CONTROL OF SILVERLEAF WHITEFLY WITH THE NEEM PRODUCT AZADIRACHTIN AS BOLLWHIP™ IN UPLAND COTTON IN ARIZONA

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Abstract

Experiments were conducted with azadirachtin as the product Bollwhip™ against the silverleaf whitefly (SLWF). The effects of azadirachtin on beneficial arthropods and on *Lygus* plant bugs were studied also. In 1997, Deltapine® 5415 was planted and furrow irrigated in plots 192.5 ft. in length and 6 rows across (40-in. rows). Two fallow skip rows and 8 ft. alleys separated plots of 0.09ac each. In 1998, Deltapine® NuCOT 33[B] was planted and furrow irrigated in plots 109 ft. in length and 12 rows across (40-in. rows). Four fallow skip rows and 20 ft. alleys separated plots of 0.1 ac each. Bollwhip™ was used in a 4.5% formulation. In 1997, it was used at 3 rates: 3, 6, and 9 oz product /ac The treatments were part of 16-treatment random block design that included a "best agricultural practice regime", a water-treated control, and an adjacent 1-ac block control. In 1998, Bollwhip™ was used at 6 oz product/ac These treatments were part of a 12-treatment random block design that included a "best agricultural practice regime", an embedded control, and an 1-ac block control. Eggs, small nymphs, and large nymphs were sampled from leaves taken from 5 plants per plot, from the fifth main-stem leaf down from the first expanded terminal leaf. Each sample was counted from a 1-in. disk taken between the main leave stem and the next lateral vein. Adults were sampled from 30 leaves/plot, same location using a binomial decision of counting a leaf as positive if 3 or more adults were present. Weekly sweeps were taken in all plots for predators, parasites, and *Lygus.* Applications were made by ground with 3 nozzles/row; 1 overhead, and 2 with swivel nozzles angled upward on drops. Sprays were applied at 80 psi and 30 gal./ac In 1997, Bollwhip™ was effective at controlling silverleaf whiteflies at all three levels used. The seasonal mean reduction for 8-weekly applications was better than 5-fold less eggs, 4-fold less small nymphs, and 3-fold less large nymphs, than for the block control (all significant at $P<0.0001$, ANOVA). Yield was excellent and large bolls with non-sticky cotton were produced. In 1998,cotton growth in central Arizona was atypical. The spring was wet, June temperatures were below average, cotton grew slowly (about three weeks late by July), and the SLWF populations increased very gradually. The SLWF action threshold was reached on Aug. 5. Bollwhip™ and Applaud™ (different treatment plots) were applied at that time. Immature SLWF populations peaked on August 9 and never recovered. Immature SLWF populations in Bollwhip™ plots were consistently lower than in the embedded control plots, but were significantly lower at $P< 0.05$ only for the mean number of eggs. In two years of study with the biorational pesticide, azadirachtin, cotton under treatment with Bollwhip™ had productive yields and was not sticky in a good production year. In a poor production year, we showed that a single application of Bollwhip™ or Applaud™ had similar efficacies against immature SLWF. Bollwhip™ is EPA registered and should have a place in IRM/IPM programs. Progress was also made with ground application technology by achieving spray pressures of 250 psi with spray components for booms that were "off-the-shelf " parts and readily available from spray equipment dealers.

Introduction

The silverleaf whitefly (SLWF), *Bemisia argentifolii* Bellows and Perring *(*aka sweet potato whitefly, strain B), *Bemisia tabaci* Gennadius) has been a serious pest of numerous crops, worldwide including the United States (Henneberry et al. 1998). Numerous studies have been conducted on this pest from 1989 to the present. There have been continuous efforts to develop efficacious control regimes to suppress this pest (see bibliography, Naranjo et. al. 1997,1998). The basic control premise has been to develop integrated pest management (IPM) against SLWF for specific crops (Akey 1992, Akey et al. 1996). A broader but crucial perspective is the development of integrated crop management (ICM) because silverleaf whitefly is found on numerous crops and weeds both temporally and spatially throughout the year.

An important component of the chemical control portion of IPM is the development of insecticide resistance management (IRM) (Dennehy et al.1996a, 1996b). A strong effort must be made to use chemical agents in ways that prevent arthropods from developing resistance to them with a goal of keeping the target and other pests from losing susceptibility to particular pesticides. An important strategy is to rotate classes of insecticides that evoke different detoxification mechanisms for the insecticide class used. The more classes of pesticides that are available usually require more and different detoxification mechanisms that will be needed by the target pests. In addition to conventional chemicals for control, biorational control agents often require different detoxification modes. Included in this group are insect growth regulators, pheromones, agents that disrupt water balance and several compounds found in neem trees.

