Chemical Control of Aphid Populations in Cotton Using Hydraulic and Electrostatic Sprayers and Aphid Alarm Pheromone

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ABSTRACT

In experimental cotton fields in Lianoverghi, Imathia, Greece in 1995 (cultivar Zeta-2) and Velestino, Magnesia in 1996 (cultivar Corina), experiments comparisons were made between different application methods for chemical control of aphids. There were five treatments in a randomized complete block design in four replications. The treatments were: control, cyhalothrin sprayed with hydraulic or electrostatic sprayer and cyhalothrin with pheromone sprayed with hydraulic or electrostatic sprayer. Observations of the presence of aphids were taken 1-2 days before and 7-8 and 20 days after the applications. The predominant aphid species in both regions was Aphis gossypii Glover. The electrostatic sprayer was more effective than the hydraulic. The presence of the pheromone did not change the efficiency of the insecticide with either method. Both methods were less effective when aphid populations were high. Aphid populations were high in untreated plots 7 days after spraying, but later declined below populations in the treated plots, possibly because of the activity of natural enemies. The electrostatic sprayer was less efficient than the hydraulic when aphid populations were very high and full grown plants formed a continuous canopy.

Introduction

The widespread use of insecticides has led to increased pest resistance and caused adverse effects in the environment, yet only 20% or less of the active ingredients reach the target (Arnold and Pye, 1980). The problems arising from the use of insecticides have concentrated efforts to find alternative strategies and methods in pest control that are both effective and more benign environmentally.

Electrostatic spray charging techniques and semiochemicals have been used in integrated pest management, including aphid control. The electrostatic sprayer (Arnold and Pye 1980; Coffee 1979; 1980) uses lower volume in pesticide applications, produces small charged drops and directs them to the target. (*E*)-*β*-farnesene is the alarm pheromone of many aphid species including *Myzus persicae* (Sulzer) (Edwards *et al.,* 1973), *Phorodon humuli* (Shrank) (Pickett and Griffiths, 1980) and *Lypaphis erysimi* (Kaltenbach) (Rothamsted report, 1983). When the pheromone is released from aphids attacked by predators or parasitoids it causes dispersal of other individuals feeding nearby (Nault *et al.,* 1973). (*E*)-*β*-farnesene can enhance the effectiveness of contact pesticides presumably by stimulating aphid mobility (Griffiths and Pickett, 1980). However, laboratory observations on A. gossypii had not indicated such a role (Pye, unpublished data).

The present study aimed at comparing the efficiency of electrostatic and hydraulic spray application when used in conjunction with the aphid alarm pheromone on the chemical control of cotton aphids.

Materials and Methods

In experimental cotton fields in Lianoverghi, Imathia, Greece in 1995 (cultivar Zeta-2) and Velestino, Magnesia in 1996 (cultivar Corina), experiments were carried out to compare different methods of chemical control of aphids. Five treatments were set up in a randomized complete plot design in 4 replications. The plot size was 4 rows of 5m long, with a plant spacing of 1m between the rows and 10 cm within the row (Figure 1). Plots were spaced 2m apart.

The treatments were: control, lambda cyhalothrin (Karate) and lambda cyhalothrin with aphid alarm pheromone ((E)-*β*-farnesene) sprayed with a hydraulic or an electrostatic (APE 80, Arnold and Pye, 1980) sprayer. In 1995 one spray application was performed on 23 June. In 1996 two spray applications were performed on 16 July and 14 August. The pyrethroid lambda cyhalothrin was used at 50ml EC/1000 m^2. Application volumes were 5.2 lt. for the hydraulic and 108 ml for the electrostatic sprayer. (E)-*β*-farnesene was used at 0.1mg/m^2.

Aphid populations were recorded 3 times: 1-2 days before the application, 7-8 days and 16-20 days after the application. In each case, the live aphids of the 4 upper leaves of twenty plants were counted. The plants were randomly selected from the 2 central rows of each plot. The data were square root transformed and subjected to a two-way analysis of variance (Mead, 1989).

Results and Discussion

In both years the predominant aphid species on cotton was *A. gossypii*. In the 1995 experiment, there were fewer aphids 8 days after the application in the treated plots than in the control, although a there was high variability amongst the control plots and the number of aphids did not appear to differ significantly from the treatments. With the electrostatic sprayer, the number of aphids was lower than in the other treatments. The presence of the pheromone did not appear to have any effect in the efficiency of insecticide with either method of application. This is in line with results obtained in Rothamsted (Pye, unpublished data), where *A. gossypii* did not respond with alarm to the effect of the pheromone. This was also observed in lab tests with aphids collected from the field test areas in the present study. Twenty days after the application, the number of aphids in the control was lower than after 8 days, possibly indicating an increased activity of natural enemies. Similar results were obtained in the treatment with the hydraulic sprayer. With the electrostatic sprayer, however, the number of aphids was higher than in the control or with the hydraulic sprayer, presumably due to the higher efficiency of the application of the electrostatic sprayer, wit possible adverse effects on beneficial insects (Table 1).

