INTEGRATING BIOLOGICAL CONTROL WITH SELECTIVE INSECTICIDES FOR ENVIRONMENTALLY SOUND MANAGEMENT OF COTTON APHIDS

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Abstract

The development of cotton aphid resistance to insecticides has brought about a need for a better understanding of the roles played by biological control agents in the cotton agroecosystem. The objectives of this research were to evaluate the interactions of pesticides and natural enemies in suppressing aphid populations. Four treatments were evaluated during the course of this study: (1) weekly application of Provado; (2) weekly application of Bravo; (3) application of Provado when aphid thresholds are exceeded; (4) untreated control. Weekly Provado treatments significantly reduced cotton aphid populations in 1996 and 1997. The entomopathogenic fungus, *Neozygites fresenii*, appeared to greatly reduce aphid population levels during both years as well. No significant differences in yield were observed for either year.

Introduction

The cotton aphid, *Aphis gossypii*, was first reported as a pest of cotton in the mid 1800's (Paddock 1919). More recently, cotton aphids have become a serious pest of cotton throughout the Cotton belt. *A. gossypii* was the most economically important cotton pest during the 1991 growing season (Hardee and Herzog 1992). Early season damage by cotton aphids can result in discoloration, disfigurement, and in severe cases death of the plant. Late season infestations can lead to sticky cotton, a condition in which cotton lint adheres to textile equipment during fiber processing, as well as sooty mold. In addition, there are varying reports concerning the impact of cotton aphids on cotton yield loss. Estimates may range from little or no impact to as much as 243 lbs. of seed per acre.

The cotton aphid's high reproductive rate and rapid developmental time make the development of insecticide resistance a major threat. In recent years cotton aphids have shown increasing resistance to carbamate, organophosphate, and pyrethroid insecticides (Kerns and Gaylor 1991). In addition, the use of in-furrow insecticides at planting has been shown to contribute to resistance (Hardee and O'Brien 1990). The alternative practice of early-season insecticide sprays may enhance the development of resistance even more (Hardee and Ainsworth 1993). In some cases serious outbreaks of secondary pests have occurred following treatment of cotton aphids with organophosphate insecticides. Applications of pyrethroid insecticides to control armyworms have been credited with cotton aphid outbreaks as well (King et al. 1987). Destruction of the cotton aphid's natural enemy complex by pesticides has also been credited with outbreaks of this pest. Hardee and Herzog (1991) have reported that chemical treatments targeted for other cotton pests disturbed and delayed the onset of natural controls for the cotton aphid in Mississippi. In light of this information, it appears that reliance on insecticides for control of the cotton aphid may lead to further resistance and loss of these management tools. The use of parasitoids, predators, and pathogens may become a major component in the management of this pest.

A number of aphid predators and parasites occur in cotton and function more effectively in a reduced-insecticide system. One of the most effective natural enemies of the cotton aphid is the entomopathogenic fungus, *Neozygites fresenii* (Nowakowski). *N. fresenii* was first reported from aphids in cotton in Arkansas (Steinkraus et al. 1991).

Fungicides and pesticides have been reported to disrupt the effectiveness of entomopathogenic fungi (Glare and Milner 1991). The application of carboxin, a carbamate, at planting has been shown to reduce *N. fresenii* prevalence in *A. gossypii* (Smith and Hardee 1996). Etridiazole and metalaxyl have been shown to reduce *N. fresenii* prevalence in *A. gossypii* during the early season as well (Smith and Hardee 1996). Fungicides don't appear to significantly affect *N. fresenii* infection of *A. gossypii* during the late season. This result is most likely due to the degradation or inactivation of fungicides before the late season. Adverse effects of fungicides on *N. fresenii* have been reported to exist in fields where cotton has been planted repeatedly for several years and when high early season aphid population levels are followed by high late season aphid population levels. These two conditions should be considered the times that biological control is most needed by the grower (Smith and Hardee 1996). Due to the complex interactions between *A. gossypii*, *N. fresenii*, and pesticides, further studies are required to devise methods of control that will conserve and utilize the natural controlling agent, while at the same time effectively manage the pest.

Another important biological control agent of cotton aphids is its parasitoid complex. Braconid parasitoids of the subfamily Aphidiinae appear to be the most promising for use in cotton aphid biological control programs. Members of this complex include *Aphidius colemani* Viereck, *Aphidius matricariae* Haliday, *Ephedrus cerasicola* Stary, and *Lysiphlebus testaceipes* Cresson (Van Steenis 1992). This parasitoid has been reported to persist in areas where insecticides have been applied, making it a potentially valuable component in integrated pest management systems for cotton aphids (Kerns and Gaylor 1993). With the

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exception of *L. testaceipes*, very few of these parasitoids have been involved in in-depth studies with cotton aphids and little is known of their relationships with this pest.

