EFFECTIVENESS OF DIFLUBENZURON ON BOLL WEEVILS IN CENTRAL TEXAS RIVER BOTTOMS AREA[1/,2/]

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ABSTRACT

In tests during 3 consecutive years, applications of the insect growth regulator (IGR) diflubenzuron caused substantial reductions in adult boll weevil emergence from field-collected infested squares. Generally, maximum reductions were produced 3-6 wk after initiation of treatments after which an apparent influx of untreated weevils reduced the effects of the IGR. Furthermore, results in 1976 demonstrated a distinct difference in weevil responses to different doses of the IGR. In that year, season averages of boll weevil mortality were 46.4, 67.4, and 77.3% at the 35, 70, and 140 g AI/ha rates, respectively. We conclude that optimum use of diflubenzuron in the central Texas River Bottoms and other areas may involve other strategies such as area-wide treatments, planting of rapidly fruiting determinant cotton varieties, and fall diapause control programs.

INTRODUCTION

Maximum total cotton acreage in the central Texas River Bottom area is about 50,000 much of which is irrigated and farmed intensively for high crop production. In this area, pest insect population pressures and thus chemical insecticide usage are among the highest in the state. While early season pests such as the boll weevil, *Anthonomus grandis* Boheman, are often a significant problem, the usual major pests in this area are the cotton bollworm, *Heliothis zea* (Boddie), and the tobacco budworm, *Heliothis virescens* (F.); this is especially true on the irrigated cotton.

Heliothis problems in the central Texas River Bottoms are often described as "chronic." However, research and experience have shown that insecticide treatments for early season pests, and especially the boll weevil, frequently deplete beneficial arthropod populations which results in increased damage from the bollworm and tobacco budworm. In addition, populations of the tobacco budworm are often highly resistant to most conventional chemical insecticides. Therefore, any method(s) which effectively controls the boll weevil while conserving the beneficial species that regulate *Heliothis* populations is of particular advantage to cotton producers in central Texas. Because of its potential to selectively control the boll weevil (Taft and Hopkins 1975, Lloyd et al. 1977, Ganyard et al. 1977) while having less harmful effects on beneficials, use of the insect growth regulator (IGR) diflubenzuron (*N*[[(4-chlorophenyl)amino]carbonyl]-2,6-difluorobenzamide, Dimilin®, TH-6040) may prove advantageous (Ables et al. 1977, Keever et al. 1977, Wilkinson et al. 1978). We tested this IGR in central Texas cotton fields during the 1976, 1977, and 1978 growing seasons.

1/ In cooperation with the Texas Agricultural Experiment Station, Texas A&M University, College Station, TX 77843.

2/ This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the USDA nor does it imply registration under FIFRA as amended. Also, mention of a commercial product in this paper does not constitute an endorsement of this product by the USDA.

METHODS AND MATERIALS

1976 Tests. Diflubenzuron (W-25, 25% AI) was applied aerially to 3 adjacent fields of commercial cotton ('TAMCOT SP-37') at rates of 35, 70, or 140 g AI in 4.5 L of crop oil (Savol®) and 13.6 L of water/ha. Applications of the IGR began on June 19 when the cotton was at the "pinhead square" stage and were continued at 5-day intervals until August 5. Two nearby fields of 'Stoneville 213' cotton were used as an untreated control and a standard treatment (1682 g methyl parathion + 841 g toxaphene + 140 g chlordimeform/ha applied at 5-day intervals from July 7 to August 3), respectively.

Following the 1st diflubenzuron treatment, boll weevil-damaged squares were collected from all fields once or twice a week and returned to the laboratory for observations of adult boll weevil emergence. Additionally, populations of boll weevils, *Heliothis* spp. and beneficial arthropods in all fields were sampled 2 or 3 times/wk; observations of fruit development and damage by pests were also recorded.

1977 Tests. The IGR was applied with a ground sprayer to subplots in a 6.25-ha field of Stoneville 213 cotton at the rate of 70 g AI in 9.1 L Savol and 36.4 L water/ha. Due to inadequate supplies of the chemical, the 1st application was not made until after F_1 weevils had entered the field. Each of 7 applications was made at 7-day intervals. A small untreated plot adjacent to a field treated with conventional insecticides and located 165 m away was also studied. Samples were made as in 1976.

1978 Tests. Diflubenzuron was tested in an integrated control study along with releases of the egg parasite *Trichogramma* and/or applications of the microbial insecticides Dipel® and Elcar® for control of *Heliothis* spp. (Bull et al. 1979). The IGR was applied at the rate of 70 g AI/ha on 2 adjacent 10-ha fields. Six to 9 applications were made, 3 by air and the remainder by ground sprayer. A 0.5-ha plot was left untreated as a control. Much of the test area was replanted twice and finally irrigation was needed to establish a stand. Because some of the cotton was fruiting before treatments were begun, boll weevils were probably present at the time of the 1st treatment.

