PHYSIOLOGICAL AND YIELD RESPONSES OF COTTON TO MID-SEASON COTTON APHID INFESTATIONS IN CALIFORNIA

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Abstract

Cotton plant response to cotton aphid density was examined in grower field and small plat studies in 1995 and 1996. Plant response was quantified in terms of photosynthetic rate, boll size, retention, and yield. High aphid densities during the early period of squaring and boll-filling had no significant effects on seed cotton yield in the grower field test in 1996. Damage from other arthropod pests may have masked the effects of aphids. A moderate cotton aphid density developed in small plot tests in 1996, In the late planting date cotton (15 May), there was a significant relationship between cotton aphid density and sed cotton yield. A 0.36 lb. seed cotton loss per aphid-day was found. This value is slightly lower, but comparable to that shown in a 1994 study. Photosynthetic rates were significantly influenced by aphid density over a range of densities from 25 to 1260 per leaf. Photosynthetic rates declined by about 40% over this range of aphid densities

Introduction

The cotton aphid (*Aphis gossypii* Glover) has emerged as a significant pest of cotton in the San Joaquin Valley and in other cotton production regions. Although this insect has commonly infested California cotton fields for many years, it has only reached damaging levels since about 1986. Godfrey and Rosenheim (1996) summarized some of the factors associated with the rise of pest status of cotton aphid. Control of this pest with insecticides has been extremely unpredictable, often necessitating repeat applications. These repeat applications of broad-spectrum materials exasperate the disruption of biological control of other key cotton arthropod pests.

The importance of the cotton aphid in California cotton production has increased dramatically in recent years. In 1994 and 1995, the cotton aphid ranked as the first or second most important cotton arthropod pest of California cotton (Williams, 1995, 1996) with a 4-5% loss of the more than $1 billion value crop. During the early-mid 1980's, cotton aphid was not even mentioned as a pest of California cotton in this same yearly survey.

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Several types of damage are caused by cotton aphids in cotton. Upon becoming a pest of cotton in California (from about 1986 to 1991), cotton aphid infestations generally occurred during the early (April-May) and late (Sept.-Oct.) growing season. Infestations on seedling cotton (first 6 weeks following plant emergence) can be at extremely high densities and can stunt seedling growth. However, Rosenheim (1995) showed that cotton plants can compensate for this damage with yields generally not reduced, and thus these infestations are noneconomic. Early-season aphid populations are often quickly controlled by a complex of natural enemies. Late-season infestations are a major concern for cotton producers as the honeydew produced by cotton aphids contaminates the lint of open bolls. This produces a situation called sticky cotton, in which the cotton in difficult to harvest and to gin. Rosenheim, (unpl.) has conducted research on thresholds for late-season aphids

Beginning in 1992, cotton aphid infestations during the mid-season (June - August) have occurred in California. This infestation timing is common in Texas, Arkansas, Oklahoma (Slosser et al. 1989). Mid-season aphids are potentially the most damaging as the aphids are competing with the developing squares and bolls for the limited photosynthates. Biological control provides only limited management of mid-season aphid (Rosenheim et al. 1994).

Several studies on yield loss relationships for mid-season aphids have been conducted; however, thresholds will likely differ among geographical areas. Andrews and Kitten (1989) showed a curvilinear relationship between aphid density and cotton yield with steeply declining yield to about 200-250 aphid-days and less severe slope at higher aphid day values. Fuchs and Minzenmayer (1995) investigated cotton aphid effects on yield in Texas. Treatment guidelines of 50-100 aphids per leaf for 10-14 days have been proposed in Texas. In California, Kerby (unpl.) showed a 13.4% reduction in cotton boll size, and similar reduction in yield, from a severe July aphid infestation. Fuson et al. (1995) calculated a preliminary threshold of 1500 aphid-days from a late July infestation. This threshold was derived from a compilation of data from three planting dates (31 March, 21 April, and 13 May). Results showed a significant difference in the yield response among the three dates, therefore indicating that plant developmental stage is an important consideration. Finally, McNally and Mullins (1996) reported a 4 lb. lint/acre loss per each aphid/leaf increase with peak aphid populations from 30 to 150 per leaf. Additional studies as reported herein were conducted in 1995 and 1996 to further define the threshold for mid-season aphids.

Materials and Methods

Cotton plant response to cotton aphid was examined by using insecticides with various degrees of activity and several application timings to manipulate natural cotton aphid infestations and to achieve various levels of aphid stress, i.e., aphid-days. A test was conducted in a grower field in 1995 and 1996. Plot size was either 4 rows by field length (1995) or 4 rows by 40' (1996).

