MANAGEMENT OF LATE-SEASON INFESTATIONS OF COTTON APHIDS AND SWEETPOTATO WHITEFLIES (STRAIN B) IN PIMA COTTON IN THE SAN JOAQUIN VALLEY

Larry D. Godfrey
Dept. of Entomology and Nematology
Univ. of California
Davis, CA
Treanna Pierce
UC Davis Entomology
Shafter, CA
Surendra K. Dara
Univ. of California Cooperative Extension - San Luis Obispo Co. and Ventura Co.
San Luis Obispo, CA

Abstract

The efficacy of registered and experimental insecticides against mid- to late-season infestations of cotton aphids and sweetpotato whiteflies were evaluated in Pima cotton in the San Joaquin Valley in 2013 and 2014. Whitefly and aphid populations were high and persistent in 2013 averaging over the 5-week study and sampling period 99.9 and 33.4 aphids and whitefly nymphs per leaf, respectively. In 2014, aphid populations were low (averaging <10 per leaf) but whitefly infestations were again significant (averaging 91.1 nymphs per leaf). In both years, two insecticide applications were utilized at ~2 week intervals to bring populations under control. Several registered products were very effective against cotton aphids including Assail, Carbine, Lorsban 4E and Lorsban Advanced; other products nearing registration that were very effective on aphids were Pyrifluquinazon, Torac, Transform, and Sivanto. The applicability of these products to the late-season window still needs to be evaluated. Some organic treatments showed promise; Metarhizium brunneum + Azagard and Botanigard + Azagard averaged ~65% effectiveness over all sample dates. Botanigard + low rate of Sivanto reduced aphid populations by 98% which was more effective than Sivanto alone at the full rate. This 98% effectiveness was equal to that of five of the other treatments averaged over the sample period. Sweetpotato whitefly strain B control was more challenging. The most effective treatment reduced nymphal populations by 60 and 70% in 2013 and 2014, respectively. Assail alone and with Lambda-Cy, Knack, Oberon, Courier, Danitol + Orthene was the most effective registered treatments. Other products nearing registration with good whitefly activity were Pyrifluquinazon and Sivanto. Botanigard + low rate of Sivanto also provided a ~65% whitefly nymph reduction.

Introduction

The sweetpotato whitefly, *Bemisia tabaci* (Gennadius), has been a long-time pest of field crops in California. Damaging infestations have occurred sporadically within the San Joaquin Valley in several economically important crops. The situation with the pest changed significantly in the mid-1980's when the biology and damage potential changed and intensified greatly. These changes were first noted in the western U.S. in southern California and Arizona in the 1980's and particularly the early 1990's (Gonzalez et al. 1992). Some of the changes noted were host plant shifts, overall higher population levels, increased difficulties controlling this whitefly, and a greater linkage of populations with ornamental plants in urban areas and other native plants particularly for overwintering. This "new" whitefly was identified as a new biotype/strain called the "B" type; formerly also called a new species, *B. argentifolii*, the silverleaf whitefly. In the San Joaquin Valley (SJV) of California, the sweetpotato whitefly Strain B was first found in July 1992; in 1993, populations of this pest were found in cotton fields in late July (Godfrey et al. 1994). This trend continued in 1994 as whitefly populations occurred about 3 weeks earlier than in 1993 and this pest infested cotton fields in June and built to fairly high densities in some fields (Godfrey et al. 1996).

One of the factors favoring the development of populations in the SJV was the wide host range of the Strain B whitefly. This high level of crop diversity in the SJV created nearly ideal conditions. A generalized host plant sequence for sweetpotato whitefly strain B in the southern SJV (moving through the season) was found to be spring melons, acala cotton, pima cotton, fall melons, weeds, carrots, lettuce, cole crops, alfalfa, and citrus. This pest developed into a significant cotton pest in some areas of the SJV, namely, near cities (overwintering in cities on ornamental plants) and the southern and eastern sides of SJV. Over the late 1990's and early 2000's, pest control advisers learned to effectively manage these whiteflies in these key areas and this pest never developed into a valley-wide problem as initially feared.

Most of our whitefly management recommendations used in California cotton came from the excellent research conducted in Arizona (Ellsworth et al. 2006). The severity of the problem in Arizona and the earlier infestation of this pest into Arizona compared with the SJV facilitated this research being conducted. Some SJV-targeted brochures on whiteflies were developed, grower meetings were held, information was published in the Pest Management Guidelines (Univ. of California Statewide IPM Program 2013), and some adaptive research was conducted in California cotton, particularly Pima cotton.

