IMPACT OF NATURAL ENEMIES ON COTTON APHID MANAGEMENT IN GEORGIA

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Abstract

The cotton aphid has been the focus of a great deal of research in the years since it was first identified as a serious pest of cotton. Nevertheless, basic questions about the biology and the economic impact of this insect remain. This study was undertaken to evaluate the impact of natural enemies on cotton aphid populations, and to assess the impact of aphids on cotton yield and quality. Four treatments were evaluated (1) an untreated control, (2) a fungicide treatment to reduce the activity of the entomopathogenic fungus *Neozygites fresenii*, (3) an imidacloprid treatment when aphids were present on 50% of plants, and (4) an imidacloprid treatment when aphids were present on >>50% of plants and natural enemies were present. Studies were conducted for three seasons (1999, 2000, and 2001) in commercial cotton fields with one-acre plots and four replicates of each treatment (total of 16 acres per year). Cotton aphid population development was similar in all three seasons with peak aphid numbers occurring in early July and declining rapidly thereafter as fungal epizootics decimated aphid populations. Imidacloprid applications in early July effectively suppressed aphid populations but were followed closely by fungal epizootics. Arthropod natural enemies were not abundant in the study and had no observable effect on aphid populations. Seed cotton yield and lint quality were not significantly affected by aphid infestations.

Introduction

The cotton aphid, *Aphis gossypii*, has become a major pest management concern for producers in Georgia and across the U.S. Cotton Belt in recent years. The destruction of arthropod natural enemies following insecticide applications and the development of insecticide resistance by the aphid have played a major role in elevating the pest status of this insect (King et al. 1987, Grafton-Cardwell 1991, Hardee and Adams 1998, Kerns et al. 1998). The incidence of increased cotton aphid reproduction following applications of certain insecticide chemistries, particularly pyrethroids, has also been a factor contributing to recent increases in aphid related damage (Sosser et al. 1989, Kerns and Gaylor 1993, Rummel et al. 1995). Many studies have attempted to quantify the impact of the cotton aphid; nevertheless, basic questions about the biology and economic impact of this insect remain.

The success of the Boll Weevil Eradication Program, the introduction of Bt-transgenic cotton, and the development of new, more selective insecticide chemistries have created an environment in the Southeast that is ideally suited for the development of true integrated pest management strategies for cotton insect control. Natural enemies of the aphid are often abundant in cotton, but their potential for suppressing aphid populations is only poorly understood (Kerns and Gaylor 1993).

In the current study, we tracked populations of cotton aphids and their natural enemies, measured the effects of aphid infestations on cotton yield, and evaluated the role of natural enemies in suppressing aphid populations. The objectives of our sudy were to evaluate the impact of natural enemies on cotton aphid populations and to assess the impact of aphid infestations and management on cotton yield and quality.

Experimental Design

Studies were conducted for three growing seasons in commercial cotton fields planted in Bt cotton (DPL 33b and DPL 458 in 1999 and 2000, 2001 respectively) near Tifton, GA. Four treatments were replicated four times in 16 one-acre plots (RCB design). Treatments were: 1) untreated control; 2) fungicide treatment to reduce the activity of the entomopathogenic fungus *Neozygites fresenii*; 3) current practice of applying imidacloprid when aphids were present on $\geq$50% of cotton plants; and 4) Natural Enemy Threshold: natural enemy numbers incorporated into aphid spray thresholds (described below).

The natural enemy threshold treatment utilized a set of decision rules to trigger aphicide use. The rules were dynamic, in that they varied by relative abundance of selected natural enemies. The rules were such that insecticide was to be applied when:

15 aphids were present/leaf if no fungus, parasitoids, or predators; OR 30 aphids were present/leaf if no fungus, 10% aphids mummified, 0.3 coccinellids adults/row foot, 0.2 coccinellid larvae/row foot; OR 50 aphids were present/leaf if 10%visible fungus, no predators or parasitoids; OR 70 aphids were present/leaf if 10% visible fungus, 10% mummified aphids, 0.3 coccinellid adults/row foot, 0.2 coccinellid larvae/row foot. In practice, none of the pre-defined conditions were met during either year of the study. As a result, the "Natural Enemy Threshold" treatment was equivalent to the untreated control.

Weekly fungicide applications were made in selected plots for suppression of *N. fresenii* related fungal epizootics. Three applications of chlorothalonil (1.17 liters/ha) were made on 5, 13, and 21 July 1999. Six applications of azoxystrobin (0.94 liters/ha) were made in 2000 on 26 and 30 June and 6, 12, 19, and 26 July. Five applications of azoxystrobin (0.94 liters/ha) were made in 2001 (27 June and 4, 11, 17, and 26 July).