In addition, in 1995 and 1996, small plot tests were conducted on the Univ. of California Cotton Research Station near Shafter, CA. In 1996, cotton ('Maxxa') was planted on 15 April and on 15 May for this study. Standard production practices were used. Cotton aphid densities were determined at weekly intervals. As the populations reached ~10 aphids per leaf, the following treatments were applied for Study 1, 1.) Furadan 4F @ 0.25 lbs. AI/A, 2.) Lorsban 4E @ 0.19 lbs. AI/A, 3.) Lorsban 4E @ 0.38 lbs. AI/A, 4.) Lorsban 4E @ 0.75 lbs. AI/A, and 5.) untreated. These applications were made on 19 July. Study 1 was done to examine the effects of various aphid densities on cotton yield as the different insecticides and rates resulted in different levels of aphid control. For Study 2, Furadan 4F @ 0.25 lbs. AI/A was applied on 1.) 19 July, 2.) 29 July, 3.) 5 Aug., and 4.) 12 Aug., as well as having 5.) untreated plots. Study 2 was conducted to examine the influence of aphid control at various points in the infestation. Once a treatment regime was initiated, the goal was to maintain the respective level of aphid control throughout the study (until cut-out). Both Study 1 and Study 2 were done in each planting date.

Aphid densities were monitored in each plot (8 rows x 60' x 4 replications) at weekly intervals. Ten 5th main stem node (MSN) leaves per plot were sampled; cotton aphid incidence was also recorded on the terminals of the same plants. Plant mapping was conducted periodically throughout the season in all treatments as well as an end-of-season plant mapping. Cotton yields were collected 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 effected by aphid stress. Finally, plant gas exchange measurements were made weekly from mid-July to late August with a portable photosynthesis system. Plants with a range of aphid densities were sampled. Photosynthetic rates were analyzed to determine the influence of aphid injury on cotton plant physiology. Samples were taken from a fully-illuminated 4th MSN leaf during the mid-day (from 1100 to 1400).

Results and Discussion

In 1996, aphid densities in the grower field plots peaked at nearly 1000 per leaf on 28 June. The infestation started on ~7 June and populations crashed in early July and the field remained void of aphids the rest of the season. The infestation corresponded with cotton growth stages of 7 to 14 nodes. Yield results from this test showed no significant effects of cotton aphids on yield. Damage from other pests, including lygus bugs and silverleaf whiteflies, may have masked some of the aphid effects. In addition, aphid stress occurred relatively early in the cotton squaring and boll-filling period; the short duration of the stress may have mitigated the effects of the aphids.

In the small plot studies in 1996, cotton aphid densities reached ~10 per leaf in mid-July and the treatments were applied soon thereafter. Cotton aphid densities reached a maximum of about 500 per leaf and an average of 80 aphids per leaf on 1 Aug. This would be classified as a moderate aphid density. Aphid populations remained until late August. Treatments generally managed the population as desired and allowed a range of aphid densities to be set up. Aphid densities from the May 15 planting date cotton Study 1 are shown in Fig. 1. The influence of cotton aphid density on seed cotton yield (15 May planting date) is shown in Fig. 2. A yield loss of 0.36 lbs./aphid-day was noted. This value is slightly lower, but comparable to that shown in our 1994 study (Fuson et al. 1995).

The relationship between aphids on the terminals and the aphid density on the 5th MSN leaf was determined. If this relationship is strong and consistent, sampling aphids on the terminals could allow the development of user-friendly sampling plans. However, aphid populations on the fifth MSN leaf were similar on plants classified as with and those without aphids on the terminals (Fig. 3, 4). In fact, on some dates, plants without aphids on the terminals had more aphids on the fifth MSN leaf then plants with aphid-covered terminals. It appears that observing the terminals for aphids will not suffice for a sampling method.

As another means to evaluate the effects of cotton aphids on cotton productivity, plant photosynthetic rates were recorded using a portable photosynthesis system. Photosynthetic rates were significantly influenced by aphid density over a range of densities from 25 to 1260 per leaf (Fig. 5). Photosynthetic rates declined by about 40% over this range of aphid densities.

Acknowledgments

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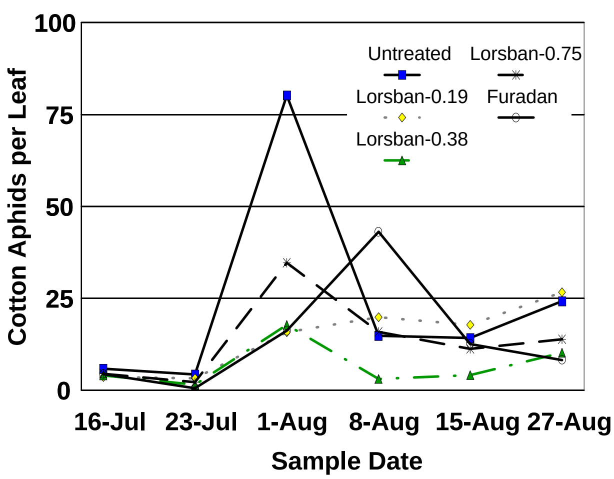

Fig. 1. Cotton aphid population density from cotton in Study 1; 15 May 1996 planting date.

