APHIDS AND WHITEFLIES IN THE SAN JOAQUIN VALLEY OF CALIFORNIA IN 1995

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Abstract

The cotton aphid has developed into a key pest of cotton in California. The common pattern of seasonal dynamics of cotton aphid populations has changed repeatedly over the last 15 years. The cotton aphid has evolved from a non-pest to an early-season and late-season pest to a pest throughout the growing season and particularly during the mid-season. The silverleaf whitefly has emerged as an extremely serious cotton pest in many of the arid production areas. This pest was first found in the San Joaquin Valley in 1992 and has caused some late-season problems in cotton. Several characteristics of these pests make them regional pests and therefore difficult to manage on an individual field basis. We summarize seven characteristics of the cotton aphid and silverleaf whitefly which make them regional pests. We will emphasize the cotton aphid since we have the most research experience with this pest in California, and thus far, this species has resulted in the greatest economic loss in SJV cotton. Biological factors which may lead to aphid outbreaks will be discussed.

Introduction

Cotton Aphid

The cotton aphid, *Aphis gossypii*, has become a key arthropod pest of cotton in California. Historically, lygus bugs and spider mites have been the primary arthropod pests of cotton in California and in the forefront of IPM programs. In 1994, cotton aphids ranked second to spider mites for estimated yield losses in California cotton (Williams 1995) and aphids were probably the most important pest from a management standpoint. Cotton aphids in 1995 caused the greatest estimated yield loss among the complex of arthropod pests in the California cotton agroecosystem (5-6%).

The cotton aphid is not a new insect in California. Smith (1942) reported this species as a sporadic pest of cotton in certain fields in some years. UC cotton recommendations from the 1960's and 1970's listed the cotton aphid as a minor pest. Early-season stunting of cotton plants and the potential for lint contamination were listed as the major concerns.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:128-132 (1996)
National Cotton Council, Memphis TN

From 1986-88, unusually high cotton aphid population densities occurred in California cotton. It was speculated that environmental conditions may have influenced the overwintering aphid mortality and thus the development of populations of natural enemies in the spring. During the late 1980's and early 1990's, high aphid densities were commonly found on pre-squaring cotton and on late-season (following boll opening) cotton. The late-season infestations were of concern because of the potential for sticky cotton. Direct yield losses from cotton aphids on pre-squaring or late-season were rare (Rosenheim et al. 1995). Yield losses from cotton aphids across the Belt were also rare, as this pest's impact on yield was rated as "minimal" compared with a severe potential loss of quality (Wilson and Carter 1991).

Beginning in 1992, cotton aphid population outbreaks were observed during the mid-season period (squaring to cut-out). This period of hot, very dry environmental conditions had not been thought previously to be conducive for aphid reproduction/survival. Infestations were noted in late June and continued to expand through July and August. The influence of these "mid-season" infestations on cotton yield was thought to be substantial and has now been experimentally shown to significantly impact cotton lint yield. Aphid infestations during the squaring/boll formation period continued and intensified during the 1994 and 1995 growing seasons. During both years, outbreaks developed in early-mid July and persisted until late August (Fig. 1), as well as some infestations during June. Thus, the common pattern of seasonal dynamics of cotton aphid populations has changed repeatedly over the last 15 years. The cotton aphid has evolved from a non-pest to an early-season and late-season pest to a pest throughout the growing season and particularly during the mid-season.

Silverleaf Whitefly

Several species of whiteflies, including banded-wing, greenhouse, and iris whitefly, have historically infested California cotton fields. Outbreaks and yield losses have, however, been extremely rare. In 1992, the silverleaf whitefly (SWF), *Bemisia argentifolii*, was first found in the San Joaquin Valley (SJV). Low density infestations were found in cotton in Kern County in the southern SJV (Gruenhagen et al. 1992). There has been great concern about this pest because it has caused devastating crop losses in other areas, e.g., Texas, Arizona, and southern California. Both yield losses and sticky cotton can result from SWF outbreaks. SWF distribution and population magnitude in the SJV in 1993 and 1994 expanded from the initial SWF infestation area in Kern County. Populations occurred earlier and densities were higher in 1994 than in 1993 (Godfrey et al. 1994, 1995). Cotton yield losses from SWF were, however, low. Sticky cotton from SWF was also rare, although some high late-season populations did develop. In 1995, SWF population dynamics were similar to those in 1993; populations were lower and delayed compared with 1994 (Godfrey et al., unpub.). Unfavorable spring environmental conditions in 1995 were believed to be reponsible for the population decline.

