Preliminary evaluation of absolute sampling methods for *Lygus*

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Justification and Problem Statement

The western tarnished plant bug is a key pest of cotton in western arid production regions. Populations of lygus bugs are difficult to monitor because adults are active fliers, and nymphs inhabit cryptic habitats and move rapidly when disturbed. Management decisions are complicated by these difficulties. Because the principal management tactic for lygus bugs is chemical pesticides, treatment decisions based on inaccurate sampling data may result in either unnecessary crop loss, or unneeded pesticide applications that my contaminate the environment and induce secondary pests. Considerable effort has been devoted in cotton production regions of the West and Mid-South to evaluate and improve sampling methodology for lygus bugs. However, in recent efforts the criteria for the selection of sampling methods have focused on maximum numbers of bugs collected or apparent precision of population estimates without consideration for the fidelity of those estimates to actual bug populations. Development of efficient and practical absolute or near-absolute sampling methods for one or more stage of lygus would allow more meaningful evaluation and perhaps calibration of relative methods.

Our initial proposal was to evaluate absolute population estimation techniques including caging, whole plant inspections, and plant bagging. However, success in our early efforts at marking, releasing, and recovering adult lygus changed our focus to using this technique to calibrate the sweep net method for adult lygus. The mark-release-recapture technique offers significant advantages over absolute sampling techniques. Among those are the ability to establish bug populations of known density at the crop stages of interest, rather than relying on unpredictable natural populations, and the ability to control the age distribution of the population sampled. Most importantly, the ability to establish lygus populations of known density eliminates the often considerable variation associated with absolute population density estimates. This variation is typically unaccounted for in efforts to calibrate relative sampling methods, but can constitute a substantial source of error in the resulting relationships.

Procedures

Marking and handling of bugs. Marking efforts were intended to meet two criteria, 1) allow unambiguous and rapid identification of released bugs, and 2) eliminate the ability of adult lygus to fly. Previous efforts to similarly mark bugs used Testors paint and were unsuccessful (Wilson et al. 1984). However, Raulston et al. (1998) used fingernail polish to mark and prevent the flight of boll weevil adults in studies to estimate collection efficiency of a pneumatic sampler.

Preliminary efforts to mark bugs involved using a fine paint brush to place a droplet of fingernail polish at the point at which the wings overlapped. Several brands and colors were evaluated, and most were satisfactory. Tests in which small cohorts of bugs (usually 10) were painted with various colors indicated the marking procedure eliminated flight and did not produce significant mortality.

Evaluation of bug retention on plants. Establishment of known bug populations requires that released bugs remain on the desired row sections. Preliminary evaluations of bug movement from plants were conducted using 39-inch sections of row which were enclosed by a wooden frame. Each frame was constructed of 1" × 4" pine lumber, and dimensions were about 57" × 30" (L × W, outside). Four frames were used for each evaluation. Before each evaluation, 39-inch sections of row were selected and isolated by removing adjacent plants for a distance of about 39 inches from each end of each section. Frames were then centered over the row sections. Beds and furrows under the frame were leveled and the base of the frame was sealed with soil. The top edge of each frame was then coated with Tangle-Foot adhesive. Burial of the bottom surface of the frame and coating of the top surface with adhesive was intended to prevent bugs from leaving the plants by walking.

Bug movement from plants was evaluated on 30 May, and 3 and 6 June. Plant height from the soil surface to the mainstem terminal averaged 6.7, 8.2, and 8.2 inches on these respective dates. Corresponding numbers of mainstem true leaves were 7.1, 7.8, and 8.2. Median fruiting phenologies were either 'sub-pinhead' (squares < 2 mm in width, including bracteoles, 30 May), or 'pin-head' (bud enclosed by the bracteoles < 3 mm in diameter, 3 and 6 June). For each test date, 10 marked bugs were released onto the upper leaves of separate plants after 7:00 PM. The following morning (between 9:00 – 10:00 AM), the plants, frame, and surrounding soil surface was examined for marked bugs. Recovered bugs were recorded as captured in the adhesive, recovered dead, or recovered alive. After each test each frame was moved to a new row section.

Determination of sweepnet collection efficiency. Our objective was to determine 1) the proportion of lygus adults present that are collected by the sweepnet, and 2) whether this proportion is consistent enough to be of practical use.

For each sampling date we used four population levels (10, 20, 40, and 60 bugs / 33 row ft) individually established on sections of row. Each population level was replicated twice on each date using a completely randomized design. The only deviation from this design was on 8 July, when 72 bugs were inadvertently released into a row assigned to the 60 bugs/row treatment. The study was established in a plot of Pima cotton ('Phytogen 800') 48 rows wide by about 300 ft long and planted to 40-inch rows. The field was characterized by a marked difference in soil type near the southern margin which resulted in much smaller plants compared to plants in the remainder of the field. This difference was exploited to allow evaluation in plants of similar fruiting phenology but different plant height and canopy development during similar time periods. A tier of eight study rows was established on each end of the plot. The tier on the northern end of the field began about 50 ft from the northern field margin. The tier on the southern end began about 30 ft from the southern margin. Both tiers extended 33 ft toward the field center. The outermost row of each study area marked the 6th row from the field margin. In each study area, eight rows were designated for bug releases and sampling, with each sample row separated by four buffer rows. Each sample row was 33 ft in length, and a buffer area of about 3 ft was established at each end of each row by removing plants. On each subsequent sample date, the entire tier of sample rows was shifted one row farther from the field margin. Also, on each sample date, two of the frames used in the evaluations of bug movement from plants were established between the tier of sample rows and the northern (or southern) field margin. Plants for enclosure in the frames were selected based on their similarity to those in the sample rows, and the frames were placed using the same procedures previously described. Frames were moved to new locations for each sample date.

Consecutive samplings alternated between northern and southern tiers of rows, beginning with the northern tier, until the plant canopy was nearly closed in the northern tier (8 July). After 8 July, only the southern tier was used. Also, beginning on 23 July, sample rows in the southern tier were shifted 20 rows farther from the western field margin to avoid large differences in plant height within the sample tier. At that time, the number of buffer rows separating sample rows was reduced from four to three.

On each sample date except 8 July a total of 280 marked bugs were used. A total of 260 bugs were released into sample rows as previously described for the frames, but making an effort to distribute the bugs as evenly as possible down the row. Ten additional bugs were released into each of the frames to provide an estimate of availability of bugs for sampling on each date. Sampling was conducted on 12 dates (10, 20, 24, and 27 June; 1, 3, 8, 11, 16, 23, and 30 July; 6 August). Wild bugs collected from alfalfa were used on 30 July and 8 August. These bugs were collected 3-4 days before release.

Bugs were released into sample rows and frames after 7:00 PM on the evening before sampling. Samples were collected between 9:15 and 9:45 AM the following morning. Each row was sampled by taking 10 sweeps with a standard 15-inch sweepnet. Pendulum sweeps were used, with one pass of the net across one row constituting a sweep. All samples were collected by the same person, and the time to collect each sample was recorded to provide a measure of consistency of walking speed down the row. Concurrent with sample collection, plants within the frames were examined for marked bugs, and to collect plant data.

Linear regression was used to examine the relationship between population levels of marked bugs and numbers of bugs recovered by the sweep net for each sample date. For these calculations, we assumed each pass of the sweepnet sampled 15 inches of row, resulting in a total of 12.5 ft of sampled row per 10 sweeps. The expected number of bugs collected, assuming 100% collection efficiency (number of bugs released × 12.5 ft/33 ft), was used as the independent variable, and the number of bugs collected by the sweepnet was used as the dependent variable. The regression equations for all sample dates were examined for common slopes. Based on these analyses, regressions from the various dates were pooled into two groups, each described by a common regression equation.

