WHITEFLY MANAGEMENT IN ARIZONA: LOOKING AT THE WHOLE SYSTEM

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Abstract

Whiteflies remain a threat to production of cotton in Arizona. Looking at a series of commercial-scale trials, levels last season were delayed compared to previous years, but at higher densities than in 1995, an outbreak year. Efforts must be expended to optimize insect growth regulator (IGR) use and integrate these tactics with other aspects of crop and pest management. Broad spectrum insecticide use prior to treatment for whiteflies with IGRs alters the ecology of the system. Whitefly densities consistently increased after disruption with a *Lygus* insecticide relative to *Lygus*-untreated areas. While *Lygus* control is a production imperative, guidelines are presented for minimizing the impact of this disruption. The modes of action for the two IGRs differ substantially and result in subtle changes in population age structure and dynamics. The consequences of these changes impact natural enemies and should be noted by producers when selecting an IGR or monitoring populations after treatment. Re-treatment after initial IGR sprays depends on many factors. While apparently similar levels of suppression are possible when only one IGR is used, regimes using both available IGRs resulted in the fewest number of damaging large nymphs late in the season, just prior to defoliation. Conventional insecticides rotated according to pre-IGR introduction guidelines ('95IRM') also suppressed populations significantly and comparably to IGR regimes until late in the season. Then, whitefly densities rose aggressively just prior to defoliation and pyrethroid susceptibility was significantly reduced in the 95IRM regime. Full adoption of IGR-based technology along with 'Bt' cotton allows growers to better manage whiteflies with fewer disruptions which can lead to secondary pest outbreaks, pest resurgence, and insecticide resistance.

Introduction

Whitefly management in Arizona has advanced to such a degree in the last few years that scientists, practitioners, and growers are challenged to further refine our understanding and improve all aspects of management of this pest. Part of this understanding and improvement is best served by stepping back and examining whiteflies within whole systems. While Arizona has enjoyed huge gains in whitefly control, control cost reduction, and cotton quality (Tables 1 and 2), we must continue to improve adoption of our best technologies and strategies for coping with all our pests. Dramatic reductions in the number of sprays against whiteflies (Table 1) and the whitefly control proportion of the total insect control budget (Table 2) has shifted the focus off of this key pest in our system and contributed to some complacency in the grower community. For example, overall insect growth regulator (IGR) usage was down by 30% in 1997 (about 170,000 application-acres) as compared to 1996 in spite of heavier late season whitefly pressures and a 30-day increased IGR-use window this past year. Of the 1.81 sprays used against whiteflies, only about 0.5 sprays were IGRs. This is invaluable chemistry in our system and our studies are aimed at optimizing their use for whitefly management and integrating this technology within whole systems of integrated pest management.

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Materials & Methods

A large-scale trial (about 8 A) was conducted using NuCOTN 33B and three different contrasted whitefly control regimes—Applaud® used first, Knack® used first, and conventional chemistry rotated according to recommendations developed prior to the introduction of the IGRs ('95IRM'). Each regime whole plot was split in half to accommodate two different timings of IGR re-treatment. The recommended threshold used (t1) was 1 large nymph / disk plus 3–5 adults / leaf (Ellsworth et al. 1995, 1996a,c). The higher level targeted (t2), >1.5 large nymphs / disk (Ellsworth et al. 1996b, c, 1997), was never reached after the regulated waiting period, so the second IGR was not used in these treatments. This, in effect, created a contrast of one IGR used versus two IGRs; however, the former required just two total sprays for whiteflies while the latter required four total sprays. When *Lygus* invaded the field, prior to any whitefly treatments, half of each sub-plot was treated once with Vydate C-LV® (1 lb ai/A), creating another level of contrasts (*Lygus* treated vs. untreated). The 95IRM regime was not split and received five total sprays against whiteflies (3 non-pyrethroid and 2 non-pyrethroid) plus the one spray for *Lygus*.