RESULTS AND DISCUSSION

1976 Tests. Data on boll weevil damage to squares in the diflubenzuron-treated and untreated fields (Table 1) revealed no clear dose response among treatments, probably because boll weevil populations were variable and tended to be higher in the more rapidly fruiting fields. However, the large amount of damage observed in the untreated field during July and early August suggested that boll weevil densities in the general area were quite high. Damage was substantially lower in all of the diflubenzuron-treated fields than in the check.

Measurements of damage to squares in individual fields are of little value in determining the efficacy of diflubenzuron. The IGR does not kill adult weevils but instead inhibits egg hatch or development of small larvae within the damaged squares. Thus, many squares used for oviposition by weevils remain on the plants and continue to develop a normal boll (Taft and Hopkins 1975). A more useful indication of the effectiveness of diflubenzuron is the emergence of adult weevils from squares with oviposition punctures collected in treated fields. The emergence data plotted in Fig. 1 reveal a distinct difference in response to doses of the IGR. The seasonal averages of boll weevil mortality were 46.4, 67.4, and 77.3% at 35, 70, and 140 g AI/ha, respectively. Maximum boll weevil suppression was achieved during late June and early July. On July 4 the 3 different rates of the IGR appeared to be about equally effective. The F_2 adult weevils and/or an influx of weevils from surrounding fields apparently occurred in mid-July because the emergence of adults from collected squares increased

TABLE 1. Boll Weevil Damage to Cotton Treated with Different Rates of Diflubenzuron, 1976.[a/],[b/]

Month	35 g AI/ha		70 g AI/ha		140 g AI/ha		Untreated	
	$\bar{X}$ no. squares/ha	$\bar{X}$ % boll weevil damage	$\bar{X}$ no. squares/ha	$\bar{X}$ % boll weevil damage	$\bar{X}$ no. squares/ha	$\bar{X}$ % boll weevil damage	$\bar{X}$ no. squares/ha	$\bar{X}$ % boll weevil damage
June	16,883	4.6	60,462	4.1	103,895	3.3	392,777	1.5
July	190,285	3.9	229,822	3.7	244,273	5.2	395,640	22.8
August[c/]	232,646	6.7	165,272	12.0	214,569	10.0	220,954	50.4

[a/]Figures represent means of thirty-six 1.95-m samples obtained 2-3 times/wk. Treatments began on June 19 and were applied at ca. 5-day intervals until August 5.
[b/]Adapted from House et al. 1978.
[c/]Represents a single date, August 1.

TABLE 2. Mean No. of *Heliothis* Eggs and Larvae per 0.4 ha and Percentage Square Damage in 4 Insecticide-Treated Field Plots and an Untreated Plot, July 1976.

Treatment	Eggs	Small larvae	Large larvae	% damaged squares	$\bar{X}$ total no. squares
Untreated	4,104	600	1,056	7.2	142,380
Standard[a/]	16,368	240	264	2.7	106,458
Diflubenzuron 30 g AI/ha	2,640	360	192	2.0	87,024
Diflubenzuron 70 g AI/ha	2,208	480	336	4.6	103,404
Diflubenzuron 140 g AI/ha	4,200	456	600	3.8	104,320

[a/]Treated with methyl parathion + toxaphene + chlordimeform at 1682, 841, and 140 g AI/ha, respectively.

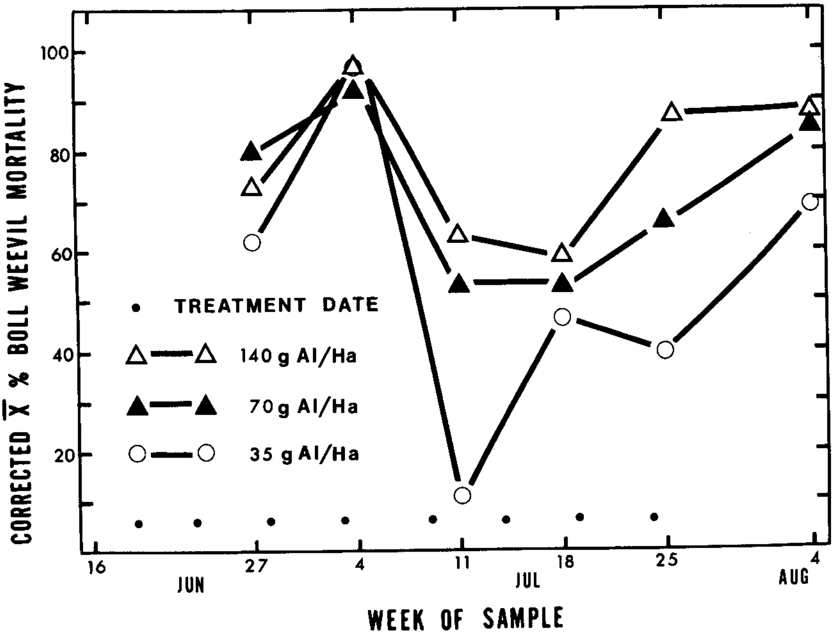

FIG. 1. Corrected $\overline{X}$ % boll weevil mortality in infested squares collected from cotton fields treated with diflubenzuron.

as did square damage in the field. Some degree of control was restored later in July and in August.