Our sample rows were designed to accommodate 10-sweep samples because of the logistical constraints imposed by the availability of bugs and the labor associated with marking. However, a 10-sweep sample is smaller than that used in many research or monitoring programs. To examine the influence of sample size on model adequacy, duplicate 10-sweep samples within a sample date were pooled to make a single 20-sweep sample for each combination of population level and sample date. The relationship between numbers of bugs collected and expected numbers of bugs was examined using linear regressions as for the 10-sweep samples.

Results and Discussion

Evaluation of bug retention on plants. Preliminary studies indicated most marked bugs placed on plants within the frames remained on the plants, although it was apparent that many bugs did not remain on the plant on which they were originally placed. Recovery of live bugs from the frames ranged from 70 to 100%, and averaged 92.5%. Three (2.5%) of the 120 released bugs were found dead, and 2 (1.7%) were captured in the adhesive on the top edge of the frame base. Four released bugs (3.3%) were not accounted for.

Determination of sweepnet collection efficiency. Sampling studies to evaluate the collection efficiency of the sweepnet were initiated on 10 June when the median stage of fruit development was matchhead square. Plant populations averaged about 47,500 plants/acre on the northern field end and 43,300 plants/acre on the southern end. Sampling continued until canopy closure (8 July, early bloom, northern sampling tier) or cut-out (6 August, southern sampling tier; Table 1).

Table 1. Sample dates and corresponding plant measurements in evaluation of sweepnet collection efficiency.

Date	Field end	Plant height (in.)	No. nodes	Median fruiting stage
10 June	North	9	9.2	matchhead square
20 June	South	9	10	matchhead square
24 June	North	16.5	14.3	one-third grown square
27 June	South	11.8	13.3	one-third grown square
1 July	North	21.8	15.7	candle
3 July	South	15.5	14.3	one-third grown square
8 July	North	26.6	18.2	bloom
11 July	South	18.5	16.2	candle
16 July	South	21	16.2	boll
23 July	South	20.8	17.5	boll
30 July	South	20.6	17.3	boll
6 August	South	20.2	17.2	boll

Based on the recovery of bugs from the frames, about 86.2% (207 of 240) of released bugs were available for capture at the time of sampling. Only one bug (0.4%) was recovered from the adhesive on the frames, and 13 (5.4%) were recovered dead. Most bugs recovered dead were partially eaten, and predation by both nabids and ants was observed. Only 7.9% of released bugs were not accounted for. Recovery of live bugs from frames on individual sample dates ranged from 70% (16 July and 6 August) to 100% (1 and 3 July). Recovery was ≥80% on nine of the 12 sample dates, so we made no effort to adjust population levels released in sample rows to account for mortality.

Sampling times were very consistent, ranging from 6.4 to 7.4 seconds per 10 sweeps. Sampling times on the two sample dates with the largest averages (8 July, 7.4 sec; 16 July, 7.3 sec) were recorded by a different individual than on other dates (range from 6.4 to 6.8 sec). This suggested the differences in sampling times observed were more dependent on the person recording times than on variation in actual times to collect the samples.

Regression equations for individual sampling dates were combined into two groups. A sharp decrease in the regression slopes occurred at a plant height of roughly 20 or 21 inches, with some overlap in plant height between the two groups. Analysis of the regressions corresponding to the first group (mean plant height from 9 to 20.8 inches) indicated a common slope adequately described the pooled data ($P = 0.996$). The resulting regression equation was $y = -0.195 + 0.226x$, where y is the number of bugs collected in 10 sweeps, and x is the expected number of bugs per 12.5 ft of row (the area sampled by 10 sweeps). This model explained 56.5% of the variability in the data. A no-intercept model fitted to these data indicated that collection efficiency of the sweepnet was about 21.4%.

The pooled data for sample dates with the generally larger plants yielded a regression model of $y = 0.165 + 0.067x$, with x and y defined as above. However, the model only explained 21.4% of the variation observed in the data. The corresponding no-intercept model for these data indicated that sweepnet collection efficiency on these sample dates was only about 7.6%.

Analyses of sample data pooled for population levels within dates (20-sweep samples) resulted in the same groupings of regressions as for the 10-sweep samples. The regression model for the first group, representing generally smaller plants, was $y = -0.390 + 0.226x$. This regression explained 75.1% of variation in the data. The corresponding no-intercept model indicated a sweepnet collection efficiency of 21.4%. The model for the second group of plants, which were generally larger, was $y = -0.026 + 0.081x$, explaining 39.2% of variation in the data. Based on the no-intercept model, collection efficiency of the sweepnet in the larger plants was 8.0%.

The results of our study illustrate the potential usefulness of the mark-release-recapture method for sampling studies of lygus adults. Based on our results, sweepnet sampling during the morning hours provides predicted population estimates that are sufficiently accurate to be useful in research and monitoring efforts, especially on plants less than 20 inches in height. However, the relationship between sweepnet-based population estimates and actual lygus population levels becomes more variable with increasing plant development. The factors responsible for the sharp decline in sweepnet collection efficiency later in the season are not fully understood. Additional research will be needed to identify and quantify these factors.

Few contemporary sampling studies of lygus utilize absolute population estimates because of the labor involved and the perceived inadequacies of these methods. Our mark-release-recapture technique can be easily adapted to unambiguously define factors such as time of day effects, plant size and development, varietal differences, bug age and physiological status, and the variation among individual samplers.

References

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ACALA VARIETY TRIALS IN THE SAN JOAQUIN VALLEY

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Acala cotton varieties were grown on about 100,000 acres out of the greatly reduced total acreage of about 275,000 acres in 2008. Part of the reason for continuing changes in acreages is overall reductions in planted cotton acreage in California in recent years, but part is also related to shifts to Pima and non-Acala Upland cotton. There are tradeoffs in shifting to Pima (typically reductions in yields) and in shifts to non-Acala Uplands (typically lower price for lint), and growers need reliable, unbiased information regarding expected lint yields and fiber quality in order to make reasonable, lower-risk decisions. The San Joaquin Valley Cotton Board will remain the avenue for varieties to enter our "Approved Variety" testing program. Within Acala testing, the combined SJV Cotton Board and the UCCE Farm Advisor Approved Acala trials represents a source for broadly-based information on varietal performance. Separate trials involving newly-available CA Upland varieties continue to be conducted by Hutmacher and staff at Shafter and West Side REC sites to complement SJVCB / Approved Acala studies. Variety evaluations for yield and quality performance for varieties submitted into the Approved Variety program are initially the responsibility of the San Joaquin Valley Cotton Board. The Farm Advisors extend these evaluations by adding some continuing field testing of newly-approved and broadly-planted Approved Acala cotton varieties to the Acala tests of the SJV Cotton Board.

