EFFECTS OF DEFOLIANTS ALONE AND IN COMBINATION WITH INSECTICIDES ON BOLL WEEVIL AND WHITEFLIES IN COTTON: C. EFFECTS ON SILVERLEAF WHITEFLY

Tong-Xian Liu, A. N. Sparks, Jr. and Ge-Mei Liang
Texas Agricultural Research and Extension Center
Texas A&M University
Weslaco, TX
S. M. Greenberg
Integrated Farming & Natural Resources Research Unit
USDA-ARS
Weslaco, TX

Abstract

Application of Def for defoliation of cotton in the field had little effects on the eggs, second and older instar nymphs of silverleaf whitefly, *Bemisia argentifolii* Bellows & Perring. However, application of Def significant reduced the survival rate (30%) of first instar nymphs compared with untreated control (70%). Def, in combination with two insecticides, Karate (a pyrethroid) and Guthion (an organophosphate) also decreased the survival rates of first, second and third instar nymphs. Almost all chemical treatments did not significantly affect the survival rate of fourth instar nymphs and pupae compared with untreated control. Although numbers of *B. argentifolii* adults caught on yellow sticky cards varied greatly among treatments on different dates, the differences were generally not significant. However, numbers of parasitoids, *Eretmocerus* spp. and *Encarsia* spp., caught on yellow sticky cards were significantly fewer in the plots treated with Def, Def+Guthion and Def+Karate and in untreated control than those in the plots treated with Karate and Guthion alone.

Introduction

Silverleaf whitefly, *Bemisia argentifolii* Bellows & Perring, formerly known as sweetpotato whitefly, *Bemisia tabaci* (Gennadius), is one of the most important pests of cotton, vegetables and other crops in the Unites States. The whitefly became a major pest in Texas and other southern states in 1990. This species is a well-known pest in many other parts of the world, causing damage through direct feeding and honeydew deposition, and as a vector of viral plant diseases. Direct crop damage caused by the whitefly was estimated >$500 million in 1992-1993 in the U.S.(Perring et al. 1993), and the losses caused by the whitefly in south Texas in 1991 was estimated at $24 million and $29 million on cotton and vegetables, respectively (Riley and Sparks 1993). In cotton, damage ranges from honeydew deposits on open cotton lint on which black sooty mold (fungus) grow, to reduced plant vigor and premature defoliation. Experience in the Lower Rio Grande Valley has shown that in the heaviest infestations yield reductions can be severe with losses of more than 500 pounds of lint per acre (Riley and Sparks 1993).

Cotton is generally considered as a source of whiteflies and therefore a liability for nearby vegetables in south Texas (Legaspi et al. 1997). However, cotton or other crops could serve as sources of natural enemies or as whitefly sinks, given the right timing and circumstances. The spring-summer cotton and fall-winter-spring vegetable cropping system in south Texas is unique, and this sequencing of crop production allows whiteflies to thrive year-round, and the overlap of production seasons allows for easy transition from one crop to the next. The most rapid increases in whitefly density generally occur in cotton which is grown during the hottest and driest months.

Application of defoliants has been an important component of cotton production in the US (Chu 1992). During the cotton defoliation season, whiteflies take off from the defoliated leaves where they were feeding and emerging, and migrate to nearby field crops or weeds. Enormous numbers of whiteflies have been found on all "green" wide-leaf plants, including summer-fall vegetables and many species of weeds, after cotton defoliation . At that time, whiteflies can also be seen on vehicles, farming machinery, people, and in the open air. It is not unusual to find that the leaves of some small plants are totally covered by whitefly adults. In addition, some older nymphs on defoliated cotton leaves are able to continue their development to adults that will migrate to new hosts. Similarly, parasitoids and predators of whiteflies and other insects have to migrate or disperse to nearby environment for new hosts or prey. Some endoparasitoids (i.e. *Eretmocerus* spp. and *Encarsia* spp.) of whitefly in the hosts on defoliated leaves gradually mature and emerge, then disperse to new environment for hosts, and others die before emergence.