Several biological characteristics of cotton aphid and silverleaf whitefly make these pests very difficult to manage. The short developmental time and high reproductive rate result in rapid population buildup (Rosenheim et al 1994). More importantly, the high dispersal activity of these two pests make them regional or area-wide pests. This greatly increases the challenge for designing and implementing effective IPM programs. To optimize management, control strategies cannot be executed on individual fields, but rather area-wide consideration is needed.

Here we summarize seven characteristics of the cotton aphid and silverleaf whitefly which make them regional pests. We will emphasize the cotton aphid since we have the most research experience with this pest in California, and thus far, this species has resulted in the greatest economic loss in SJV cotton. Biological factors which may lead to aphid outbreaks will be discussed.

Cotton Varieties

Nearly 100% of the cotton acreage in the SJV is planted with pubescent cotton leaf cultivars. Several studies across the Belt and in California have shown that pubescent cotton lines compared with glabrous cotton line are more susceptible to whitefly and cotton aphid build-up (Leigh unpublished, Godfrey unpublished, Leigh et al. 1994). A replicated field study was conducted in 1994 comparing the susceptibility of 11 approved SJV acala cotton varieties to silverleaf whitefly and cotton aphid. The least favored cultivar had 50% fewer cotton aphids and 75% fewer silverleaf whiteflies (seasonal average) compared with the most favored cultivar. The least preferred cultivar had smooth-leaf characteristics with only 0.5 trichomes per cm^2 leaf tissue. The other cultivars ranged from 32 to 60 trichomes per cm^2 leaf tissue.

Cotton Type

Pima cotton production was approved for the SJV in 1989. In 1995, there was ~110,000 acres of pima cotton out of the 1.2 million total cotton acres. A 1990 study at the UC Cotton Research Station by Leigh and Wynholds showed that the initial aphid colonization on 21 June was similar among Pima S-6 and three acala cultivars (Prema, Royale, and SJ-2). However, on 23 July and 1 August, there were about 5 times more cotton aphids on the pima than the acala cotton cultivars. Rosenheim (unpublished) has validated these results in commercial fields.

Planting Date

Cotton planting date influences cotton aphid population dynamics. Slosser et al. (1992) showed in the Rolling Plains of Texas that cotton planted in late-June had higher aphid densities than cotton planted in April or May. In California, replicated field studies in 1994 similarly showed that cotton planted on 31 March and 21 April had lower cotton aphid densities than cotton planted on 13 May (Fuson & Godfrey 1995, Fuson 1995). On 27 July, aphid densities of 27, 57, and 169 aphids per leaf were found for the early-, mid-, and late-planted cotton, respectively (Fig. 2). In addition, the late-planted cotton produced more dark morph aphids and more alate aphids than the other two planting dates (Table 1). The cotton planting season in California during 1994 and 1995 was especially prolonged. Unfavorable spring growing conditions (cool, wet) delayed planting and, compounded with seedling diseases, resulted in replanting. More advanced production practices, especially plant growth regulators for manipulating vegetative growth, have also enabled later planting dates. These late-planted fields could be acting as foci for aphid build-up and subsequent movement into other fields.

Production of Alate Aphids

The cotton aphid is an extremely plastic insect. It can readily adapt to environmental conditions, host plant quality, and biotic factors. Rosenheim et al. (1995) discussed the seasonal biology and polymorphism of this pest. The incidence of cotton aphid morphs influences population dynamics and probably other aspects of cotton aphid biology. Aphids can also respond to the environmental conditions by producing alate (winged) individuals. This commonly occurs with crowded conditions. Averaged across twelve fields, the incidence of alatiform nymphs, those developing wings, during the mid-season increased as the aphid density exceeded 32 aphids per leaf (Fig. 3). During aphid outbreaks, densities can commonly exceed 200 aphids per leaf. These alate aphids can readily disperse to neighboring cotton fields, and probably fly several miles. This inference is reinforced by observations made in several cotton fields in which no alatiform nymphs were produced but alate adults(=immigrants) were found. During the mid-season period, i.e., aphid outbreak, the percentage of sampled fields that produced no alatiform nymphs declined from 80 to 20% (Fig. 4) . However, the density of alate adults in these fields ranged up to 0.8 per leaf (Fig. 4). These fields were not producing alate individuals but were acting as a sink for winged aphids. These conditions would favor an aphid outbreak across the SJV that is initiated from several widely-dispersed foci.