The neem tree, *azadirachtia indica*, a *Meliaceae*, is a tall spreading tree. It has white flowers, complex foliage, and swollen olive-like fruits, used for shade. The neem tree seed has a viability of only a few weeks. Numbers of trees are estimated at 18,000,000 in India-Burma sub continent. It was introduced to West Africa early this century and is a

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:914-918 (1999)
National Cotton Council, Memphis TN

primary fuel source in some African countries. Later, it was introduced to Saudi Arabia and the Caribbean. Uses of neem are quite ubiquitous (see Nat. Res. Council 1992, Schmutterer 1995). Natural pesticides are present in seeds and leaves. There are numerous medical uses from seed, bark, and leaves: antiseptic, antiviral, and antifungal. Additionally, there may be possible anti-inflammatory, hypotensive, and anti-ulcer effects. it has been used for dental hygiene: tooth decay and healing of gum inflammation. There are reports that it has been uses for male birth control.

Extracts of neem produce complex mixtures of compounds, triterpenoids, and others; including the azadirachtin group. Azadirachtin has been shown to have several different modes of action against arthropods. These modes include: antifeedant activity, growth in addition (including insect growth regulator effects), cytotoxic action. Its bactericidal and fungicidal properties may also act against symbionts. Additionally, ovicidal activity has been reported.

In respect to the classification of azadirachtin as a pesticide, it partially fits as a "biopesticide" within the US, EPA definition of 1996. It also fits the broader classification of a biorational agent from 1994 and earlier definitions (Stansly et al.1995). Azadirachtin qualifies as a "fast-track" agent in the EPA low risk group.

In the US, a number of companies have investigated azadirachtin for commercial products. These products have ranged from numbered compounds to registered pesticides. We have conducted field trials on azadirachtin since 1992. A summary of efficacy results (percent reduction from control) for 1992-1995 follows: Azatin®/AD1000) 96% [AgriDyne /Valent®-USA], Margosan-O® 84% [Grace Sierra (now Thermo Trilogy Corp.), Azatin® 89% (AgriDyne now Thermo Trilogy Corp.), and Align® - 89% (Agridyne now Thermo Trilogy Corp.).

Here, we report experiments conducted with azadirachtin as the product Bollwhip™ against the silverleaf whitefly (SLWF). We have been studying the effects of azadirachtin on beneficial arthropods and on *Lygus* plant bugs, also.

Materials and Methods

Azadirachtin was used as Bollwhip™ at 4.5% product (Thermo Trilogy Corp., Columbia, MD)

1997

Deltapine® 5415 cotton was planted and furrow irrigated in plots 192.5 ft in length and 6 rows across (40-in rows) separated by 2 fallow rows and 8-ft. alleys. Plots were 0.09 ac each. Applications were made with a ground -spray rig with a 47ft. boom capable of spraying 6 rows / pass on each side of the rig. The boom was set up to have 3 nozzles/row; 1 overhead, and 2 with swivel nozzles angled upward on drops. Nozzles with disc-core type hollow cone spray tips were set up with D5-C23 combinations, (Tee Jet®, Spraying Systems Co., Wheaton, IL.) Sprays were applied at 80 psi and 30 gal. /ac

The experimental objective was to determine an effective dose rate. Three rates (treatments) were tried: 3, 6, and 9 oz of product /ac. These treatments were part of a 16-treatment random block design that included a "best agricultural practice regime"(Table 1), and a water-treated control. Each treatment was replicated 4 times in the random block. Once a treatment was initiated, it was applied weekly. Applications were begun on June 19, 1997 and conducted weekly for 12 weeks (maximum spray interval was 10 days). An exception was the "best agricultural practices regime" that was threshold driven. Five applications were made between July 18 and Sept. 5. The start date was based on University of Arizona recommendations (Ellsworth et al. 1996, Ellsworth and Watson 1996). Also included was a nearby, untreated, 1-ac solid-planted, unsprayed, block control.

Dyne-Amic™ was used as an adjuvant at 0.5% V/V (Helena Chemical Co., One HY Crop Row, Memphis, TN).