A few studies have addressed the effects of cotton defoliants on cotton pest insects, particularly whiteflies, and natural enemies. Moghaddam et al. (1993) found that after applications of Dropp (thidiazuron) or a combination of Dropp with Def (S,S,S-tributylphosphorotrithioate), number of *B. tabaci* (Gennadius) decreased, and no whiteflies were found on cotton leaves 21 d after application. Greenberg et al. (2000) reported that Def and Dropp, the two most commonly used defoliants used in south Texas, have significant lethal and sublethal effects on whiteflies and parasitoids, *Eretmocerus eremicus* Rose & Zolnerowich in the laboratory and greenhouse tests. Over 85% of eggs, 67-70% of young nymphs and 21-30% of old nymphs and 94-97% of adult whiteflies were killed by Def, Dropp or Def+Dropp in the laboratory tests, whereas the mortalities were lower in the greenhouse tests. However, the effects of these defoliants did not significantly reduce female progeny and longevity of *E. eremicus* if they parasitized old whitefly nymphs. Deryabin (1986) found that some cotton defoliants, magnesium chlorate or calcium chloride-chlorate, substantially reduced population of spider mites and aphids, as well as their natural enemies, including *coccinellids, Orius, Stethorus*, larvae of *Chrysoperla carnea* and other predators by 24 and 34%, respectively.

Although defoliants are used in every season in south Texas, the role of these defoliants on *B. argentifolii* and their natural enemies are unknown. The objective of this study was to determine the effects of defoliants and defoliant-insecticide combinations on survival, migration and dispersal of *B. argentifolii* and their parasitoids after cotton plants were defoliated.

Materials and Methods

Cotton Field and Experimental Design

Detailed information on the cotton field and experimental design has been described in Greenberg et al. (2001).

Chemicals and Rates

Defoliant, Def 6 (S,S,S-tributylphosphorotrithioate, Bayer, Kansas City, MO); two insecticides, a pyrethroid, Karate 2.08CS (lambda-cyhalothrin, Zeneca, Wilmington, DE), and a organophosphate, Guthion 2L (azinphosmethyl, Bayer, Kansas City, MO), were used in this study. Field rates for all chemicals were: full rate of Def at (2 pts/ac), full rate of Dropp at (0.2 lb/ac), full rate of Karate at (0.03 lb [AI]/ac), half rate of Guthion (0.25 lb [AI]/ac), full rate of Def + full rate of Karate, full rate of Def + half rate of Guthion. Untreated plots were used as controls. Each plot was 6 rows of cotton and 45 m long. Each treatments had three replications. Defoliant and insecticides were applied on 25 July 2000.

Effects of Defoliant Alone and in Combination with Insecticides on *B. argentifolii* Immatures

Test 1: Field Counts. A fifth leaf from the terminal of each of 5 plants per plot were randomly selected, and numbers of large nymphs (third and fourth instar nymphs and pupae) were counted on 26, 28 and 31 July; 1, 3 and 6 days after chemical application.

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Test 2: Laboratory Examination - Survival of Immatures. Cotton leaves, the fifth from the terminal of each of 10 plants per plot, were randomly collected on 26 July, 1 day after the application of chemicals. The leaves were brought to the laboratory. Twenty living individuals of each developmental stage (egg, first, second, third and fourth instar, and pupae) from different leaves from each treatment were marked with an ink pen. Each leaf was then inserted with petiole down into a plastic vial with water. The immatures were checked daily for survival until they developed to the next stage or died.

Test 3: Laboratory Examination - Whitefly Adult and Parasitoid Adult Emergence. To test the effect of applied chemicals on adult emergence for *B. argentifolii*, the third, fifth and seventh leaf from the terminal was collected on 26, 28 and 31 July; 1, 3 and 6 days after chemical applications. The 10 leaves of each age from each plot were placed in paper bags and held in the laboratory for 3 weeks. Number of adults emerged from each bag was examined.

In addition, on the leaves for whitefly adult emergence as described above, parasitized nymphs (n=1-71) were marked. The leaves were held in paper boxes for 3 weeks, and emerged parasitoids (*Eretmocerus* spp. and *Encarsia* spp.) were checked.