Insecticide Efficacy

Several insecticides provide good control of cotton aphids in California; however, no product can perform adequately under the intense aphid pressure experienced in 1995. The insecticide toxicity to aphids, residual on the leaf surface, spray coverage on mid-season plants, aphid distribution on the plants, and particularly potential for reinvasion all limit insecticide efficacy. Insecticide efficacy on aphids has been evaluated the last 4 years. Several treatments, out of the 20 tested, provided excellent short-term aphid control. However, the residual control was limited, and no control was seen past 14 days after treatment (Fig. 5). In addition, product efficacy appears to be declining in many cases. The percentage control at 7 and 14 days after treatment was consistently less in 1995 than in 1994 (Fig. 6). Evaluations during both years were done in the same field using the same protocol. The development of insecticide resistance may be partially responsible for these results, but other contributing factors are also present. The persistent aphid pressure in 1995 was the most important factor.

Aphid Population Rebounds

Results from field testing in 1995 showed interesting results on aphid population dynamics following insecticide applications. Following the dissipation of aphid active insecticides or the application of poorly active materials, aphid population densities rebounded substantially. Data from 1995 show this trend with all 19 insecticide treatments tested. Compared with the aphid density in untreated plots, densities in the treated plots were up to 4 times greater at 21 days after treatment (Fig. 7). Some of these treatments provided up to 98% population reduction at 7 days after treatment. Therefore, the treated plants in some way created a favorable environment for aphid reinvasion, reproduction, and establishment. The exact mechanism is not known. Destruction of natural enemy populations may be one plausible explanation; many of these treatments have detrimental effects on populations of natural enemies. However, given the small plot size (4 rows x 50 feet), the surrounding cotton that was not treated with foliar insecticides, and the high degree of beneficial insect mobility, this may not fully explain the aphid population rebound. Changes in cotton plant chemistry and sublethal effects which altered aphid reporoductive biology are other possible explanations. From a practical standpoint, this points to the need to intensify field monitoring efforts in treated fields as the insecticide residual/efficacy wanes. Also, treatments with these materials applied for other pests, such as lygus bugs, may cause similar result with aphids.

Insecticide Resistance

Cotton aphids have a long history of rapid and frequent attainment of insecticide resistance. Kerns and Gaylor (1992) and Grafton-Cardwell (1991) have documented cotton aphid resistance to several materials. Evaluations during 1994 and 1995 have shown resistance to several insecticide products. Knabke et al. (1995) reported decreasing aphid susceptibility to Capture and Thiodan in testing conducted from June to September 1994 in SJV cotton. Fuson and Godfrey (1995) conducted discriminating dose evaluations in late July/Aug. and found that cotton aphids were resistant to Capture, Thiodan, and Lorsban in 85, 62, and 0% of the tested cotton fields in 1994. Resistance monitoring was expanded in 1995 throughout the southern SJV. Aphids were found to be resistant to Capture (77% of fields) and Thiodan (12% of fields). No resistance was found to Lorsban, but Grafton-Cardwell identified a low incidence of Lorsban resistance in the central SJV (personnel communication). The slightly lower incidence of resistance in 1995 compared with 1994 may reflect that more of the bioassays were done in mid-July before the majority of the aphid-targeted applications were made.

