The University of Arizona
Agricultural Experiment Station
Cooperative Extension

Neonicotinoid Use in Cotton: Response to EPA Proposed Interim Decisions for Arizona
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Comments submitted by the Arizona Pest Management Center, University of Arizona

EPA-HQ-OPP-2012-0329 - Acetamaprid
EPA-HQ-OPP-2011-0865 - Clothianidin
EPA-HQ-OPP-2011-0920 - Dinotefuran
EPA-HQ-OPP-2008-0844 - Imidacloprid
EPA-HQ-OPP-2011-0581 - Thiamethoxam

Date: May 4, 2020

The Arizona Pest Management Center is host to the University of Arizona's expert IPM scientists including Ph.D. entomologists, weed scientists and plant pathologists with expertise in the strategic tactical use of pesticides within IPM programs that protect economic, environmental and human health interests of stakeholders and the society at large. In coordination with the Western Integrated Pest Management Center, we contribute to federal comments on issues of pest management importance to stakeholders throughout the desert southwest including Arizona, New Mexico, Nevada, Colorado and the southeast desert regions of California.

At this time, we wish to respond to the Agency's Proposed Interim Decision for the foliar neonicotinoid use in cotton, with special reference to **acetamiprid**, on behalf of stakeholders.

Who We Are

Dr. Peter Ellsworth is Director of the APMC, State IPM Coordinator for Arizona and Professor of Entomology / Extension IPM Specialist with expertise in developing IPM systems in cotton and other crops and measuring implementation and impact of IPM and pest management practices. Dr. Al Fournier is Associate Director of the APMC / Associate Specialist in Entomology, holds a Ph.D. in Entomology, and has expertise in evaluating adoption and impact of integrated pest management and associated technologies. He works with the Western IPM Center, representing stakeholders in the desert Southwest states in EPA registration reviews. Mr. Wayne Dixon holds a B.S. in Computer Information Systems and develops tools and data used in IPM research, education and evaluation, including management of the APMC Pesticide Use Database.

These comments are the independent assessment of the authors and the Arizona Pest Management Center as part of our role to contribute federal comments on issues of pest management importance and do not imply endorsement by the University of Arizona or USDA of any products, services, or organizations mentioned, shown, or indirectly implied in this document.

Four sections below detail: our IPM strategy in cotton as context to acetamiprid use; what we know about our chemical use patterns in general; acetamiprid use patterns and why it remains key to our industry; and recent acetamiprid efficacy against *Bemisia* whiteflies.

1) Insect Management and IPM in Arizona Cotton, the Context for Strategic Use of Acetamiprid

Despite cotton market doldrums, arthropod IPM in Arizona cotton continues to post impressive numbers. In 2018, the USDA declared the pink bollworm eradicated from the U.S., a feat of enormous significance, especially given that boll weevil eradication activities continue in the U.S. more than 30 years later. The remaining two key pests are the invasive whitefly, *Bemisia argentifolii*, and the indigenous plant bug, *Lygus hesperus*. Highly selective and safe insecticides for whitefly control have been in development for the past three decades and now include 7 different modes of action that are fully selective and 1 additional mode of action that is partially selective (i.e., **acetamiprid**). The opportunities for safe and effective control of whiteflies without harm to the suite of invertebrates that support the Arizona cotton system are many.

Since 2006 and then since 2012, respectively, two fully safe and selective insecticides were developed for efficient Lygus control, Carbine and Transform (flonicamid and sulfoxaflor, respectively). These two insecticides have all but eliminated further uses of acephate or oxamyl as primary Lygus controls. **Neonicotinoids do not play a role in Lygus control in Arizona cotton**, though some, including acetamiprid, demonstrate efficacy against another mirid, the cotton fleahopper (*Pseudatomoscelis seriatus*), which is infrequently a pest that requires chemical control here.

A broader suite of controls as promoted by IPM enables a sustainable path forward even in the face of existing resistances. For example, whiteflies are controlled through the use of 1 or more of 8 modes of action currently. **Active resistances are known in some whitefly populations to at least 4 of these modes of action (e.g., acetamiprid, buprofezin, pyriproxyfen, and spiromesifen**; Pier & Ellsworth, unpubl. data). Yet, producers are able to manage these resistances through wise product selection and rotation among effective modes of action. This approach makes even the products compromised by resistances available and effective for longer periods of time.

The Arizona system has come to rely extensively on the conserved fauna naturally present in cotton fields, namely arthropod predators with generalized habits of feeding on key and secondary pests throughout the season. **Conservation biological control is central to the function of the cotton insect IPM system, especially when it comes to whitefly management.**

“Residual” for the substances in our system is made up of two overlapping components. The first is the chemical residual provided by the chemistry itself, which is subject to rather fixed effects of metabolism and environmental degradation. With few exceptions, insecticide half-lives are measured in hours and days, not weeks or months. We typically do not see chemical efficacy in excess of 10–14 d for any of the compounds in use for whitefly control. The second component is "bio-residual" or the extended period of suppression possible by natural factors including natural enemies and weather when selective chemistries are used (Ellsworth & Martinez-Carrillo 2001). When properly managed, bio-residuals have been measured for up to 2 months in the cotton-whitefly system of Arizona. However, as they are governed by complex biological and ecological processes, bio-residuals are variable in duration and can be largely disabled by the use of broad-spectrum insecticides.

In 2019, we launched new tools for measuring and understanding the largest fraction of bioresidual in the system, i.e., the generalist predators that have been found to be key to ongoing suppression of whiteflies in Arizona cotton (Vandervoet et al. 2018). We have identified 8 new predator "thresholds" for 6 different generalist predators that can be used in conjunction with our standard, pest-centric thresholds to adjust or modify actions relative to spraying whiteflies. These new, biological control informed thresholds have been taught to hundreds of growers and pest managers in a 5-state, binational region of desert cotton production (Arizona, southern California, Baja California, Sonora, and Chihuahua, Mexico). Short publications and laminated guides available in English and Spanish have been published and distributed widely (Figure 1) (Ellsworth et al. 2019a,b,c; Vandervoet et al. 2019).

