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ACTIVITY OF NEONICOTINOIDS AGAINST APHIDS, PREDACEOUS ARTHROPODS AND OTHER PESTS

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Abstract

Three neonicitinoid insecticides (acetamiprid, thiamethoxam, and imidacloprid) and one organophosphate insecticide (dicrotophos) were evaluated for control of the cotton aphid (*Aphis gossypii* Glover). In addition, the effects of these chemistries on populations of predators, pests and eggs of *Helicoverpa zea* were monitored during the 2002 and 2003 seasons in both conventional and B.t. cotton. Acetamiprid and thiamethoxam provided adequate control of *A. gossypii*, whereas dicrotophos, at times, flared populations. Imidacloprid was less effective in controlling *A. gossypii* than either acetamiprid or thiamethoxam. Dicrotophos controlled stink bugs and cotton fleahoppers but had an adverse impact on predators which resulted in higher populations of lepidopterous pests later in the season. Acetamiprid and thiamethoxam demonstrated ovicidal activity against *H. zea.* The neonicotinoids exhibited varying activity against sucking pests, predaceous arthropods, and later-developing populations of lepidopterous pests.

Introduction

The cotton aphid, *Aphis gossypii* Glover, was first reported as an economic pest in South Carolina in 1854 (Slosser et al. 1989). By 1991, this insect had become one of the most important pests of cotton in the United States (Hardee and Herzog 1992). The extremely sticky and heavy honeydew deposits that aphids secrete stresses cotton plants. This stress is a major concern and can be even more intensified during drought conditions. Although insecticides are used for extremely high populations, the fungus (*Neozygites fresenii)* has been a major biological control agent of *A. gossypii* in South Carolina for several years and has eliminated populations of this pest (Hardee and Burris 2003). In addition to aphid control, the effects of the insecticide against pests and predaceous arthropods should be considered. Turnipseed and Sullivan (1998) found that early season applications of broad spectrum insecticides often decreased predaceous arthropod populations and resulted in increased levels of lepidopterous pests and boll damage. Common insecticides used for cotton aphid control include dicrotophos, a broad-spectrum organophosphate, and more recently, the neonicotinoids. The neonicotinoids are particularly active against sucking pests. This study was designed to test the effectiveness of neonicotinoids against cotton aphids and other pests and to evaluate predator mortality due to insecticidal applications.

Materials and Methods

Two tests (T1A and T2A) were conducted in 2002, and three tests (T1B, T2B, and T3B) were conducted in 2003 at the Clemson University Edisto Research and Education Center near Blackville, South Carolina. All tests were arranged using a randomized complete block design. T1A consisted of plots of conventional cotton 12 rows by 45 feet with four replicates. T2A consisted of plots of B.t. cotton 12 rows by 40 feet with six replicates. T1B (B.t. cotton) and T2B (conventional cotton) each consisted of plots 12 rows by 40 feet, and T3B consisted of plots of conventional cotton 6 rows by 20 feet. T1B, T2B, and T3B were replicated 5 times. Treatments consisted of three neonicotinoids (acetamiprid, thiamethoxam, and imidacloprid), one organophosphate (dicrotophos), and an untreated control. Each neonicotinoid was applied at a rate of 0.047 lbs ai/ac. Dicrotophos was applied at a rate of 0.50 lbs ai/ac. Neonicotinoids and dicrotophos were applied at 8.5 gallons per acre at 58 psi using a CO_2 backpack sprayer that covered two rows with four hollow cone nozzles. T1A applications were made on 19 June, 26 June (imidacloprid and dicrotophos only), and 03 July, and T2A applications on 26 July and 09 August. T1B applications were made on 23 June, 30 June (imidacloprid only), and 07 July; T2B on 18 July; and T3B on 24 July. T2B and T3B were conducted only for ovicidal experiments.

Cotton aphids were sampled directly from plants by counting the number of aphids on either the top three leaves or the top third of 20 or 25 plants per plot. Sucking pest damage was assessed by observing the number of warts, punctures, and/or seed/lint staining in 25 cotton bolls per plot. Pests and predators were sampled using one meter beat cloths. For ovicidal tests, freshly-deposited *Helicoverpa zea* (bollworm) eggs were collected from the field approximately four hours after application, and then placed in Petri dishes in the lab. Eggs were observed for three to four days to see if hatching had occurred. Data were analyzed using analysis of variance, and means were separated using Fisher's protected least significant difference test.