Results & Discussion

As part of this continuing series of commercial-scale trials conducted at the Maricopa Agricultural Center, we are able to examine seasonal whitefly dynamics and make comparisons across years. In prior years of commercial testing, an untreated check was not possible; however, in 1997 untreated plots were established and showed that whiteflies had the potential to become extremely dense. In 1997, whiteflies reached threshold levels approximately 3–4 weeks later than in 1996, but at about the same time as in 1995 which was widely considered an outbreak year. Furthermore, nymphal levels were sustained at a higher density for a longer period of time than in 1996 or 1995 (Fig. 1). As growers watched this population unfold, many believed that 1997 was going to be a "light" year mainly because of this late start. The decision to use the more costly IGRs was difficult for some, and many opted to use conventional chemistry instead. Other pest problems also contributed to the decision to use broad-spectrum insecticides.

Impact of *Lygus* Control on Whitefly Management

Lygus is a key pest of cotton in Arizona, and the control measures available are broad-spectrum in nature. The *Lygus* spray contributed in minor ways to whitefly mortality, especially of the first instars, as measured in life table studies (see Ellsworth et al., this volume). However, large nymph and adult levels were significantly higher in the *Lygus*-treated areas relative to the untreated areas regardless of whitefly treatment regime. The effect was noticeable for adults one week after spraying; however, it was more pronounced and consistent across all comparisons for large nymphs, three weeks later (Fig. 2). Therefore, the disruption of natural enemies, especially predators, by the *Lygus* spray led to a release of the whitefly populations. Yields, however, were significantly reduced (0.3–0.6 bales / A) where *Lygus* were left unsprayed. *Lygus* control is a production imperative; however, there are several steps that can be taken to lessen the negative impact of these sprays. Spray only when sampling indicates threshold level populations and *Lygus* nymphs are present. Use singular compounds only, because they are shown to be as effective (see Ellsworth, this volume) as higher priced and harsher combination materials. Limit the number of sprays required by using the materials and rates adequate to reduce *Lygus* levels. Intensify sampling for whiteflies after treatment for other pests, and place greater emphasis on large nymph numbers (see Ellsworth et al. 1996b).

Comparative Effects of the IGRs

The impacts of each IGR on whitefly populations and sources of mortality are distinct (Ellsworth et al., this volume). Applaud has more immediate impact on the nymphal age distribution than Knack. The Applaud regimes had fewer adults and substantially fewer large nymphs than the Knack regimes one week after initial treatment (Fig. 3). Thereafter the populations in both regimes became more similar. This study, as in previous studies, also showed that Knack treatments temporarily exhibit higher egg populations and lower small nymph populations relative to Applaud treatments (Ellsworth et al. 1997). This is due to the egg and adult female sterilization properties of Knack, and the time delay required for Applaud to kill young instars. In this study, the yields were not significantly different among any of the whitefly regimes (about 3 bales / A). Preliminary results also indicated no stickiness in any of the plots including the untreated plots which had excessive signs of sooty mold. Rains, other weathering, and microbial processes may have contributed to the degradation of stickiness residues in these plots.

Proper timing of IGR re-treatment

Methods for assessing populations and determining the need for triggering the first IGR are well-studied and substantiated in field studies (Ellsworth et al. 1995, 1996a–c, 1997). Determining the need for a second application with the alternate IGR is less well understood and complicated by the assessment of risk to late season stickiness. Most growers do not use both IGRs (est. < 10% in the last two years); however, current recommendations suggest the need for both in chronically infested areas that anticipate the need for more than 30 days of whitefly control (Ellsworth et al. 1997). This study did not result in a re-triggering of the second IGR in half the IGR plots. Thus the comparison can only be made of one IGR versus both IGRs. In these contrasts, it is difficult to find any population differences through the majority of the season. Nevertheless, on the last date of sampling, well past irrigation termination and only one day prior to defoliation, large differences were observed between the one- and two-IGR spray scenarios (Fig. 4). The latter strategy also had two additional non-pyrethroid sprays complicating any inference. Nonetheless, the last spray of the season in both regimes was the same, endosulfan+Ovasyn®, yet large nymph populations were upwards of five-fold higher in the one-IGR regimes than the two-IGR regimes just prior to defoliation (Fig. 4). Depending on the crop condition, defoliant used, soil moisture and rainfall, cotton can remain "green" and host whiteflies for 1–3 weeks after defoliation. This is enough time for significant nymphal development and honeydew deposition. In this test, yields and stickiness levels were not different between the one-IGR (2 total sprays) and the two-IGR (4 total sprays) regimes. Further work is planned for this aspect of IGR optimization in 1998.