Data on *Heliothis* populations and their damage to squares during July are presented in Table 2. Insecticide applications reduced predator populations in the standard field (Ables et al. 1977) and apparently allowed an increase in numbers of *Heliothis* eggs. However, the standard insecticides also provided good control because numbers of *Heliothis* larvae and square damage remained low. Larval populations and % square damage by *Heliothis* spp. in the diflubenzuron-treated plots were generally a little higher than in the insecticide standard plot. The untreated plot had higher numbers of larvae and more damage than any of the treated plots.

1977 Tests. Populations of boll weevils were low to moderate and, similar to our 1976 results, diflubenzuron treatments again reduced the emergence of adult weevils (Table 3). Furthermore, damage by both weevils and *Heliothis* was lower than in the untreated plot (Table 4). On the basis of % adult emergence from squares, control of weevils during late July and August declined substantially. We suspect that an influx of untreated weevils from the adjacent control plot may have produced this decline in control.

1978 Tests. Table 5 shows the average adult weevil emergence from squares collected in the diflubenzuron treated and untreated plots during July and August. As in 1976 and 1977, the IGR caused a marked reduction in emergence. However, boll weevil densities were very high, and an apparent influx of adults from adjacent untreated areas eventually resulted in inadequate control.

TABLE 3. Percentage Emergence of Adult Boll Weevils from Squares Collected Within Diflubenzuron-Treated (70 g AI/ha) and Untreated Cotton Fields, 1977.[a/,b/]

Date (week of sample)	$\bar{X}$ % emergence diflubenzuron-treated	$\bar{X}$ % emergence untreated
July 3	48	61
10	25	38
17	26	65
24	15	90
31	35	46
Aug. 7	30	35
14	36	46
Seasonal $\bar{X}$	31	54

[a/] Initial treatment was made on June 30 and treatments continued at 7-day intervals until August 11.
[b/] Adapted from House et al. 1978.

CONCLUSIONS

In tests during 3 consecutive years, applications of diflubenzuron caused substantial reductions in adult boll weevil emergence from field-collected infested squares. Generally, maximum reductions were produced 3-6 wk after initiation of treatments and thereafter effects of the IGR decreased.

Several studies have demonstrated effective boll weevil control (> 95%) throughout the cotton growing season when the IGR was used (Lloyd et al. 1977, Ganyard et al. 1977, Ganyard et al. 1978). However, these studies were conducted under conditions of relatively low boll weevil density and isolation of test fields which sufficiently negated immigration of boll weevils from untreated areas. Our studies suggest that adequate season-long control of boll weevils in the central Texas River Bottoms, and other areas of relatively heavy and continuous weevil pressure, may be more difficult to obtain and will depend on several factors. Due to the mode of action of diflubenzuron (i.e., inhibited reproduction) and the boll weevil's capacity for rapid increase of within-field populations, the IGR must be applied at the "pinhead square" stage or earlier if sufficient initial suppression is to be achieved in heavy infestations. Additionally, diflubenzuron must be applied at regular 5- to 7-day intervals for extended periods to maintain control since damaging weevil populations may develop within 2-3 wk after termination of treatments (Ganyard et al. 1977, House et al. 1978; Bull et al. 1979). Thus, in some cases the effective maximum use of diflubenzuron in boll weevil population management may require an area-wide control approach (Ganyard et al. 1978, House et al. 1978) and/or integration with other management strategies such as use of rapidly fruiting determinate cotton varieties (Walker et al. 1976) which may allow escape from heavy late-season weevil populations.

It should be emphasized that much of our data were obtained in unreplicated tests and that in 2 yr of these tests various factors such as poorly timed initial treatments probably reduced the potential for adequate control by the IGR.

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TABLE 4. No. of Squares and Percentage Damage by Boll Weevil and *Heliothis* in Diflubenzuron-Treated and Untreated Cotton Fields, 1977.[a],[b]

Date (week of sample)	Diflubenzuron-treated			Untreated		
	No. undamaged squares/ha	% damage (boll weevil)	% damage (*Heliothis*)	No. undamaged squares/ha	% damage (boll weevil)	% damage (*Heliothis*)
June 26	242,428	1.6	0.5	610,521	2.2	0.1
July 3	653,114	1.8	3.4	863,068	2.9	1.2
10	576,451	3.9	11.2	879,934	3.9	2.5
17	439,555	1.4	26.2	483,724	4.2	28.4
24	323,534	0.9	29.2	332,560	11.6	23.1
31	275,692	3.4	12.4	-	-	-
August 7	155,258	1.1	25.5	6,364	20.0	40.0

[a] Figures represent means of 6-12 1-m samples obtained twice weekly. Treatments at 7-day intervals began on June 30.
[b] Adapted from House et al. 1978.

TABLE 5. Percentage Emergence of Adult Boll Weevils from Squares Collected Within Diflubenzuron-Treated and Untreated Cotton Fields, 1978.[a]

Month	$\bar{X}$ % emergence diflubenzuron-treated	$\bar{X}$ % emergence untreated
July	22.2	64.8
August	22.2	66.8
2 month $\bar{X}$	22.2	65.8

[a] Treatments were initiated on June 28 and applied at ca. 5-day intervals until August 21.

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