Whitefly Management in Arizona: Conservation of Natural Enemies Relative to Insecticide Regime

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Abstract

Field studies were conducted in 1997 to evaluate strategies for management of whitefly (Bemisia tabaci). We evaluated the effects of different insecticide regimes (conventional and insect growth regulators [IGR]) on the abundance of native parasitoids and predators associated with whitefly in Arizona cotton. Immature parasitoids were most abundant in untreated control plots and there was little difference among insecticide regimes. Percentage parasitism was low overall (< 30%), but was highest in Knack plots and lowest in untreated control and Applaud plots. Predator populations were lowest in plots treated with conventional insecticides, and there were several instances where weekly or season-long populations of several predator species/groups were slightly depressed in IGR plots compared with the untreated check. Overall, results are encouraging and indicate that use of IGRs helps to conserve populations of native natural enemies.

Introduction

Significant advances have been made in managing whiteflies in Arizona cotton over the past few years. Sampling methods and action thresholds have been developed for efficiently timing the use of conventional insecticides and insect growth regulators (IGRs) (see Ellsworth et al. 1998). In part, these advances also have prompted renewed interest in examining and improving our understanding of the role of natural enemies in cotton pest management. Many species of beneficial arthropods naturally inhabit cotton fields and it is generally thought that they play an important role in maintaining many potential cotton pests (e.g., cotton leafperforator, beet armyworm) at harmless levels. They also may contribute to control of key cotton pests like whitefly, *Lygus* and pink bollworm. In 1996 we initiated studies to examine natural enemy conservation in relation to different whitefly management practices. These commercial-scale trials suggested that the use of the IGRs Applaud (buprofezin) and Knack (pyriproxyfen) may conserve populations of predators and whitefly parasitoids (Naranjo and Hagler 1997). These studies were continued in 1997 under quasi-commercial conditions at the Maricopa Agricultural Center. We report here the comparative population dynamics of native parasitoids and predators relative to different whitefly management systems. The overall whitefly management trial is described by Ellsworth (1998) and detailed studies to estimate causes and rates of whitefly mortality due to natural enemies and other factors are presented in Naranjo et al. (1998).

Materials and Methods

The study was conducted using NuCOTN 33B and contrasted four whitefly control regimes; Applaud used first, Knack used first, a rotation of conventional insecticides (1995-IRM), and an untreated control. The threshold for first and second IGR treatment was 1 large nymph/disk plus 3-5 adults/leaf (Ellsworth et al. 1996). A rotation of conventional insecticides were used as needed after both IGRs were applied. All conventional insecticide applications were made at 5 adults/leaf (Ellsworth et al. 1995). One insecticide application was made for *Lygus hesperus* over the entire experiment with Vydate C-LV (1 lb ai/A) on 25 July. All applications were made by ground and seasonal usage of insecticides is summarized in Table 1. Each insecticide regime was replicated 4 times using a randomized block design in a total area of about 8 acres. Additional detail on the entire experiment is provided in Ellsworth et al. (1998).

Parasitoid abundance and activity was estimated by taking weekly leaf samples (20-30 per plot) from the 7th mainstem node from the terminal. In the laboratory we counted all larval and pupal parasitoids of each genus (*Eretmocerus* and *Encarsia*) and all unparasitised 4th instar whitefly nymphs on the entire leaf. We calculated an index of parasitism based on the percent 4th instar nymphs parasitized. The abundance of arthropod predators was estimated weekly in each plot with standard 38 cm sweepnets. Twenty-five sweeps were taken in each of two locations for a total of 50 sweeps in each plot. We recorded the abundance of approximately 30 species of arthropod predators from our samples. For week by week analyses we combined predators into 4 broad groups: beetles, spiders, true bugs (excluding *Lygus*) and other (primarily of green lacewing larvae and a small predatory fly). We further analyzed the mean weekly abundance over the season for all major predator species/groups

Results and Discussion

All plots were treated *Lygus* on 25 July (Table 1). The first insecticide applications for whitefly control were made 29 July. Whitefly densities increased late season, and conventional materials were necessary in IGR by early September. A total of 4 applications were used in IGR treatments and a total of 5 applications were needed in the conventional treatment for whitefly control.