Over the last 20 years, the California research and extension group have concentrated efforts on cotton aphids (Godfrey and Leser 1999). This pest has been a more general, serious wide-spread cotton pest in the SJV than whiteflies. Studies were done on biology, management (short-term and long-term), economic impacts, etc. Data were extended to the cotton community via written and electronic publications, oral presentations and one-on-one contacts within the state.

Both sweetpotato whitefly strain B and cotton aphid pose a serious threat to the California cotton industry through their feeding and excretion of honeydew on the cotton plant. Late-season populations are the most serious concern due to the possibility of contaminating exposed lint with honeydew creating sticky cotton and marketing concerns for the industry. The critical importance of lint quality, the absence of fall precipitation which when present can remove some honeydew, warm fall period which allows for continued reproduction of these pests, the increased level of production of Pima cotton having a longer maturation period in the fall than Acala cotton, and the reliance on aerial application making deposition difficult for the large cotton canopy with these pests infesting the leaf undersides are all factors underscoring the significance of this situation. In addition, some of the crop protection tools used to manage mid- and late-season aphids and whiteflies have been removed from the market, with others being seriously considered for registration modifications and finally some active ingredients are showing a reduced level of efficacy due to building levels of insecticide resistance.

In 2013 and 2014, some changes in sweetpotato whitefly strain B populations and severity in the SJV were noted. As previously stated, management of this pest had been accomplished with a fairly stable, successful program for the previous ~15 years. Cotton aphid populations often show erratic patterns spatially and temporally but whitefly populations in the SJV had been "constant" over the years. But in 2013, whitefly populations developed earlier than normal and in areas where they were not normally a problem. In addition, populations continued to develop instead of level-off in cotton as we have seen in some years. Finally in many areas, management with insecticides was very challenging. To compound the situation, cotton aphid populations also developed in some areas. These pest populations provided us the opportunity to develop some up-to-date efficacy information on registered and experimental insecticide efficacy against cotton aphids and sweetpotato whiteflies.

Materials and Methods

Field research on Pima cotton was conducted at the West Side Research and Extension Center (Fresno Co.) and the Shafter Research Station, Shafter, CA (Kern County) in 2013 and 2014, respectively. Field research was conducted to evaluate the activity of several foliar treatments (experimental and registered products) against mid-season to late-season whitefly and aphids. A plot size of 5 rows by 50 feet long with 4 blocks was used. The applications were made with a high clearance sprayer at 20 gallons per acre (2013) and 30 gallons per acre (2104) with 5 nozzles per row to achieve good coverage. Whitefly and cotton aphid populations were monitored weekly from early July to the time of treatment to monitor build-up. Treatments were applied as the threshold levels were reached. Treatments were applied on Aug. 16 and Sept. 3, 2013 and on Sept. 3 and Sept. 17, 2014. Treatments as listed in Table 1 (2013) and Table 2 (2014) were evaluated. Some of these products have strengths in aphid control whereas others are stronger in terms of whitefly control. However with a mixed population as was present in these plots, the desire was to see which treatment had the greatest utility in this situation. Sweetpotato whitefly strain B and cotton aphid populations were quantified from 5th mainstem node leaves with 10 leaves sampled on each date in each plot. Sampled leaves were inspected in the laboratory using a dissecting microscope. Whitefly adults were visually counted in the field by carefully turning leaves over and recording number of adults. The numbers of whitefly 2nd, 3rd, and 4th instar nymphs along with light and dark colored cotton aphid adults and nymphs were tabulated. Seed cotton yields were collected with a commercial picker; samples were ginned and lint turnout determined and lint yields per acre calculated. Finally lint stickiness was measured using a Lintronics FCT (Fiber Contaminant Tester). In 2103, lint was hand-harvested from each plot on 4 October and ginned with a mini-gin. In addition, stickiness was determined from hand-harvested and machine-harvested lint collected on 4 and 6 November, respectively. In 2014, lint was hand-harvested on 10 November for evaluation. Picker-harvested samples from 12 November were also collected.

The following treatments as shown in Table 1 were evaluated in 2013.

Table 1.