Research - Recent Years: 2007 and 2008

Program Operations Summary for 2007 – 2nd and 3rd year SJVCB Acala & UCCE Acala Trials. These evaluations were done at the UC Research Centers at Shafter and West Side, plus large-scale county grower locations. The Acala varieties included in the test were:

2007					
Company providing seed	Variety Name	Year in SJVCB Testing Program	Company providing seed	Variety Name	Year in SJVCB Testing Program
Bayer / CPCSD	Summit **	SJVCB standard	Delta and Pine Land	DPX 06L008F	2
Bayer	C-506	2	Delta and Pine Land	DPX 06L200F	2
Delta and Pine Land	DPX 04T 048	2	Delta and Pine Land	DPX 06L205F	2
Bayer	C-305 (ultima RF)	3	Phytogen	Phy-725 RF	3
Phytogen	P02X-7040	3	Phytogen	Phy-72	Already approved

Delta and Pine Land	DPX-03T590	Already approved	Bayer	C-504	Already approved
Bayer	Daytona RF	Already approved	Phytogen	Phy-78	Already approved
United Ag Products	DGOA-265BR	Already approved			
2008					
Bayer	Daytona RF	Already approved	Phytogen	Phy-725RF	Already approved
Phytogen	Phy-72	SJVCB standard	Phytogen	Phy-755 WRF	2nd year testing

1st Year Screening Trials SJVCB Acala & UCCE Acala Trials. These entries were grown in the smaller-scale UC Research Centers at Shafter and West Side, and Acala varieties in test were:

2007					
Company providing seed	**Variety. Name**	**Year in SJVCB Testing Program**	**Company providing seed**	**Variety Name**	**Year in SJVCB Testing Program**
Bayer / CPCSD	Summit **	SJVCB standard	Bayer	C-107	1
Bayer	C-207	1	Phytogen	Phy-72	Already approved check
Phytogen	Phy-755 WRF	1	Phytogen	P03X-7082	1
Phytogen	P06X-7131	1	Stoneville	ST-4427B2RF	1
2008					
None- no entries provided for screen by companies					

Testing Locations for 2008 Field Variety Trials (Joint UC and SJVCB Acala Programs):

Sites for Field Trials in 2nd & 3rd year tests			**Sites for Field Trials in 1st year tests**	
Shafter Research Center (Kern County)			West Side Research Center (Fresno Co.)	Shafter Research Center (Kern County)
Tulare County (east of Waukena)	Fresno County (north of Mendota)		Both locations set aside and proposals made – but no company entries	
West Side Research Center (Fresno Co.)	Merced County (west of Dos Palos)			

Data collection and availability from field trials:

Summaries of prior year trial results are available at http://cottoninfo.ucdavis.edu). In addition, results are presented at the Cotton Workgroup meetings and at winter and spring grower/PCA meetings of the University of California.

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PIMA VARIETY TRIALS IN THE SAN JOAQUIN VALLEY

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The objectives of these studies with Pima cotton are primarily to evaluate new, approved, and high interest varieties under different environmental conditions and management regimes practiced at REC sites and grower fields across the San Joaquin Valley region of California. Variety evaluations for yield and quality performance for varieties submitted into these trials are initially the responsibility of the San Joaquin Valley Cotton Board. The farm advisors extend these evaluations by adding some continuing field testing of newly-approved and high interest varieties to the Pima tests of the SJV Cotton Board. Pima acreages continue to change. The reason for continuing changes in acreages is overall reductions in planted cotton acreage in California in recent years, but part is also related to increasing shifts to Pima. There are tradeoffs in shifting to Pima (typically reductions in yields) and in shifts to non-Acala Uplands (typically lower price for lint), and growers need reliable, unbiased information regarding expected lint yields and fiber quality in order to make reasonable, lower-risk decisions. Acreage will continue to be volatile with changing input costs and disparities in cotton prices between non-Acala Upland, Acala and Pima cottons.

The overall objective of this research is to develop a continuing data base on growth, development, yield and quality parameters of Pima varieties of cotton, focusing first on approved Pima varieties.

Varieties were tested under a range of environmental conditions and management across the test locations of the SJV. Field evaluations of Pima varieties were conducted at two UCCE Research Center locations (West Side and Shafter) plus four or five large-scale grower field trials. While we will try for one grower field site in each of the six San Joaquin Valley cotton-producing counties, in recent years it has been more difficult to identify cooperators in several counties. The tests are supervised by Bob Hutmacher in cooperation with the UCCE Agronomy Farm Advisors and other UC staff in each participating county.

Tests are done in randomized complete block designs with 3-4 replications. Harvest data is collected using commercial spindle pickers, with seed cotton weights determined for all replications. Six-pound samples of seed cotton are run through the Shafter REC research gin to determine turnout and lint percentage, and to provide samples to be sent in to vendors for HVI analyses and other quality evaluations. Results are tabulated by locations and statistically analyzed using analysis of variance and mean separation procedures.

Entries in these field evaluations for 2008 trials are included in the following tables:

1st Year Screening Trials SJVCB Pima & UCCE Pima Trials. These entries were grown in the smaller-scale UC Research Centers at Shafter and West Side.

2008					
Company providing seed	**Variety Name**	**Year in SJVCB Testing Program**	**Company providing seed**	**Variety Name**	**Year in SJVCB Testing Program**
Bayer	E-108	1	Bayer	E-208	1
Olvey & Assoc.	OA-360	1	Olvey & Assoc.	OA-361	1
Phytogen	PO7X-8206RF	1	Phytogen	PO7X-8210RF	1
Phytogen	PO7X-8212RF	1	Phytogen	PO7X-8213RF	1
Phytogen	PO7X-8214RF	1		S-7	SJVCB standard

2nd and 3rd year SJVCB Pima & UCCE Pima Trials. These evaluations were done at the UC Research Centers at Shafter and West Side, plus large-scale county grower locations.

2008					
Company providing seed	**Variety Name**	**Year in SJVCB Testing Program**	**Company providing seed**	**Variety Name**	**Year in SJVCB Testing Program**
Bayer	E-106	3	Phytogen	PHY-830	3
	S-7	SJVCB standard	Phytogen	PHY-800	Already approved
Delta and Pine Land	DP-340	Already approved	Delta and Pine Land	DP-357	Already approved
Delta and Pine Land	DP-353	Already approved	Hazera	*HA-195	High Interest

*HA-195 is a hybrid included in the test at Grower and Farm Advisor request as a comparison – this HA-195 variety is not included at all locations (included or not as each grower/cooperator decides) .

Testing Locations for 2008 Field Variety Trials (Joint UC and SJVCB Pima Programs):

Sites for Field Trials in 2nd & 3rd year tests			**Sites for Field Trials in 1st year tests**	
Shafter Research Center (Kern County)	Kings County (south of Corcoran)		West Side Research Center (Fresno Co.)	Shafter Research Center (Kern County)
Tulare County (north west of Lemoore)	Fresno County (south east of Huron)			
Fresno County (west of Riverdale)	West Side Research Center (Fresno Co.)			

Data collection and availability from field trials: Summaries of prior year results are available at http://cottoninfo.ucdavis.edu). In addition, results are presented at Workgroup meetings and at winter and spring grower/PCA meetings of the University of California.

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California Uplands Advanced Strains Screening Trials

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Changes in the California cotton industry enacted in 1998 allow for a much broader range of varieties to be grown in the SJV. It will be important for growers to have unbiased sources of varietal performance information that will answer some of the questions regarding yield performance, growth characteristics and quality of available varieties. These trials involving newly-available CA Upland varieties complement the combined SJV Cotton Board and the UCCE Farm Advisor Approved Acala studies. Trials include standard varieties of Acalas in order to have some more complete indices of varietal comparisons. The range of yield potential as well as the range of quality characteristics across the varieties now available will mean that growers have an even more difficult job than usual in balancing the combination of yield and quality (and resulting price).

