INSECTICIDAL CONTROL OF APHIDS, IMPACT ON LADY BEETLES AND YIELD RESPONSE

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Abstract

Cotton aphids are a common pest of cotton grown in the High Plains of Texas. The objectives of this three-year study included: 1) to determine the efficacy of commonly used aphicides at mitigating aphid populations in cotton, 2) to determine which aphicides have the least detrimental impact on key aphid predators, and 3) to collect data to support or refute the current aphid action threshold. In 2008, the aphid population was treated near the action threshold of 50 aphids per leaf. By 5 DAT, Intruder, Carbine, Bidrin, Centric and Trimax Pro all had significantly fewer aphids than the untreated, but Trimax Pro had more aphids than the other insecticides. Based on regression analysis, the action threshold necessary to prevent yield loss should have been closer to 20 aphids per leaf. At the time, the cotton was stressed from heavy boll filling. In 2009, the aphid population was averaging 138 aphids per leaf at application. At 7 DAT results were similar to 2008, except that Centric and Trimax Pro failed to reduce the aphid population below threshold. In 2010, treatments were similar to previous years, but also included Belay, sulfoxaflor, and an imidacloprid + spirotetramat mix. Results were similar to previous years. Belay performed similar to Trimax Pro and sulfoxaflor and the imidacloprid + spirotetramat mixture were similar in efficacy to Intruder, Carbine and Bidrin. In 2010, a regression analysis suggested that 50 aphids per leaf was a suitable threshold. In this test, the cotton was at the early-boll filling stage and under little stress. Against an aphid population infesting pre-bloom non-stressed, dryland cotton, Intruder performed well, but no yield response was detected. Aphids may be more damaging to cotton with increasing plant stresses. All of the neonicotinoid insecticides (Belay, Centric, Intruder, Trimax Pro and imidacloprid + spriotetramat) were harsh on lady beetle larvae, Bidrin and sulfoxaflor were moderately harsh, and Carbine was least harsh.

Introduction

Cotton aphids, *Aphis gossypii* Glover, are a common pest of cotton grown in the high plains of Texas. Where aphid outbreaks occur, natural enemies such as lady beetles are undoubtedly one of the most important natural factors for reducing aphid numbers below economically damaging levels. Key predators are not only important in suppressing aphid populations below threshold, but are also important in preventing resurgence of aphids post treatment and assisting in control following treatment. The University of Arkansas has developed a decision making process that incorporates lady beetle counts for determining when to treat for aphids.

The Texas AgriLife Extension Service action threshold for initiating an insecticide application targeting aphids in cotton is 50 aphids per leaf prior to boll opening and 10 aphids per leaf thereafter. The low threshold after boll opening is to prevent honeydew accumulation on the lint, resulting in sticky cotton.

The objectives of this study included: 1) to determine the efficacy of commonly used aphicides at mitigating aphid populations in cotton, 2) to determine which aphicides have the least detrimental impact on key aphid predators, and 3) to collect data to support or refute the current aphid action threshold.

Materials and Methods

Three tests were conducted in 2008-2010 at the Texas AgriLife Research and Extension Center in Lubbock, and a fourth was conducted in eastern Gaines County, Texas in 2010. In Lubbock, 'DeltaPine 174 RF' was planted on 4 June 2008, 9 June 2009 and 20 May 2010 on 40-inch rows and irrigated using furrow run irrigation. The Gaines Co. site was conducted on dryland cotton. In all tests, plots were 4-rows wide × 25-60 ft long. Plots were arranged in a randomized complete block design with 4 replicates. At the

Lubbock location, an aphid outbreak was induced by overspraying the entire test area with Karate 1EC (lambda cyhalothrin, 4 fl-oz/acre). The aphicide treatments and rates for the Lubbock tests are outlined in Table 1.

Table 1. Aphicide treatments and rates.