To assess the efficacy of natural enemies, four types of exclusion cages (no cage, open cage, partial exclusion cage, and total exclusion cage) were placed in each plot. Three cages of each type were placed on individual fruiting branches in each plot (with 20-30 aphids initially in each cage). Cages were examined three times weekly to count aphids and natural enemies. Cages were monitored in two periods in 1999: 30 June to 12 July, and 15 July to 9 August. Cages were monitored continuously in 2000 and 2001: 28 June to 7 August and 21 June to 23 August respectively.

Aphid populations in each treatment were assessed by counting aphids on the first fully-expanded terminal leaf and a mature middle leaf of 20 randomly selected plants per plot. Natural enemies were counted using a 1-meter shake cloth, sampling 24 row feet in each plot. Aphids were collected weekly for diagnosis of infection by *N. fresenii*. Data were analyzed using Proc MIXED (SAS Institute Inc. 1988).

Results

Aphid Populations

Heavy aphid infestations occurred in 1999 and 2000 with population peaks in early July in both years (Tables 1 and 2). Temporal patterns of aphid population increase and decline were similar in all three years. However, peak aphid population densities in 2001 were much lower than in the previous two years (Table 3). Imidacloprid applications (5 July 1999 and 6 July 2000) were effective for aphid suppression in "current practice" treatments. The effect of an imidacloprid application on 11 July 2001 could not be discerned as aphid numbers in all plots declined with the onset of a fungal epizootic. Aphid populations crashed in all treatments in early July in all years as a result of epizootics caused by *N. fresenii*. Aphid population decline coincided with 15% fungus infected aphids in 1999 and 2000, but was delayed in 2001. An epizootic caused a dramatic reduction in aphid numbers in 2001 but only after the incidence of infection had exceeded 50%. Fungicide treatments were not effective at suppressing epizootic development in any year of the study.

Predator Populations

Coccinellid larvae and adults were the most abundant arthropod natural enemies observed each year (Tables 4, 5, and 6). Coccinellid numbers were not affected by treatment but did vary significantly by sample date. Abundance of coccinellids was highest late in the season in 1999. This peak in predator number occurred after aphid populations had declined and coincided with heavy infestations by the silverleaf whitefly. Increases in coccinellid abundance coincided with peak aphid populations in 2000 and 2001. The impact of the predator on the aphids could not be determined because of fungal epizootics caused by *N. fresenii*. Other aphid predators were observed, but not in high numbers. Parasitoids were very rare or absent in all years.

Cage Treatments

Aphid numbers varied among cage type and treatment, but there were no clear patterns of increased aphid density in relation to cage type in any year of the study. The entomopathogenic fungus *N. fresenii* suppressed aphid populations in all cage types in all three years.

Yield and Quality

There were no significant differences in seed cotton yield between any of the treatments in 1999, 2000, or 2001 (Table 7). No impact of cotton aphid feeding on lint quality could be shown in this study. There were no significant differences in lint strength, length, or micronaire that could be correlated to aphid infestations in either year (Tables 8 and 9). Quality data from the 2001 growing season are pending analysis.

Conclusions

In spite of severe early season aphid infestations in 1999 and 2000, no detrimental effect on seed cotton yield or lint quality was seen. Arthropod natural enemy numbers were low in all treatments in both years, possibly a result of severe drought conditions, and there was no clear impact of predators or parasitoids on aphid populations. Coccinellids were more abundant in 2001 studies, but parasitoids remained rare. The fungal pathogen *Neozygites fresenii* was an extremely effective aphid control agent; epizootics caused by this fungus reduced aphid numbers to very low levels in all three years of the study. Imidacloprid applications effectively suppressed aphid infestations but were not economically justified as yields from treated plots were no different than controls. It is possible that fungal epizootics may have masked any potential yield effect from aphicide applications. Aphid population crashes occurred in 2001 only after the level of fungus infected aphids had greatly exceeded 15%. The lower aphid densities in 2001 may help explain this result-- fewer aphids result in decreased fungal inoculum thus requiring higher percent infection to initiate epizootics.

The consistency of fungal epizootic development and the lack of difference in yield or quality between imidacloprid treated and untreated plots indicate that early season insecticide applications targeting aphids should be avoided in Georgia. However, the use of a lower treatment threshold for aphids may provide yield and/or quality benefits. This issue will be addressed in subsequent studies.

Conservation of insect natural enemies is important. Though not present in high numbers for much of this study, predators and parasitoids may play an important role in preventing the recurrence of aphid infestations after fungal epizootics have occurred. Drought in 1999 and 2000 may have been an important factor reducing the number of natural enemies that were observed. Under more typical moisture conditions in 2001 aphid populations did not reach the high levels observed the previous two years, and aphid predator populations were greater. As seen in 1999 and 2000, aphid populations in 2001 never rebounded after the fungal epizootic occurred in July.