The primary objective of this project is to test non-Acala CA Upland varieties under a broad range of environmental and management conditions throughout the San Joaquin Valley. The goal of this project is to provide independent University of CA data on varietal yield, growth performance and quality at a minimum of two SJV locations over years to give a broad-based idea of the consistency or lack of consistency in varietal performance. This information all is collected as part of a large data base that describes the degree of cultivar differences in earliness, components of growth as measured using data from final mapping, and quality of yield (Fiber characteristics, seed percent) as well as yield potential. CA Upland screening trials give growers a continuously-updated comparison of newly-available non-Acala Upland varieties from a wide range of seed companies versus one or two Acala varieties which have been available in the SJV for one or more years. These tests are not replicated in any other independent tests done by UCCE, and represent an opportunity to evaluate some of the newer varieties from seed companies for yield performance and fiber quality characteristics.

Studies are being conducted again at the Shafter and West Side Research and Extension Centers in randomized complete block designs with four replications. These two locations represent a sandy loam and clay loam soil type, respectively. Plot size at the Research station locations will be four 40-inch rows by 70 feet in length (quarter plot length), with 19 varieties being tested in 2008.

Entries in these field evaluations for 2008 trials are included in the following table:

Program Summary for 2008 – Advanced Strains Trials. These evaluations were done at the UC Research Centers at Shafter and West Side.

2008					
Company providing seed	**Variety Name**		**Company providing seed**	**Variety Name**	
Phytogen	PHY-375 WRF		Phytogen	Phy-72	Approved Check
Bayer	FM-835 LLB2		Bayer	FM-840 B2F	
Bayer	FM-1735 LLB2		Bayer	BCSX-4366 B2F	
Bayer	ST-4498 B2RF		Bayer	ST-5458 B2RF	
Delta and Pine Land	07W505 DF		Delta and Pine Land	07W902 DF	
Delta and Pine Land	07X440 DF		Delta and Pine Land	MCS0701 B2RF	
Delta and Pine Land	06T201 F		USDA-ARS	SJ-08U01	
USDA-ARS	SJ-08U02		USDA-ARS	SJ-08U03	
USDA-ARS	SJ-08U04		USDA-ARS	SJ-08U010	
USDA-ARS	SJ-08U011				

Data collection and availability from field trials:

Summaries of prior year trial results are available at http://cottoninfo.ucdavis.edu). In addition, results are presented at the Cotton Workgroup meetings and at winter and spring grower/PCA meetings of the University of California.

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Management of Key Cotton Arthropod Pests with Insecticides and Acaricides

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Abstract. The late-season sucking insect complex (cotton aphids and sweetpotato whiteflies) has hindered cotton production in the San Joaquin Valley (SJV) during the 2000's. The effects on cotton quality have been most problematic. Insecticides are a primary management tool for late-season insect infestations and Lorsban® 4E is a commonly used treatment. Recent concerns over volatile organic compounds in the SJV have pinpointed emulsifiable concentrate pesticide formulations, particularly Lorsban 4E, as contributing factors. The activity and mode of action of this formulation make it ideal for controlling aphids on the leaf undersides within the large canopy. This research examined the efficacy of alternative chlorpyrifos formulations and other aphid-active materials against mid-season and late-season infestations of cotton aphids and as a second objective pinpointed and refined the threshold level for treatment of populations. Members of the neonicotinoid class of chemistry, organophosphates, and carbamates and single representatives from the pyridinecarboxamide and pyridine azomethines classes were compared. Aphid populations in 2007 were fairly low and well below threshold values. For mid-season populations, 12 of the 19 treatments provided at least 80% control. Assail® 70WP and Carbine® exhibited the best combination of speed-of-kill, efficacy, and residual control. Aphid control during the late-season period was more effective than that seen in past years with six of the eight treatments providing good to excellent control.

INTRODUCTION

VOC issues are still in the forefront of pesticide regulatory activities especially in the SJV. Lorsban 4E and EC formulations in general continue to be an important product for management of sucking insects in cotton. Efficacy, price, pest spectrum, and alternative chemical class to aid in resistance management are all attributes of this product for use in cotton. As a first attempt at mitigating this problem, fumigant use is being addressed; however, that certainly does not preclude actions on the EC insecticides in the near future. The demand for high quality cotton has intensified, so this along with the increase in Pima cotton acreage, has placed an added burden on effective management of sucking insects. With the possible restriction of Lorsban 4E use because of volatile organic compound issues, alternative products as well as alternative chlorpyrifos formulations were evaluated. Product efficacy may vary with cotton development. During the late-season period, when aphid and whitefly control is critical in order to protect lint quality, the hardened-off leaf tissue may restrict uptake of some products. That is thought to be the strength of Lorsban 4E in that it fumes which aids in penetration of the large canopy.

PROCEDURES

Two field studies were conducted specifically for this objective during the summer of 2007. Overall, aphid populations in 2007 were low in cotton, especially upland cotton, which hindered our success. Therefore, a mid-season (applied on 30 Aug.) and a late-season test (applied on 1

Oct.) were conducted. In both studies, field plots were treated with ground equipment at 20 GPA. Aphid populations were quantified prior to treatment and four times and three times during the 2 weeks following application for the mid- and late-season tests, respectively. Populations were assessed by collecting 10 leaves per plot (5th main stem node leaf from the plant terminal) and counting the aphids (whitefly nymphs were also counted) in the laboratory under magnification. For the mid-season test, products evaluated included 1.) organophosphates – Lorsban 4E, Dibrom 8, 2.) neonicotinoids – Assail 70WP, Assail 70DF, Assail 30SG, Centric 40WG, Trimax Pro, 3.) carbamates – Vydate C-LV, and 4.) cyclodiene organochlorine - endosulfan. Alternative formations of chlorpyrifos were evaluated – Lock-On, Lorsban 75WDG, and GF-1253 (experimental low VOC formulation that has been developed by the manufacturer). Materials from two additional classes of chemistry were included, 1.) Carbine® (flonicamid) from a new class of chemistry (the pyridinecarboxamide class) was registered for the 2007 season primarily for lygus bug control but also has excellent activity on cotton aphids and 2.) Fulfill (pymetrozine) from the pyridine azomethines class. For the late-season test, the list of applicable products was considerably smaller including Curacron 8EC and Lorsban 4E (organophosphates), Assail 70WP, Assail 70DF, and Assail 30SG (neonicotinoids), and Carbine (pyridinecarboxamid). Alternative formations of chlorpyrifos, Lock-On and GF-1253, were evaluated. Overall, 20 treatments were compared in the mid-season test and 9 in the late-season test.

RESULTS

Aphid populations in 2007 were low and very clumped in distribution. For the mid-season test, populations started at ~4 aphids per leaf (the threshold before boll opening [which this was] is 50-100 aphids per leaf and after boll opening it is 5-10 per leaf) and increased slightly over the next 14 days. Populations during the late-season were also in the 3-5 aphids per leaf range. On aphid populations occurring during the mid-season, several products were very effective (using 80% control as an arbitrary value), including neonicotinoids (Provado, Trimax Pro, Centric, Assail [all three formulations]), organophosphates (Lorsban 75WDG, GF-1253, and Dibrom), carbamate (Vydate), Carbine, and Fulfill (Fig. 1). The other two formulations of chlorpyrifos, Lorsban 4E and Lock-on, provided control slightly under 80%. Assail 70WP and Carbine exhibited the best combination of speed-of-kill, efficacy, and residual control. Aphid control during the late-season period was more effective than that seen in past years (Fig. 2). Carbine 50DF, Assail 30SG, GF-1253, Assail 70DF, Lock-on, and Curacron 8E were unusually effective with Assail 70WP and Lorsban 4E showing a lower level of control.

Similar studies were done in 2008 but data summaries, analyses, and interpretation are ongoing.

Table 1. Treatments evaluated in aphid management studies, 2007.