Treatment[a]	Active Ingredient	Rate (product/ac)
1) Untreated	--	--
2) Bidrin 8	Dicrotophos	8.0 fl-oz
3) Carbine 50WG	Flonicamid	1.5 oz
4) Centric 40WG	Thiamethoxam	2.0-2.5 oz[b]
5) Intruder 70WSP	Acetamprid	0.6-0.75 oz[b]
6) Trimax Pro 4.44SC	Imidacloprid	1.8 fl-oz
7) Belay 2.13SC[c]	Clothianidan	6 fl-oz
8) GF-2372 50WG[c]	Sulfoxaflor	0.35 oz
9) CMT-4586[c]	Imidacloprid + Spirotetramat	8.0 fl-oz

[a]All treatments included crop oil concentrates at 1.0% v/v in 2008-09, and Dyne-Amic at 0.25% v/v in 2010; CMT-4586 also included 28% UAN at 2.5% v/v.
[b]Rate for Centric was 2.0 oz in 2008-09 and 2.5 oz in 2010 and the rate for Intruder was 0.75 oz in 2008 and 0.6 oz in 2009-10.
[c]Applied only in 2010.

The Gaines Co. site consisted of an untreated and Intruder at 1.0 oz + Dyne-Amic (NIS) at 0.25% v/v. All treatments were applied with a CO_2 pressurized hand boom calibrated to deliver 10 gallons/acre. The boom consisted of 2 hollow cone TX-6 nozzles per row, spaced at 20 inches. The aphid population was estimated by counting the number of aphids per leaf. Five 3 to 4 node terminal and five mid to lower canopy leaves were randomly sampled per plot.

In Lubbock, predators were estimated utilizing a 36-inch x 40-inch black drop cloth. Drop cloths were laid between the rows and approximately 1.5 ft-row of cotton were shaken onto the drop cloth from each row. The type and number of predators were counted and recorded. Only lady beetle larvae data are presented. At the Gaines Co. site, lady beetle larvae were estimated using whole plant inspections (10 plants per plot). The % reduction in lady beetle larvae relative to the untreated was estimated using Henderson-Tilton's equation.

The plots were harvested in 2008 in Lubbock and 2010 in Gaines Co. using a 28" hand basket stripper. Six samples were taken from the middle two rows of each plot totaling 1/1000 of an acre. In 2010, entire plots were harvested at the Lubbock site using a 4-row cotton stripper. Samples were ginned at the Texas AgriLife Ginning Facility in Lubbock. In 2009, yield data was not taken due to herbicide damage compounded by an early freeze.

All count data were analyzed using PROC MIXED and the means were separated using an F protected LSD ($P < 0.05$). The 2008 and 2010 yields were correlated with aphid densities using a exponential decay linear regression model.

Results and Discussion

Aphids

On 21 August, 2008, prior to application, the aphid population averaged 33.24 aphids per leaf across nodes 3-4 and lower canopy leaves. There were no statistical differences among treatments at this time. Although the aphid population was not at the treatment threshold, the population appeared to be rapidly increasing. Treatments were initiated on 23 August. At the time of application, the cotton was in the mid-boll filling stage. By 5 DAT, all of the insecticides appeared to have had ample time to demonstrate efficacy and all of the treatments had significantly fewer aphids than the untreated (Figure 1); however, Trimax Pro did not differ from the untreated in the number of aphids infesting the mid to lower canopy (data not presented). Additionally, there were significantly more aphids in the Trimax Pro treated plot than the other insecticides.