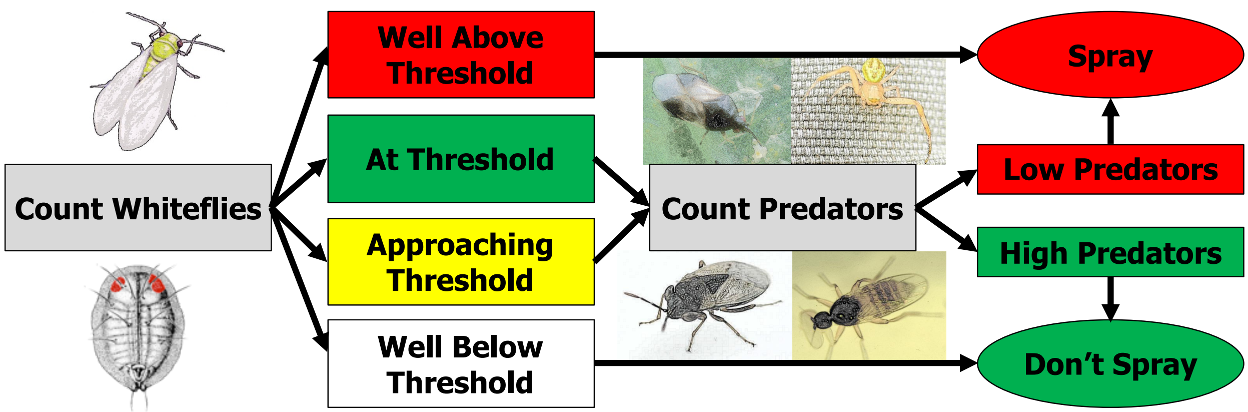

Figure 1. Decision flow for taking appropriate action to control whiteflies in Arizona cotton using predator-based thresholds to inform pest-centric thresholds (modified from Vandervoet et al. 2019).

2) IPM in Arizona Cotton Drives Insecticide Use to Low Levels, Understanding Use Patterns

Lygus and whiteflies were targeted by 84% of the total sprays made against arthropods in Arizona cotton (2015–2019) (Figure 2). Whiteflies are the number one quality-limiting pest. Lygus bugs are the number one yield-limiting pest. The 14-year statewide average is 2.09 ± 0.2 sprays for all arthropod pests. This is the "post-selective" period during which there have been fully selective tools available for the control of all Arizona's major cotton pests.

Our understanding of insect management practices is second to none, because of our annual program of measuring cotton pest losses and impact assessment directly with stakeholders. In 2019, 23 respondents representing 38.5% of the acreage in Arizona provided insight into the challenges they faced last year (Figures 3–5). In general, risks of pest resurgence and secondary pest outbreaks increase as the amount of non-selective insecticides are used. Those problems lead to more spraying. Thus, pest managers are heavily incentivized to seek out and use compounds known to be fully selective to beneficials, especially the 6 predator species identified as key to whitefly IPM in cotton.