Effects of Defoliant Alone and in Combination with Insecticides on *B. argentifolii* Adults and Parasitoids

Yellow sticky cards (2 x 4 in) were used to trap whiteflies, parasitoids and other insects. Yellow cards were placed at canopy level of the cotton plants on a wooden stick (70-90 cm high). Three cards were placed in the middle row of each plot, about 8 m apart. The cards were replaced in the field one day before the chemical application. The cards were collected and replaced with new ones at 1-3 d intervals after the chemical applications. All arthropods trapped on the cards were identified and counted in the laboratory.

Data Analysis

Numbers of *B. argentifolii* adults on yellow sticky cards, emerged from treated leaves, nymphs on treated leaves, survival rates of immatures, and numbers of parasitoids caught on yellow cards, emerged on treated leaves, were analyzed using analysis of variance, and means were separated using the least significant different test (SAS Institute 1996).

Results and Discussion

Effects of Defoliant Alone and in Combination with Insecticides on *B. argentifolii* Immatures

Test 1: Field Counts. Numbers of large nymphs on cotton leaves counted in the field are shown in Table 1. Numbers of large nymphs on leaves were not significantly different on 26 July, 1 day after treatment. However, significant differences were found on 28 and 31 July, 3 and 6 days after treatment. On 28 July, more large nymphs were found on the leaves in untreated and Def+Guthion plots than in other plots. On 31 July, again, more large nymphs were found on the leaves from untreated plot than all other plots. This result indicates that Def, Def+Karate, Karate, and Guthion, as well Def+Guthion (in the later date) did reduce populations of *B. argentifolii* nymphs in the field.

Test 2: Laboratory Examination - Survival of Immatures. As shown in Table 2, Def alone and in combination with insecticides did significantly affect the survival rates of young nymphs but not eggs, older nymphs and pupae (Table 2). Significant lower survival rates of first instar nymphs (13.3-30.0%) were found in the treatment of defoliant alone and in combination with insecticides compared with 70% survival rate in untreated control. Generally, the cotton leaves treated with Def alone had higher survival rates in all immatures stages of *B. argentifolii* than those treated with combinations of Def+insecticides, especially in Def+Guthion. Karate and Guthion alone did not have significant effects on *B. argentifolii*, although lower survival rates were found. However, we do not know if Guthion and Karate, in combination with Def, added any synergistic effects on *B. argentifolii* to Def.

Test 3: Laboratory Examination - Whitefly Adult and Parasitoid Adult Emergence. Table 3 shows numbers of B. argentifolii adults emerged from leaves at 1, 3 and 6 days after treatment. Although numbers of adults emerged varied greatly among the treatments on different leaves on the three different sampling dates, no treatments gave consistent effects on adult emergence.

The percentage of parasitoid adults emerged varied from 23.2% on Guthion-treated leaves to 47.5% on Def+Karate-treated leaves, and no significant difference among all treatments (Table 4).

Def used as a synergist in combination with insecticides has been reported by Horowitz et al. (1988). They found that Def in combination with two pyrethroids, cypermethrin and permethrin, had high toxicity to *B. tabaci* in both laboratory and field tests. In field test, 99.2% mortality of *B. tabaci* was obtained with a single application of Def+cypermethrin, whereas Def alone only gave 77-81% mortality.

Effects of Defoliant Alone and in Combination with Insecticides on *B. argentifolii* Adults and Parasitoids

Although numbers of *B. argentifolii* adults caught on yellow sticky cards varied greatly from date to date among the treatments (Figure 1), there was no clear picture showing significant effects among the treatments. Generally, more whitefly adults were caught on yellow sticky cards in the plots treated with Karate and Guthion, and slightly fewer in the plots treated with Def and untreated control. It appeared that fewer whitefly adults took off and flew in the untreated plots because the plants were green, and abundant young and nutritious leaves were available. However, we do not know exactly why fewer whitefly adults were caught in the plots treated with Def or Def+insecticide.

Numbers of parasitoids, *Eretmocerus* spp. and *Encarsia* spp., caught on the yellow sticky cards are shown in Figure 2. Generally, among the treatments, yellow sticky cards placed in Def-treated plots caught similar numbers of parasitoids to those in untreated plots, but had significantly fewer parasitoids than other chemical-treated plots. Numbers of parasitoids caught on yellow sticky cards placed in the Karate-treated plots was the greatest, followed by those placed in Guthion and Def+Karate-treated plots.

