STRATEGIES FOR INSECTICIDE RESISTANCE MANAGEMENT OF SILVERLEAF WHITEFLY POPULATIONS IN TWO UPLAND COTTONS: GROUND APPLICATIONS OF INSECT GROWTH REGULATORS AND PYRETHROIDS

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Abstract

The silverleaf whitefly (SLWF), *Bemisia argentifolii* often interacts between melons, cotton, and vegetables and is particularly difficult to control. Integrated crop management should be considered necessary for SLWF control, but a first step is to develop integrated pest management (IPM) for specific crops; e.g.,cotton. IPM strategies that reduce the likely development of insecticide resistance and help bridge biological with chemical control are desirable. This work investigated two insecticide regimes that included two IGR' s, Applaud™ and Knack™. In the first regime, Applaud™ was applied first early in the SLWF season, followed by Knack™. Then, non-pyrethoid insecticides somewhat "soft" on beneficials were applied followed by pyrethroids. The second regime began with pyrethroids followed by "soft" insecticides with the two IGR' s applied last. Also, we investigated efficacy of ground application at 15 gal./ac, at two pressures, 40 and 225 psi, using a boom with drops and 5 nozzles per row. The trial was conducted on two contiguous fields of 80 acres total.

Over a 12-week sampling period, the following statements can be made. For eggs, by week 3, twice as many eggs were present in plots of the IGR first regime that were sprayed at 40 psi than in the other treatments. By week 6, continuing through week 9, numbers of eggs and immature SLWF for all treatments were approximately the same. However, for weeks 10-12, plots in the second regime of pyrethroid first treatments had twice as many eggs as plots in the first regime of IGR first treatments. The highest number of eggs at the end of the trials was approximately 2000 per 3.88 sq. cm. for pyrethroid first plots sprayed at 40 psi. Large nymphs peaked at week 2 with highest numbers in pyrethroid first plots. I G R first plots treated at 225 psi had less large nymphs than plots treated at 40 psi.

The insecticide regimes used in these studies tested insecticide resistance management (IRM) strategies for integration in true IPM application to promote biological control by beneficial arthropods and prevent insecticide resistance from occurring.

Introduction

The silverleaf whitefly (SLWF), *Bemisia argentifolii* Bellows and Perring, (Aleyrodidae: Homoptera) a.k.a. Sweetpotato whitefly, *Bemisia tabaci* Gennadius strain B. has many diverse hosts at any time during the year. SLWF populations that interact between melons, cotton, and vegetables are particularly difficult to control. Additionally, control strategies are made even more difficult by the presence of SLWF populations in urban and rural ornamentals and in alfalfa throughout the year. Integrated crop management (ICM) should be considered vital for area-wide control of SLWF. A first step is to develop integrated pest management (IPM) for specific crops involved, in this case, cotton. Presently, chemical control is the primary component of IPM for cotton. Insecticide resistance management (IRM) regimes need to be developed to avoid resistance problems brought on by frequent use of pyrethroids and the few other chemicals available. Ideally, they should incorporate a high diversity of efficacious insecticides from different chemical classes and utilize combinations of them in sequences dependent on SLWF population levels. to help prevent insecticide resistance. Also, they should minimize detrimental (pesticidal) impact on beneficial arthropods and promote biological control of SLWF, (Akey 1992, 1993, Akey et. al. 1996, Ellsworth et. al.1996a,b, Henneberry and Butler 1992). To date, SLWF has been controlled most successfully with highly efficient broad-spectrum insecticide combinations; e.g., pyrethroids in combination with another insecticide (see Faust, 1992, section C of the sweetpotato whitefly: 5-year plan for development of management and control methodology; and the supplements that followed, Hennebery et al., 1993-1996).

In Arizona for the 1996 cotton season, a section 18 (an emergency provision to use a pesticide for control of a specific pest, restricted by several use criteria, and not labeled for that pest) was granted to the state by the federal Environmental Protection agency (EPA) that permitted a single application each of two insect growth regulators (IGR's), Applaud™ (buprofezin) and Knack™ (pyriproxyfen). Trials were needed to determine appropriate insecticide regimes that included these I G R's.