Conclusions

The cotton aphid has proven to be an extremely difficult pest to manage in California cotton. Clearly, an integrated approach must be used to ameliorate damage from this pest. In the short-term, insecticides can offer some assistance, but cotton aphid populations seen in 1995 cannot be managed effectively with insecticides. In addition, the evolution of insecticide resistance and the high production costs (insecticides/acaricides) to growers are problematic. Many advancements have been made in aphid thresholds and sampling over the last 5 years, however, some fine-tuning of these parameters is still in progress. Management schemes to reduce the San Joaquin Valley-wide cotton aphid population levels are needed to optimize management. Improved host plant resistance, more effective natural enemies, and modified cultural practices are among the long-term, more stable solutions to cotton aphid outbreaks.

Acknowledgments

This research was supported in part by grants from Cotton Incorporated State Support, University of California Statewide Integrated Pest Management Project, and several agrichemical companies. The technical assistance of Paul Wynholds and the cooperative efforts of several UC Farm Advisors is greatly appreciated.

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Table 1. Influence of cotton planting date on incidence of dark morph cotton aphids and alate cotton aphids - 1994.

Cotton	% Dark Morph Aphids			% Alate Aphids		
Planting Date	27 July	3 Aug.	17 Aug.	27 July	3 Aug.	17 Aug.
31 March	0.2	1.6	0.6	6.6	2.9	3.5
21 April	0.9	1.2	0.5	5.0	6.0	2.3
13 May	14.1	20.8	12.8	3.6	6.3	6.4

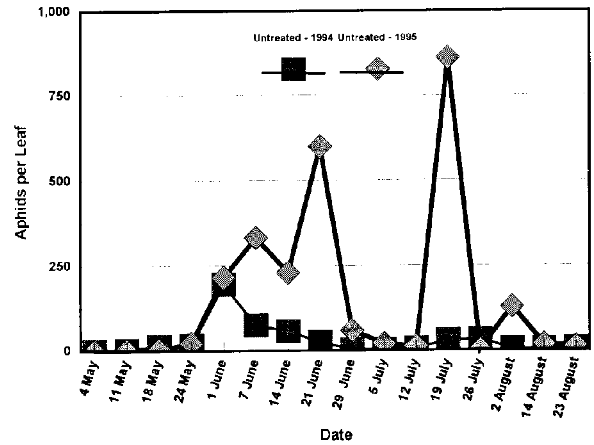

Fig. 1. Cotton aphid seasonal density on cotton in 1994 and 1995; Tulare County

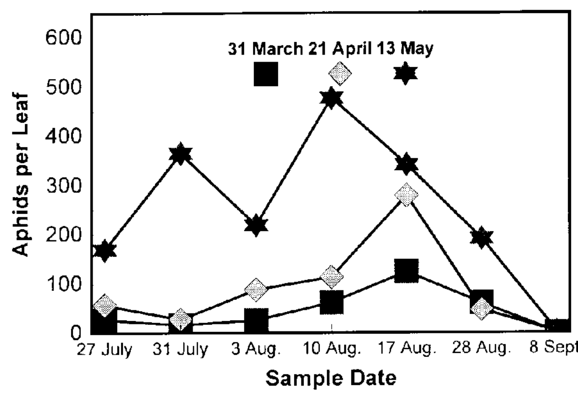

Fig. 2. Influence of cotton planting date on cotton aphid population density - 1994.

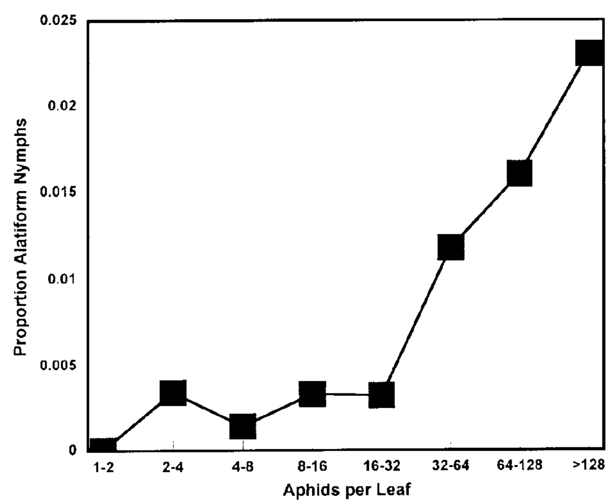

Fig. 3. Influence of cotton aphid density on the production of winged aphids.