	Treatment	*Rate (Product/A)*
1	Lorsban Advanced	32 fl. oz.
2	Carbine 50DF	1.7 oz.
3	Untreated	---
4	Assail 70WP + Bifenture 10DF + Abamectin 0.15EC	2.3 oz. + 16 oz. + 16 fl. oz.
5	Assail 70WP + Lambda-Cy 1EC + Abamectin 0.15EC	2.3 oz. + 5.12 fl. oz. + 16 fl. oz.
6	WF1	6.84 fl. oz.
7	WF2	6.84 fl. oz.
8	Transform WG	0.75 oz.
9	Transform WG	2.25 oz.
10	Knack	10 fl. oz.
11	Venom 70SG	3 oz.
12	Belay 2.13SC	6 fl. oz.
13	Sivanto	10.5 fl. oz.
14	Assail 70WP + Abamectin 0.15EC	1.1 oz. + 16 fl. oz.
15	Pyrifluquinazon SC	2.4 fl. oz.
16	Pyrifluquinazon SC	3.2 fl. oz.
17	Torac 15EC	14 fl. oz.
18	Cyazypyr 10SE	13.5 fl. oz.

R-11 spreader activator nonionic surfactant (Wilbur-Ellis Company) at 0.25% was included with all treatments except treatment 18 where methylated seed oil was substituted also at 0.25%.

The following treatments as shown in Table 2 were evaluated in 2014.

Table 2.

	Treatment	*Rate (Product/A)*
1	Lorsban Advanced	32 fl. oz.
2	Carbine 50DF	1.7 oz.
3	Untreated	---
4	Assail 70WP + Lambda-Cy 1EC	2.3 oz. & 5.12 fl. oz.
5	Oberon 2SC	16 fl. oz.
6	Oberon 2SC + Requiem EC	16 & 32 fl. oz.
7	Courier SC	12.5 fl. oz.
8	Transform WG	0.75 oz.
9	Transform WG	2.25 oz.
10	Knack	10 fl. oz.
11	Venom 70SG	3 fl. oz.
12	Sivanto	14 fl. oz.
13	Assail 70WP	1.1 oz.
14	Pyrifluquinazon SC	3.2 fl. oz.
15	Torac 15EC	14 fl. oz.
16	Danitol 2.4EC + Orthene 97	9.0 fl. oz. & 1.0 lb.
17	Lorsban 4EC	32 fl. oz.
18	Leverage 360	3 fl. oz.
19	Metarhizium brunneum (MET52) + Azagard	16 & 16 fl. oz.
20	Botanigard ES + Azagard	2 qts. & 16 fl. oz.
21	Botanigard ES + Sivanto	1 qt. & 10.5 fl. oz.

R-11 spreader activator nonionic surfactant (Wilbur-Ellis Company) at 0.25% was included with all treatments.

Results and Discussion

2013

Cotton Aphids: Aphid populations averaged 82 aphids per leaf on the day of treatment. In untreated plots, populations were >50 per leaf for ~3 weeks post-treatment and peaked at 228.6 aphids per leaf at 10 days after treatment (DAT). This long period of high aphid populations is unusual. At 3 DAT, only the Transform (2.25 oz. rate), Assail+Abamectin and Assail+Lambda-Cy+Abamectin provided at least 90% control. Six of the treatments reached this level of control at 7 DAT (all three Assail treatments, Carbine, Transform [2.25 oz.], and WF1. Twelve of the seventeen treatments achieved 90% aphid control at 10 DAT. Residual aphid control was excellent as eight treatments still maintained ≥90% control at 21 DAT, including Assail, Assail + Lambda-Cy + Abamectin, Carbine, Knack, Sivanto, Transform [2.25 oz.], WF1, and WF2. Average cotton aphid populations per treatment are shown in Fig. 1.

Sweetpotato Whitefly (Strain B) Nymphs: Populations of WF nymphs in untreated plots averaged 10.4 and 14.5 nymphs per leaf at the time of application and for the period following the first application, respectively. Pyrifluquinazon SC (2.4 oz.), Lorsban Advanced, and Cyazypyr 10SE provided the greatest immediate control (at 3 DAT) of WF nymphs with ~40% control. Later samples following the first application showed the maximum percentage control from NNI-0101 (3.2 oz.) at 74% reduction at 14 DAT (Fig. 8). Following the second application, WF nymphal populations in untreated plots increased to >100 nymphs per leaf on 10 DAT. On this date of peak population, several treatments provided ≥85% including Assail+Bifenture+Abamectin, Assail+Lambda-Cy+Abamectin, Carbine, Pyrifluquinazon SC (both rates), and Knack. Average whitefly nymph populations per treatment are shown in Fig. 2.