Treatment	Rate (form./A)	Rate (lbs. AI/A)
Mid-Season Test		
1. Provado 1.6F	3.75 fl. oz.	0.047
2. Lorsban 4E	32 fl. oz.	1.0
3. Centric 40WG	2 oz.	0.047
4. Carbine 50DF	2.8 oz.	0.088
5. Carbine 50DF	2.28 oz.	0.071
6. Assail 70WP	0.6 oz.	0.025
7. Assail 70WP	1.1 oz.	0.05
8. Assail 30SG	2.5 oz.	0.047
9. Trimax Pro	1.8 fl. oz.	0.063
10. Thiodan 3EC	24 fl. oz.	0.56
11. Untreated	---	---
12. GF-1253	24 fl. oz.	0.75
13. Fulfill 50WDG	2.75 oz.	0.086
14. Dibrom 8	1 pts.	1.0
15. Assail 70DF	1.1 oz.	0.05
16. GF-1253	32 fl. oz.	1.0
17. Vydate C-LV	25.5 fl. oz.	0.75
18. Lorsban 75WDG	1.0 lb.	0.75
19. Lock-on	64 fl. oz.	1.0
20. Carbine 50DF + Dibrom 8	2.28 oz. + 16 fl. oz.	
Late-Season		
1. Carbine 50DF	2.8 oz.	0.09
2. Assail 30SG	3.7 oz.	0.07
3. GF-1253	32 fl. oz.	1.0
4. Assail 70DF	1.7 oz.	0.07
5. Lock-on	64 fl. oz.	1.0
6. Curacron 8E	8 fl. oz.	0.5
7. Assail 70WP	2.3 oz.	0.094
8. Lorsban 4E	32 fl. oz.	1.0
9. Untreated	---	---

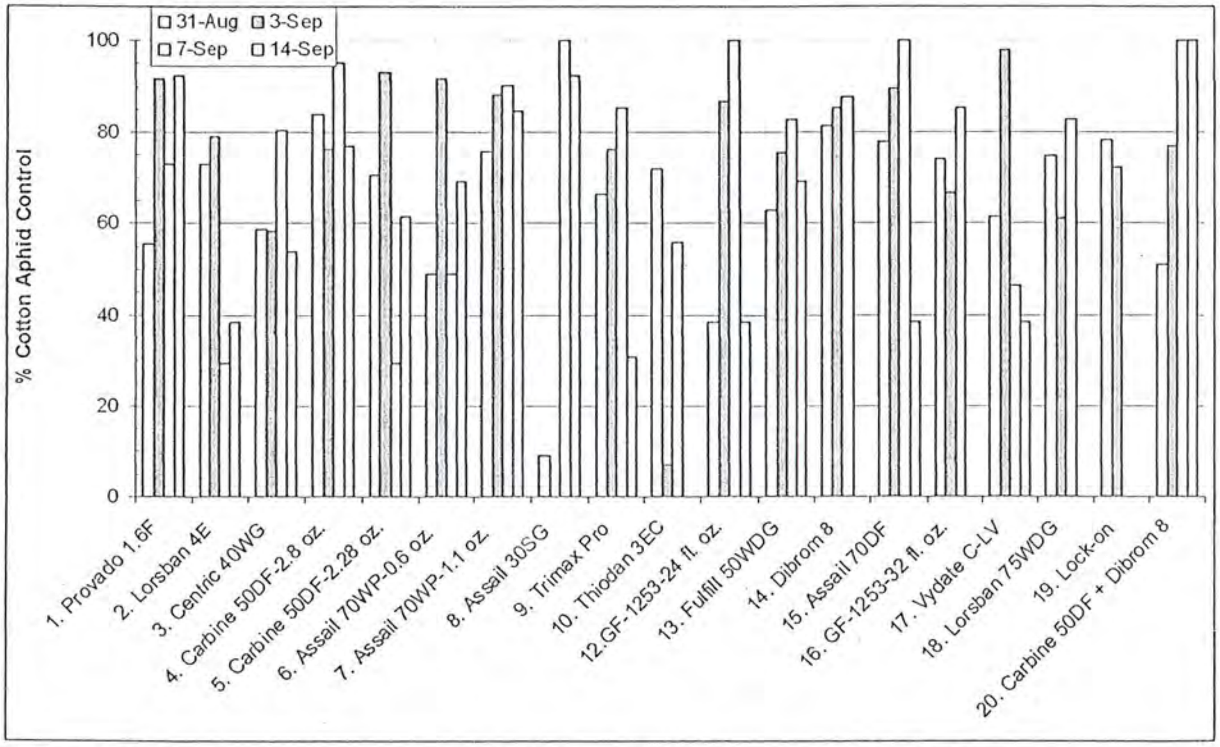

Figure 1. Mid-season cotton aphid control from selected insecticides in 2007.

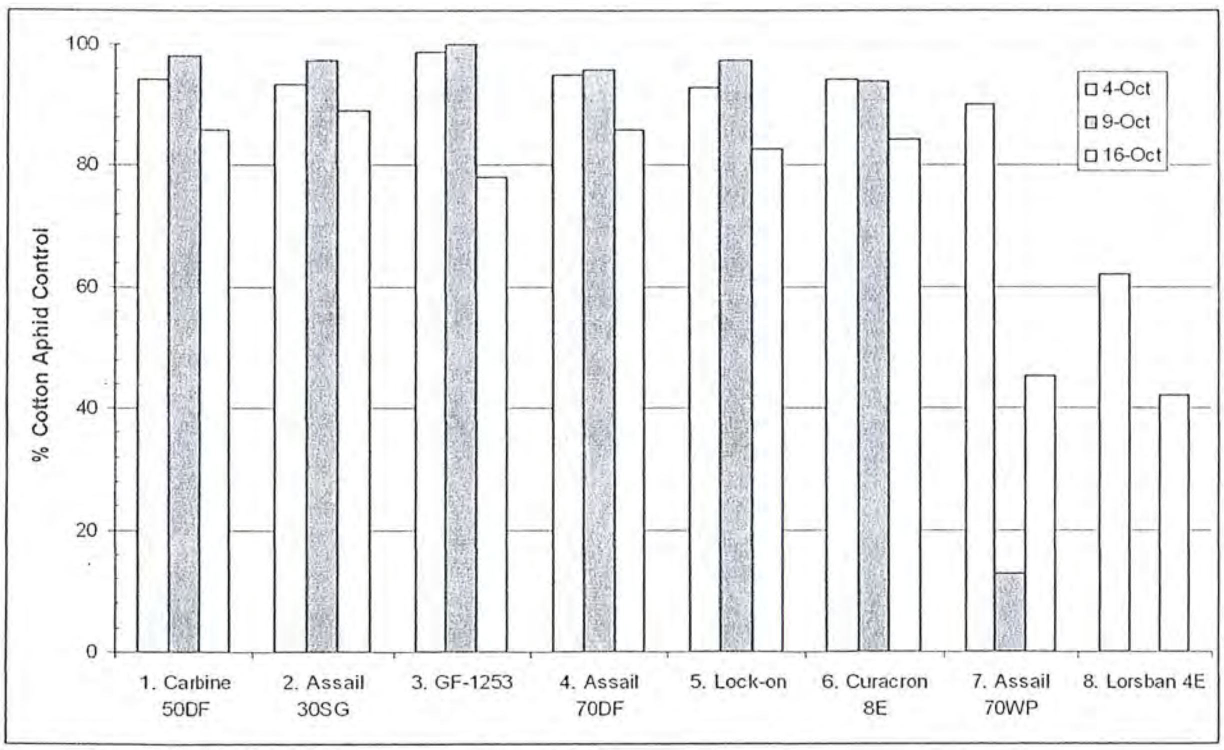

Figure 2. Cotton aphid in late-season test, 2007.