Results and Discussion

Although aphid populations on 02 July in T1A were much lower in acetamiprid and thiamethoxam-treated plots (Table 1), differences were not significant. On 08 July (Table 1), plots treated with dicrotophos had significantly higher populations of cotton aphids than in neonicotinoid-treated plots, and though not significant, aphid numbers in dicrotophos-treated plots were two times higher than in untreated plots. In T1B (Table 2, 27 June), after one application, there were no significant differences in cotton aphid populations. However, by 09 July only the neonicotinoids gave significant control of cotton aphids, with acetamiprid and thiamethoxam exhibiting excellent control (Table 2).

Acrosternum hilare (green stink bug) was the primary sucking pest present in T2A (Table 3, 12 August). Dicrotophos significantly reduced numbers of green stink bugs, and thiamethoxam exhibited some suppression although numbers were not significantly different from the untreated plots. On 27 August (Table 3), number of bolls exhibiting stink bug damage was significantly lower in dicrotophos-treated plots compared with untreated plots. Neonicotinoids were similar to untreated plots.

Thiamethoxam and dicrotophos exhibited excellent control of *Pseudatomoscelis seriatus* (cotton fleahopper) in T2A on 30 July, 4 days after one application (Table 4). Acetamiprid exhibited moderate control, and imidacloprid was the only treatment that did not significantly reduce cotton fleahopper populations. On 12 August, three days after a second application, all neonicotinoids and dicrotophos gave effective and significant control. However, two applications of imidacloprid were required to produce effective control.

Geocoris punctipes (big-eyed bug) and *Solenopsis invicta* (red imported fire ant) accounted for over half of the total predators sampled in T2A on 12 August. Lady beetles and lacewings were excluded because of their close association with aphid populations. Acetamiprid and imidacloprid treatments were not significantly different from the control for either big-eyed bugs or fire ants, but thiamethoxam and dicrotophos caused significant reductions in populations of both predators (Table 5).

Predators observed in T2A (Table 6), three days after two applications included *Geocoris punctipes*, *Solenopsis invicta*, *Orius insidiosis* (insidious flower bug), and various species of spiders. Predator numbers in acetamiprid and imidacloprid plots were similar to the untreated control, and numbers of *H. zea* larvae among these three treatments were statistically similar. However, thiamethoxam and dicrotophos caused significant reductions in these predators, and as a result, these plots exhibited significantly higher numbers of *H. zea* larvae compared to control plots.

Tests against freshly-deposited *H. zea* eggs in 2003 (Table 7- T2B, T3B) showed that both acetamiprid and thiamethoxam exhibited significant ovicidal activity. No ovicidal activity was exhibited by imidacloprid and dicrotophos. However, even though acetamiprid and thiamethoxam are similar in ovicidal activity, their difference in predator mortality is more important.

In conclusion, our research demonstrates that acetamiprid and thiamethoxam exhibited excellent control against cotton aphids. Imidacloprid gave good control, but dicrotophos exhibited poor control, especially after a second application. Neonicotinoids are ineffective against green stink bugs when compared to dicrotophos, although thiamethoxam gave some suppression. In activity against cotton fleahoppers, there are differences among neonicotinoids in that two applications of imidacloprid were required for effective control compared to a single application of acetamiprid and thiamethoxam. Also, there are differences among neonicotinoids in activity against predaceous arthropods, later developing populations of *H. zea*, and eggs of *H. zea*. Acetamiprid and imidacloprid exhibited lower predator mortality than thiamethoxam which resulted in thiamethoxam exhibiting a higher number of *H. zea* larvae. Also, acetamiprid and thiamethoxam showed significantly more ovicidal activity than imidacloprid.

References

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Table 1. Activity of neonicotinoids and dicrotophos against cotton aphids in conventional cotton in 2002, T1A.

Treatments	Mean no. *Aphis gossypii* on top 3 leaves of 25 plants	
	02 July[1]	**08 July[2]**
Acetamiprid (0.047 lb ai/A)	74.50 a	86.80 b
Thiamethoxam (0.047 lb ai/A)	92.80 a	155.80 b
Imidacloprid (0.047 lb ai/A)	465.00 a	166.30 b
Dicrotophos (0.50 lb ai/A)	1298.30 a	2551.80 a
Untreated	1427.50 a	1301.00 ab

[1]13 days after 1st application for acetamiprid and thiamethoxam and 6 days after 2nd application for imidacloprid and dicrotophos.
[2]5 days after 2nd application for acetamiprid and thiamethoxam and 5 days after 3rd application for imidacloprid and dicrotophos.

Table 2. Activity of neonicotinoids and dicrotophos against cotton aphids in B.t. cotton in 2003, T1B.