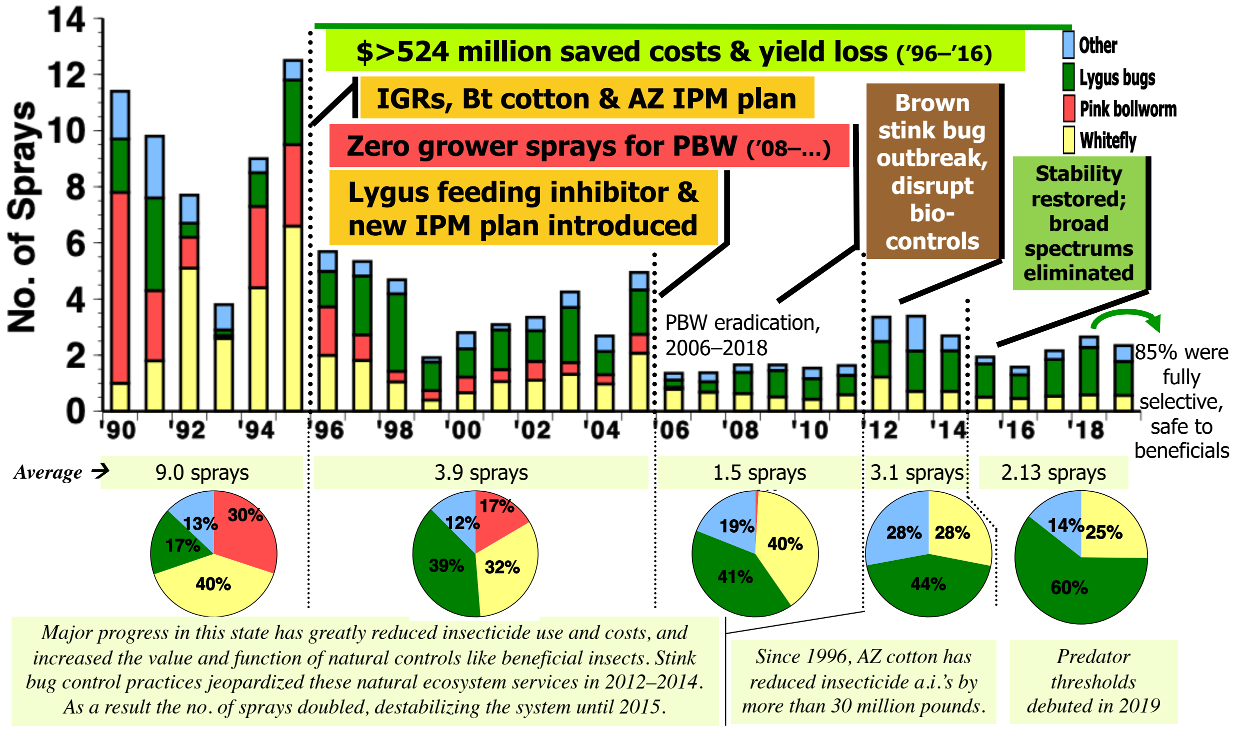

Figure 2. Average number of sprays made statewide by Arizona cotton growers to control insects and other arthropod pests. Lygus and whiteflies are targeted by 84% of the total sprays made against arthropods in Arizona cotton (2015–2019). Hard, product-based technologies, PQZ (pyrifluquinazon) and Sefina (afidopyropen), and soft, knowledge-based technologies, new predator thresholds for whitefly management, were introduced to growers in 2019. Source: *Cotton Pest Losses Database*, Ellsworth, unpubl.

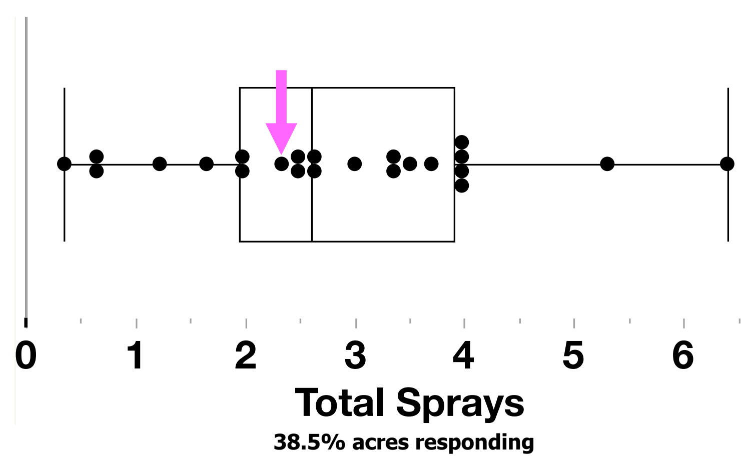

Figure 3. Distribution of total number of foliar insecticide sprays reported by respondent (N=23; ca. 39% of state's acreage reporting) for Arizona cotton in 2019. Average (purple arrow) = 2.34. Source: *Cotton Pest Losses Database*, Ellsworth, unpubl.

Figure 4. Reported foliar insecticide use counts (number of licensed professional, Pest Control Advisors, PCAs) and targets by respondent (N=23) for Arizona cotton in 2019. Targets in brackets were not reported by PCAs in 2019 but are known efficacies for the compound. Colored dots represent a reported respondent's use of a product, with colors indicating safety or selectivity for beneficial arthropods (based on Ellsworth et al. 2006 and Ellsworth et al., unpubl). [Selectivity of spinetoram and etoxazole is assumed but has not been research tested in the Arizona cotton system.] *Pyrethroids and organophosphates are each ineffective at control of *Bemisia* whiteflies but can be mixed in order to achieve efficacy that overcomes whitefly resistance to pyrethroids. Source: *Cotton Pest Losses Database*, Ellsworth, unpubl.

Fully selective insecticides dominate the cotton marketplace, because of the efficacy against the targets and their safety to beneficials including key predators in the system. Broad spectrum insecticides still play a role, where alternatives don't exist (e.g., crickets, false chinch bugs, pale-striped flea beetles). Partially selective materials are used sparingly; two, both neonicotinoids, were in use in 2019.