Assessment of Fusarium in SJV Cotton: Field Evaluation Support and Variety Screening Evaluations

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PROJECT SUMMARY

In California, Fusarium wilt of cotton has been considered a potentially serious fungal disease caused by the organism *Fusarium oxysporum vas infectum* (also called "FOV"). However, in the past, damage associated with Fusarium in SJV cotton has been notable only in production areas with the combination of: (a) moderate to high populations of a specific race of FOV (usually race 1); (b) soils with a sandy or sandy loam texture; and (c) root knot nematodes present in high-enough populations to cause significant galling and root damage. Past research generally indicated that FOV damage was worst when both FOV inoculum and nematodes were present in relatively high concentrations. Methods used in the past to limit damage to cotton associated with Fusarium wilt have been to avoid planting cotton in soils in which the combination of sandy or sandy loam texture is combined with the presence of root knot nematode, or grow cotton only infrequently as part of a crop rotation that includes crops less likely to build soil inoculum loads.

Various stages of this fungal organism can survive for a very long time in the soil, so most past studies have concluded that use of chemicals for eradication will generally be unsuccessful, and at best will give short-term control. Most all past work on Fusarium evaluations done in CA has been with Acala varieties. Some recent work by Pete Goodell (UCCE IPM Regional Advisor and Phil Roberts, UC Riverside Nematologist has also confirmed that at least two contemporary Pima varieties show significant foliar and vascular staining symptoms when exposed to soils high in Fusarium inoculum and root knot nematodes, with plant damage and stand losses similar to Acala varieties grown previously in the same fields. Assistance from Michael Davis (UC Davis Extension Plant Pathologist) in those studies confirmed that symptoms and plant damage in Pima plants was due to FOV, so evidence indicates that Pima can have at least similar susceptibility to prevalent Fusarium races where the root knot nematode:Fusarium combination exists.

Within the past five years, cotton fields with Fusarium symptoms were discovered in loam and clay loam soil sites which do not support significant populations of root knot nematode. Since mid-summer 2002, the infection of cotton plants, symptoms of FOV-related damage, and sometimes significant stand losses and stunting without involvement of root damage due to root knot nematodes has been confirmed in many fields in four counties of the SJV (Tulare, Kings, Fresno and Kern Counties). In these fields, the damage has been identified by the Principal Investigators as being caused by a different race of Fusarium oxysporum vas infectum, (namely "Race 4"). Using modified DNA gene mapping methods, Dr. Michael Davis and Yumee Kim of UC Davis Plant Pathology Dept. have worked with samples identified and collected by UCCE staff Hutmacher, Wright, Roberts, Marsh and Munk and their staff. This race 4 FOV can be clearly identified as different from Australian FOV races and different from the most-studied

Fusarium species (mostly races 1, to lesser extent race 3) prevalent in sandy loam soils and problem areas of the SJV for decades.

Capabilities and research continue to be important to allow:

- Assessment of field plant samples for the type of Fusarium occurring in grower fields (When growers request assistance in sample collection and analysis)
- set up and operation of cotton germplasm screening trials under pressure of race 4 FOV to identify relative resistance / susceptibility of both Upland and Pima materials

Screening trials have continued to be conducted at a greenhouse location (UC Kearney Research and Extension Center) which has been used successfully over the past five years. Additional field trials for screening germplasm will be conducted where field sites with race 4 FOV are identified and providing that willing cooperators can be found and retained for continuing studies.

We have been able to gain access to the following field screening sites in infested fields:

- In 2006, we identified and used one small site (about 0.3 acres) in Kern County, and one larger one (about 1.2 acres) in Fresno County for purposes of field screening trials.
- In 2007, a larger Kern County site (about 1 acre) was available for field screening, a 1 acre site is being used in Fresno County, and two smaller sites (about 0.2 to 0.3 acres each) are being utilized for screening, selection and seed increase purposes in Fresno and Kern Counties.
- In 2008, we used the same large Kern County site (about 1 acre) along with the same 1 acre site for large scale screening in Fresno County in an infested site. We also have two additional sites we have used in Kern County, one that is about 0.3 acres and another that is about 0.2 acres in size. Screening has been done at each of these trial sites in 2008.

This project is dependent upon cooperation with Dr. Michael R. Davis (UC Davis Plant Pathology), as Dr. Davis is the pathologist we are working with to send samples for FOV race identification and classification. Results of field screening evaluations for race 4 FOV resistance/tolerance are provided annually (or more often if available) to seed companies who provide materials for testing, as well as to the USDA-ARS genetics program at Shafter and interested cooperating researchers.

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Race 4 Fusarium Field Evaluations of Chemical and Cultural Controls to Reduce Inoculum Survival

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Greenhouse studies have evaluated the impact of metam sodium applications, with and without solarization films and associated soil heating, on development of FOV symptoms in varieties of cotton previously recognized as highly-susceptible (a Pima, Phytogen 810-R or DP-744) or moderately susceptible (an Acala, Phytogen-72). The soil media used was a 1:2 mix of soil from a highly infested field site mixed with steam-treated potting mix. Trays of soil mix received the treatments and post-treatment, the soil was transferred into clean, waxed cardboard containers to plant out the seed for further evaluations of disease symptom development and plant survival percentages. In metam sodium trials, three different rates of metam sodium alone did not significantly impact the survival rate (about 30%) or symptoms (root vascular stain index rating averaging about 3 on a scale of 0 (no symptoms) to 5 (severe symptoms) in highly-susceptible Pima varieties. In the moderately susceptible Acala variety, the metam sodium treatments improved the survival rate and reduced vascular stain ratings when compared with untreated soil. In the first trial, averages of about 90% survival were recorded for treated soil versus about 60% survival for untreated. In the second trial, an average of about 90% survival was recorded for treated soil versus about 70% for untreated.

Soil chemical treatments were also evaluated in microplot studies in field FOV race-4 infested sites. With metam sodium, more susceptible Pima cultivars had higher levels of damage and worse mortality rates than less susceptible cultivars (even at metam rates of 20 to 60 gal/acre). Only the 80 gal/acre rate provided more consistent improvements with more FOV-susceptible cultivars, but the 60 gal/acre rate also improved survival rates consistently with moderately susceptible cultivars. With Topsin M and Ridomil soil in-furrow banded applications, only the higher rate Ridomil drench (3 fl oz rate) and 4 or 6 lb Topsin rate significantly improved seedling survival with more susceptible cultivars, but had less consistent effect with more tolerant cultivars. In addition to soil chemical treatments, approximately 70 seed treatment combinations were evaluated in an infested soil site in Kern County and Fresno County in 2007. These treatments were provided and applied by the following companies in order to represent a broad range of available chemistries: Bayer Crop Science, Syngenta Corporation, Wilbur Ellis, Valent and some others with smaller sets of treatments. The treated seed was planted in replicated, single row plots 15 feet in length in April, 2007. Four sets of plant population counts were done in these trials in May, June, July and August, and in mid-August foliar and root vascular staining evaluations were done. The range of seed treatments tested to date had relatively limited impact on cotton plant survival rates in both susceptible and more-resistant types, with survival rates in the best performing treatments with more susceptible varieties improving from about 10 to 15 percent to in the range of 25 to 35 percent. These field and greenhouse evaluations will largely be completed with the 2008 growing season unless additional new chemical materials are provided for evaluations.