Results from this study indicate that Karate had the least effect of the treatments tested on the parasitoids. Although the yellow sticky cards in Guthion-treated plots caught fewer parasitoids than those in Karate-treated plots, the effects might not be directly related to Karate and Guthion themselves. Whereas we do not know the reason why the yellow sticky cards caught similar numbers of parasitoids in untreated and Def-treated plots, possible explanations might be that in the Def-treated plots, application of Def might affect the emergence or migration of parasitoids, whereas in untreated plots, parasitoids might not likely fly high or disperse with the presence of hosts (live whitefly nymphs), and therefore, fewer were caught on the yellow sticky cards. Because Karate and Guthion had no effects on leaf defoliation, we do not know why more parasitoids were caught on the yellow sticky cards. Perhaps, the odors or other chemical cues stimulated the parasitoids to take off, fly high and be caught.

Other Arthropods Caught on Yellow Sticky Cards

Many species of insects and spiders were caught on the yellow sticky cards (Table 5). Most of these insects have been identified to family, and some were identified to genus or species. The unidentified species will be identified later Numbers and species of insects and spiders caught on were not significantly different among the treatments.

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Table 1. *Bemisia argentifolii* large nymphs (3rd and 4th instars) directly counted from the 5th leaf from the terminal of a cotton plant (n = 5) after application of defoliant and insecticides on cotton (July 2000, Weslaco, TX).

	No. large nymphs per leaf*		
	26 July	**28 July**	**31 July**
D**	4.20	0.40b	0.07b
D+K	1.20	1.53b	0.00b
D+G	1.47	3.13a	0.40b
G	1.07	0.67b	0.47b
K	2.07	0.47b	0.67b
CK	3.33	3.07a	4.20a

*Means in the same column with the same letters are not significantly different at $P = 0.05$ (DMRT, SAS Institute 1996)
**D-Def, K-Karate, G-Guthion, CK-Control.

Table 2. Survival rates of *Bemisia argentifolii* immatures after application of defoliant and insecticides on cotton (July 2000, Weslaco, TX)

	Survival rate (%)*					
Treatment	**Egg**	**1st instar**	**2nd instar**	**3rd instar**	**4th instar**	**Pupa**
D**	53.0a	30.0b	52.7a	44.5a	55.2a	71.3a
D+G	46.6a	13.3b	16.7c	32.2a	43.8a	55.8 b
D+K	33.3b	19.1b	37.6b	13.3b	26.9b	56.7 b
G	36.7b	20.0b	40.0a	36.7a	60.0a	43.3 b
K	54.1a	32.1b	44.4a	51.9a	41.9a	70.7a
CK	60.0a	70.0a	60.0a	50.0a	60.0a	70.0a

*Means in the same column with the same letters are not significantly different at $P = 0.05$ (DMRT, SAS Institute 1996).
**D-Def, K-Karate, G-Guthion, CK-Control.

Table 3. *Bemisia argentifolii* adults emerged from the 3rd, 5th and 7th leaves from each cotton plant (n = 10) after application of defoliant and insecticides on cotton (July 2000, Weslaco, TX).

	26 July*			28 July			31 July		
	3rd	**5th**	**7th**	**3rd**	**5th**	**7th**	**3rd**	**5th**	**7th**
D**	0.3b	4.7	2.7	1.0b	4.3	5.7b	0.0	1.3bc	-
D+K	0.3b	4.7	4.3	0.3b	3.7	14.7a	0.0	0.0c	7.0
D+G	2.7ab	2.0	3.3	0.7b	7.3	4.7b	0.0	1.0bc	6.5
G	2.7ab	5.3	6.0	0.3b	3.0	2.3b	0.7	1.3bc	3.0
K	6.0a	10.3	12.7	0.7b	8.0	17.0a	1.0	3.0b	6.3
CK	3.0ab	13.0	5.7	3.0a	4.3	4.0b	1.0	11.0a	4.3

**Means in the same column with the same letters are not significantly different at $P = 0.05$ (DMRT, SAS Institute 1996).
**D-Def, K-Karate, G-Guthion, CK-Control.

