LARGE SCALE WHITEFLY MANAGEMENT AND TRIALS USING INSECTICIDE ROTATIONS TO DEVELOP IPM STRATEGIES FOR ARIZONA UPLAND COTTON

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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. Efficacious insecticides from different chemical classes (including biopesticides) were rotated and compared with pyrethroid (low chemical class diversity) based regimes. The rotational regimes (high diversity) were investigated as a component of insecticide resistance management, (IRM) for use in IPM programs. We conducted 3 field trials by ground application between 1993-1995. The 1st 2 trials used 4 blocks of 5 ac each for a total of 20 acres each; and the 3rd trial, part of a larger trial, used 18 plots of 5 ac each, for a total of 90 acres.

In two of the trials, yields of cotton were similar between the high and low diversity chemical regimes. In the 2nd trial, the low diversity regime had yields of 2.5 compared with 2.3 bales/ac for the high diversity regime which included biopesticides (significant at $P < 0.05$). The 1st 2 trials used ground applications with 25 or 30 gal./ac., 70 psi, and booms with 18 in. drops; the 3rd trial used ground applications similar to grower usage with, 15 gal./ac, 40 psi, and a broadcast boom without drops. The most significant application difference occurred not between the two types of ground equipment but between the more efficient ground application in the 2nd trial compared with an aerial control of "best agricultural practices" movement in fields surrounding the 20 ac trial site. In this case, the low diversity regime had yields by aerial application of 2.5 compared to 3.4 bales/ac by ground application (significant at $P < 0.05$).

The tendency toward increased resistance to Danitol in the 2nd trial and the seasonal effect of increased resistance as the season progressed in the 3rd trial, leaves uncertainty regarding resistance which will require further study.

The IRM management programs tested in these three studies tried to use true IPM and present methods of insecticide usage to promote biological control by beneficial arthropods and prevent insecticide resistance from occurring. The use of different action thresholds for different parts of the insecticide season proved useful toward achieving these objectives. Likewise, the absence of sticky cotton in any of the regimes tested in all three studies shows that these management strategies prevented the occurrence of sticky cotton.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:817-819 (1996)
National Cotton Council, Memphis TN

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. Integrated crop management should be con-sidered a vital component of systems to control SLWF. A first step is to de-velop integrated pest management (IPM) for specific crops involved, in this instance, cotton. Presently, SLWF has been controlled most successfully with highly efficient broad-spectrum insecticide combinations, e.g., pyre-throids in combination with another insecticide (see section C of the sweetpotato whitefly: 5-year plan for development of management and control methodology, Faust, 1992; and the supplements that followed, Henneberry et al. 1995, 1994, and 1993).

IPM strategies need to be developed that avoid resistance problems brought on by use of pyrethroids. Rotational insecticide regimes, that incorporate a high diversity of efficacious insecticides from different chemical classes and utilize combinations of them in sequences dependent on SLWF population levels, need investigation to determine if such regimes abate development of insecticide resistance (Akey et al. 1995, Dennehy et al. 1995 a,b).

An important challenge to the practical application of IPM is to utilize both biological and chemical control in a compatible manner in the field to achieve true IPM, e.g., bridge biological control with chemical control. Bioinsecti-cides (biorationals) need to be incorporated in such regimes. Not only to help prevent insecticide resistance but to minimize detrimental insecticidal impact on beneficial arthropods and promote biological control of SLWF, (Akey 1993, Akey et al. 1992, Henneberry and Butler 1992).

Here, we report a summary of 3 field trials conducted by ground application in 1993-1995 (the 1995 trial included aerial applications not reported here, see Ellsworth et. al., these proceedings 1996). Specific objectives were to 1) investigate insecticide regimes of registered conventional and biopesticides, 2) conserve beneficial arthropods, and 3) reduce insecticide resistance, particularly to pyrethroids. A key criterion for determining the suitability of a diverse rotational regime for SLWF control programs was to have cotton yields comparable with control plots (conventional insecticide application regimes, "best agricultural practices").

Materials and Methods

The three studies, 1) 1993, 2) 1994, and 3) 1995, respectively were conducted in upland cotton, *Gossypium hirsutum* L cv DPL 5415, planted on 40 in. centers, and furrow irrigated. Pesticides applications were by ground rig. The nonionic wetter/spreader/penetrant adjuvant, Kinetic (Helena Chemical Company) was used at 0. 125 percent V / V with all foliar (liquid) treatments.

Studies 1 and 2

Study 1 was conducted at Sundance Farms of Coolidge, AZ (Akey et al 1994) and study 2 (Akey et al. 1995)at the Maricopa Agricultural Center, University of Arizona, Maricopa, AZ. The experimental fields were solid planted and divided into four 5-ac blocks. Each block was subdivided into replicated strips. In study 1, there were 5 subplots within each block and 5 sampling sites within each subplot for a total of 25 samples/date. In study 2, there were subplots within each block and 5 sampling sites within each subplot for a total of 15 samples date. Leaf samples were taken to sample SLWF eggs and large immatures. Sticky traps were used to sample adult SLWF in study 1. Standard sweep net samples were used to estimate beneficial arthropod populations. Ground applications were with a John Deere HI Cycle 6000, outfitted with a boom that had inverted “Y” drops with Tee jet nozzles by Spray Systems Inc. to penetrate the canopy at 70 psi. Each row was sprayed by 5 nozzles (2 side and I overhead) with 25 gal./ac delivered in study 1 and 30 in study 2.