Impact of IGR use on pyrethroid resistance / performance

While 1995 will be remembered for the year of 'uncontrollable' whiteflies (Ellsworth et al. 1996c), reductions in whitefly susceptibility to pyrethroids have continued to be measured in laboratory bioassays since then (Dennehy et al. 1997). In spite of apparent good field performance, decreased reliance on pyrethroids, and increased use of IGRs, putative resistance to pyrethroids is still evident after repeated pyrethroid use. In yellow sticky-card bioassays of adults, significantly reduced susceptibility to a representative pyrethroid combination (Danitol®+Orthene®) was evident in the 95IRM regime after just two field uses of pyrethroids (Fig. 5; Castle, unpubl. data). Field performance of the conventional materials in the 95IRM was considered excellent; however, selection for pyrethroid resistance is a threat when we depend on conventional chemistry alone for season-long control of whiteflies. The 5-spray regime of the 95IRM had equivalent whitefly levels to the 2- or 4-spray IGR regimes until the last sample date, one day before defoliation. This sample showed significantly higher levels of large nymphs in the 95IRM relative to the 4-spray Applaud or Knack regimes (i.e., both IGRs plus two non-pyrethroids), yet still much lower than the untreated check (Fig. 6). This, perhaps, could have signalled future late-season decline in pyrethroid performance in these plots, and possible control or stickiness problems, had this crop been terminated later in the season. This also underscores the need to balance the benefits of later season production with the added risks of stickiness, other late season insect pressures, and resistance to or field failures of insecticides. It also shows the benefits of an IGR-based system which can delay and reduce or eliminate the need for pyrethroids later in the season and therefore reduce the risk of accelerated resistance in this still important group of insecticides.

Acknowledgments

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Table 1. Arizona statewide average number of sprays made for whitefly control and resulting lint quality (1990–1997).

Year	No. of SWF sprays	Lint Quality (est.)
1990	1.00	—
1991	1.80	some stickiness
1992	5.10	very sticky
1993	2.60	clean
1994	4.40	mostly clean
1995	6.60	compromised
1996	1.99	very clean
1997	1.81	clean

Table 2. Arizona statewide average costs of control for whitefly and proportion of overall foliar insecticide budget (1990–1997).

Year	SWF Control($ / A)	% of Total Insect Control
1990	12.00	10.5
1991	25.20	24.0
1992	91.80	74.7
1993	52.00	74.4
1994	88.00	63.5
1995	145.20	67.5
1996	57.84	47.1
1997	52.72	49.0

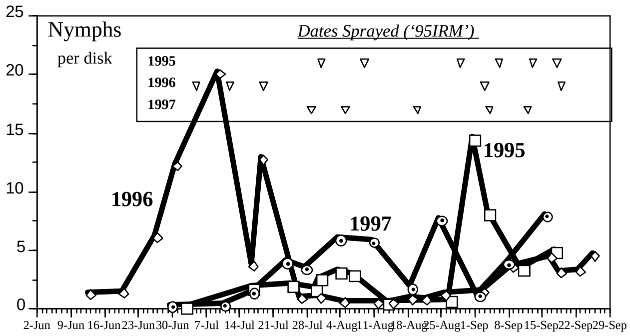

Figure 1. Seasonal Dynamics of Whiteflies, 1995–1997: Total nymphs per disk (3.88 sq. cm.) for the conventional insecticide regime (95IRM). Sprays for each year are denoted by triangles. 1997 populations were 3–4 weeks delayed compared to 1996, yet comparable to 1995. 1997 had higher nymphal populations for a longer period of time than in 1995 or 1996.