*** This research was supported in part by the State Support Committee of Cotton incorporated and the CPCSD Board for 2008.**

Population development, selection, and evaluation for heat stress, fiber quality, lint yield, and pest resistance

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Objectives: To improve cotton germplasm with potential heat stress tolerance, better fiber quality, lint yield and pest resistance, broadening the genetic base of cotton.

Justification and Problem Statement

Over the last 35 years, the cotton germplasm base used in plant breeding has narrowed. This relatively narrow genetic diversity has been suggested as a contributor to an apparent plateau in breeding progress. It may also represent an impediment to efforts to sustain high yields (May and Taylor, 1998; Meredith, 1992; Ulloa, 2006). Since the re-establishment of a cotton breeding effort within the USDA-ARS, Western Integrated Cropping Systems Research Unit, we have focused on increasing genetic diversity through acquisition of novel germplasm (from multiple sources including non-commercial landraces and species of wild cottons).

Cotton varieties grown commercially in California such as Acala Maxxa and Phytogen 72 yield poorly in the heat stress environment of Maricopa, AZ. In the San Joaquin Valley (SJV), when above normal temperatures occur during the critical stage of peak flowering, yield losses may occur in response to the heat sensitivity of varieties that are currently grown here. In addition, the vulnerability of cotton production in California to race 4 Fusarium wilt highlights the need for comprehensive research to protect the future of the cotton industry in the San Joaquin Valley. This strain of Fusarium has proven especially damaging to most varieties of Pima cotton (Hutmacher et al., 2005). Development of host-plant resistance is currently the most economic and effective strategy for managing Fusarium wilt (Ulloa et al., 2006).

To improve cultivar performance above current heat stress, yield, fiber quality, and pest resistance baselines, it is essential that new genetic variability be introduced into elite germplasm pools used by breeding programs. Currently, we continue to make progress on germplasm development for heat stress tolerance, better fiber quality, lint yield and pest resistance.

Summary

We continue to advance breeding lines from a germplasm pool created in 2002 in Maricopa, AZ (USDA-ARS) utilizing four double cross populations, which involved cultivars ST 474, Phytogen 72, Maxxa, DP565, SG 248, and NM67 as parents in different cross-combinations. Potential heat tolerant breeding lines are currently being evaluated in Florence, SC, Tifton, GA, Baton Rouge, LA, Maricopa, AZ, and Shafter, CA. From 70 lines tested in 2006 in non-replicated progeny tests, 16 were selected for replicated testing across the five locations in 2007.

In California, these 16 lines exhibited superior fiber characteristics, with lint percentages ranging from 36.0 % to 42.0 % , upper half mean fiber lengths ranging from 1.20 to 1.29 inches, and strengths ranging from 23.0 to 26.0 grams/tex in 2006. Field experiments utilized a randomized complete block design with four replications. In 2007, these 16 lines also exhibited superior fiber characteristics, with lint percentages ranging from 35.3 % to 40.3 % , upper half mean fiber lengths ranging from 1.11 to 1.21 inches, and strengths ranging from 32.0 to 36.7 grams/tex (HVI). In comparison, 'Phytogen 72' exhibited lint percentage averaging 41 % , upper half mean fiber length averaging 1.15 inches, and strength averaging 34.2 grams/tex (HVI). Currently, we are testing selected breeding lines to validate improved heat tolerance, yield, and fiber quality properties for future release. We hope that by this coming fall or early next year, we will release improved germplasm from this project. Demonstration plots will be available for viewing during the September 16, 2008 field day at the University of California Research and Extension Center, Shafter, CA.

Recently, the Agricultural Research Service, United States Department of Agriculture, and University of California released four Pima cotton germplasm lines (SJ-07P-FR01, SJ-07P-FR02, SJ-07P-FR03, and SJ-07P-FR04). SJ-07P-FR01 – FR03 lines originated from a cross of germplasm lines 8810 and NMSI 1601, which was originally accomplished at the New Mexico State University at Las Cruces, NM in 1997. SJ-07P-FR04 is a population originating from re-selection within P 73. Based on the results of field and greenhouse studies, these lines possess good, but not complete, levels of resistance to Fusarium wilt (FOV) race 4. In addition, these lines produced moderate yields of cotton lint with good to superior fiber length and strength. Cotton breeders in California need alternative sources of germplasm for improving resistance of Pima cottons to this disease. We hope that the SJ-07P-FR lines will provide needed alternative sources of FOV resistance, and will broaden the genetic base of resistant germplasm critical to maintaining a healthy Pima cotton industry in the San Joaquin Valley of California.

Currently, we are in the process of gathering and analyzing data for an additional germplasm release with improved resistance to race 4 FOV, fiber quality, and yield. These Pima breeding lines originated from a cross made by Dr. Richard Percy between PS 6 and 89590 cultivars. These lines have been tested for three years, and have exhibited excellent levels of FOV resistance. We are also advancing 20–25 Pima lines that were selected under FOV race 4 infested field conditions for the past two years. We hope that this improved Pima germplasm will contribute to the current germplasm resources available for development of future commercial cultivars grown in California.

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Management of Root-knot Nematode

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The objective of this project is to evaluate new products for management of root-knot nematode on carrots. Root-knot nematodes (*Meloidogyne* sp.) are widely distributed throughout California and are the most important nematode pest of carrot. Current control methodology relies on the use of Metam sodium and Telone II.

The potential for loss of the standard chemical nematicides due to various environmental concerns is great enough to warrant a continued search for alternatives. Each year, a number of "promising" candidates are promoted by various sources. These include chemical nematicides, and what are termed natural or novel products or soil amendments. Even though many of these may not prove to be efficacious, demonstrating this by comparison to a standard nematicide treatment provides valuable justification for maintaining current registrations. Such a process succeeds in sorting out those that do truly have potential for nematode management.

A crop rotation followed by natural products trial is currently in progress. Rotation crops currently being grown are cotton, carrots and cantaloupe. The rotation crops will be followed by treatments with natural products and Telone II as a standard.

The majority of the carrots grown in California are grown in Kern County and the Shafter station provides climatic and cultural conditions similar to those in local grower fields.

Management and Damage Potential of Lygus Bugs to Black-eye Cowpeas

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Abstract. Lygus bugs are a severe pest of bean production in many parts of the Central Valley. Insecticides should be combined with other management approaches to provide cost-effective management of this pest. Registered and experimental insecticides were evaluated to determine their efficacy against lygus bugs (adults and nymphs) and impacts on bean yield and quality in blackeye cowpeas.

INTRODUCTION

Lygus bugs (*Lygus hesperus*) are a severe pest and hindrance to bean production in California. Several types of beans are potentially damaged by this pest including Blackeye cowpeas, large and baby limas, and common beans. Thresholds vary by bean type and growth stage and management plans have been developed for this pest on dry beans (UC IPM Pest Management Guidelines: Dry Beans, UC ANR Publication 3446). Lygus bugs may be present throughout the growing season although populations tend to be highest from mid-July to early Sept. Populations also vary based on field location, i.e., proximity to overwintering areas, distance from nearby crops that might build lygus bug populations, etc. and year variation due to winter conditions and abundance of native vegetation. Lygus bugs have some 300 plant hosts (crop and weed species). Lygus bugs have sucking mouthparts with which they pierce and consume plant tissue. The type of damage varies with plant age. During early bud and flowering stages, lygus bugs cause bud and flower loss resulting in reduced yields. Lygus bugs feeding on young, developing seed pods cause pitting and blemishes on table market beans, and reduce germination in seed beans. Research is ongoing on lygus bug movement among crops and the influence of cropping patterns on bug levels within large geographical areas. Promising research is also ongoing on breeding beans that have resistance to lygus bugs. However, presently, field sampling and timely use of insecticides are the primary means to manage lygus bug populations in the field. This strategy does not represent a stable management approach, however, because lygus bugs have the capacity to develop resistance to insecticides. Repeated applications of a product will select for a population of bugs that "resists" the toxicant. Therefore, there is the need to continue investigations on alternative insecticides that can be used and, importantly, on alternative management approaches. Secondly, regulatory actions can also influence the availability of insecticides.