Treatments	Mean no. *Aphis gossypii* on top 3 leaves of 20 plants 4 days after 1st application[1]	Mean no. *Aphis gossypii* in top 1/3 of 20 plants 2 days after multiple applications[1]
Acetamiprid (0.047 lb ai/A)	14.2 a	14.6 c
Thiamethoxam (0.047 lb ai/A)	18.2 a	56.6 c
Imidacloprid (0.047 lb ai/A)	71.0 a	243.2 bc
Dicrotophos (0.50 lb ai/A)	66.8 a	1620.8 a
Untreated	272.2 a	1529.0 ab

[1]2 applications of acetamiprid, thiamethoxam, and dicrotophos made on 23 June and 07 July. 3 applications of imidacloprid made on 23 June, 30 June, and 07 July.

Table 3. Activity of neonicotinoids and dicrotophos against green stink bugs in B.t. cotton in 2002, T2A.

Treatments	Mean no. *Acrosternum hilare* in 3 meters of row 3 days after 2nd application[1]	Mean damage[2] in 25 bolls 18 days after 2nd application[2]
Acetamiprid (0.047 lb ai/A)	8.00 ab	16.00 a
Thiamethoxam (0.047 lb ai/A)	4.50 ab	12.00 ab
Imidacloprid (0.047 lb ai/A)	12.30 a	15.50 a
Dicrotophos (0.50 lb ai/A)	0.20 b	6.25 b
Untreated	13.00 a	15.75 a

[1]2 applications made on 26 July and 09 August.
[2]Warts, punctures, and/or seed/lint staining.

Table 4. Activity of neonicotinoids and dicrotophos against cotton fleahoppers in B.t. cotton in 2002, T2A.

Treatments	Mean no. *Pseudatomoscelis seriatus* in 3 meters of row	
	4 days after 1st application[1]	**3 days after 2nd application[1]**
Acetamiprid (0.047 lb ai/A)	2.50 bc	0.30 b
Thiamethoxam (0.047 lb ai/A)	0.70 c	0.50 b
Imidacloprid (0.047 lb ai/A)	4.80 ab	2.00 b
Dicrotophos (0.50 lb ai/A)	0.50 c	0.20 b
Untreated	8.20 a	7.80 a

[1]2 applications made on 26 July and 09 August.

Table 5. Activity of neonicotinoids and dicrotophos against big-eyed bugs and red imported fire ants in B.t. cotton in 2002, T2A.

Treatments	Mean no. in 3 meters of row- 3 days after 2nd application[1]	
	Geocoris punctipes	***Solenopsis invicta***
Acetamiprid (0.047 lb ai/A)	12.70 a	14.50 a
Thiamethoxam (0.047 lb ai/A)	4.80 cd	0.80 b
Imidacloprid (0.047 lb ai/A)	7.00 bc	14.70 a
Dicrotophos (0.50 lb ai/A)	0.70 c	0.00 b
Untreated	10.30 ab	23.30 a

[1]2 applications made on 26 July and 09 August.

Table 6. Activity of neonicotinoids and dicrotophos against predators and bollworm larvae in B.t. cotton in 2002, T2A.

Treatments	**Mean no. predators[1] in 3 meters of row 3 days after 2nd application[2]**	**Mean no. *H. zea* in 3 meters of row 3 days after 2nd application[2]**
Acetamiprid (0.047 lb ai/A)	45.33 a	1.17 abc
Thiamethoxam (0.047 lb ai/A)	23.17 b	2.33 a
Imidacloprid (0.047 lb ai/A)	41.67 a	0.83 bc
Dicrotophos (0.50 lb ai/A)	6.17 b	2.00 ab
Untreated	55.50 a	0.33 c

[1]*Geocoris punctipes*, *Orius insidiosis*, *Solenopsis invicta*s, and various species of spiders.
[2]2 applications made on 26 July and 09 August.

Table 7. Activity of neonicotinoids and dicrotophos against bollworm eggs in conventional cotton in 2003, T2B and T3B.

Treatments	**Mean no. unhatched *H. zea* eggs of 10 eggs**	
	3 days after one application[1]-T2B	**4 days after one application[2]-T3B**
Acetamiprid (0.047 lb ai/A)	6.33 a	7.00 a
Thiamethoxam (0.047 lb ai/A)	6.00 a	5.33 ab
Imidacloprid (0.047 lb ai/A)	3.00 b	3.33 b
Dicrotophos (0.50 lb ai/A)	1.60 b	-------
Untreated	1.60 b	3.80 b

[1]Application made 18 July.
[2]Application made 24 July.