Three of the 5-ac blocks were used for a specific insecticide regime in which the insecticides used in the regime were rotated by different chemical classes. The insecticides used in these regimes were chosen so that those believed to be less harmful to beneficial arthropods were used in early and mid-season. These 3 regimes by 5-ac block were designated as Rotations I-Ill (ROT). The 4th block (ROT IV) received a low diversity insecticide regime, pyrethroid based, that was the same as that applied to the rest of the surrounding farm fields. These fields were treated by ground application in study 1 and aerial application in study 2 and were used as controls as “best agricultural practices”.

Study 3

Study 3 was conducted at the Maricopa Agricultural Center, University of Arizona, Maricopa, AZ within a commercial scale whitefly management trial that had experimental variables of application methods (aerial vs. ground), treatment action thresholds (1, 3, or 5 SLWF adult/leaf), and chemical use regimes (low [pyrethroid] and high [insecticide resistance management, [IRM] chemical diversity regimes) (Ellsworth et. al. 1996, these proceedings, Akey 1995). A complete random block design was used with individual plots of 5 acres each, replicated 3 times.

Whitefly population density was estimated not less than weekly using the binomial leaf-turn method and sampling 30 plants/plot (Ellsworth et. al. 1995, Naranjo et. al. 1996). The same leaves were used to determine numbers of SLWF eggs and nymphs for a total of 540 ground-plot samples/date. Ground plots were planted with 12 solid rows, and 2 skip rows for application access by a John Deere 4-wheel drive tractor with a 240 gal. spray tank and overhead boom without drops. Applications were at 40 psi at 15 gal./ac.

Results

Study 1

For early season control, the first two 5-ac blocks received aldicarb 5 lb./ac (Temik®) at planting and a side-dress application of 15 lb./ac. On the first 5-ac block (ROT 1), pink bollworm (PBW) pheromone as NOMATE® was put out with chlorpyrifos (LOCK-ON®) 3 times (weekly) against PBW at Pin-head Square and NOMATE® alone twice as determined by PBW pressure (via Delta traps). On the second 5-ac block (ROT II) that received aldicarb, three applications were made with thiodicarb (Larvin®) at pin-head square against PBW. On the third 5-ac block (ROT III), oxamyl (Vydate®)/methomyl (Lannate®) was applied for early season pest and PBW control. The fourth block (ROT IV) was a “best agricultural practices” per the farm protocols and did receive aldicarb as a side dress treatment.

For mid-season control on the first 3 blocks (ROT I, II, and III), biorational agents were used for pest arthropod control as needed with the intent of preserving beneficial arthropod populations. These agents, primarily targeted toward lepidopterous pests, were BT (Biobit®), and Diflubenzuron (Dimilin®). Also, Potassium salts of fatty acids (M-PEDE®), and petroleum oils (Saf-T-Side Oil® and JMS Stylet Oil®) were used as needed on SPWF during June and July. Adult SLWF numbers of 2-3 per plant or large immature numbers of 3-4 per leaf were considered action thresholds. The leaf selected for the immature threshold count was the one with the highest count, usually the fifth main stem node from the top of the plant

For late season control, when the SPWF action thresholds of 2-3 large immatures or adults per leaf was exceeded, amitraz (Ovasyn®) with endosulfan (Thiodan, 2C®) was applied twice at weekly intervals in ROT I- III. Block IV (ROT IV) received the regular farm schedule/applications. The pyrethroid, esfenvalerate (Asana®) was applied twice. Though not necessary in this study, if additional control had been needed a different class of insecticide would have been used.

In September, mean numbers of SPWF/cm^2 of leaf in all plots ranged as follows: eggs, 13.5 - 29.5 (differences ns), and large immatures, 2.0 - 3.0 (differences ns). Counts were made for SPWF adults and for beneficial arthropods: *Chrysopa* adults and nymphs, *Hippodamia*, *Geocoris*, *Orius*, *Nabis*, *Collops*, *Lygus*; adults and nymphs, *Zelus/Sinea* (Assassin bugs), parasitic wasps, predacious flys, and spiders.

Cotton was terminated expediently (about 4 nodes above 1st cracked boll) and harvest aids were used as needed, Ethephon (Prep® and thidiazuron (Dropp®). Yield was 2.68 bales/ac (means of 1388 lb./ac) and differences between blocks was not statistically significant. The cotton lint and leaves from all blocks and the remainder of the field were not sticky.