Eretmocerus eremicus and *Encarsia meritoria*, two native whitefly parasitoids were present throughout the season. *Eret. eremicus* was dominant, comprising about 80% of all parasitoids collected. Rates of parasitism were low in the early season, peaked (20-30%) in mid August and declined into September. Parasitism averaged about 8.4% over the whole experimental area for the entire season. Immature parasitoid abundance differed significantly among insecticide regimes on many post-treatment dates and were consistently highest for the untreated control (Fig. 1). There was relatively little separation among insecticide treatments which largely reflects the high levels of whitefly control resulting in few hosts available for parasitoid development. Percentage parasitism of 4th instar whitefly differed among treatments on 4 of 6 post-treatment dates and was generally highest for Knack plots and lowest for Applaud and untreated control plots (Fig. 1). Despite the moderate levels of parasitism observed here, detailed life table studies (Naranjo et al. 1998) indicate that parasitism is a very minor component of overall mortality within a whitefly generation.

Many of the 30 or more species of predators that we collected and recorded occurred at extremely low densities (< 1 per 50 sweeps). To facilitate analysis of predator abundance we pooled species into four broad groups; beetles, spiders, true bugs, and other. Average densities of predaceous beetles were low (< 3 per 50 sweeps) over the whole season and the only significant differences occurred near the end of the season where densities in untreated control plots were higher than in all other treatments on two dates (Fig. 2). The remaining predator groups were affected on the majority of post-treatment sampling dates. The abundance of true bugs (e.g. *Geocoris, Orius, Nabis* etc.) was consistently lower in conventional insecticide plots, and generally higher in the untreated control. Densities of true bugs in IGR plots were fell between those in conventional and untreated plots , especially toward the end of the season. The same pattern was evident for spider abundance, although there was less separation among untreated and IGR plots and overall densities were low (< 6 per 50 sweeps). The other group, which consisted primarily of green lacewing larvae and *Drapetis mediata* (predaceous fly of adult whiteflies) was the most abundant group, and there were several sampling dates where densities in IGR plots were significantly lower than the untreated control. Densities were consistently lowest in the conventional plots (Fig. 2).

Analyses of seasonal means were conducted for 12 species/groups that occurred at moderate to high densities (Table 2). Mean densities of 5 of the 12 species were statistically higher in IGR plots compared with 95-IRM plots and mean densities were significantly greater in untreated control plots compared with 95-IRM plots for 7 species. Mean densities of 2 species (*Geocoris punctipes* and *Drapetis mediata*) were significantly higher in control plots compared with IGR plots. There were no differences in mean densities of any species between the two IGR regimes.

The IGRs Applaud and Knack are highly effective in suppressing whitefly populations (Ishaaya and Horowitz 1992, Ellsworth et al. 1997, Ellsworth et al. 1998) and their use is generally considered to be compatible with natural enemy conservation (Gerling and Sinai 1994, Jones et al. 1995, Liu and Stansly 1997, Nagai 1990). Our evaluations of natural enemy abundance generally support these conclusions. Compared with conventional insecticides, use of IGRs conserved parasitoids and predators. However, in comparison to untreated plots, populations of natural enemies were depressed in IGR plots on several sampling dates and season-long populations of several abundant predators were similarly affected. These effects were small relative to the impact of applying conventional materials and it is unclear whether these reductions were associated with direct toxic effects or associated reductions in prey populations (see Ellsworth et al. 1998). Overall, our results are encouraging and indicate that use of IGRs for suppression of whiteflies helps conserve populations of native natural enemies. Many of the predators we examined are known to prey on whitefly in cotton (Hagler and Naranjo 1994a,b) and observations of whitefly mortality in the field (Naranjo et al., 1998) suggest that conservation may translate into enhanced levels of predation that substantially contribute to overall control of whiteflies in cotton. These studies are discussed in the following paper.

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References

Ellsworth, P. C, S. E. Naranjo, S. J. Castle, J. R. Hagler & T. J. Henneberry. 1998. Whitefly management in Arizona: Looking at the whole system. This volume.

Ellsworth, P.C., J.W. Diehl, T.J. Dennehy & S.E. Naranjo. 1995. Sampling Sweetpotato Whiteflies in Cotton. IPM Series No. 2. The University of Arizona, Cooperative Extension. Publication #194023. Tucson, AZ. 2 pp.

Ellsworth, P.C., J.W. Diehl & S.E. Naranjo. 1996. Sampling Sweetpotato Whitefly Nymphs in Cotton. IPM Series No. 6. The University of Arizona, Cooperative Extension. Publication #196006. Tucson, AZ. 2 pp.

Ellsworth, P.C., J.W. Diehl, I.W. Kirk & T.J. Henneberry. 1997. *Bemisia* growth regulators: large-scale evaluation. *In* P. Dugger & D. Richter[ed.], Proceedings. Beltwide Cotton Conferences, Cotton Insect Research and Control Conference, Nashville, TN. pp. 922-929.