Sweetpotato Whitefly (Strain B) Adults: Populations of whitefly adults in the untreated ranged from 0.75 to 7.9 adults per leaf. There were no strong trends for numbers across treatments.

Cotton Yield: Lint yield was highest in the Carbine and Transform (0.75 oz.) and these two treatments had significantly more yield than in Assail + Lambda-cyhalothrin + Abamectin, WF1, Venom, and Cyazypyr. The difference from high to low was ~300 lbs./A.

Lint stickiness: From the 4 October samples, only lint from Assail + Lambda-Cy + Abamectin and Sivanto treatments were classified as non-sticky. Similarly, lint from the hand-harvested (4 November) and picker-harvested (6 November) samples was all classified as sticky.

2014

Cotton Aphids: On the day of the first application, there were 4.4 cotton aphids per leaf. Over the entire sampling period, aphid numbers averaged less than 5 per leaf for the 4+ week sampling period. With these low populations, few significant data on aphid management came from this study. Averages per treatment are shown in Fig. 3. We continued to sample the plots following the harvest aid applications (made on 6 October and 20 October). Both of these applications also included an insecticide to try to manage aphid and whitefly populations and to minimize the deposition of honeydew during this period. Aphid populations post-harvest aid application were as high as 74.9 per leaf. At 5 DAT, the population had declined slightly down to down to 1.8 per leaf in untreated plots.

Sweetpotato Whitefly (Strain B) Nymphs: Whitefly nymphal levels were at 41.6 nymphs per leaf - ~50% 1st/2nd instars, 40% 3rd instars and 10% 4th instars. Levels in the leaf disk which is the sampling zone determined in the Arizona studies were 0.9 3rd instars and 0.4 4th instars = 1.3 total. Adult numbers were 3.2 per leaf. The Arizona threshold which has been tentatively adopted for use in California is 1 nymph (3rd and 4th instar)/disk or 3 adults on leaf. Therefore, the values in this study were at the threshold for treatment recommended in Arizona.

At 5 DAT, levels were significantly higher in untreated than in seven treatments, including Assail + Lambda-Cy, Oberon, Oberon + Requiem, Courier, Botanigard with Azagard, Assail, and Lorsban 4EC. Populations were 60.25 in the untreated and averaged 21.7 nymphs per leaf in these seven treatments with the lowest numbers. At 8 DAT, there were no significant differences in whitefly nymph numbers among the 21 treatments. There was a 65% difference from the treatment with the most nymphs (Venom) to the treatment with the fewest nymphs per leaf (Metarhizium brunneum [MET52] with Azagard. The untreated plots had one of the highest densities of nymphs at 50.85 per leaf and these were distributed at ~35-40% 1st-2nd and 3rd instars as well as ~25% 4th instars. At 12

DAT, whitefly nymph counts ranged from 20.5 (Assail + Lambda-Cy to 86.35 (Botanigard with Azagard) per leaf. The highest value was significantly higher than that in 16 other treatments. Eleven treatments resulted in whitefly counts of 35 per leaf or less. Following the second application (2 DAT2), whitefly nymph levels ranged from 9.55 (Courier) to 80.45 (Lorsban Advanced) per leaf. Compared with the untreated, Courier was the only treatment providing at least 75% whitefly nymph control. Whitefly nymph populations increased substantially by the 7 DAT2 sample date. Levels in untreated plots were 193.4 per leaf - a nearly 5-fold increase from the previous sample date 5 days prior. This population level stood alone in the statistical analyses. The next ranked treatment was about a 50% reduction compared with that in the untreated. Seven treatments provided 90% nymphal control, which was the best seen in the test thus far - Assail + Lambda-Cy; Pyrifluquinazon, Torac, Oberon + Requiem, Courier, Sivanto, and Oberon. At 12 DAT2, the untreated had the highest number of whitefly nymphs and significantly more than all the other treatments except Transform (both rates), Metarhizium brunneum (MET52) with Azagard, and Botanigard with Azagard. Courier, Sivanto, Oberon, and Botanigard + Sivanto provided 90% nymph control and Assail + Lambda-Cy, Knack, and Danitol + Orthene reduced levels by 80%. Whitefly nymphal densities started to decline due to plant senescence and cooler weather from this point onward. Average nymph populations are shown in Fig. 4.