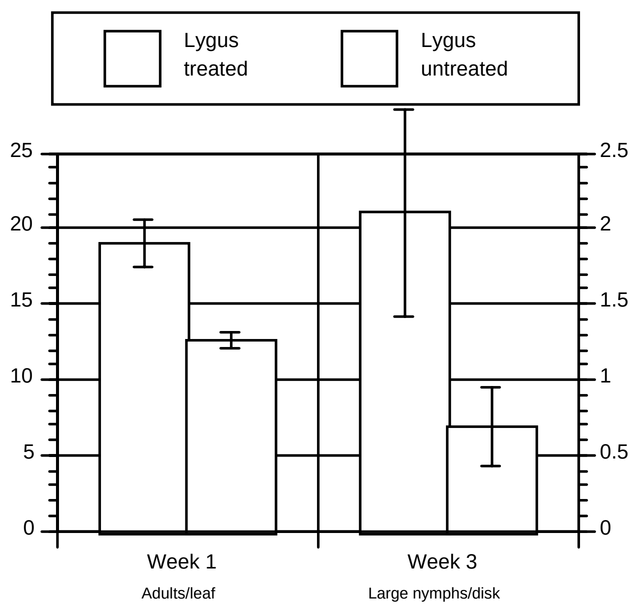

Figure 2. Impact of *Lygus* Control on Whitefly Management: Numbers of adults per leaf (left) one week after initial IGR treatment and numbers of large, visible nymphs per disk (3.88 sq. cm.) (right) three weeks after initial IGR treatment for the *Lygus*-treated and *Lygus*-untreated split-plots. *Lygus* were treated once with Vydate C-LV four days before initial IGR treatments.

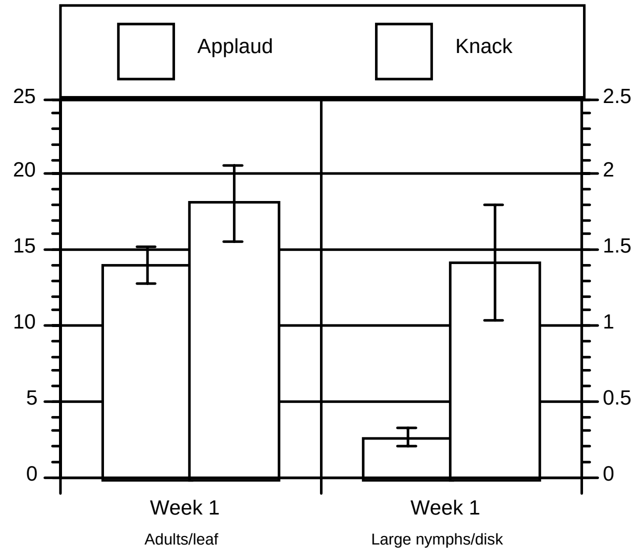

Figure 3. Comparative Effects of IGRs: Adults per leaf (left) and large, visible nymphs per disk (3.88 sq. cm.) (right) one week after treatment with the IGRs, Applaud or Knack. Applaud has a more immediate suppressive effect than Knack on adults and large nymphs via molting inhibition of nymphs. Adult and nymph dynamics were similar thereafter.

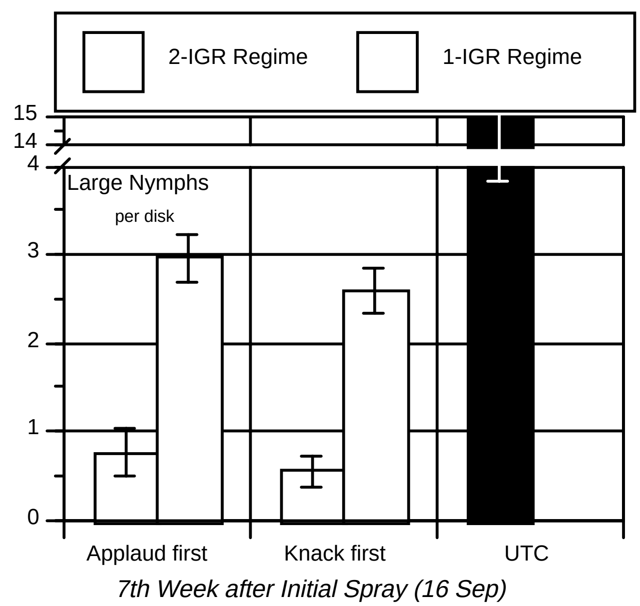

Figure 4. Impact of Using One or Both IGRs: Large, visible nymphs per disk (3.88 sq. cm.) seven weeks after the initial IGR treatment. Both regimes provided for levels far below that of the UTC, but only the 2-IGR regime suppressed large nymphs through defoliation. There were no differences prior to this point in the season.