1998

Deltapine® NuCOTN 33[B] was planted and furrow irrigated in plots 109 ft. in length and 12 rows across (40-in. rows). 4 fallow skip rows and 20 ft. alleys separated plots of 0.1 ac each. Applications were made with the same ground spray rig as in 1997 but with a different boom configuration. The boom was set up to have 5 nozzles/row; 1 overhead, and 2 drops with 2 swivel nozzles angled upward. Nozzles with disc-core type hollow cone spray tips were set up with D2-C13 combinations, (Tee Jet®, Spraying Systems, Wheaton, IL.). Sprays were applied at 250 psi and 30 gal. /ac

Kinetic™ was used as in adjuvant at 0.13% V/V (16 oz/100 gal), (Helena Chemical Co., Memphis, TN)

The experimental objective was to determine if Bollwhip™ at 6 oz product/ac was an effective control agent against SLWF. Bollwhip™ treatments were planned to be threshold driven at a low action threshold.

Deltapine® NuCOTN 33[B] was planted to control pink bollworm, cabbage looper and beet armyworm. For *Lygus* control, an overspray of oxamyl (Vydate® C-LV, E. I. Du Pont De Nemours and CO, Wilmington, DE) was used once at 0.5 lb. ai/ac

Planned BAP treatment included the IGRs, buprofezin (Applaud™ 70 WP, AgrEvo USA Co., Wilmington, DE and pyriproxifen, (Knack™ Valent USA, Walnut Creek, CA).

Total number of treatments in the random block design was 12. Total number of plots was 48, with 24 to the east of the untreated block control and 24 to the west, respectively.

Applications began when SLWF threshold for treatment was met (Univ. AZ recommendations).

Sampling and Data Analysis, 1997 and 1998

Eggs, small nymphs, and large nymphs (latter included large 3rd's, small 4th's, and red-eye nymphs [pupae], Akey 1992) were sampled from leaves taken from 5 plants in 1997 and 10 plants in 1998 per plot, from the fifth main-stem leaf down from the first expanded terminal leaf. Each sample was counted from a 2.22 cm diameter disk ($cm^2 = 3.88$). The disk sample was taken between the main leaf vein and the next lateral vein (Ellsworth and Watson 1996; Diehl et al.1997). Numbers of 0.5-1.0 large nymphs/leaf disk are equal to 0.13-0.26/cm^2. Results reported here are in mean no./cm^2.

Adult SLWF were sampled from 30 leaves/plot, same location using a binomial decision of counting a leaf as positive if 3 or more adults were present (Ellsworth et al. 1996, Naranjo et al.1996). In 1998, all adults were counted in the BAP and embedded control plots. The binomial decision method was used for all other treatments.

Weekly sweep samples were taken in all plots for predators, parasites, thrips, and *Lygus*; a sample consisted of 25 sweeps per plot.

Analysis was by ANOVA: 1997; pre-season, whole season, 1st half and 2nd half of season; and 1998, pre-season and whole season. Analysis for means separation were conducted when the ANOVA was significant. Units were reported as means, standard error, percent reduction from the untreated control, and / or percent reduction from the block control.

Results

1997

Azadirachtin as Bollwhip™ was effective at controlling silverleaf whitefly at all three levels used (Fig.1). The best control was effective against small nymphs as reflected in the lower numbers of larger nymphs, especially near the end of the season in late August and early September.

The block control, which was solid planted and almost an acre in size, was a better comparison as an untreated check than the embedded random water control.

Comparison of endosulfan and azadirachtin efficacies showed that endosulfan treatments held the nymphal stages to means of about two nymphs per sample disk (Fig.2). However, azadirachtin had means of about four nymphs. This is excellent control and produced open bolls with non-sticky cotton. Cotton in the block control was very sticky by the first week in Sept., both lint and leaves (Fig. 3).

The BAP treatment had only five sprays for the entire season against SLWF. The numbers of immatures were higher in this treatment than in the other treatments; never the less, control was still sufficient to produce clean, non-sticky cotton (Fig.3).

1998

The 1998 cotton season in central Arizona was atypical because of a wet spring and a June that was below average in temperature. The cotton crop grew slowly and was about three weeks behind schedule by June. The SLWF populations increased very gradually. On August 5, the SLWF action threshold was reached by a combination of high adult populations and relatively low immature populations. Bollwhip™ and Applaud™ (first treatment of the BAP) were applied at that time. Immature SLWF populations peaked on August 9 and never recovered (Figs. 4, 5, 6). Therefore, the first application of Bollwhip™ and of Applaud™ was the only application of those agents. Immature SLWF populations in Bollwhip™ plots were consistently lower than in the embedded control plots, but were significantly lower at $P< 0.05$ only for the mean number of eggs (Fig. 4).