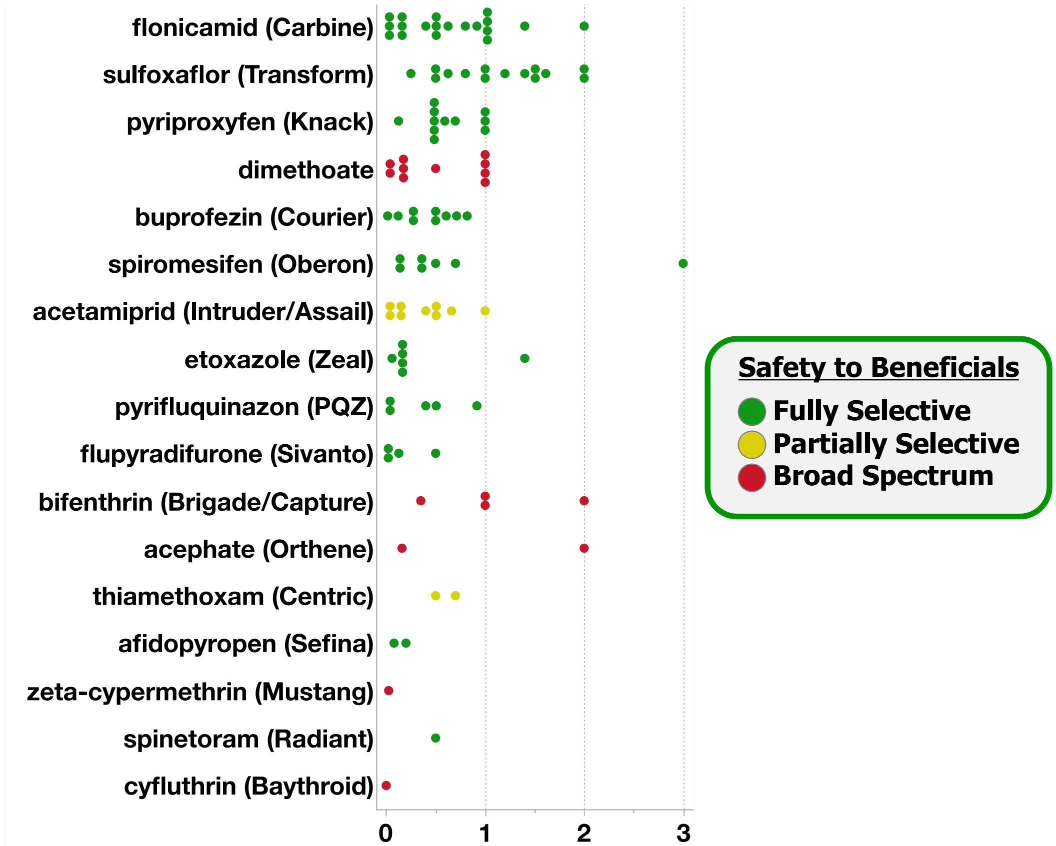

Figure 5. Number of sprays of foliar insecticide use by respondent (N=23) for Arizona cotton in 2019. Colored dots represent a reported respondent use and the type of product used, categorized by safety or selectivity for beneficial arthropods. Green = a fully selective insecticide; Yellow = a partially selective insecticide; Red = a non-selective insecticide. Source: *Cotton Pest Losses Database*, Ellsworth, unpubl.

3) Understanding Neonicotinoid Use Patterns in Arizona Cotton, Acetamiprid is Key

Neonicotinoids in general are used in cotton, however, those other than acetamiprid play a minor role in Arizona (Figure 4–6). **Clothianidin** use spiked in 2012 with the onset of a 50-yr record outbreak of the brown stink bug, *Euschistus servus* (Figure 6; also see Figure 2). Growers at the time had hoped this neonicotinoid would perform in the control of this stink bug; however, results were poor. Despite modest effects on *Lygus hesperus*, **clothianidin is effectively no longer used or marketed here**. Last uses were in 2013.

Imidacloprid use modestly spiked the following year (2013) with a similar hope for some efficacy against the brown stink bug. Research of the time was showing that there were no chemical control options for brown stink bug that were effective or economically justified. **Imidacloprid use today is negligible and in part remains because of the marketing of premixes containing imidacloprid**. Active foliar residues of imidacloprid under our extreme summer conditions of high temperatures and high solar radiation are very short, on the order of hours to days, and plant uptake via this foliar route in cotton is poor. Due to its poor efficacy and residual, imidacloprid is not recommended for whitefly control (Ellsworth et al. 2006).

Dinotefuran and **thiamethoxam** are rarely used in Arizona cotton as foliar sprays. When they are in use, we are in active discussions with stakeholders about appropriate product substitutions. For example, the targets in Figure 4 for thiamethoxam (Centric) could be controlled by appropriate product substitutions to the fully selective options of flonicamid, sulfoxaflor, pyrifluquinazon or flupyradifurone, or even the partially selective and more bee safe neonicotinoid, **acetamiprid**.

