	22	491	88	76	96%
RIL 105	3	279	76	76	99%
RIL 106	278	693	76	108	60%
RIL 107	267	534	76	108	50%
RIL 108	238	864	76	88	72%
RIL 109	59	811	108	88	93%
RIL 110	6	416	88	108	98%
RIL 112	3	386	88	76	99%
RIL 113	44	748	76	88	94%
RIL 114	9	431	108	76	98%
RIL 115	133	405	76	88	67%
RIL 116	41	304	76	88	86%
RIL 119	77	767	88	88	90%
RIL 120	40	973	76	88	96%
RIL 121	32	438	76	88	93%
RIL 122	120	368	88	76	67%
RIL 124	256	998	76	88	74%
RIL 125	218	756	76	76	71%
RIL 126	77	961	76	152	92%
RIL 127	84	419	76	108	80%
RIL 128	3	184	88	76	98%
RIL 129	17	1030	76	88	98%
RIL 130	11	510	88	88	98%
RIL 131	4	399	88	76	99%
RIL 132	37	476	108	76	92%
RIL 133	8	496	76	108	98%
RIL 134	4	231	88	76	98%
RIL 135	1	363	152	88	100%
RIL 136	15	151	108	108	90%
RIL 137	79	862	76	76	91%
RIL 139	40	498	76	76	92%
RIL 140	1	193	108	88	99%
RIL 141	28	1439	88	76	98%
RIL 142	3	362	76	76	99%
RIL 143	35	387	76	108	91%
RIL 144	27	300	76	76	91%
RIL 145	295	450	108	76	34%
RIL 146	1	59	76	76	98%
RIL 147	157	1239	88	76	87%
RIL 148	100	652	108	88	85%
RIL 149	60	792	76	76	92%
RIL 150	170	896	76	76	81%

RIL 151	22	189	108	88	89%
RIL 154	8	741	76	88	99%
RIL 155	26	468	76	76	94%
RIL 156	93	512	88	108	82%
RIL 159	7	390	76	88	98%
RIL 160	24	738	76	76	97%
RIL 162	124	456	88	76	73%
RIL 163	144	460	88	152	69%
RIL 165	81	293	76	88	72%
RIL 166	1	243	108	108	99%
RIL 167	233	540	88	76	57%
RIL 169	23	410	76	88	94%
RIL 170	79	450	76	76	82%
RIL 172	159	515	108	108	69%
RIL 173	16	906	76	88	98%
RIL 174	22	206	108	76	89%
RIL 175	36	388	76	108	91%
RIL 177	2	569	88	88	100%
RIL 178	35	686	76	76	95%
RIL 179	70	1145	76	88	94%
RIL 180	11	588	76	88	98%
RIL 182	128	948	76	88	87%
RIL 183	6	286	88	76	98%
RIL 184	57	1036	76	88	95%
RIL 186	26	822	76	76	97%
RIL 187	45	136	108	76	67%
RIL 188	93	287	152	108	67%
RIL 191	41	395	76	76	90%
RIL 193	168	763	152	108	78%
RIL 194	9	787	108	88	99%
RIL 195	262	278	88	108	6%
RIL 196	43	1642	88	76	97%
RIL 197	43	844	88	76	95%
RIL 198	11	625	76	76	98%
RIL 199	4	523	88	76	99%
RIL 200	3	388	152	88	99%
RIL 201	39	426	76	76	91%
RIL 202	41	1032	76	88	96%
RIL 203	22	323	88	88	93%
RIL 204	74	487	108	108	85%
RIL 205	68	913	88	108	93%
RIL 206	10	689	76	88	99%

RIL 207	2	365	108	76	99%
RIL 208	8	93	76	88	91%
RIL 209	10	934	76	88	99%
RIL 210	2	193	108	88	99%
RIL 211	83	143	76	108	42%
RIL 213	22	851	76	76	97%
RIL 214	81	429	88	76	81%
RIL 215	20	483	76	76	96%
RIL 216	46	516	88	76	91%
RIL 217	169	444	76	76	62%
RIL 218	38	578	88	76	93%
RIL 219	40	125	76	88	68%
RIL 220	96	232	76	88	59%
RIL 221	284	777	88	76	63%
RIL 222	94	618	88	152	85%
RIL 224	95	211	88	76	55%
RIL 225	7	538	88	76	99%
RIL 226	69	473	76	88	85%
RIL 227	48	197	88	108	76%
RIL 229	11	227	88	76	95%
RIL 233	157	677	108	88	77%
RIL 234	74	864	76	88	91%
RIL 235	11	498	88	88	98%
RIL 236	70	845	76	88	92%
RIL 237	86	833	76	88	90%
RIL 238	259	526	88	76	51%
RIL 239	99	462	76	88	79%
RIL 240	4	967	76	76	100%
RIL 241	4	270	108	108	98%
RIL 242	188	533	88	108	65%
RIL 243	121	802	76	108	85%
RIL 245	122	224	108	76	45%
RIL 246	13	487	88	76	97%
RIL 247	309	383	76	76	19%
RIL 248	16	190	88	108	92%
RIL 249	2	302	108	88	99%
RIL 250	1	480	88	88	100%
RIL 252	193	845	108	88	77%
RIL 253	43	298	108	76	85%
RIL 254	60	667	76	88	91%
RIL 255	34	168	88	76	80%
RIL 256	41	691	88	88	94%

RIL 257	190	554	76	88	66%
RIL 258	122	337	108	76	64%
RIL 259	43	224	108	88	81%
RIL 261	39	901	88	108	96%
RIL 263	83	652	88	76	87%
RIL 265	1	206	152	152	99%
RIL 266	54	508	76	76	89%
RIL 267	55	300	108	88	82%
RIL 270	99	410	76	88	76%
RIL 271	59	522	76	76	89%
RIL 272	7	665	88	76	99%
RIL 273	57	731	76	88	92%
RIL 274	83	203	88	88	59%
RIL 275	17	727	76	76	98%
RIL 276	308	914	76	88	66%
RIL 278	48	472	88	88	90%
RIL 279	83	1010	108	88	92%
RIL 281	8	939	76	76	99%
RIL 283	18	729	88	76	98%
RIL 284	219	733	76	76	70%
RIL 285	12	458	88	108	97%
RIL 286	59	1101	76	88	95%
RIL 287	32	364	76	76	91%
RIL 288	1	186	76	76	99%
RIL 289	5	373	76	76	99%
RIL 290	97	652	76	76	85%
RIL 291	11	369	76	108	97%
RIL 292	63	542	76	88	88%
RIL 294	11	431	108	88	97%
Dompe 95	62	738	23	94	92%
UC 92	116	605	129	55	81%
UC Haskell	380	1090	22	113	65%