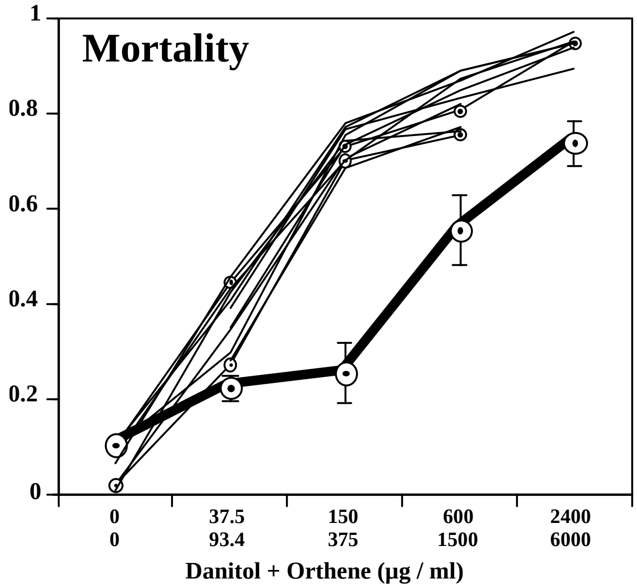

Figure 5. Impact of IGR Use on Pyrethroid Resistance: Dose response curves for adult whiteflies assayed on sticky-yellow cards with a model pyrethroid combination at different times through the season. All insecticide regimes at each of 3 times during the season produced similar results (family of curves at left); however, whiteflies from the '95IRM' regime showed a significant reduction in susceptibility to pyrethroids on the last date of study (large line at right). This occurred after field exposure to three non-pyrethroid and two pyrethroid combination sprays.

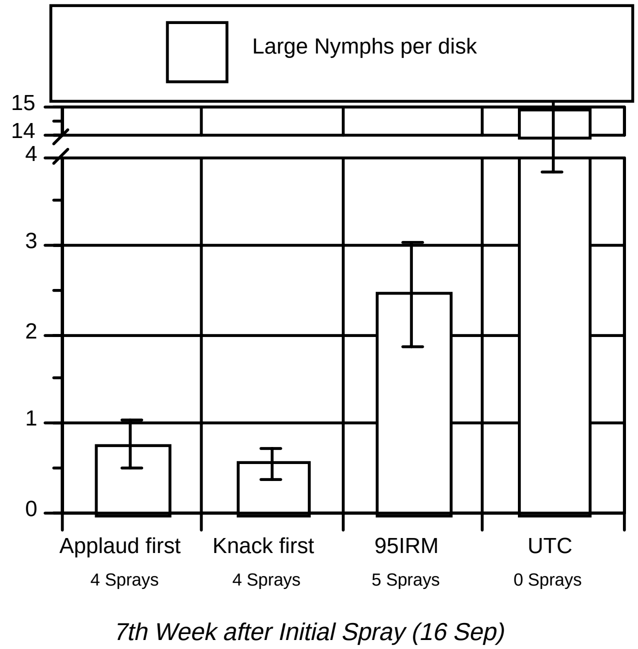

Figure 6. Impact of IGR Use on Pyrethroid Performance: Large, visible nymphs per disk (3.88 sq. cm.) for three insecticide regimes and an untreated check on the seventh week after initial whitefly treatment. Either IGR used first, followed later by the alternate IGR and two non-pyrethroid sprays, suppressed large nymphs more than a conventional rotational regime (95IRM) with five sprays. Prior to this point in the season, the 95IRM regime (3 non-pyrethroid and 2 pyrethroid combinations) provided comparable control to the IGR-regimes.