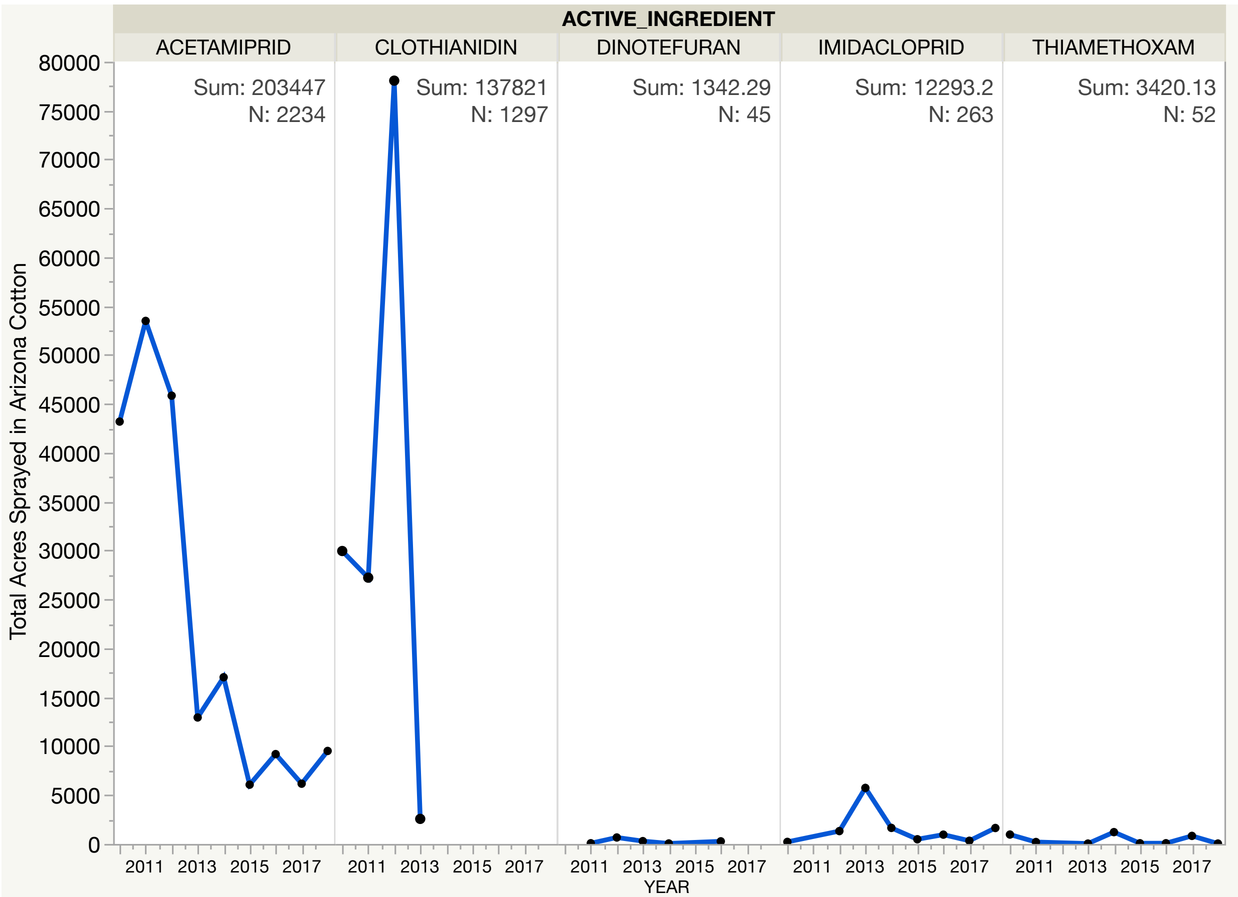

Figure 6. Total number of acres sprayed with neonicotinoids on Arizona cotton (2010–2018). Cotton acreage averaged 175,946 ± 15,318, with a maximum acreage in 2011 (266,422 acres) and a minimum in 2015 (105,538 acres), inclusive of Pima cotton. Typically, acetamiprid is sprayed on 5–30% of the cotton acreage in Arizona, ca. 9.3% in 2019. Sum = total acres sprayed for the 9-yr period depicted; N = total number of fields sprayed for 9-yr period depicted. Source: *Arizona Pest Management Center Database*, Fournier, Dixon & Ellsworth, unpubl.

Thus, **reductions in the maximum seasonal rates for the aforementioned neonicotinoids would not pose any special problems for our cotton producers.** When they are used, their frequency of use is usually no more than one spray (e.g., see Centric thiamethoxam in Figure 5). So, even with seed treatment uses included in seasonal caps, the proposed label changes would not impact these minor use patterns. With whiteflies as targets, there are many and better alternatives to these four neonicotinoids. However, in less common situations, some of these might be used for aphid, cotton fleahopper, or flea beetle control. With the exception of flea beetles, there are more selective and effective alternatives. Thiamethoxam might therefore rarely be needed for flea beetle control at stand establishment, especially if organophosphates or pyrethroids are further limited by regulatory or marketing actions in the future.

Acetamiprid is the key foliar neonicotinoid in use in Arizona cotton. It is sprayed typically on 5–30% of our cotton acres (Figure 6). The primary target is *Bemisia* whiteflies, where it excels at adult and immature control, in part because of strong translaminar and acropetal movement. Usage was higher a decade ago but has declined in more recent years. Reasons for this include:

a) perceived, declining efficacy (but see Section 4 below for recent efficacy results)
b) documented, but spatially and temporally, variable resistances in whiteflies
c) rate increases, permitted under Arizona SLN, increased costs of control
d) manufacturer increases in product costs
e) registration of newer options for control (PQZ, Sefina, Sivanto)

Despite these changes, **acetamiprid remains a critically important foliar neonicotinoid for our growers**. And despite reductions in efficacy, **Assail (acetamiprid) routinely exceeds the adult and large nymph control provided by the newest chemistries** (see Section 4). It is particularly important in those situations where adult whiteflies rapidly immigrate and overtake a cotton field, due to nearby source crops or weeds declining in quality due to harvest, irrigation practices, or tillage / herbicide use.

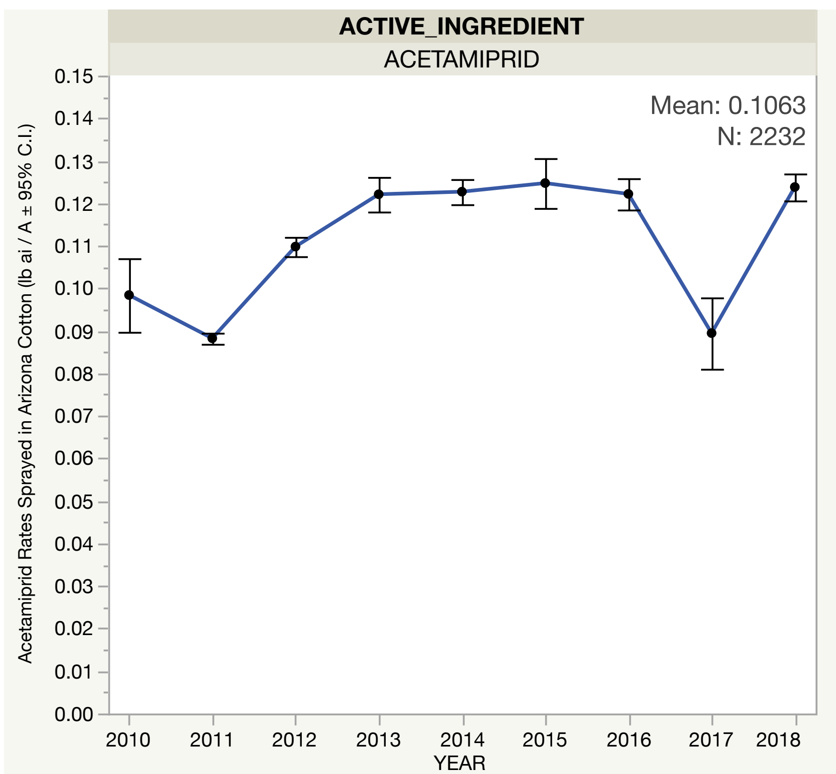

Figure 7. Average rates for acetamiprid applied to Arizona cotton (2010–2018). Mean = average rate used over the 9-yr period depicted; N = total number of fields sprayed for 9-yr period depicted. Source: *Arizona Pest Management Center Database*, Fournier, Dixon & Ellsworth, unpubl.

