APHID MANAGEMENT IN THE SAN JOAQUIN VALLEY: HISTORY, STATUS, NEEDS

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Abstract

In the California San Joaquin Valley (SJV), the cotton aphid (*Aphis gossypii* Glover) has escalated from an occasional pest to an annual, severe pest over the last 10 years. Starting in about 1994, infestations have occurred during any portion of the growing season with the infestations during the squaring/boll-filling and after boll opening periods being of the most concern. In 1995 and 1997, the cotton aphid was assessed as the most economically important arthropod pest of SJV cotton, exceeding the traditionally important pests of spider mites and lygus bugs. Although the cotton aphid is not a new insect in the SJV, the change in the bionomics of this pest dictated that updated research be conducted on the biology, damage thresholds, management, etc. of this pest. A brief review of this research will be reported herein, as well as a discussion of the status of cotton aphid in the SJV. Some directions for future research will be outlined.

Introduction

The cotton aphid (*Aphis gossypii* Glover) has escalated from an occasional pest to a severe pest over the last 10 years in the San Joaquin Valley (SJV) of California. This has occurred in a series of steps; from about 1986 to 1991 the highest aphid densities were observed on cotton before squaring and again after boll opening. In 1992, high aphid densities developed during the mid-season period (July and August), and this trend has continued and reached a maximum in 1995. 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 cotton industry in California reacted to this "new" pest. A meeting, sponsored by the California Cotton Growers Association and Univ. of California Cooperative Extension, was held in November 1995 to discuss cotton aphid management (and other pest management issues) and to develop strategies for short-term and long-term research needs. The ideas were a consensus of grower, pest control advisor, cotton industry, and Univ. of California personnel representatives (Goodell et al. 1997).

The cotton aphid is not a new insect in the SJV. Smith (1942) and Swift (1958) reported on the biology of this pest in the SJV. Occasional outbreaks, especially in the cotton production area in eastern Tulare County, have occurred. However, the changes in the bionomics and importance of this pest dictated that updated research be conducted on the biology, damage thresholds, management, etc. of this pest. A brief review of this research will be reported.

History:

Cotton Aphid Biology

With the initial outbreaks of aphids in cotton in 1986 and 1987, there was some uncertainty of the species involved. The black bean aphid (*Aphis fabae*) was thought to be involved (Goodell 1988); however, it was later identified as *Aphis gossypii*. It was obvious that the cotton aphid existed as several phenotypes. The color variation extended from light yellow to green to dark green/black. The plasticity in color was related, in part, with a variation in adult size (darker aphids are larger). The seasonal biology of the cotton aphid was one of the initial research thrusts. Dark morph aphids were found to develop more rapidly, give birth to more offspring, to obtain a larger size than light morph cotton aphids (Wilhoit and Rosenheim 1993, Rosenheim et al. 1994). The differences in size and fecundity were 2.5 to 3x over the range of phenotypes (light yellow to black). With these life history parameters, the yellow morphs were found to have an intrinsic rate of increase of 0.2 compared ~0.5 for the dark morphs. Therefore, the dark aphids were implicated in the population explosions in the field. The factors associated with the production of dark morph aphids were identified in a laboratory study as cooler temperatures, shorter day lengths, and nutrient-rich host plants (Rosenheim et al. 1994).

Natural Aphid Management/Noninsecticidal Control

Several studies have been conducted over the last 10 years on various aspects of natural control of cotton aphids in the SJV. Biological control is an important natural control measure for several arthropod pests of SJV cotton. Predators and parasitoids effectively reduced aphid populations on pre-reproductive stage cotton (Rosenheim et al. 1997, Colfer and Rosenheim 1995). However, during the mid- and late-season, biological control of the cotton aphid is poor. In controlled experiments, green lacewings (common during the mid- and late-season) are effective predators of cotton aphids; however, the complex of hemipteran predators disrupt aphid biological control (Rosenheim et al. 1995, Rosenheim and Cisneros 1994). These hemipteran predators feed rather indiscriminately and consume potential beneficial as well as pest insects.

The susceptibility of the approved California acala cotton cultivars to aphid population development was evaluated in 1993 and 1994. Some slight differences were found,

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although the most commonly grown varieties were equally susceptible (Godfrey and Wynholds, unpl.). These varieties were classified as hairy-leaf which is a trait associated with higher aphid densities.

Agronomic and production inputs significantly influence cotton aphid densities. Previous research in California, and in Texas and the mid-south, has shown that aphid populations are greater with late cotton planting (Slosser et al. 1992, Fuson et al. 1995, Godfrey and Rosenheim 1996), high levels of nitrogen fertilizer (Cisneros and Godfrey, 1998), and by previous applications of some insecticides. Aphid populations increases have been noted following applications of cyhalothrin in Texas (Kidd et al. 1996), several oganophosphates, carbamates, and pyrethroids in California in large field plot tests (Godfrey and Rosenheim 1996), and bifenthrin and cyfluthrin in single plant "plots" (Fig. 1). The effects of soil moisture on cotton aphid population development have been erratic.

Thresholds

Development of treatment thresholds was a primary emphasis of the ~10 years 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), account for the classification of early season aphids as non-pests. In a limited region in the SJV, early-season aphid populations persist, but in most of the valley a conservative treatment approach is warrented on early-season aphids.

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. Research by Fuson et al. (1995) and Godfrey et al. (1997) supported an economic injury level of 1500 aphid-days and a working treatment threshold of 50-100 aphids per leaf (5th main stem node leaf) for 7-10 days.

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).