Table 4. Percentages of parasitoids emerged from treated leaves.

	No. parasitized	No. emerged	% emerged*
D**	41	14	33.7a
D+K	83	44	47.5a
D+G	55	18	40.0a
G	26	8	23.2a
K	40	18	41.0a
CK	8	3	37.5a

*Means in the same column with the same letters are not significantly different at $P = 0.05$ (DMRT, SAS Institute 1996).
**D-Def, K-Karate, G-Guthion, CK-Control.

Table 5. List of insects and spiders caught on yellow cards in cotton field from 23 July to 11 August, 2000 (Weslaco, TX).

Order and Family	No. of species
Araneida (Spiders)	3
Coleoptera	
Chrysomelidae	3
Coccinellidae	1
Curculionidae	2
Elateridae	1
Malachiidae	1
Diptera	
Chironomidae	1
Tabanidae	1
Hemiptera	
Anthocoridae	2
Coridae	1
Geocoridae	1
Miridae	2
Piesmatidae	1
Reduviidae	2
Homoptera	
Aphididae	2
Cicadae	1
Cicadellidae	4
Psyllidae	2
Tingidae	2
Hymenoptera	
Anthophoridae	1
Aphelinidae	6
Braconidae	2
Trichogrammatidae	2
Lepidoptera	
Geometridae	1
Hesperiidae	1
Neuroptera	
Chrysopidae	1
Thysanoptera	
Phleoethripidae	1
Thripidae	2

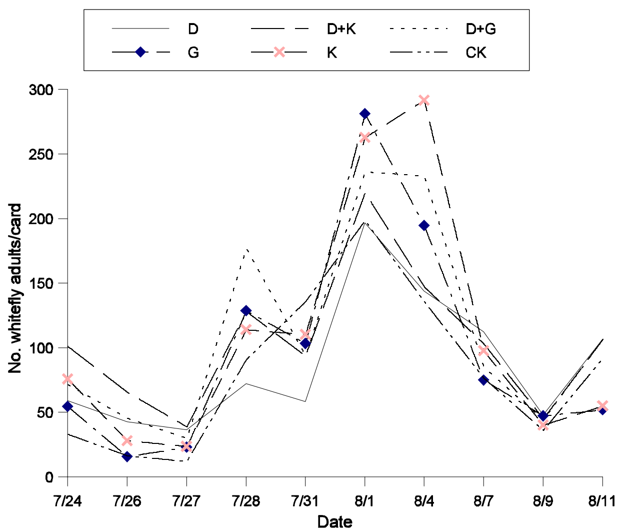

Figure 1. Numbers of *Bemisia argentifolii* adults trapped on yellow sticky cards after applications of defoliant and in combination with insecticides. D-Def, K-Karate, G-Guthion, CK-Control.

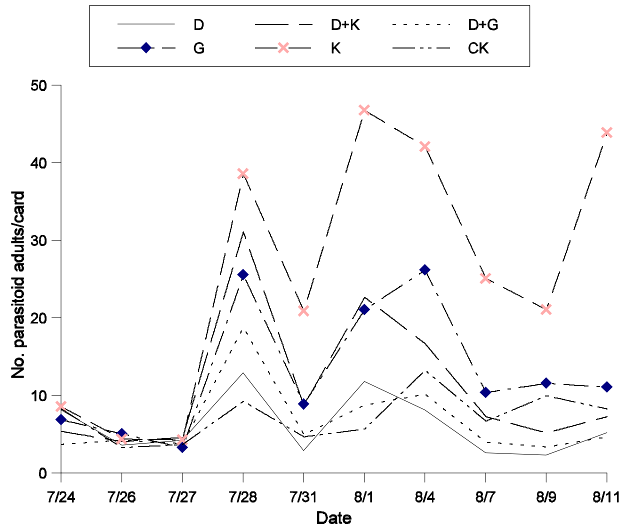

Figure 2. Numbers of parasitoid adults (*Eretmocerus* spp. and *Encarsia* spp.) trapped on yellow sticky cards after applications of defoliant and in combination with insecticides. D-Def, K-Karate, G-Guthion, CK-Control.