Here, we report a field trial conducted by ground application in 1996. The specific objectives of this experiment were to determine if 1) is control more efficient if IGR's are used first and pyrethroids last versus pyrethroid used first and IGR's used last, 2) what effects do these sequences have on resistance management, and 3)

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will a more efficient ground spray result in significantly higher yields or net profits. A key criterion for determining the suitability of a diverse rotational regime of IRM for SLWF control programs was to have cotton yields comparable with control plots without higher net costs. (conventional insecticide application regimes, "best agricultural practices").

Materials and Methods

The study was conducted at the Maricopa Agricultural Center, University of Arizona, Maricopa, AZ near a commercial scale whitefly management trial (Ellsworth et. al. 1997). It was conducted in upland cotton, *Gossypium hirsutum* L cv SG 259 and DP 5415, planted on 40 in. centers, and furrow irrigated. Planting was on a 6-plant / 2-skip row pattern. This resulted in 75% of planted cotton on occupied land. Five-acre plots actually were 3.3 acres of planted cotton.

The layout and plot map are shown in fig.1. The left most plot, 1 P1T1 is north and right most plot, 12 P2 T1 is south. The 2 fields combined were about 80 ac.

Pesticides applications were made by ground rig with a John Deere ™ 4-wheel drive tractor with a 240 gal. spray tank and overhead boom. These were applied with a boom designed for more efficient under leaf coverage by having drops and swivels with 5 nozzles / row at 15 gal./ac..

The experimental factorial was 2 X 2 X 3 . The first factorial was chemical sequences, 1) IGR's (Applaud then Knack) applied with pyrethroid applications applied last, and 2) Pyrethroids applied first and I G R's (Applaud then Knack) applied last. The second factorial was two application pressures, 1) 40 psi, and 2) 225 psi., The third factorial was 3 replicates. Replicates 1 and 2 were planted with upland cotton SG 259 and replicate 3 with DP 5415. The plots were in a random block design in a single tier across both fields for a total of 12 plots.

The treatment action threshold used was an average of 3 large nymphs per 3.88 cm sq. leaf disk and 5 SLWF adults / leaf. Whitefly population densities were estimated not less than weekly. The 5th mainstem leaf down from the terminal at the top of the plant was used for population determinations and 30 plants / plot were sampled. For adults, the binomial leaf turn count method was used (Ellsworth et al. 1995, Naranjo et al. 1996). The same leaves were used to determine numbers of SLWF eggs, nymphs (Ellsworth et al. 1996c, Diehl et al. 1997).

Products or tank mixes of products (all identified by their trade mark name and rate given in lb ai/ac, and presented alphabetically;i.e., not by order of usage) used in these tests against SLWF included: Applaud, 0.35; Capture/Penncap-M, 0.04/0.5; Capture/Lannate, 0.04/0.5; Danitol/Orthene, 0.2/0.5; Danitol/Vydate, 0.2/0.5, Karate/Lannate 0.04/0.5; Karate/Penncap-M, 0.04/0.5; and Knack, 0.054. Dimilin,Vydate, and a bait mix of Nomate / Lorsban 0.5 were used as needed on all plots as "over sprays" against beet armyworm, plant bugs (*Lygus)*, and pink bollworm, respectively.

Results

Population numbers are shown in Figures 2-5. The x axis gives the weekly sample data begining on/about July 1 and the y axis gives the eggs and nymphs as means/leaf diskand the adults as mean no./5th main-stem leaves from the terminal. The first application was made 3 days later on July 3. For eggs (Fig.2), by week 3, twice as many eggs were present in plots of the IGR first regime that were sprayed at 40 psi than in the other treatments. By week 6, continuing through week 9, numbers of eggs and immature SLWF for all treatments were approximately the same. However, for weeks 10-12, plots in the second regime of pyrethroid first treatments had twice as many eggs as plots in the first regime of IGR first treatments. The highest number of eggs at the end of the trials was approximately 2000 per 3.88 sq. cm. for pyrethroid first plots sprayed at 40 psi. Large nymphs peaked at week 2 with highest numbers in pyrethroid first plots. I G R first plots treated at 225 psi had less large nymphs than plots treated at 40 psi.

By week 4, all SLWF populations in all plots were under control by the treatments that they received, and remained so through the season, Figures 2-5. The applications required to obtain this control are shown in Figure 6.