The rate structure for acetamiprid is different in Arizona for cotton due to the institution of a 50% rate increase under a Special Local Needs (SLN) registration that has been in place since 2012 to combat acetamiprid-resistant whiteflies (Figure 7). The federal Section 3 labeled rate of 0.10 lbs ai / A is still adequate to control most *Bemisia* whiteflies in cotton. However, most practitioners use rates that exceed the main label, using the Arizona SLN label. There is general recognition that the partial selectivity benefits of acetamiprid diminish as rates increase to the SLN maximum. As a result, too, these higher rates are associated with greater risk of secondary mite outbreaks. Despite these increased risks to non-target arthropods, there have been no reported incidents involving bee safety.

4) Recent Efficacy of Acetamiprid in Arizona Cotton Against **Bemisia** *Whiteflies*

In 2019, a whitefly field trial was conducted to examine the efficacy of 16 treatments, including Assail (acetamiprid) used at maximum Federal (0.1 lbs ai / A) and State SLN (0.15 lbs ai / A) rates (Table 1).

Acetamiprid's efficacy against adults and forthcoming eggs and large nymphs remains outstanding and a critical tool for our producers (Figures 8–11). This trial contained many compounds with known whitefly efficacy. All performed essentially as could be predicted from prior trials. In general, Assail, PQZ, Sivanto, and both of the insect growth regulators, Courier and Knack, performed well. Sefina also controlled whiteflies but required a second spray. Of the two experimentals, UA1901 failed to perform, but UA1902 provided some measure of whitefly efficacy.

Assail remains our most potent adulticide, which often manifests as lower egg numbers (Figure 8). Assail treatments also had the lowest levels of small nymphs in this trial (Figure 9). Large nymphs represent the "gold" standard for understanding the commercial value of a given product in whitefly control. The Assail treatments again led the trial (Figure 10). PQZ and Sivanto also maintained sub-threshold levels of large nymphs.

Many times, growers inappropriately fixate their attention on the more visibly active whitefly adults. While they are very important in whitefly management, their activity is secondary to that of the more cryptic large nymphs, which deposit copious honeydew on foliage and fiber. That said, pest managers are encouraged to measure both life stages and pay attention to imbalances in whitefly levels relative to the thresholds recommended (Ellsworth et al. 2006).

Even though there are known resistances to acetamiprid, the **Assail treatments continue to deliver the best adult control relative to these treatments even at the 2.3 oz rate** (Figure 11). PQZ and Sivanto continued their trend of maintaining sub-threshold levels of adults.

Acetamiprid remains among the most effective *Bemisia* whitefly chemical controls available to Arizona cotton producers. However, cotton producers are acutely aware of two issues: whitefly resistance to insecticides, and the keystone role that conservation biological control plays in our system. As a result, **acetamiprid use remains stewarded, modest, restrained, and strategic in Arizona cotton**. It is typically called upon to help mitigate large migrations of adults into cotton fields or as a late season option to control adults and immatures, preventing honeydew deposits on exposed cotton fibers.

Table 1. Treatment, product, formulations, and rates for each treatment in the 2019 Whitefly Efficacy Trial. Each product was sprayed broadcast, 2 nozzles per row at 20GPA, using an adjuvant (Dyne-Amic 0.25% v/v, unless otherwise noted). **, No adjuvant (Ellsworth, Pier & Bordini, unpubl. data).

Trt #	Name	Product	Formulation		Rate (lbs ai/A)	lbs ai/gal	Mix in oz / A	Total No. of Sprays
1	acetamiprid	**Assail3.5oz**	70	WP	0.15	0.70	3.5	1
2	acetamiprid	**Assail2.3oz**	70	WP	0.1	0.70	2.3	1
3	buprofezin fb thiamethoxam	**Courier fb Centric fb Centric**	3.6 fb 40	SC fb WG	0.35 fb 0.0625	3.6 fb 0.4	12.5 fb 2.5	2
4	pyrifluquinazon	**PQZ**	1.87	SC	0.047	1.87	3.2	1
5	pyrifluquinazon	**PQZ**	1.87	SC	0.035	1.87	2.4	1
6	flupyradifurone	**SivantoHL5oz**	3.33	HL	0.1300	3.33	5.0	1
7	flupyradifurone	**SivantoHL7oz**	3.33	HL	0.1825	3.33	7.0	1
8	afidopyropen	**Sefina**	0.42	DC	0.0460	0.42	14.0	2
9	afidopyropen**	**Sefina****	0.42	DC	0.0460	0.42	14.0	2
10	pyriproxyfen	**Knack**	0.86	EC	0.067	0.86	10	1
11	pyriproxyfen +V10433**	**Knack+ V10433**	0.86 + 0.375	EC	0.067	0.86 + 0.375	10 + 6	1
12-13	UA1901	**UA1901**						3
14-16	UA1902	**UA1902**						2
17	UTC-Carbine	**UTC-Carbine**						0
18	UTC-Acephate	**UTC-Acephate**						0