Hagler, J. R. & S. E. Naranjo. 1994a. A qualitative survey of two coleopteran predators of *Bemisia tabaci* (Homoptera: Alyerodidae) and *Pectinophora gossypiella* (Lepidoptera: Gelechiidae) using a multiple prey gut content ELISA. Environ. Entomol. 23: 193-197.

Hagler, J. R. & S. E. Naranjo. 1994b. Determining the frequency of heteropteran predation on sweetpotato whitefly and pink bollworm using multiple ELISAs. Entomol. Exp. Appl. 72: 63-70.

Ishaaya, I. & A. R. Horowitz. 1992. Novel phenoxy juvenile hormone analog (pyriproxyfen) suppresses embryogenesis and adult emergence of sweetpotato whitefly. J. Econ. Entomol. 85: 2113-2117.

Jones, W. A., D. A. Wolfenbarger & A. A. Kirk. 1995. Response of adult parasitoids of *Bemisia tabaci* to leaf residues of selected cotton insecticides. Entomophaga 40: 153-162.

Liu, T. X. & P. A. Stansly. 1997. Effects of pyriproxyfen on three species of *Encarsia*, endoparasitoids of *Bemisia argentifolii*. J. Econ. Entomol. 90: 404-411.

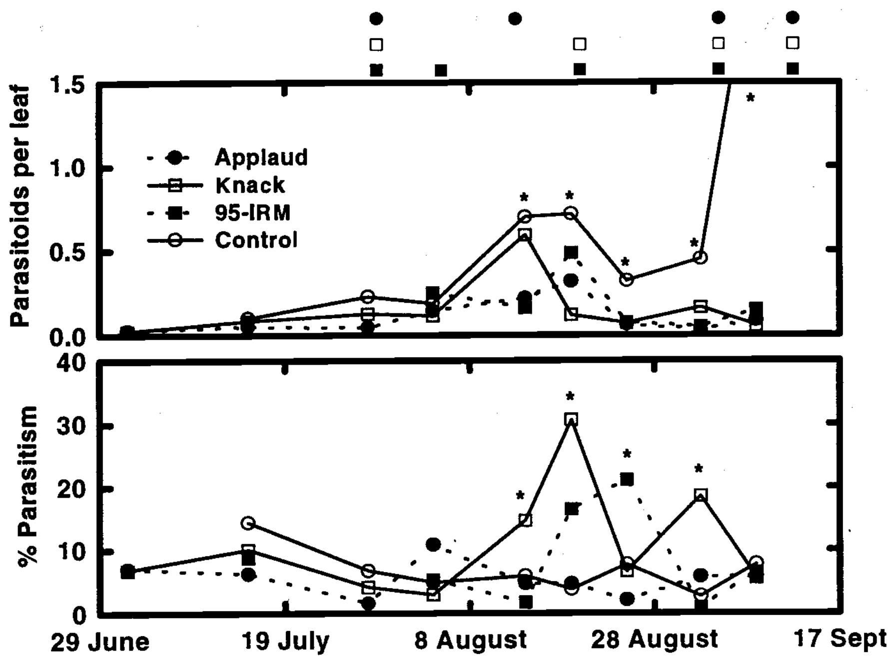

Fig. 1. Weekly densities of parasitoids and % parasitism in relation to insecticide regime at MAC. Asterisks denote significant treatment differences ($P < 0.05$). Symbols above graphs denote application dates for the indicated insecticide regime.