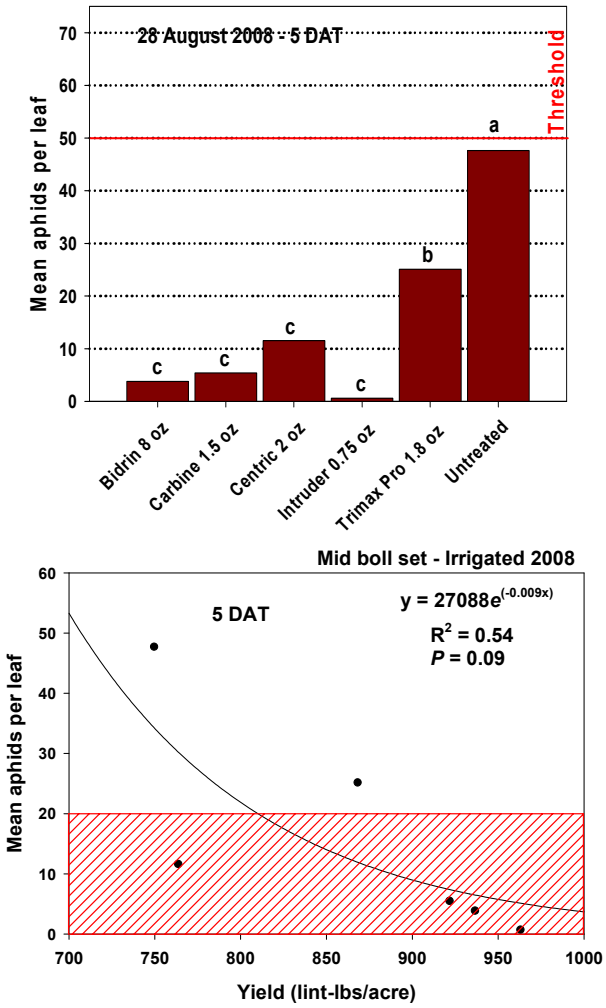

Figure 1. Lubbock, aphids per leaf averaged across 3-4 node and mid to lower canopy leaves. Columns capped by the same letter are not significantly different (top). Linear relationship in 2008 of cotton aphid density at 5 DAT and yield (bottom).

The relationship between aphids and yield in 2008 suggests that the action threshold to prevent yield reduction should have occurred before the aphid population exceeded 20 per leaf (Figure 1). The current action threshold in Texas is 50 aphids per leaf. During the mid-boll filling stage, there is extremely high demand on the cotton plant for photosynthetic nutrient and water resources. It is conceivable that the current aphid threshold is too high for cotton under high stress.

In 2009, the aphicide application occurred when the cotton was at a physiologically similar time to 2008 (mid-boll filling). In 2009, the aphid population was substantially greater than in 2008. On 28 August, the aphid population was averaging 138.28 aphids per leaf averaged across 3-4 node and lower canopy leaves, and there were no statistical differences among treatments.

At 7 DAT, all of the treatments had fewer aphids than the untreated but under higher aphid pressure, Centric and Trimax Pro both failed to adequately reduce the aphid population (Figure 2). Bidrin initially reduced the aphid population below action threshold (data not presented), but by 7 DAT, the aphids were beginning to resurge. Intruder and Carbine were both effective.

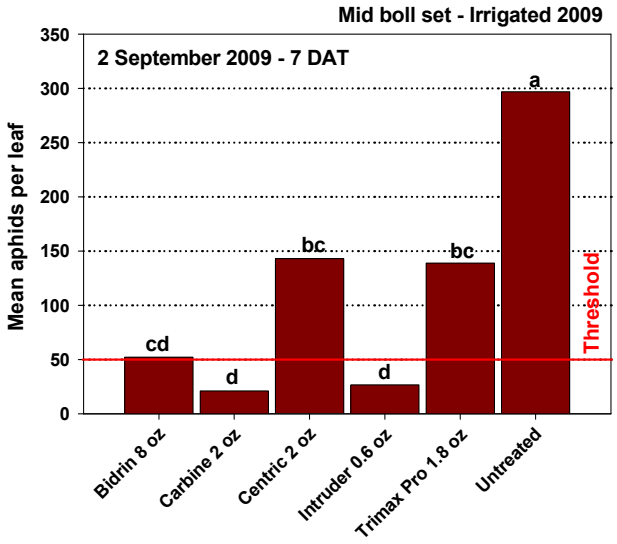

Figure 2. Lubbock, aphids per leaf averaged across 3-4 node and mid to lower canopy leaves. Columns capped by the same letter are not significantly different.