PROCEDURES

In 2007, studies were conducted on blackeye cowpeas var. 'CB-46' grown on the UC Cotton Research and Extension Center near Shafter. Naturally-occurring populations of lygus bugs were allowed to develop and applications of registered and experimental insecticides were made as the bug levels approached threshold values. Registered insecticides evaluated included

Dimethoate, Warrior, and Mustang Max; experimental (unregistered) materials included BAS320, Carbine, Diamond, and Steward.

Blackeye Cowpeas. Treatments as detailed in Table 1 were evaluated. Applications were made with a trailer sprayer pulled behind a tractor using CO_2 as the propellant. The spray set-up used drop nozzles with 5 nozzles per row to insure good coverage. The plot size was 10 rows by 75 ft. long with 3 replications in a randomized complete block design. Treatment dates were 12 July and 26 July; the beans were in early bloom stage for the initial application. A third application was planed but the low lygus bug population and the advanced maturity of the beans prevented this. Six treatments utilized the same treatment on a given plot for both application timings so season-long control could be examined; this type of treatment regime would not be recommended for resistance management considerations. In addition, Warrior was examined with an application in the first timing window compared with an application in only the second timing as well as duel application. Lygus bug populations were sampled using a standard sweep net (15 inch diameter) approximately twice per week. Ten sweeps were done in each plot and the samples were taken to the lab and adult lygus, nymph lygus, and predators were counted. In addition, high populations of spider mites and bean aphids developed in some plots so starting on 26 July leaf samples were collected and levels of these pests were quantified. Ten trifoliate leaves were randomly selected from the middle portion of the plant, bagged, and brought to the lab. Samples were soaked and agitated within a weak solution of bleach and the liquid was poured through sieves to collect the aphids and spider mites. Specimens were counted under magnification. The middle two rows of each plot were harvested on 19 Sept. and yields were estimated. Seed samples were taken at harvest from each plot and brought to the lab for seed quality evaluations. Approximately 250 seeds from each sample were evaluated for lygus stings (1 vs multiple stings/seed), fish mouth/skin cracking and other damage (mold, broken, etc.).

Similar studies were done in 2008 but data summaries, analyses, and interpretation are ongoing.

RESULTS

Blackeye cowpeas. Overall Lygus bug populations were low to moderate at this site. For the 2 weeks following the first application, populations averaged slightly over 1 lygus per sweep which exceeds the threshold of 0.5 per sweep. The population was approximately 70% nymphs and 30% adults during this period. Over this 2-week period, Steward, Warrior, and Diamond provided about 70-75% control; Carbine about 65% control, Dimethoate 50% control, and BAS320 30% control (Table 2). Activity of several products was maximized on lygus bug nymphs (such as Carbine which was equally effective as Steward, Warrior, and Diamond on nymphs) and there was greater activity of some products nearer the time of application. Following the second application, populations were too low to draw any strong conclusions. Yields ranged from 2650 in the Diamond treatment to 4255 lbs./A in the Warrior two application treatment (Table 3). In terms of lygus sting damage on the beans, values ranged from 4.1 to 8.3%. The highest level of damage was in the untreated plots (although the damage in the BAS320 treated pots was 8.2%) and the lowest level of damage was in the Steward treatment.

Table 1. Treatments evaluated in Lygus Bug management study on blackeye cowpeas.

	Treatment	Rate (lbs. AI/A)	Product/A (oz.)	Timing (application)^A
		Blackeye Cowpea Studies		
1	BAS 32005 I*	0.25	29.6 fl. oz.	1,2
2	Carbine 50WG**	0.08	2.75 oz.	1,2
3	Diamond 0.83EC**	0.09	12 fl. oz.	1,2
4	untreated	---	----	---
5	Warrior**	0.03	3.84 fl. oz.	1,2
6	Steward EC**	0.11	11.3 fl. oz.	1,2
7	Warrior**	0.03	3.84 fl. oz.	1
8	Warrior**	0.03	3.84 fl. oz.	2
9	dimethoate**	0.75	24 fl. oz.	1,2

* add Penetrator Plus@0.5% v/v ** added Silwet @ 0.25% v/v

^A see Procedures section for explanation

Table 2. Lygus Bug populations in following application 1.

	Lygus bugs per sweep		16 July			19 July		
	Treatment	Rate/A ^A	adults	nymphs	total	adults	nymphs	Total
1	BAS 32005I*	29.6	0.13	0.00	0.13	0.50	0.67	1.17
2	Carbine 50WG**	2.75	0.37	0.13	0.50	0.23	0.13	0.37
3	Diamond 0.83EC**	12	0.27	0.03	0.30	0.17	0.03	0.20
4	untreated	----	0.43	0.27	0.70	0.37	0.80	1.17
5	Warrior**	3.84	0.03	0.03	0.07	0.03	0.03	0.07
6	Steward EC**	11.3	0.20	0.07	0.27	0.07	0.17	0.23
7	Warrior**	3.84	0.03	0.17	0.20	0.20	0.17	0.37
8	Warrior**	3.84	0.67	0.67	1.33	0.50	0.60	1.10
9	dimethoate**	24	0.37	0.13	0.50	0.37	0.30	0.67
		LSD value	**0.47**	**0.27**	**0.64**	**0.30**	**0.73**	**0.83**
			23 July			26 July		
	Treatment	Rate/A ^A	adults	nymphs	total	adults	nymphs	Total
1	BAS 32005I*	29.6	0.23	0.23	0.47	0.20	1.37	1.57
2	Carbine 50WG**	2.75	0.10	0.27	0.37	0.07	0.17	0.23
3	Diamond 0.83EC**	12	0.03	0.23	0.27	0.00	0.10	0.10
4	untreated	----	0.23	0.53	0.77	0.23	1.17	1.40
5	Warrior**	3.84	0.03	0.20	0.23	0.23	0.37	0.60
6	Steward EC**	11.3	0.00	0.23	0.23	0.10	0.23	0.33
7	Warrior**	3.84	0.07	0.17	0.23	0.13	0.17	0.30
8	Warrior**	3.84	0.27	0.60	0.87	0.23	1.03	1.27
9	dimethoate**	24	0.10	0.30	0.40	0.07	0.37	0.43
		LSD value	**0.41**	**0.48**	**0.77**	**0.34**	**0.98**	**1.20**

Table 3. Yield and bean damage from Lygus bug management tests.

	Treatment	Rate/A [A]	Yield (lbs./A	% Lygus Damage
		Blackeye Cowpea Studies		
1	BAS 32005 I*	29.6	2745.7	8.2
2	Carbine 50WG**	2.75	2829.1	7.6
3	Diamond 0.83EC**	12	2650.4	5.6
4	Untreated	----	2779.9	8.3
5	Warrior**	3.84	4255.5	6.3
6	Steward EC**	11.3	2555.1	4.1
7	Warrior**	3.84	3865.4	6.9
8	Warrior**	3.84	3511.0	7.1
9	dimethoate**	24	3865.4	7.6
		LSD value	**855**	**3.6**