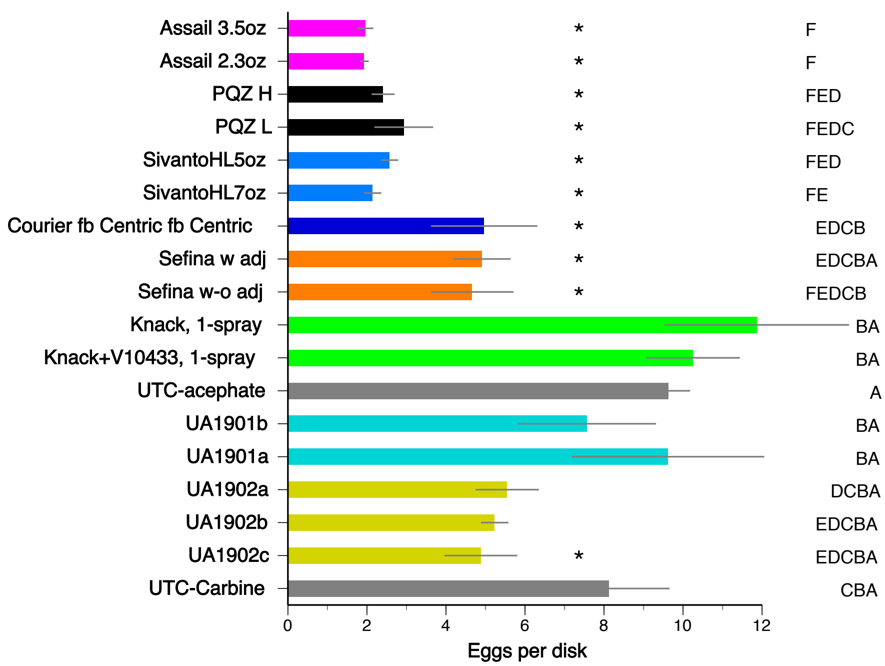

Figure 11. Seasonal mean densities of whitefly eggs per disk by treatment. *, indicate means significantly different from the UTC by Dunnett's Method (P < 0.05). Means not sharing a letter are significantly different from each other by Tukey's HSD (P < 0.05) (Ellsworth, Pier & Bordini, unpubl. data).

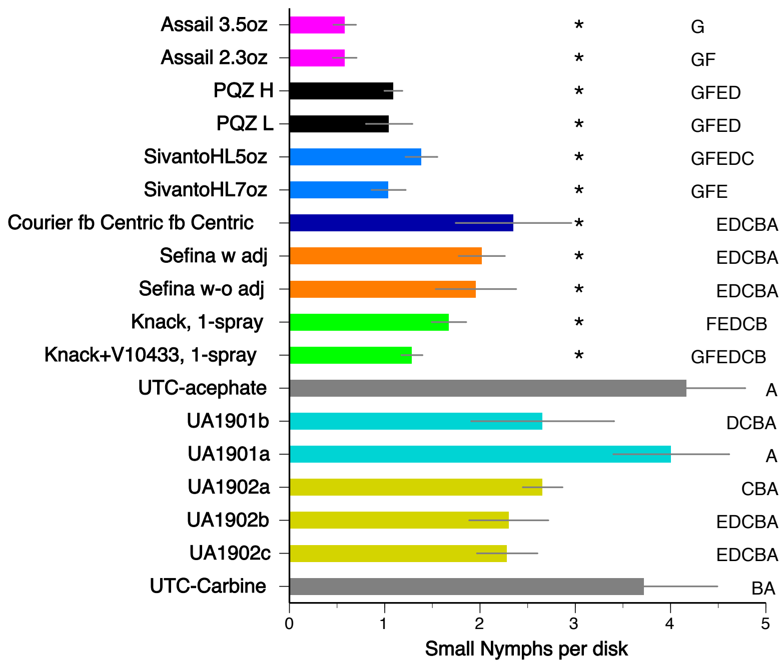

Figure 12. Seasonal mean densities of small nymphs per disk by treatment. *, indicate means significantly different from the UTC by Dunnett's Method (P < 0.05). Means not sharing a letter are significantly different from each other by Tukey's HSD (P < 0.05) (Ellsworth, Pier & Bordini, unpubl. data).