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Table 1. Mean aphid numbers in relation to treatment and sample date in 1999. Means presented are the average number of aphids for two leaves combined (one each in the upper and middle third of the plant) per plant per date (n=80 plants per treatment per date).

	Date				
Treatment	**6/23**	**6/30**	**7/8**	**7/20**	**8/3**
Control	9	71	167	8	8
Fungicide	5	69	175	9	7
Current Pract.	3	67	25	12	5
Enemy Threshold*	2	43	179	9	4

* The enemy threshold treatment was treated in the same manner as the control.

† Imidacloprid was applied to "Current Pract" treatments on 5 July.

Table 2. Mean aphid numbers in relation to treatment and sample date in 2000. Means presented are the average number of aphids for two leaves combined (one each in the upper and middle third of the plant) per plant per date (n=80 plants per treatment per date).

	Date				
Treatment	**6/23**	**6/26**	**7/3**	**7/11**	**7/18**
Control	8	13	99	120	9
Fungicide	5	23	86	118	13
Current Pract.	7	19	70	35	7
Enemy Threshold*	22	21	107	131	7

* The enemy threshold treatment was treated in the same manner as the control.

† Imidacloprid was applied to "Current Pract" treatments on 6 July.

Table 3. Mean aphid numbers in relation to treatment and sample date in 2001. Means presented are the average number of aphids for two leaves combined (one each in the upper and middle third of the plant) per plant per date (n=80 plants per treatment per date).

	Date				
Treatment	**6/22**	**6/29**	**7/3**	**7/10**	**7/26**
Control	2	17	33	56	4
Fungicide	1	17	52	49	31
Current Pract.	6	19	48	50	5
Enemy Threshold*	3	12	47	85	5

* The enemy threshold treatment was treated in the same manner as the control.

† Imidacloprid was applied to "Current Pract" treatments on 11 July.

Table 4. Mean coccinellid number per 8 row m in response to treatment and sample date in 1999.

Treatment	Date 6/15	7/4	7/25	8/3	8/10
Control	0.5	0.0	3.5	15.3	1.3
Fungicide	0.3	1.8	3.5	8.0	3.3
Current Pract.	0.5	0.8	4.3	11.5	2.8
Enemy Threshold*	0.3	2.3	8.8	11.8	2.3

* The enemy threshold was treated in the same manner as the control.

Table 5. Mean coccinellid number per 8 row m in response to treatment and sample date in 2000.

Treatment	Date 6/22	7/4	7/11	7/18	8/8
Control	1.0	5.8	31.8	19.3	6.0
Fungicide	1.5	13.3	17.8	29.8	5.0
Current Pract.	0.5	24.5	29.3	20.5	2.8
Enemy Threshold*	1.3	3.0	33.5	32.3	8.5

* The enemy threshold treatment was treated in the same manner as the control.

Table 6. Mean coccinellid number per 8 row m in response to treatment and sample date in 2001.

Treatment	Date 6/21	7/3	7/10	7/17	8/9
Control	5	6	67	51	24
Fungicide	6	12	62	64	17
Current Pract.	4	14	77	26	18
Enemy Threshold*	4	10	88	55	15

* The enemy threshold treatment was treated in the same manner as the control.

Table 7. Seed cotton yield (kg/ha) in response to treatment in 1999, 2000, and 2001. (There were no significant differences between treatments.)

Treatment	1999	2000	2001
Control	2395	2567	2530
Fungicide	2876	2733	2361
Current Pract.	2417	2896	2355
Enemy Threshold*	2313	2764	2515

*The enemy threshold treatment was treated in the same manner as the control.

Table 8. Quality of cotton in response to treatments for cotton aphids: 1999. (There were no significant differences between treatments.)

Treatment	Length	Strength	Micronaire
Control	1.06	27.23	4.60
Fungicide	1.08	28.40	4.50
Current Pract.	1.04	26.65	4.08
Enemy Threshold*	1.08	26.63	4.05

*The enemy threshold treatment was treated in the same manner as the control.

Table 9. Quality of cotton in response to treatments for cotton aphids: 2000. (There were no significant differences between treatments.)

Treatment	Length	Strength	Micronaire
Control	1.06	23.95	5.00
Fungicide	1.07	24.58	5.00
Current Pract.	1.06	24.90	4.95
Enemy Threshold*	1.06	23.55	5.15

* The enemy threshold treatment was treated in the same manner as the control.