Insecticidal Control/Resistance Management

Insecticides are a primary means of managing mid-season and late-season cotton aphid infestations. Organophosphate, carbamate, organochlorine, nicotinyl, and diamidide insecticides are all used to control aphids in California. Aphid control with insecticides can be very good (Wright et al. 1997). Several products such as amitraz + imidacloprid, chlorpyrifos, and imidacloprid gave 85%+ control at 21 days after treatment in this test. However, insecticide efficacy has often been erratic; this was observed at the onset of cotton aphid outbreaks (Goodell 1988) and has continued to date. Agronomic and environmental factors, such as cotton foliage nitrogen level, environmental conditions (which influence cotton aphid morph), and cotton plant age (planting date) all influence insecticide susceptibility (Cisneros and Godfrey 1998). Genetic-based insecticide resistance is also common in the cotton aphid. Grafton-Cardwell (1991) identified resistance to several organophosphates and to endosulfan in the mid-late 1980's in the SJV. In the early 1990's, cotton aphids in California developed resistance to bifenthrin. This product is generally ineffective for aphid control at this time. About 85% of cotton fields have aphids resistant to bifenthrin (as indicated by a 3-hour rapid bioassay) (Fuson et al. 1995, Grafton-Cardwell et al. 1997). Bioassays also showed some resistance to endosulfan (~62-71% of fields) and chlorpyrofos (~0-42% of fields).

Status:

Significant advances have been made in cotton aphid management in the SJV over the last 10 years. However, the emergence of this new pest (cotton aphid) has contributed substantially to the increased production costs for growers in the SJV. The high densities of cotton aphid beginning in July and continuing until harvest have necessitated multiple insecticide applications. Along with the silverleaf whitefly, also a relatively new pest, a significant number of applications and associated expense occur in July, August, and September. This is a part of the growing season when historically pest control costs have been minimal. In 1997, cotton aphid resulted in an estimated 3.4% yield loss and ~$38 in insecticide costs in California. Therefore, there is an acute need to better understand why cotton aphid outbreaks are occurring, i.e., what has changed over the last 10 years that could be stimulating the outbreaks. Rather than a therapeutic approach, an understanding of the ecosystem is needed such that populations of this pest can be minimized.

Needs:

At the present time, cotton aphid management is effective, but through a better understanding of the system, new management strategies and a more cost effective system could hopefully be devised. <u>Cotton aphid field life history</u> needs to be studied better. Alternate host plants (crops and weeds) for aphid buildup, overwintering host plants, aphid overwintering stage, etc. are all unknown in the California system. In addition, the factors which alter cotton aphid morph development needs to be studied in the field to supplement laboratory studies. Given that biological control is ineffective during the mid- and late-season, <u>alternative biological control agents</u> should be established. This could provide stable, cost-effective aphid management. These biological control organisms could be parasitoids, predators, or microorganisms. Development of cotton varieties with aphid resistance was a need identified at the review meeting following the 1995 growing season (a year of severe aphid outbreaks). Although this is likely a long-term project, the benefits and returns could be significant. Resistance could be obtained either through traditional breeding or through molecular methods. A better understanding of the influence of agronomic factors on aphid populations levels is needed. Data collected in small plot studies indicate that several agronomic factors could be extremely important. Ultimately a program needs to be designed and tested which integrates the agronomic inputs for maximum production with the inputs needed to limit aphid population growth. Hopefully, the inputs for these two strategies are compatible; if not some compromise will be needed. Finally, more effective and selective insecticides are needed for aphid management. Given the propensity of this species to build insecticide resistance, alternative modes of action are needed. Resistance management approaches should continue to be researched and implemented. The selectivity is important for preserving aphid natural enemies as well as biological control agents for other arthropod pests in cotton.

Summary

An extensive research effort has been directed at the cotton aphid in California. The frequent outbreaks of this pest in recent years, the increase in the pest status of cotton aphid over the last 10 years, and the disruption of the existing cotton IPM program in California have necessitated this research effort. Information on control measures, including biological, cultural, plant resistance, and insecticidal, on thresholds, and on aphid field biology has been developed. This information has been implemented by growers in the SJV and the cotton aphid is effectively controlled. However, the remedial measures needed to manage aphid outbreaks have significantly added to the costs of production and impended the economic return from cotton production. Additional research striving for a better understanding of the dynamics of aphid outbreaks and alternative management strategies is proposed. New management strategies and a more cost effective system could hopefully be devised.

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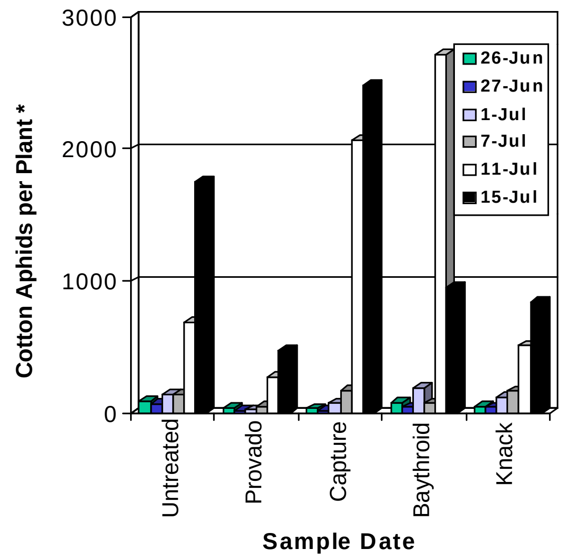

Figure 1. Influence of insecticides on cotton aphid population dynamics. Application made to single plant “plots” (each treatment replicated 6 times) on 26 June at ~10 aphids per leaf. * plants averaged 10 to 14 leaves.