The complexities of biological control systems are poorly understood. The development of aphid resistance to many insecticides makes the understanding of the roles played by biological control agents an important factor. More work is needed to determine the relationships between cotton aphids and their natural enemies in order to more effectively utilize these beneficial insects. The objectives of this research were to evaluate the interaction of insecticides and natural enemies in suppressing cotton aphid populations.

Materials and Methods

Field work was conducted at the University of Georgia Coastal Plain Experiment Station in Tifton, Georgia throughout the 1996 and 1997 growing season. Eight replications of four treatments were arranged in a Latin Square design and applied to 0.25 acre cotton plots. The treatments evaluated were: (1) untreated control, (2) foliar application of a systemic insecticide (Provado) when accepted thresholds of aphid numbers were exceeded, (3) foliar application of a fungicide (Bravo) to eliminate activity of the entomopathogenic fungi, *Neozygites fresenii*, and (4) foliar application of a systemic insecticide (Provado) to exclude aphid populations.

Aphid populations were monitored in each plot throughout the growing season by sampling individual plants. Ten plants in each plot were marked with a stake and two leaves from each plant (one from the crown of the plant and one towards the base of the plant) were marked and sampled in the field. Healthy, diseased, and parasitized aphids were counted on each of these leaves weekly. Aphids parasitized by parasitoid wasps have a milky brown color and are termed "mummies". The relative abundance of aphids (healthy, diseased, and parasitized) and predators were compared among the treatments. This information was then related to final yield for each treatment. The relationship between the treatments and activity of the aphids' natural enemy complex were evaluated as well to assess the impact of the various treatments on overall natural enemy performance. Data was analyzed using Analysis of Variance and Duncan's multiple range test.

Results and Discussion

1996 Experiment

A significant difference ($F=24.12$; $df=3$; $p<0.05$) was observed for numbers of aphids between treatments. Aphid numbers were highest in the Bravo treatment, followed by the control and Provado as needed treatments. The weekly Provado treatment appeared to significantly reduce aphid numbers (Table 1). These are the results that we expected to find during the course of this study.

A significant difference was observed for numbers of mummies between treatments ($F=12.72$; $df=3$; $p<0.05$). The weekly Provado treatment appeared to significantly reduce aphid mummy numbers (Table 1). This result was most likely due to low aphid numbers observed in this treatment.

A significant difference ($F=3.84$; $df=3$; $p<0.05$) was observed with respect to numbers of fungus-killed aphids between treatments. Fungus-killed aphids were significantly lower in the weekly Provado treatment (Table 1). This result is most likely due to low aphid numbers in this treatment as well. Aphid numbers appeared to decline after populations of *N. fresenii* peaked (Figure 1 and Figure 2).

1997 Experiment

A significant difference ($F=13.25$; $df=3$; $p=0.0012$) was observed for numbers of aphids between treatments. Aphid numbers were highest in the Bravo treatment followed by the Provado as needed and control treatments. The weekly Provado treatment appeared to significantly reduce aphid numbers (Table 2). These are the results that we expected to find during the course of this study. Aphid populations exhibited a bimodal distribution in each of the treatments, with populations peaking on 28 July and 2 September (Figure 3).

No significant ($F=3.28$; $df=3$; $p=0.727$) differences were observed for numbers of mummies between treatments. These results were most likely due to the small numbers of mummies observed in the field. Mummies were most abundant in the Bravo treatment (Table 2).

The entomopathogenic fungus, *Neozygites fresenii*, was not significantly ($F=1.28$; $df=3$; $p=0.3393$) more abundant in any one of the treatments over the others. These results may be due to the small numbers of *N. fresenii* observed in the field as well. *N. fresenii* was most abundant in the Provado as needed treatment (Table 2). The Bravo treatment did not appear to control the *N. fresenii* population as we had expected.

The low *N. fresenii* population levels observed in the weekly Provado treatment was most likely due to the low aphid population levels in that treatment. *N. fresenii* requires a high host level population before it can become established (Steinkraus et al. 1991). This phenomenon can be observed in the seasonal distribution data. *N. fresenii* population levels appear to peak just after aphid population levels peak in each treatment (Figure 3 and Figure 4).

An understanding of the entomopathogenic fungus, *Neozygites fresenii*, is essential to the management of cotton aphids in Georgia. This would include an understanding of the effects of cotton management practices on this fungus. None of the pesticides used in this study appeared to significantly effect *N. fresenii* populations. However, with the history of the effects of certain chemicals on this fungus, careful consideration should be used in the selection of pesticides when necessary.

No significant differences were observed with respect to yield (Table 1 and Table 2). Even the frequent application of an insecticide, Provado, which significantly reduced aphid population levels, failed to produce a higher yield than the control treatments. This would seem to indicate that aphid populations never reached a level that would have a harmful effect on production. The presence of the entomopathogenic fungus is most likely responsible for keeping these aphid populations in check.