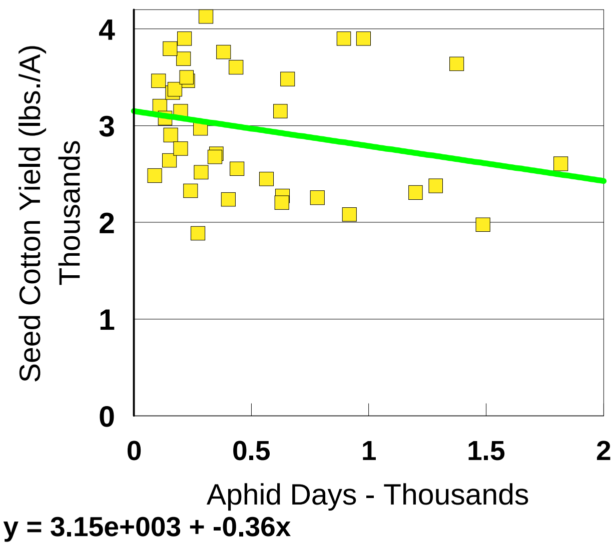

Fig. 2. Relationship between cotton aphid population density and seed cotton yield from 15 May 1996 planting date cotton. Results from Study 1 and Study 2 combined.

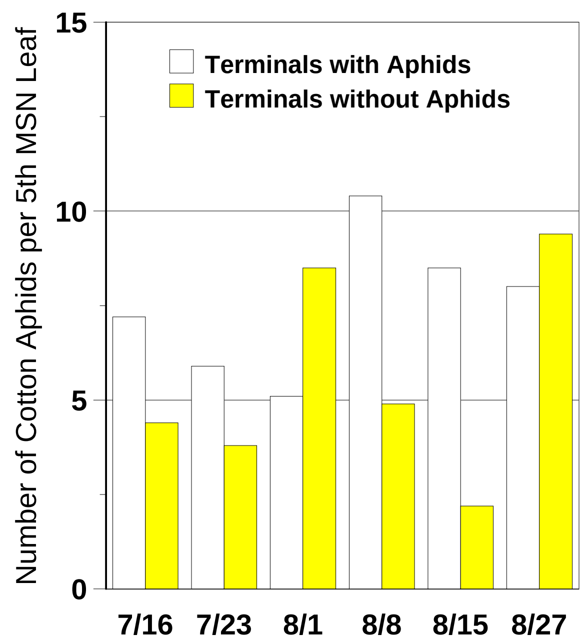

Fig. 3. Number of cotton aphids on fifth main stem node leaf of plants with and plants without aphids on the terminals; 15 April 1996 planting date.

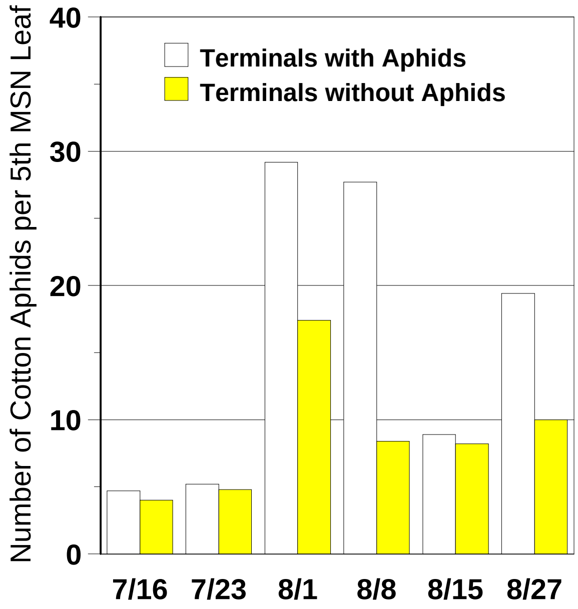

Fig. 4. Number of cotton aphids on fifth main stem node leaf of plants with and plants without aphids on the terminals; 15 May 1996 planting date.

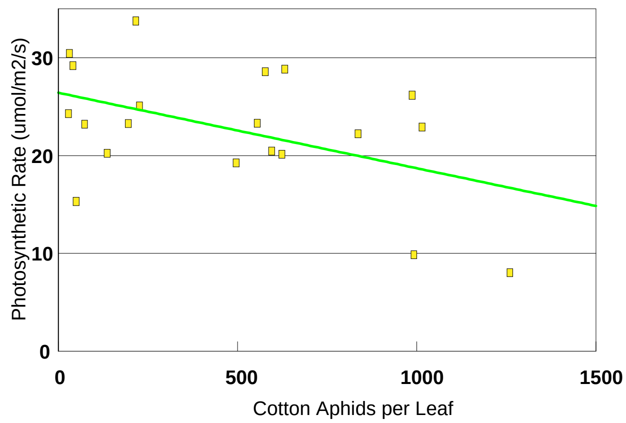

Fig. 5. Relationship between cotton aphid population density and cotton plant photosynthetic rate on 31 July.