Sweetpotato Whitefly (Strain B) Adults: At 5 DAT, whitefly adults were numerically highest in the Venom treatment at 4.9 per leaf and numerically lowest in Pyrifluquinazon averaging 0.6 adults per leaf. Thus, there was a ~90% reduction. At 8 DAT, Venom also had the highest number of whitefly adults at 7.2 per leaf. This value was significantly higher than that in all the other treatments except the 2.25 oz. rate of Transform. The untreated averaged 3.1 adults per leaf which did not differ from any of the other treatments.

Cotton Yield: Lint yield was highest in the Danitol + Orthene treatment and this treatment had significantly more yield than seven other treatment including Carbine, untreated, Oberon, Transform (both rates), Pyrifluquinazon, and Lorsban 4EC. At this point in the season, I didn't expect the aphids or the whiteflies to impact yield very much if at all. The aphids did not achieve a high enough density to affect yield. The whiteflies perhaps did but the crop was fairly well set by the dates when whiteflies were common in Sept. and early October. There was however a ~1200 lbs./A spread in the seed cotton yield values.

Lint stickiness: For the hand-harvested samples on 10 November, only lint from Courier treatment was classified as sticky. A precipitation event of 0.5" rain occurred on 31 October which may have removed some of the honeydew. Picker-harvested samples from 12 November have not been evaluated yet.

Summary

There were several effective registered products for cotton aphids including Assail, Carbine, Lorsban 4E and Lorsban Advanced. Other products nearing registration that were very effective on aphids were Pyrifluquinazon, Torac, Transform, and Sivanto. The applicability of these products to the late-season window still needs to be evaluated. Some organic treatments showed promise; Metarhizium brunneum + Azagard and Botanigard + Azagard averaged ~65% effectiveness over all sample dates. Botanigard + low rate of Sivanto reduced aphid populations by 98% which was more effective than Sivanto alone at the full rate. This 98% effectiveness was equal to that of five of the other treatments averaged over the sample period. Sweetpotato whitefly strain B control was more challenging. The most effective treatment reduced nymphal populations by 60 and 70% in 2013 and 2014, respectively. Assail alone and with Lambda-Cy, Knack, Oberon, Courier, Danitol + Orthene was the most effective registered treatments. Other products nearing registration with good whitefly activity were Pyrifluquinazon and Sivanto. Botanigard + low rate of Sivanto also provided a ~65% whitefly nymph reduction.