The information gathered during the course of this study allows us to conclude that growers in areas where the fungus is present can rely on the entomopathogenic fungus, *Neozygites fresenii,* to control aphid populations rather than relying on insecticide sprays. This would allow us to suggest that insecticide applications for cotton aphid control only be used in cases where aphid levels are excessively high, in which case the fungus is may not be present.

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Table 1. Treatment means for cotton aphids, mummies, fungus-killed aphids per ten plants, and yield: 1996.

Treatment	Aphids	Mummies	*N. fresenii*	Yield
Provado (weekly)	7.85*	0.26*	0.14*	18.20
Bravo	136.07	3.98	1.61	15.43
Provado (as needed)	59.26	1.45	2.65	16.40
Control	100.07	2.29	2.00	14.93

* denotes significant difference

Table 2. Treatment means for cotton aphids, mummies, fungus-killed aphids per ten plants, and yield: 1997.

Treatment	Aphids	Mummies	*N. fresenii*	Yield
Provado (weekly)	46.92*	0.11	0.35	9.84
Bravo	126.54	1.65	1.89	17.70
Provado (as needed)	90.49	0.75	3.15	17.73
Control	71.86	0.79	1.83	19.81

* denotes significant difference

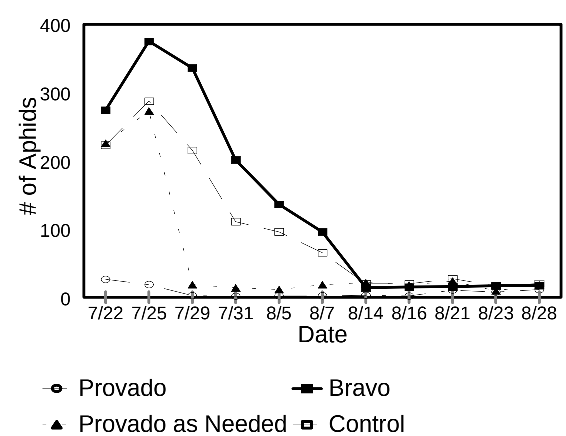

Figure 1. Seasonal Distribution of cotton aphids per 10 plants for each treatment: 1996.

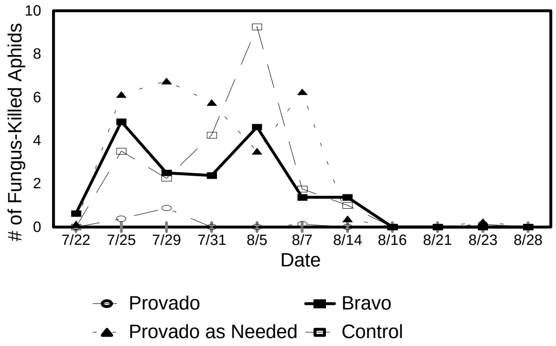

Figure 2. Seasonal distribution of aphids killed by *N. fresenii* per 10 plants for each treatment: 1996.

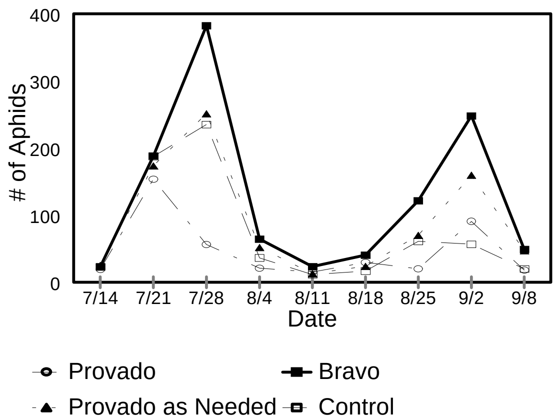

Figure 3. Seasonal distribution of cotton aphids per 10 plants for each treatment: 1997.

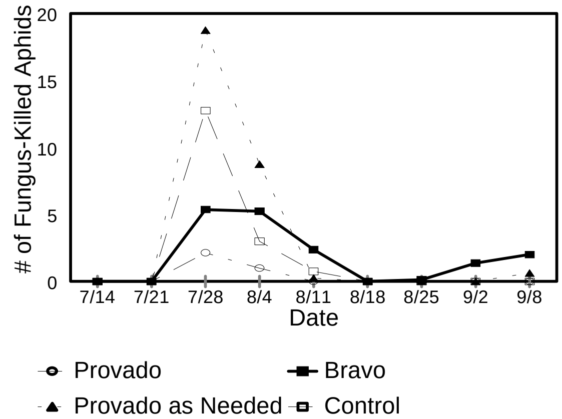

Figure 4. Seasonal distribution of aphids killed by *N. fresenii* per 10 plants for each treatment: 1997.