Discussion

The 1997 season work with the biorational pesticide, azadirachtin as Bollwhip™, was productive and encouraging particularly the yield and lack of stickiness. In the 1998 SLWF trial, we showed that a single application of Bollwhip™ or Applaud™ had similar efficacies against immature SLWF. Bollwhip™ is EPA registered and should have a place in IRM/IPM programs; perhaps before or after the use of the 2 IGRs, Applaud™ and Knack™.

Significant progress with ground application technology was made in 1998 by the achievement of spray pressures of 250 psi. These pressures were obtained with spray components for booms that were "off-the-shelf " parts and readily available from spray equipment dealers. Thirty gallons were superior to 15 gal/ac. Results from other treatments in the trial (not reported here) demonstrated that coverage obtained with greater application volumes was more important than the use of higher pressures, e.g.; 60 gal/ac at 80 psi provided better coverage than 15 gal/ac at 250 psi.

Acknowledgments

We extend our special thanks to the staff of the U. AZ, Maricopa Agricultural Center, Maricopa, and A Z for the use of farm facilities and support. We are grateful for the efforts of technician, B. Hefner, and to our summer crew: A. Bandy, K. Bodily, P. Bruns; J. Butts, C. Holly, A. Locklear, and S. Richards, and to numerous field crews and farm workers for their diligent efforts.

Disclaimer

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Table 1. Best agricultural practices regime (BAP) based on recommendations of University of Arizona, against silverleaf whitefly on cotton, 1997.

Application	Treatment	Quantity	Company
Buprofezin (July 18)	Applaud® 70WP	0.35 lb AI/ac	AgrEvo Co.
Pyriproxyfen (July 30)	Knack™ 0.86 EC	0.54 lb AI/ac	Valent USA Corp.
Amitraz	Ovasyn® 1.5 EC	0.25 lb AI/ac	AgrEvo Co.
Endosulfan (Aug 20)	Phaser®3 EC	0.75 lb AI/ac	AgrEvo Co.
3rd treatment repeated again on August 27			
Fenpropathrin	Danitol™ 2.4 EC	0.20 lb AI/ac	Valent USA Corp
Acephate (Sept 4)	Orthene® 90s	0.50 lb AI/ac	Valent USA Corp.

Adjuvant Use – Nonionic organosilicone surfactant DyneAmic® Helena Chemical Co. 0.5% v/v.

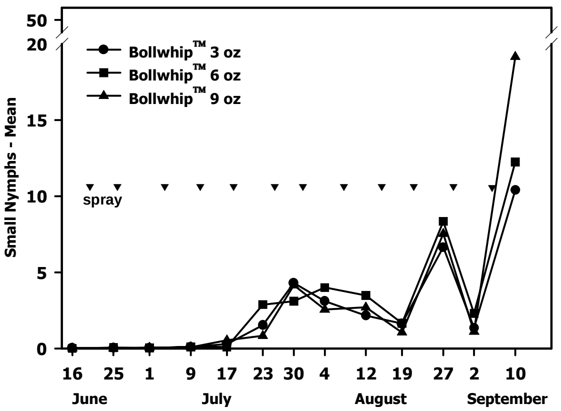

Figure 1. Effects of Bollwhip™ at 3, 6, and 9 oz product/ac on small nymphs of silverleaf white fly (SLWF) on DeltaPine® 5415 cotton in central AZ, 1997.

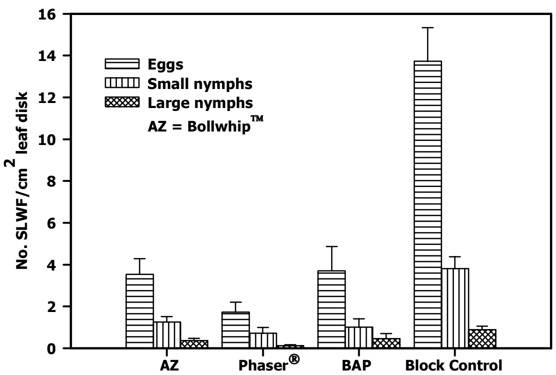

Figure 2. Effects of Bollwhip™ (mean of 3, 6, and 9 oz product/ac applications), and endosulfan as Phaser™ on eggs, and small and large nymphs of silverleaf whitefly (SLWF) compared with a Best Agricultural Practices (BAP) regime, and an Untreated Block Control in DeltaPine® 5415 cotton in central AZ, 1997.