Resistance data for Danitol/Orthenewas taken for this work (Figure 7). The baseline (control) for susceptibility was taken on July 8 and from 0.1 - 100 micrograms/ml, the log line was linear. The IGR first treatments showed the least susceptibility. However, this must be viewed in regard to the fact that near the end of the seson when the comparison data were taken, those plots had received two pyrethroid tank-mix applications. A similar result was observed in a plot in a different test that received no IGR's and was treated with convention insecticides only, Figure 8.

Yield data forthe plots, expressed in bales/ac of occupied land, showed an yield of 1.68 for the IGR's used first plots and 1.32 for the pyrethroids used first plots, significant at $P = 0.03, N = 4$, for a 2-sided t-test. These data are being examined further. Analysis of yield data showed that two fields produced the highest yields at the north end of field 26 and progressed to lower yields for more southerly located plots. This prevented us from doing a comparison between the 2 cotton varieties.

Discussion

The IRM management program tested in this study used IPM practices of insecticide specific regimes to promote biological control by beneficial arthropods and tried to prevent insecticide resistance from occurring. No insecticidal efficacy data were gathered that supported using pyrethroids first rather than using IGR's first. In that respect, this study supports the University of Arizona publication on whitefly management in Arizona cotton (Ellsworth et al. 1996b). It was apparent that more resistance data is needed to provide foundations for appropriate IRM regimes and programs (see Dennehy et al., 1996a,b). The yield increase for IGR's used first treatements was unexpected and will be studied in more detail.

Disclaimer

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply its approval to the exclusion of other products that may be suitable.

Acknowledgments

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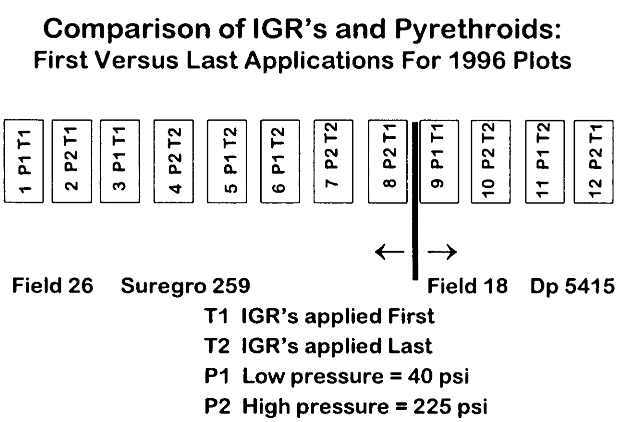

Figure 1. Layout and plot map for this study.

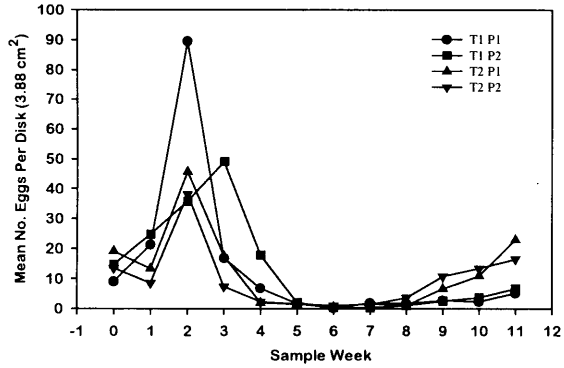

Figure 2. Population numbers for eggs of Silverleaf Whitefly.

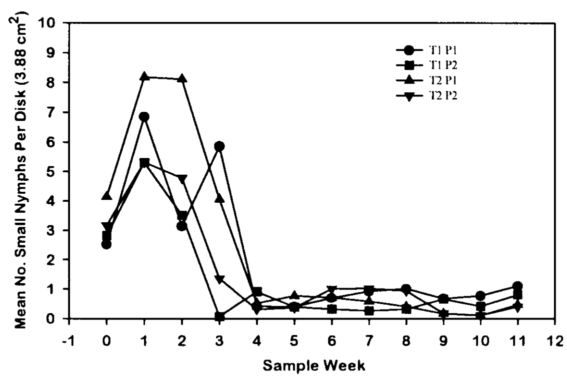

Figure 3. Population numbers for small nymphs of Silverleaf Whitefly.