In Lubbock in 2010, the aphid outbreak occurred during the early boll filling stage, and the aphid population averaged 240.59 per leaf averaged across nodes 3-4 and lower canopy leaves. At 7 DAT, all of the treatments had fewer aphids than the untreated but similar to 2008 and 2009, Trimax Pro did not reduce the aphid population below threshold (Figure 3). Belay performed similar to Trimax Pro but, unlike 2009, Centric performed moderately and was only slightly above threshold. However, Centric was applied at 2.5 oz/acre in 2010 and 2.0 oz/acre in previous years. Sulfloxaflor, CMT-4586, Bidrin, Intruder and Carbine all provided good aphid control. There was a highly significant relationship between aphids and yield at the 2010 Lubbock site. Unlike 2008, the break in yield appears to occur around 50 aphids per leaf, which agrees with the current threshold.

There were a large number of lady beetles in this test that undoubtedly contributed to the decline of aphids in the untreated. At this location we could not detect any impact on yield or relationship between aphids and yield. The cotton in this test was under very little stress, had ample water and fertility and no boll load. Thus, it appears that in the absence of stress and because the aphids occurred at a time when they would not be diverting resources away from the bolls, the impact on yield may be negligible.

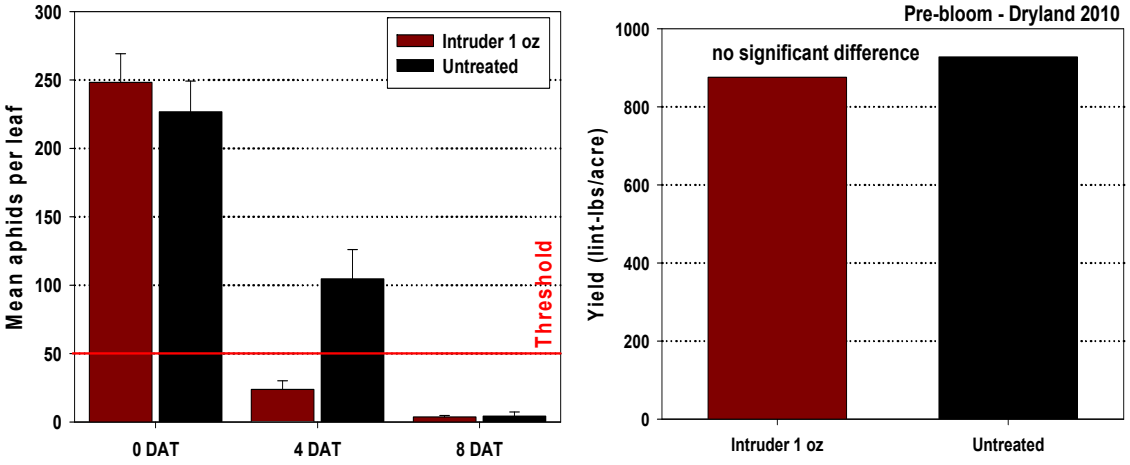

Figure 3. Lubbock, aphids per leaf averaged across 3-4 node and mid to lower canopy leaves. Columns capped by the same letter are not significantly different (left). Linear relationship in 2010 of cotton aphid density at 7 DAT and yield (right).