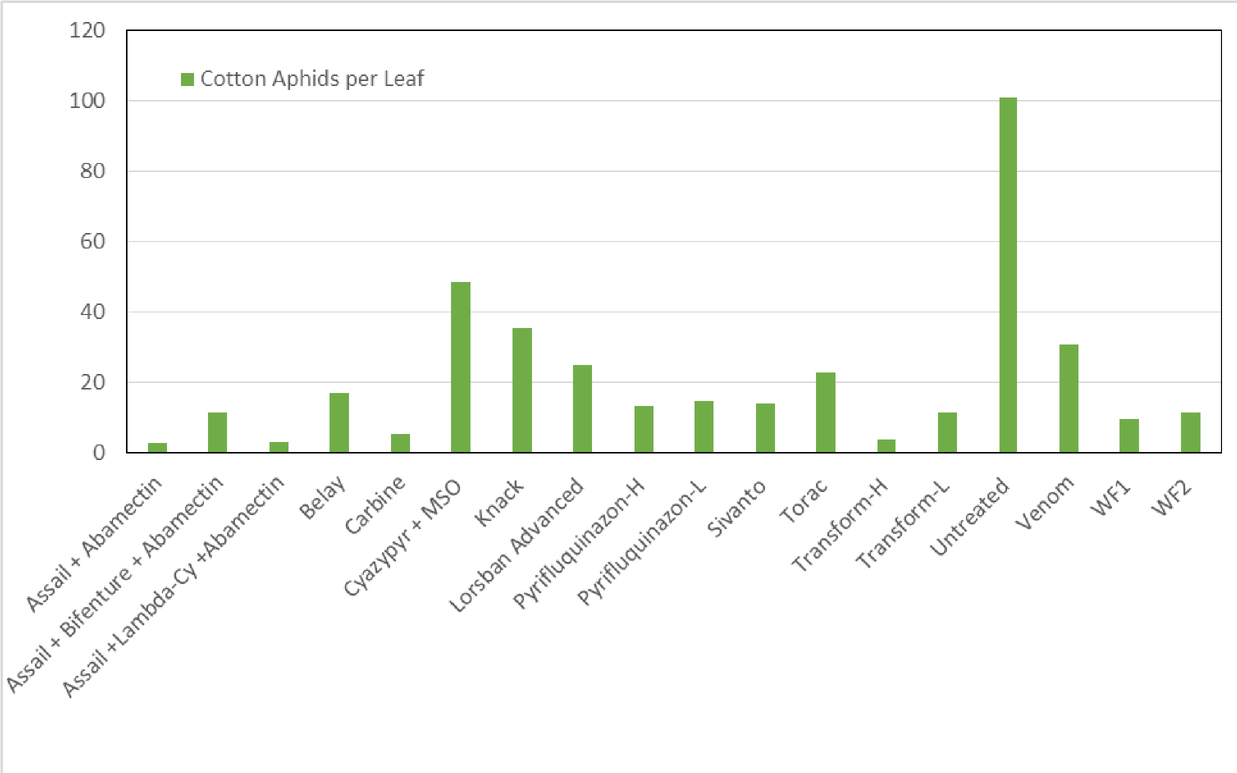

Figure 1. Average populations of cotton aphids from 19 Aug. to 23 Sept. as influenced by insecticide applications in Pima cotton in 2013.

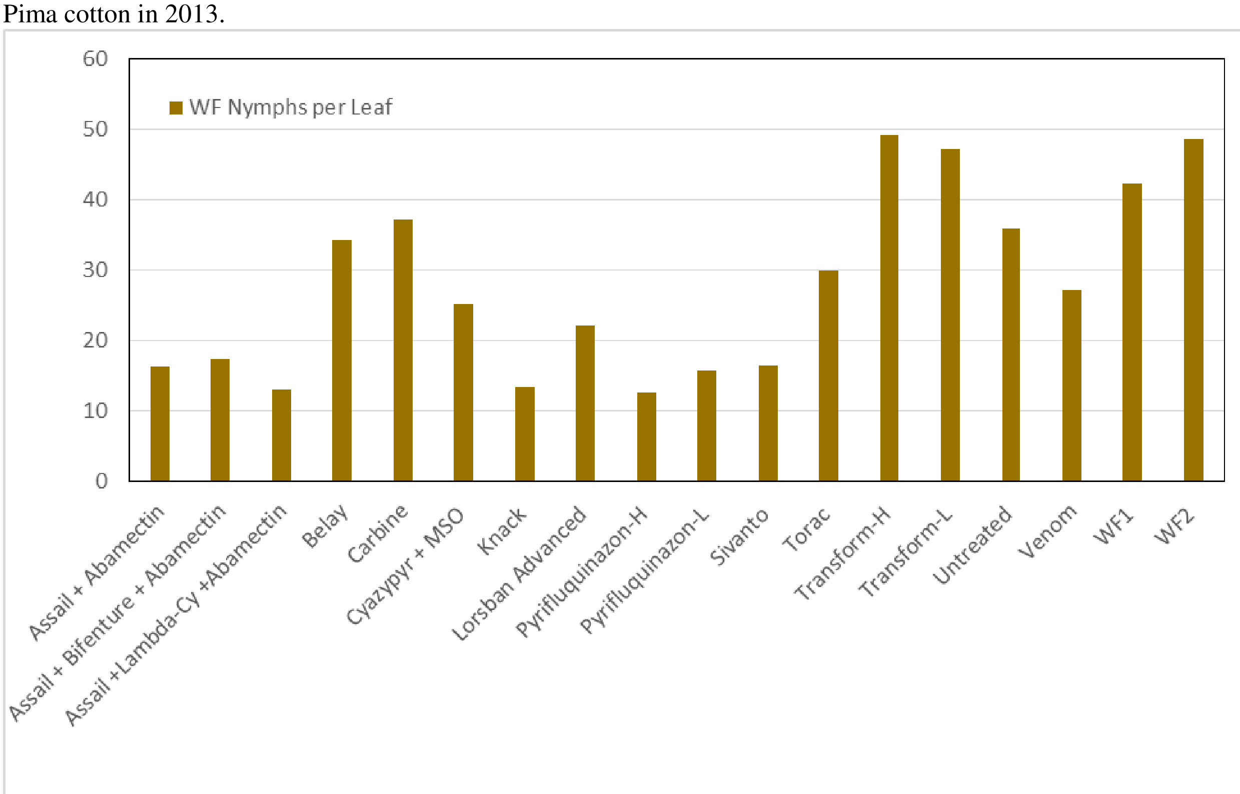

Figure 2. Average populations of sweetpotato whitefly strain B nymphs from 19 Aug. to 23 Sept. as influenced by insecticide applications in Pima cotton in 2013.