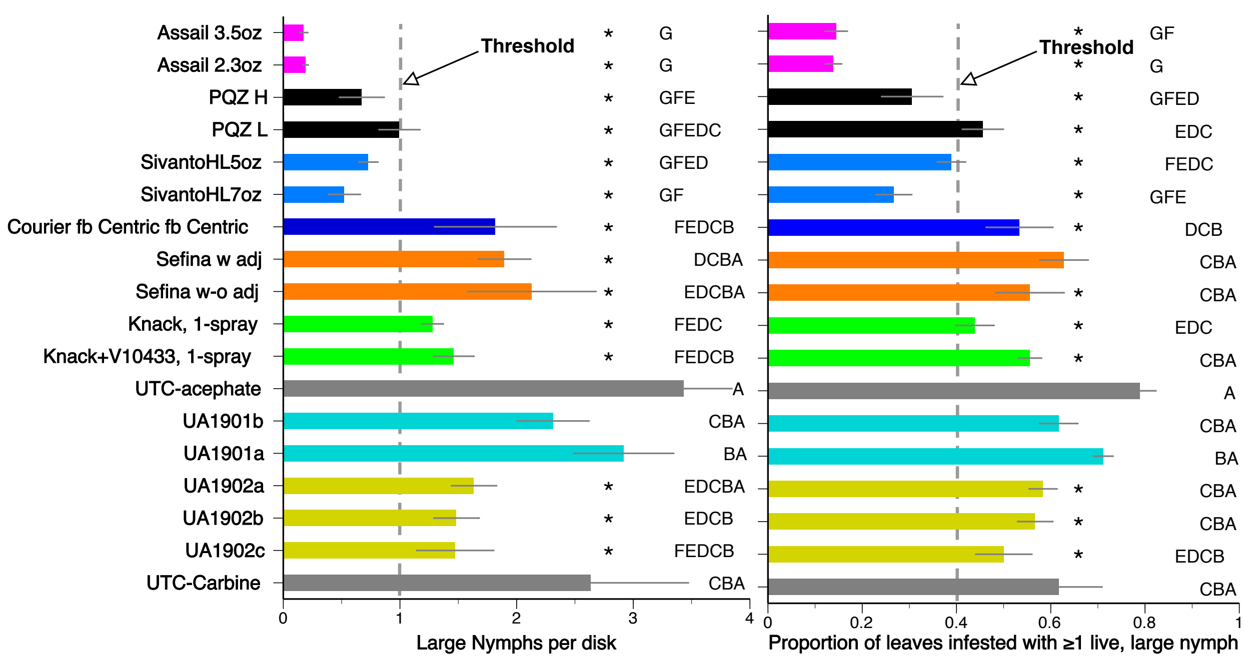

Figure 13. Seasonal mean densities of whitefly large nymphs, per disk (left) and expressed as a proportion of infested disks (right). Dashed line indicates the threshold for commercial use. Yield loss possible when large nymphs are sustained over 3 per disk. *, indicate means significantly different from the UTC by Dunnett's Method (P < 0.05). Means not sharing a letter are significantly different from each other by Tukey's HSD (P < 0.05) (Ellsworth, Pier & Bordini, unpubl. data).

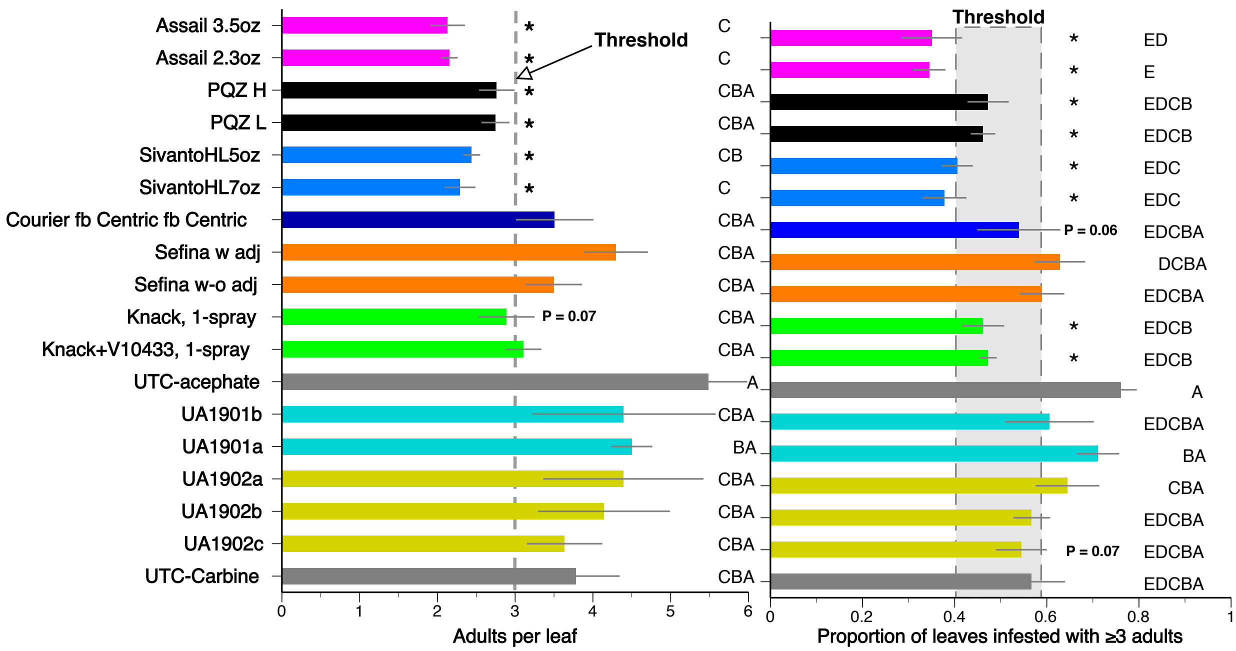

Figure 14. Seasonal mean densities of adults, per leaf (left) and expressed as a proportion of leaves infested with 3 or more adults (right). Dashed line or box indicates the threshold for commercial use. *, indicate means significantly different from the UTC by Dunnett's Method (P < 0.05). Means not sharing a letter are significantly different from each other by Tukey's HSD (P < 0.05) (Ellsworth, Pier & Bordini, unpubl. data).

Our Data and Expert Information

Through cooperative agreements with Arizona Department of Agriculture, the Arizona Pest Management Center obtains use of, improves upon, and conducts studies with ADA's Form1080 data. Growers, pest control advisors and applicators complete and submit these forms to the state when required by statute as a record of pesticide use. These data contain information on 100% of custom-applied (i.e., for hire) pesticides in the state of Arizona. Grower self-applied pesticide applications may be under-represented in these data. In addition, the Arizona Pest Management Center is host to scientists in the discipline of IPM, including experts in the usage of this and other compounds in our agricultural systems. We actively solicit input from stakeholders in Arizona including those in the regulated user community, particularly to better understand use patterns, use benefits, and availability and efficacy of alternatives. The comments within are based on the extensive data contained in the Arizona Pest Management Center Pesticide Use Database, collected summary input from stakeholders and the expertise of APMC member faculty.

Through the Crop Pest Losses and Impact Assessment program (WIPMC 2018), a Signature Program of the Western IPM Center, the Arizona Pest Management Center conducts annual surveys with state-licensed pest control advisors (PCAs), who are the primary pest management decision makers, in consultation with growers. The surveys, conducted at face-to-face meetings, provide detailed information on crop yield losses to specific insect pests, weeds and diseases, control costs, and pesticide use for the key crops, cotton and lettuce. Cotton data have been collected since 1991 and lettuce data since 2005. Data are collected for all of Arizona and neighboring production regions of California, with typical responses representing up to 65% of acres planted in Arizona. These data provide detailed information on shifting pest trends, chemical use and costs, and often compliment and augment information from the APMC Pesticide Use Database, particularly for pesticide uses for which the state does not mandate reporting.

Relevant Literature

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