MID-SEASON COTTON APHID INFESTATIONS IN CALIFORNIA: EFFECTS ON COTTON YIELD

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Abstract

Cotton plant response to mid-season cotton aphid density was examined in small plot studies from 1995 to 1997. In 1997 (the year of the most severe pressure), cotton aphid populations peaked at ~550 aphids per leaf on 21 July. The infestation persisted for about 1 month. Plant response was quantified in terms of photosynthetic rate, boll size, retention, and yield in cotton plots planted in mid-April and plots planted in mid-May. In the April-planted cotton, there was a significant linear relationship between aphid density and seed cotton yield. Losses averaged about 0.21 lbs. seed cotton per aphid-day. In the May-planted plot (with a similar aphid infestation magnitude and timing), there was not a significant relationship between aphid density and yield. Yield losses from aphids in this study occurred due to fewer bolls per plant (a 13.8% decrease comparing plots with maximum aphids vs. plots in which aphids were controlled) and smaller bolls (a 5.7% decrease in average seed cotton weight per boll). In addition, aphid injury reduced the percentage of first position bolls on the plant and increased the percentage of bolls in the second and third positions. Photosynthetic rates were 6.4% greater in treated plots (with ~20 aphids per leaf) than in untreated plots (400-550 aphids per leaf). Stomatal conductance values were affected even more severely with a 18.5% decrease from the high cotton aphid densities.

Introduction

Mid-season infestations of cotton aphid (*Aphis gossypii* Glover) initially occurred in California cotton in 1992. Previous to this (from about 1987 to 1991), cotton aphid infestations were most serious during the pre-squaring and post boll opening phases. Before the mid-1980's, cotton aphids were only an occasional pest (and in most years a non-pest) in the San Joaquin Valley (SJV). Reasons for the change in pest status of this insect are unclear, but cotton aphid management in recent years has been a priority during July and August (Godfrey and Rosenheim 1996). In 1995, the cotton aphid was recorded as one of the most economically important arthropod pest of SJV cotton, paralleling the traditionally important pests of spider mites and lygus bugs (Williams 1996). This severe economic impact was repeated in 1997 (Williams 1998). During the last few years, cotton aphid outbreaks have occurred during any portion of the cotton growing season in the SJV with the infestations during the squaring/boll-filling and after boll opening periods being of the most concern.

The development of treatment thresholds has been a primary emphasis of research on cotton aphid in California. Thresholds developed in Texas and the mid-South were used as preliminary guidelines, but because of the differences in cotton production, environmental conditions, etc. in California, specific California thresholds needed to be developed. Rosenheim et al. (1997) showed that cotton can fully compensate for aphid infestations during the pre-squaring stage; the compensatory nature of early-season cotton and the generally short duration of these early-season aphid infestations (because of the actions of natural enemies), accounts for the lack of yield loss. In a limited region in the SJV, early-season aphid populations persist, but in most of the valley a conservative treatment approach is warranted on early-season aphids. Following boll-opening, cotton aphids have the potential to deposit honeydew on the exposed lint, thereby contaminating the lint. A treatment threshold of 10-15 aphids per leaf is supported by research (Rosenheim et al. 1995). The potential for sticky cotton and the economic importance of this damage contribute to this low threshold value.

During the squaring and boll-filling period, cotton aphids compete directly with these reproductive structures for energy. The phloem-feeding aphids act as a tap for the photosynthates along with the developing bolls. Several studies on yield loss relationships for mid-season aphids have been conducted in Texas and the mid-south (Andrews and Kitten 1989, Fuchs and Minzenmayer 1995, Karner et al. 1997); however, thresholds will likely differ among geographical areas which experience various environmental conditions, cotton yield potential, cotton varieties, etc. In California, Kerby (unpl.) showed a 13.4% reduction in cotton boll size, and similar reduction in yield, from a severe July aphid infestation in 1992, the first year of severe mid-season aphid infestation. McNally and Mullins (1996) reported a significant lint yield loss under California conditions with peak aphid populations from 30 to 150 per leaf. In 1994, Fuson and co-workers calculated a preliminary threshold for a late July infestation from a study designed to examine insecticide efficacy on aphids arising in several cotton planting dates (Fuson et al. 1995). The differential aphid infestations allowed a preliminary threshold to be quantified. Results showed a significant difference in the yield response among the three cotton planting dates, therefore indicating that more research was needed to clearly delineate this response. Additional studies as reported herein were conducted from 1995 to 1997 to further define the threshold for mid-season aphids. Results from the 1996 studies were reported previously (Godfrey et al. 1997).

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Materials and Methods

Research was conducted at the Univ. of California Cotton Research Station near Shafter, CA. Naturally-occurring cotton aphid populations were manipulated with insecticides such that plots could be setup in cotton blocks planted on 17 April and on 15 May with various densities of cotton aphid. Two objectives were pursued in each planting date 1.) plots with various aphid densities ranging from 0 to the natural density (density study) and 2.) plots with aphid pressure for various periods of time (timing study). Aphid populations were manipulated using applications of Furadan 4F, three rates of Lorsban 4E, and an untreated for the density study and with sequential applications (at about 10 day intervals) of Furadan 4F with an untreated for the timing study. Once a treatment regime was initiated, the goal was to maintain the respective level of aphid control throughout the study (until cut-out). Individual plots were 8 rows x 60' x 4 replications.