Study 2

For early season control, the 1st two 5-ac ROTs received aldicarb as a side-dress of 14 lb. On ROT 1, pink bollworm (PBW) NOMATE pheromone (1.6 oz/ac) was used against PBW post pin-head square. On ROT II, an application was made thiodicarb (10 oz AI/ac) against PBW at post pin-head square. On ROT III, oxamyl (0.25 lb. AI/ac) was applied 3 times for early season pest and PBW control. ROT IV, a control, used best agricultural prac-tices for the season; usually weekly applications of fenpropathrin/acephate (0. 2 lb. AI/ac and 0. 5 lb. AI/ac).

For mid-season control, SLWF action thresholds of 2-3 adults/plant or 3-4 large immatures/leaf were used. ROTs I, II, and III received 2 applications of potassium salts of fatty acids (2% V/V). ROT IV received a 4th application of oxamyl (0.25 lb. AI/ac). Treatments in ROTs I-III tried to preserve beneficial populations.

For late season control, amitraz (0.25 lb. AI/ac) and endosulfan (1 lb. AI/ac) was applied twice in 5 days in ROTs I-III. Pyrethroid as esfenvalerate was applied twice, 1st with endosulphan, 2nd with methomyl and chlorpyrifos. BT was applied against worm pests. In ROTs I-III, SLWF populations were controlled, beneficials were not as numerous as expected, and yields were 2.3 bales/ac. In ROT IV, SLWF populations were lowest (sig $P<0.05$), but some fenpropathrin resistance occurred (ns at $P<0.05$), and yield was 3.4 bales/ac (sig. at $P<0.05$). The 3.4 bales/ac was higher than the 2.5 bales/ac (sig. $P<0.05$) yield by air application on the rest of the farm.

Study 3

The low diversity chemical regime (pyrethroid Regime) consisted of pyrethroid combined with Orthene/Danitol for the first 4 applications, followed by Capture, Karate, Asana XL, Baythroid, Karate, and Asana XL. The high diversity chemical regime consisted of the following combinations: endosulfan/Ovasyn, Vydate CLV/Curacron, Danitol/Orthene, endosulfan/ Ovasyn, Danitol/Vydate CLV, Capture/Lorsban, Karate/PenncapM, Capture/ Lannate, Asana XL/Curacron, Karate/PenncapM. These regimes enabled us to control SLWF populations during early, mid, and late season.

The adult SLWF threshold determined when an application was made but no applications were less than 7 days apart. This minimum occurred for both regimes in September. The Pyrethroid regime had the largest increases in eggs, nymphs, and adult numbers. This large change in control could be the result of reduced susceptibility, i.e. resistance in the SLWF. Bioassays for resistance indicated rather sharp changes in whitefly susceptibility to Danitol/Orthene from mid-July (prespray) to early-September. The low diversity regime, (IRM), especially in conjunction with the 5 adult SLWF threshold, resulted in a relative slowing of progression towards resistance(see Dennehy and Antilla 1996, these proceedings). However there was a decline in susceptibility in all treatments.

The number of insecticide applications needed was greatly reduced using a threshold of 5 compared to 1 adult SLWF/leaf. The higher threshold resulted in 3 to 5 less sprays and was not affected by the insecticide regime used, neither pyrethroid nor IRM. At harvest, none of the cotton was sticky. Yields were just above 2.5 bales/ac with no significant differences between insecticide regimes nor application method-, a slight but significant increase occurred in threshold 1.

Discussion

In study 1 the yield of 2.68 bales/ac for both Pyrethroid and IRM regimes was quite encouraging. In contrast, in study 2, the 3.4 bales/ac, produced by the Pyrethroid regime was higher than the 2.5 bales/ac ($P < 0.05$) yield by aerial application (Pyrethroid regime) on the rest of the farm and was significantly higher ($P < 0.01$) than the high diversity regime (IRM) of 2.3 bales/ac. Study 1 failed in respect to achieving comparable yields with IRM compared to pyrethroid regimes. It did indicate that efficient ground rig spraying was economically far ahead of the aerial applications in this study; an unexpected result. Study 2 included resistance monitoring and the occurrence of Danitol resistance, although not significant statistically, was disturbing since it occurred in the pyrethroid regime (ROT IV) and not the other 3 IRM (ROT I, II, and III) regimes (Akey et al. 1995, Dennehy et al. 1995 a, b). Interestingly, the occurrence of pyrethroid resistance occurred as the season progressed, regardless of IRM insecticide regimes in study 3) (Dennehy et al. 1996).

The IRM management programs tested in these three studies tried to use true IPM and to present methods of insecticide usage to promote biological control by beneficial arthropods and prevent insecticide resistance from occurring. The use of different action thresholds for different parts of the season contributed toward achieving these objectives. Likewise, the absence of sticky cotton in any of the regimes tested in all three studies shows that these management strategies prevented the occurrence of sticky cotton

Disclaimer

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Acknowledgments

We extend our thanks to D. A. Wuertz, Sundance Farms, Coolidge, AZ and to R. Roth, U. A Z, Maricopa Agricultural Center, Maricopa, A Z for the use of farm facilities and support. We are grateful for the efforts of our technicians, B. Hefner, and D. Meade; and to numerous field crews and farm workers for their diligent work.

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