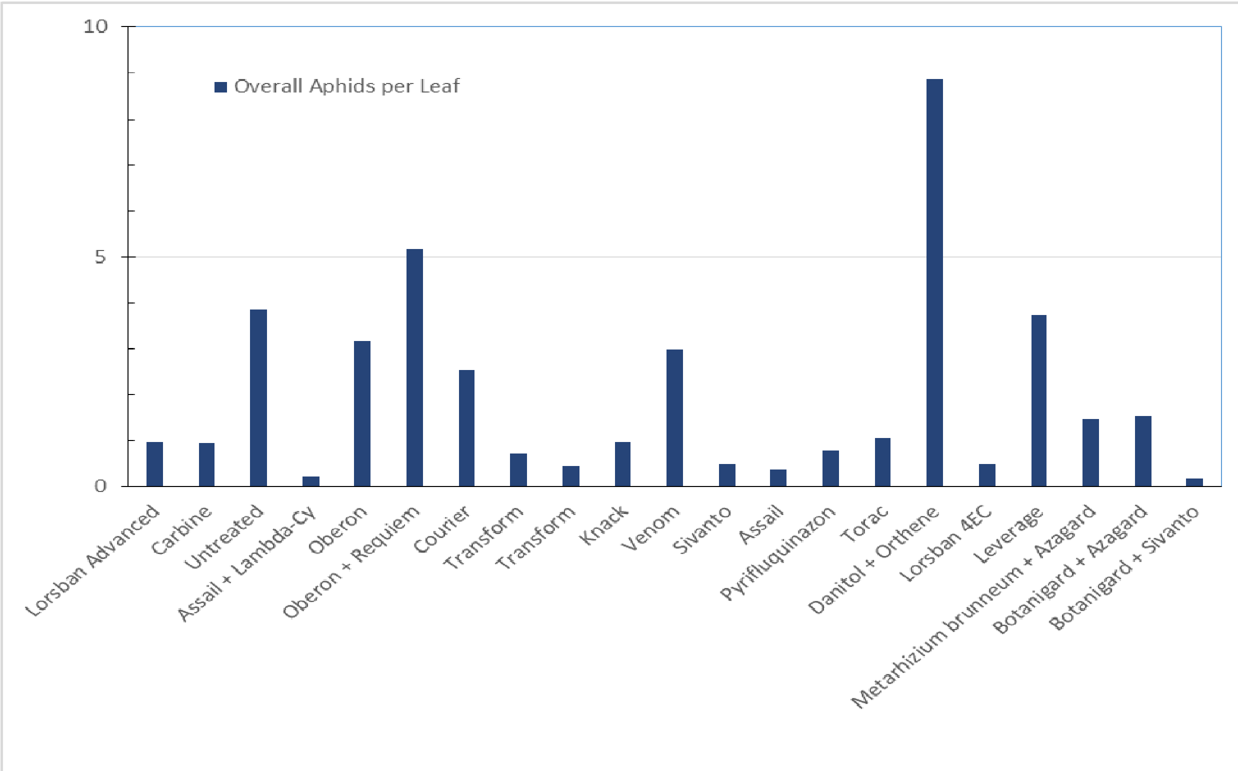

Figure 3. Average populations of cotton aphids from 8 Sept. to 3 Oct. as influenced by insecticide applications in Pima cotton in 2014.