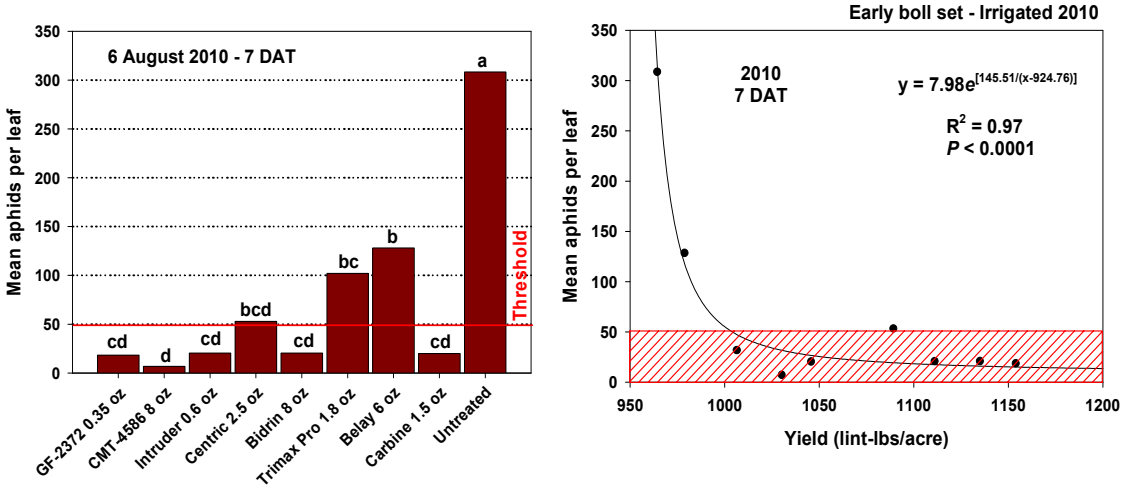

Figure 4. Gaines County, aphids per leaf averaged across 3-4 node and mid to lower canopy leaves. Columns within a DAT capped by the same letter are not significantly different (left). Yield response (right).

Lady Beetles

Convergent lady beetle, *Hippodamia convergens* Guérin-Méneville, was the most prevalent predator present at the Lubbock location during both years, while the Scymnus lady beetle, *Scymnus loewii* Mulsant, was most prevalent in Gaines Co. In the Lubbock tests, prior to treatment, lady beetle larvae averaged 9.28, 4.08 and 5.94 per 6 ft-row in 2008, 2009 and 2010 respectively, while the *Scymnus* lady beetle larvae population averaged ~16 per 6 ft-row at the Gaines Co. site. These values are well above the 1.2 lady beetle larvae per 6 ft-row suggested to bring an aphid population under control within a 7 day period. However, with the exception of Lubbock 2008, our lady beetle populations did not appear to prevent or reduce the aphid populations rapidly enough. At 3-4 DAT, lady beetle larvae were severely reduced by all neonicotinoid treatments (Centric, Intruder, Trimax Pro, Belay and CMT-4586) across all years and sites (Table 2). Bidrin and sulfoxaflor appear to have moderate impact while Carbine appears to be safest on lady beetle larvae.

Table 2. Impact of aphicides on lady beetle larvae (3-4 DAT).

Treatment[b]	Percent reduction in lady beetle larvae[a]			
	2008	2009	2010	Gaines 2010
Untreated	0.00 d	0.00 c	0.00 e	0.00 b
Bidrin	33.14 bcd	43.25 ab	51.50 bcd	-- [c]
Carbine	18.75 cd	1.84 c	25.33 de	-- [c]
Centric	53.27 abc	31.82 ab	84.40 abc	-- [c]
Intruder	55.86 ab	53.63 a	76.41 abc	80.57 a
Trimax Pro	81.25 a	46.97 ab	76.57 abc	-- [c]
Belay	--[c]	-- [c]	91.04 a	-- [c]
GF-2372	-- [c]	-- [c]	49.26 cd	-- [c]
CMT-4586	-- [c]	-- [c]	89.65 ab	-- [c]

Means in a column followed by the same letter are not significantly different based on an F protected LSD (P > 0.05).
[a]Based on Henderson-Tiltons equation.
[b]See Table 1 for rates and active ingredients.
[c]Not evaluated.

Summary

Intruder, Carbine, Bidrin, sulfoxaflor and CMT-4586 (imidacloprid + spirotetramat) all exhibited excellent activity toward cotton aphids on the Texas High Plains. Centric performed moderately and Trimax Pro and Belay were least effective. Aphids appeared to be most damaging with increasing plant stress in the form of boll load and the associated carbohydrate sink. The current Texas action threshold of 50 aphids per leaf may need to be lowered, especially when plants are stressed. All of the neonicotinoid insecticides (Belay, Centric, Intruder, Trimax Pro and imidacloprid + spriotetramat) were harsh on lady beetle larvae, Bidrin and sulfoxaflor were moderately harsh, and Carbine was least harsh.

Acknowledgements

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