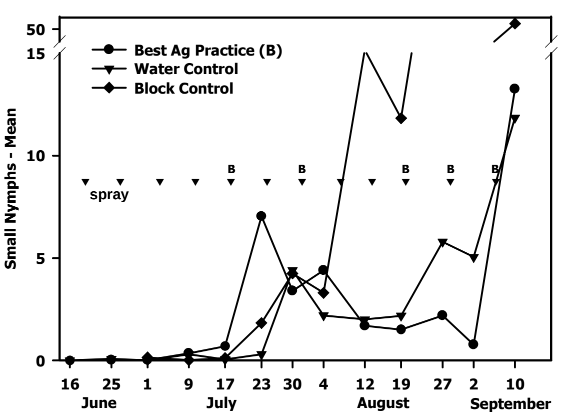

Figure 3. Effects of Best Agricultural Practices (BAP) regime, on small nymphs of silverleaf whitefly (SLWF) compared with a Water Control and an Untreated Block Control in DeltaPine® 5415 cotton in central AZ, 1997.

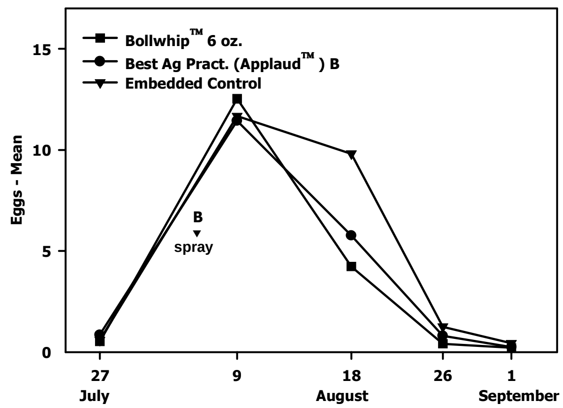

Figure 4. Effects of Bollwhip™ (6 oz product/ac) applications on eggs of silverleaf whitefly (SLWF) compared with a Best Agricultural Practices (BAP) regime, and an Untreated Embedded Control in DeltaPine® NuCOTN 33[B] cotton in central AZ, 1998.

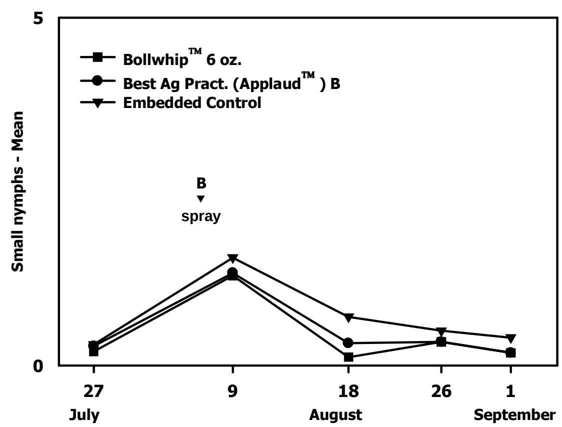

Figure 5. Effects of Bollwhip™ (6 oz product/ac) applications on small nymphs of silverleaf whitefly (SLWF) compared with a Best Agricultural Practices (BAP) regime, and an Untreated Embedded Control in DeltaPine® NuCOTN33[B] cotton in central AZ, 1998.

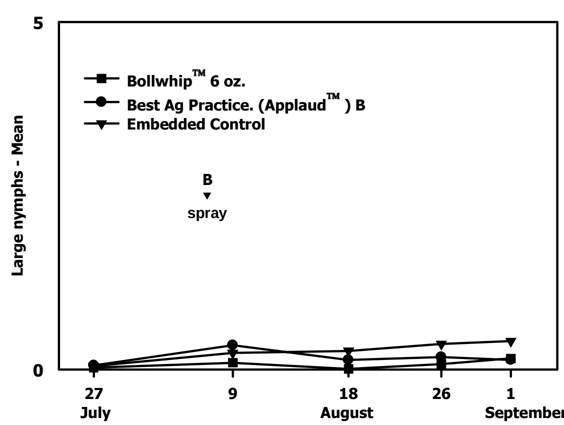

Figure 6. Effects of Bollwhip™ (6 oz product/ac) applications on large nymphs of silverleaf whitefly (SLWF) compared with a Best Agricultural Practices (BAP) regime, and an Untreated Embedded Control in DeltaPine® NuCOTN 33[B] cotton in central AZ, 1998.