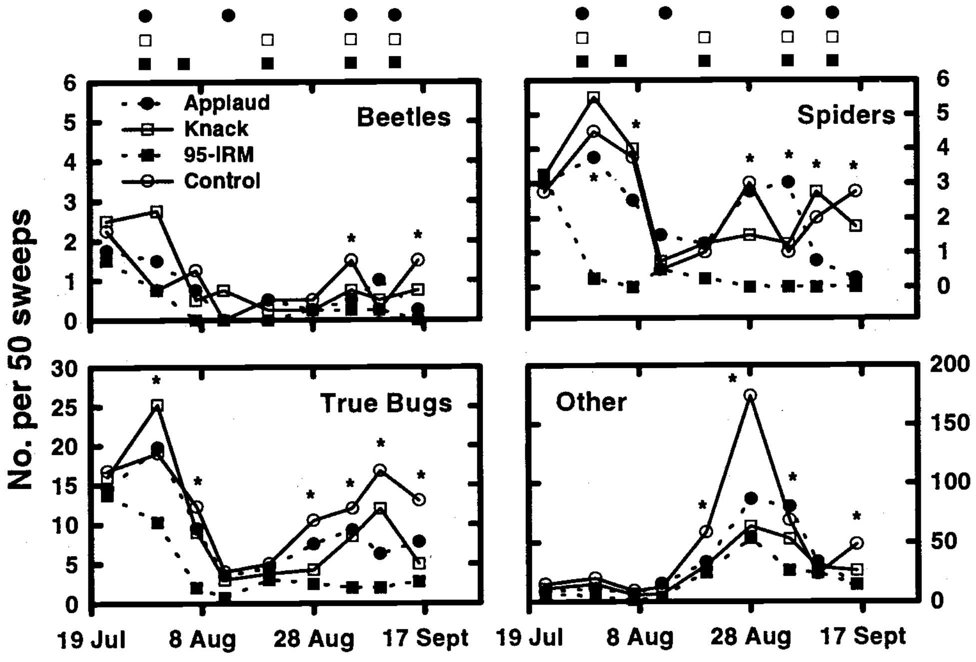

Fig. 2. Weekly densities of predators in relation to insecticide regime at MAC. Asterisks denote significant treatment differences ($P < 0.05$). Symbols above graphs denote application dates for the indicated insecticide regime.

an overall effort to demonstrate and evaluate different strategies for whitefly management in Arizona cotton (Ellsworth et al. 1998, Naranjo et al. 1998).

Materials and Methods

The study was conducted using NuCOTN 33B and contrasted four whitefly control regimes; Applaud used first, Knack used first, a rotation of conventional insecticides (1995-IRM), and an untreated control. The threshold for use of IGR treatment was 1 large nymph/disk plus 3-5 adults/leaf (Ellsworth et al. 1996). All conventional insecticide applications were made at 5 adults/leaf (Ellsworth et al. 1995). One insecticide application was made for *Lygus hesperus* over the entire experiment with Vydate C-LV (1 lb ai/A) on 25 July. All applications were made by ground and seasonal usage of insecticides for the studies described here is summarized in Table 1. Each insecticide regime was replicated 4 times using a randomized block design in a total area of about 8 acres. Additional detail on the entire experiment is provided in Ellsworth et al. (1998).

Cohorts of eggs and settled 1st instar nymphs were established over the course of one pre-spray and 3 post-spray generations between late June through early September in the replicated experimental plots described above. Because there were not enough whiteflies during the pre-spray generation, we used clip cages to introduce adult whiteflies and establish cohorts of eggs and nymphs. Cohorts in the remaining generations were identified from natural populations. Cohorts consisted of approximately 50 individuals of each stage in each plot. The location of each individual was marked on leaves with a non-toxic felt-tip pen. Each stage was then examined every 2-4 days directly in the field with the aid of a hand lens. Sources of mortality were recorded as due to insecticides, predators, parasitoids, inviable (eggs only), unknown and missing. This last category was often presumed to be associated with weather or chewing predation; however, insecticides also may have dislodged insects. In this preliminary report we present only apparent rates of mortality observed for each source. Future analyses will involve the estimation of marginal rates of mortality which corrects for the effects of contemporaneous mortality by multiple factors (e.g. predation, parasitism and insecticides) and allows for more robust comparisons among treatments.

The first post-spray cohort was established one day after spraying and continued for 14 days. The second post-spray cohort was conducted 14-27 days after initial spraying. The final cohort was conducted in untreated plots only. Only one IGR spray was made in the two IGR regimes during these studies. For the conventional regime, two sprays were made during the first post-spray cohort and one spray during the second post-spray cohort.

Results

Egg Mortality: In the first generation, prior to any insecticide sprays, the major sources of mortality were predation and missing (Table 2). Missing during this period was believed to be due to chewing predation because of large, coincident *Collops* beetle populations, and the absence of any rain or wind storms. About 6% of the eggs were inviable and 25% of the eggs hatched.

In second generation (1st post-spray generation) inviability was a major source of mortality in all regimes (Table 3). Inviability was highest in the Knack regime (69%), reflecting one of the main modes of action of this insecticide (interference with embryogenesis). Levels of egg predation were similar among the IGR and untreated regimes (19-30%) and lowest in the 95-IRM (9%). Missing was a significant source of mortality in Applaud, 95-IRM and untreated control plots. Egg hatch was lowest in the Knack regime (3%) and highest in the 95-IRM regime (34%).

Overall patterns of egg mortality changed little in the third generation (2nd post-spray generation), except that inviability was very low (< 6%) in all regimes but Knack (19%) (Table 4). Predation was again lowest in the 95-IRM compared with all other regimes. Overall, egg hatch was higher than in the second generation and was highest in the 95-IRM and untreated control (58-66%).