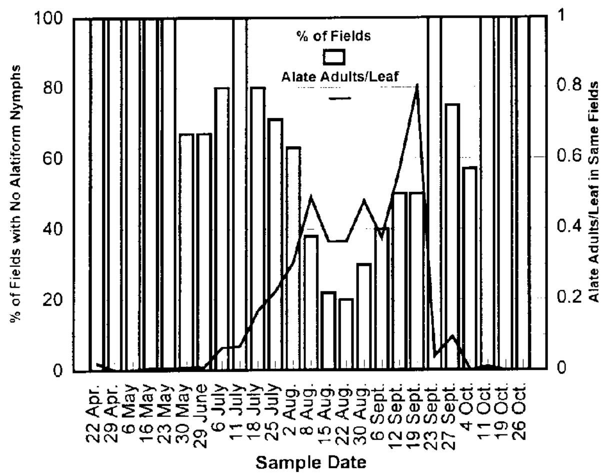

Fig. 4. Percentage of fields not producing alatiform nymphs and alate adult aphids per leaf in those cotton fields.

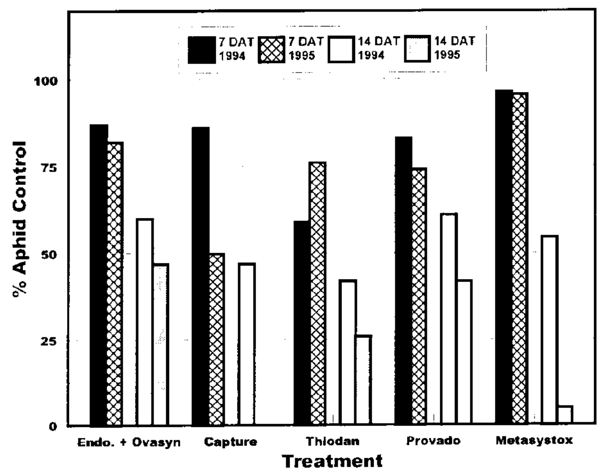

Fig. 6. Comparison of cotton aphid control efficacy with insecticides; 1994 and 1995.

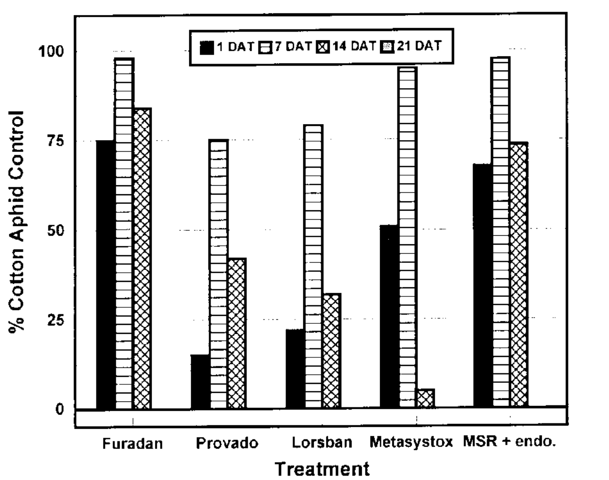

Fig. 5. Cotton aphid control from field research plots in 1995; Tulare Co., CA.

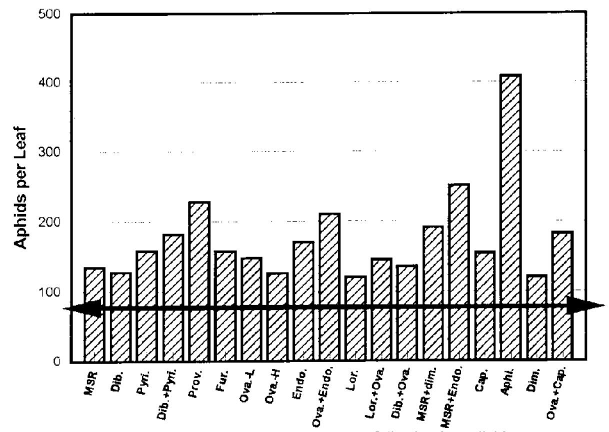

Fig. 7. Cotton aphid population density at 21 days following insecticide application in 1995; Tulare Co., CA. Line with arrows indicates the average aphid population in the untreated plots.