Irrigation, fertility, and other production practices were conducted per the area standard. The only exception was that management of other arthropod pests was done so that the aphid treatments in the study were not compromised. In 1997, spider mites were managed in June with an application of Zephyr and silverleaf whitefly was managed with a Knack application in August and Orthene+Danitol in early September.

Aphid densities were monitored in each plot at weekly intervals. Ten 5th main stem node (MSN) leaves per plot were sampled. Plant mapping was done at about weekly intervals from mid-June to mid-August. An extensive end-of-season plant mapping was done immediately before harvest. Cotton yields were collected with commercial equipment in October. In addition, bolls were hand-collected from representative zones of the plant to monitor boll weights and to determine which zone(s) were being affected by aphid stress. Finally, plant gas exchange measurements were made with a portable photosynthesis system to determine the influence of aphid injury on cotton plant productivity (photosynthesis). Samples were taken from a fully-illuminated 4^{th} MSN leaf during the mid-day (from 1100 to 1400).

Results

Aphid populations in 1997 were present in the plots beginning in late May, but at very low densities (~5 per leaf). Beginning about 1 July, populations began to build quickly and reached a peak population on 21 July. Populations declined to ~10-20 aphids per leaf by ~1 Aug. and remained low throughout cut-out. Therefore, the aphid stress was severe and lasted about 1 month in 1997.

Manipulative treatments worked very well in 1997, as planned. Treatments were started on 9 July. For the timing study, treatment regimes were started on 9, 18, and 30 July and 8 August (after the aphid population had crashed and never redeveloped). In the April planting date (density study), populations were highest in the untreated plots, peaking at ~550 aphids per leaf, and lowest in the Furadan treatment (Fig. 1). Populations in the Lorsban-treated plots were intermediate and generally responded to the A.I. rate. Aphid-day accumulation was tabulated as a means to compare aphid populations over the ~30-day period among the four planting dates and study combinations (Table 1).

Linear relationships between seed cotton yields and aphid populations (aphid-days or peak aphid density) were formed. Linear functions provided the best fit of the data. Relationships were significant ($P<0.05$) for both the density and timing studies in the April planting date cotton; however, the linear relationships were not significant for the data from the May planting dates (a trend only for the density study). Slope values and percentage seed cotton yield loss per aphid-day values are shown in Table 2. In the April planting date, slopes ranged from 0.18 to 0.25.

Plant mapping done immediately before harvest showed that high cotton aphid densities compared with low densities (i.e., Furadan-treated vs. untreated from the density study, April planting date) reduced the number of bolls per plant by 13.8%, increased the plant height slightly, decreased the percentage of bolls in the first position (67% compared with 75%), and conversely increased the percentage of second and third position bolls. Data on bolls on vegetative branches were inconclusive. Data on boll weights, collected immediately before harvest, indicated that high aphid pressure compared with low densities (i.e., Furadan-treated vs. untreated from the density study, April planting date) reduced the average seed cotton weight of first position bolls from fruiting branches 1-3 and 4-6 by 18.3 and 23.0%, respectively. Seed cotton weights from first position bolls arising from fruiting branches 10+ were actually increased slightly (8.3%) by aphid injury. Overall, seed cotton weights from individual bolls averaged 5.3 g from the Furadan treatment and 5.0 g from the untreated plots. Plots with intermediate aphid densities generally produced intermediate values in terms of plant mapping parameters and boll seed cotton weights.

Plant physiological parameters were significantly affected by cotton aphid infestations. At the time of peak population densities, plots with aphids controlled (~20 aphids per leaf) had photosynthetic rates that were 6.4% greater than untreated plots (400-550 aphids per leaf). Stomatal conductance values were affected even more severely with a 18.5% decrease from the high cotton aphid densities.

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Table 1. Aphid-day accumulations for 1997 mid-season aphid threshold study.

Plt. Date, Study	Unt.	Lorsban-1/4 rate	Lorsban-1/2 rate	Lorsban-Full rate	Fura-dan
April, density	7836	4603	3925	3112	1464
May, density	4534	2986	2922	2088	472
Plt. Date, Study	**Unt.**	**Timing 1**	**Timing 2**	**Timing 3**	**Timing 4**
April, timing	3197	798	1415	3228	4262
May, timing	4096	396	2247	5446	3156

Table 2. Slope and percentage seed cotton yield loss per aphid-day values for mid-season aphid threshold study, SJV, 1997.

	April, density	April, timing	May, density	May, timing
Slope	0.176	0.251	0.028*	none
% loss per aphid-day	0.005%	0.007%	0.001%*	none

* trend only, not significant

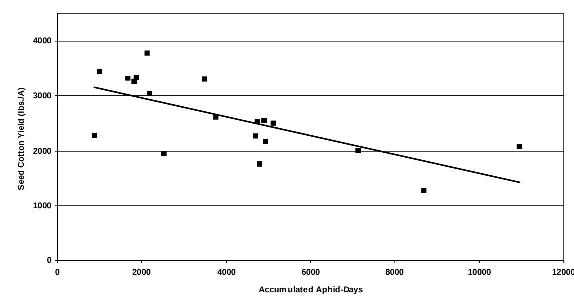

Figure 1. Relationship between seed cotton yield and cotton aphid population density (aphid-days); density study, April planting date, 1997.