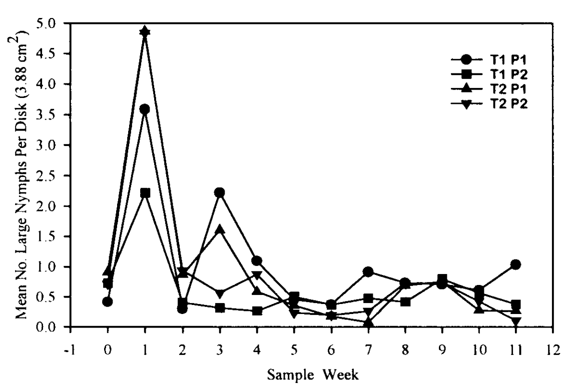

Figure 4. Population numbers for large nymphs of Silverleaf Whitefly.

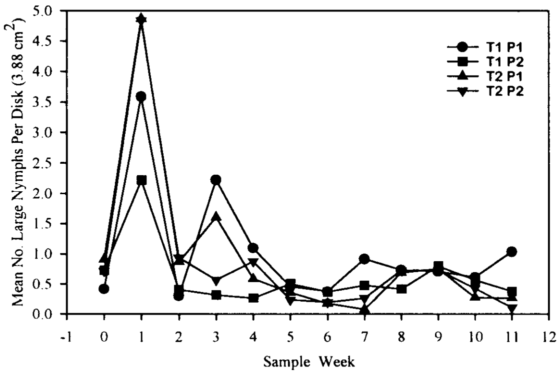

Figure 5. Populations of adult Silverleaf Whitefly.

Insecticide Application Against SLWF

Treatment	1	2	3	4	5	6
T1 P1	Applaud July 10	Knack July 25	Dan/Ort Aug 29	Cap/Lan Sept 9	Kar/Pen Sept 20	-
T1 P2	Applaud July 3	Knack July 17	Dan/Ort Aug 29	Cap/Lan Sept 9	Kar/Pen Sept 20	-
T2 P1	Dan/Ort July 3	Dan/Vyd July 14	Kar/Lan July 21	Applaud Aug 13	Knack Aug 29	Kar/Pen Sept 20
T2 P2	Dan/Ort July 3	Dan/Vyd July 14	Kar/Lan July 25	Applaud Aug 13	Knack Aug 29	Kar/Pen Sept 20

Figure 6. Treatments and application dates for control of silverleaf whiteflies in this study.Cap = Capture, Dan = Danitol, Kar = Karate, Lan = Lanate, Pen = Penncap-M, Ort = Orthene, Vyd = Vydate.

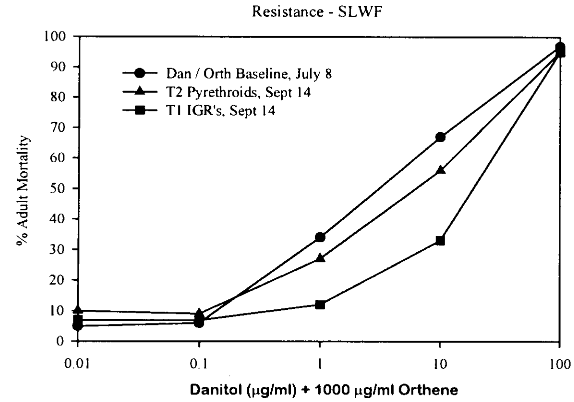

Figure 7. Resistance data for Danitol/Orthene taken for this study.

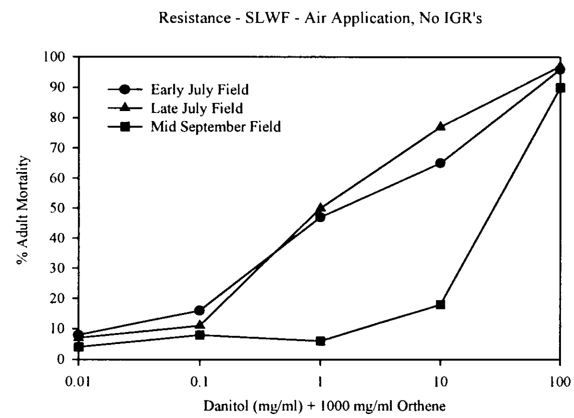

Figure 8. Resistance data taken for a plot in a different test (see Ellsworth et. al. 1997) that received no IGR's and was treated with conventional insecticides only.