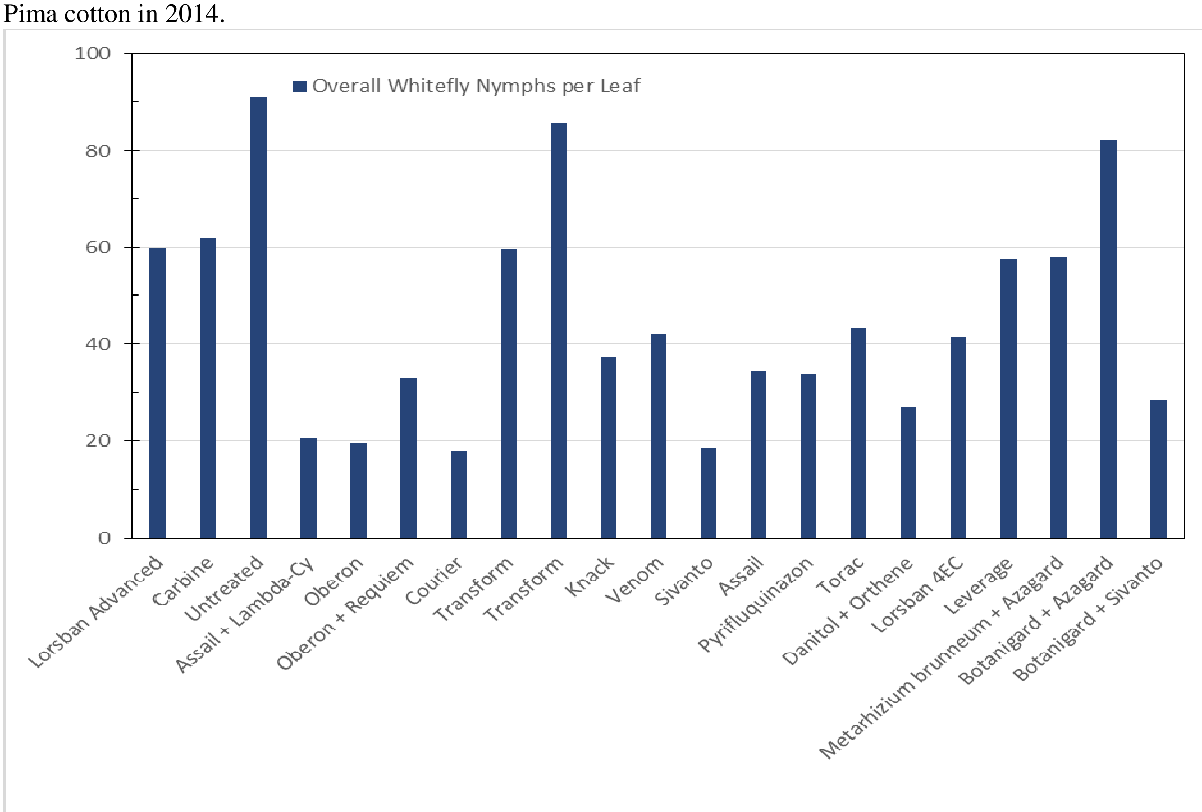

Figure 4. Average populations of sweetpotato whitefly nymphs strain B from 8 Sept. to 3 Oct. as influenced by insecticide applications in Pima cotton in 2014.

Acknowledgements

This research was supported by funding from the Cotton Incorporated California State Support program. We thank the staff of the West Side Research and Extension Center and Neal Hudson of the Shafter Research Station for technical support and the SJV Quality Cotton Growers Association for use of the Lintronics FCT (Fiber Contaminant Tester).

References

Ellsworth, Peter C., John C. Palumbo, Steven E. Naranjo, Timothy J. Dennehy, and Robert L. Nichols. 2006. Whitefly Management in Arizona Cotton 2006. Univ. of Arizona Cooperative Extension IPM Series No. 18, 4 pp.

Godfrey, L. D., P. B. Goodell, W. J. Bentley, C. G. Summers, T. Prather, and R. Coviello. 1994. Contribution of crops, weeds, and parasites to the abundance of silverleaf whitefly in San Joaquin valley cotton. Proceedings of the Beltwide Cotton Conferences, pp. 873 – 874, National Cotton Council, Memphis TN.

Godfrey, Larry, Charlie Summers, and Peter Goodell. 1996. Silverleaf whitefly in the San Joaquin Valley - year 4. Proceedings of the Beltwide Cotton Conference Volume 2:1023-1026. National Cotton Council, Memphis TN.

Godfrey, L. D. and J. F. Leser. 1999. Cotton aphid management - status and needs. Proceedings of the Beltwide Cotton Conference, Volume 1:37-40. National Cotton Council, Memphis TN.

Gonzalez, Refugio A., George E. Goldman, Eric T. Natwick, Howard R. Rosenberg, James I. Grieshop, Stephen R. Sutter, Tad Funakoshi, Socorro Davila-Garcia. 1992. Whitefly invasion in Imperial Valley costs growers, workers millions in losses. California Agriculture 46(5):7-8.

Univ. of California Statewide IPM program. 2013. UC Pest Management Guidelines – Cotton – Whiteflies - Sweetpotato Whitefly (Silverleaf Whitefly). http://www.ipm.ucdavis.edu/PMG/r114300311.html .