In the first application in 1996 the results were similar to those of the previous year. Aphid numbers, 7 days after the application, in the plots treated with the electrostatic sprayer (with or without pheromone) were significantly lower than the control. There was no significant difference when compared to the hydraulic sprayer. The highest number of aphids was, however, observed in the control. Twenty days after the treatment the lowest number of aphids was in the control, then there were significant differences from the numbers in the treatments with the hydraulic sprayer. Aphid numbers in treatments with the electrostatic sprayer were high. differing statistically from the other treatments. The presence of pheromone did not affect the insecticide efficiency on either of the observation dates (Table 2). In the second application in 1996 aphid populations recorded before the application were low in the control and higher in the hydraulic treatment although there were no significant differences between them. In the electrostatic treatment, however, numbers were significantly higher than in the other treatments. Generally, numbers in the control varied little with time. There was an initial increase after the treatment with the hydraulic sprayer with numbers not differing subsequently. Numbers of aphids were much higher with the electrostatic sprayer seven days after spraying and remained high (Table 3).

The results in the second year showed that the efficiency of the insecticide was not high, although the electrostatic sprayer was more efficient than the hydraulic sprayer. Later in the season when plants grew and there was a continuous canopy, electrostatic spraying was not effective compared to the efficiency of the method in younger plants standing separate in the field.

Conclusions

The results of this study suggest that the insecticides used only controlled aphid populations for a short period. The electrostatic sprayer is more effective in chemical control of aphids than the hydraulic one before plants are grown forming a continuous canopy. The alarm pheromone does not affect insecticide efficiency in the cotton aphid. However, the natural enemies seem to be adversely affected by the insecticides as in the non efficient electrostatically sprayed plots, the aphid populations became high. Adverse effects of insecticides on natural enemies are more intense with the electrostatic sprayer due to better coverage of the plant by the chemical.

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Table 1. Mean number of aphids per plant in three observations before and after the spraying with lamda cyalothrin at Lianoverghi in 1995 (Numbers in parenthesis denote standard deviation).

Treatment	Days from application		
	2 before	8 after	20 after
Control	1.2 (0.28) a[1]	7.5 (7.3) a[2]	2.5 (2.1) b[3]
Hydraulic	1.4 (0.75) a	1.6 (0.9) ab	3.3 (2.2) b
Hydraulic + Pheromone	1.3 (0.38) a	1.3 (1.0) ab	5.0 (2.3) b
Electrostatic	1.1 (1.22) a	0.4 (0.4) b	28.5 (23.4) a
Electrostatic + Pheromone	1.5 (0.63) a	2.8 (4.3) ab	11.9 (7.96) ab

Means within columns followed by different letters are significantly different using LSD test ($p<0.05$).
[1]df: 4,12 F=0.1, CV=30.9%, MSError=2.28,
[2]df: 4,12 F=1.71, MSError=20.51, CV=78.1%,
[3]df: 7,12 F=4.87, MSError=33.3, CV=47.5%.

Table 2. Mean number of aphids per plant in three observations before and after the spraying with lambda cyalothrin at Velestino in 16/7/1996 (Numbers in parenthesis denote standard deviation).

Treatment	Days from application		
	1 before	7 after	20 after
Control	1.9 (1.2) a[1]	80.5 (52.4) a[2]	10.7 (6.1)c[3]
Hydraulic	2.2 (1.4) a	44.6 (11.8) ab	63.3 (42.1) b
Hydraulic + Pheromone	1.4 (0.6) a	44.0 (17.7) ab	41.9 (21.1) bc
Electrostatic	1.7 (0.7) a	12.4 (9.4) c	376.1 (79.0) a
Electrostatic + Pheromone	1.5 (0.5) a	18.7 (4.2) bc	464.1 (191.0) a

Means within columns followed by different letters are significantly different using LSD test ($p<0.05$).
[1]df: 4,12 F=0,4, CV=25.7%, MSError=2.190,
[2]df: 4.12 F=6.58, MSError=52.97,CV=27.7%
[3]df: 7,12 F=64.76, MSError=82.65, CV=17.7%.

Table 3. Mean number of aphids per plant in three observations before and after the spraying with lambda cyalothrin in Velestino in 14/8/1996 (Numbers in parenthesis denote standard deviation).

Treatment	Days from application		
	1 before	7 after	16 after
Control	2.1 (1.5) c[1]	3.6 (0.8) c[2]	5.6 (1.9) b[3]
Hydraulic	5.9 (4.9) c	16.4 (10.8) c	15.5 (7.8) b
Hydraulic + Pheromone	5.2 (3.8) c	12.9 (11.5) c	11.1 (5.1) b

Electrostatic	368.4 (32.0) b	1462.9 (460) b	1283.2 (444.2) a
Electrostatic + Pheromone	630.9 (166.8)a	2015.5 (421.9) a	1526.9 (445.2) a

Means within columns followed by different letters are significantly different by LSD test ($p<0.05$).
[1]df: 4,12 F=176.13, CV=16.9%, MSError=57.09,
[2]df: 4,12 F=152.84, MSError=233.6, CV=18.64%,
[3]df: 7,12 F=154.52, MSError=180.12, CV=17.9%.

Figure 1. Design of the experimental field. Control (A), cyhalothrin sprayed with hydraulic sprayer (B), electrostatic sprayer (D), and lambda cyhalothrin with pheromone sprayed with hydraulic sprayer (C) and electrostatic sprayer (E).