GRAENICHER, S. 1910. The bee-flies (Bombyliidae) in their relations to flowers. Bull. Wisconsin Nat. Hist. Soc. 8: 91-101.
GRIMALDI, D. 1988. Bee flies and bluets: *Bombylius* (Diptera: Bombylidae) flower-constant on the distylous species, *Hedyotis caerulea* (Rubiaceae), and the manner of foraging. J. Nat. Hist. 22: 1-10.
HALL, J. C. 1981. Bombyliidae. Pp. 589-602 *in* McAlpine, J. F., B. V. Peterson, G. E. Shewell, H. J. Tesky, J. R. Vockeroth, D. M. Wood, coords. Manual of Nearctic Diptera, I. Research Branch, Agric. Canada Monog. 27: vi + 674 pp.
HOLLOWAY, B. A. 1976. Pollen-feeding in hover-flies (Diptera: Syrphidae). New Zealand J. Zool. 3: 339-350.
HULL, F. M. 1973. Bee flies of the world. The genera of the family Bombyliidae. Bull. U.S. Natl. Mus. 286: 1-687.
LUNDBECK, W. 1908. Diptera Danica. Genera and species of flies hitherto found in Denmark. II. Asilidae, Bombyliidae, Thervidae, Scenopinidae. G. E. C. Good Co., Copenhagen. 164 pp.
OLDROYD, M. 1964. The natural history of flies. W. W. Norton and Co., New York, xiv + 324 pp.
PAINTER, R. H., AND E. M. PAINTER. 1965. Family Bombylilidae. Pp. 407-446 *in* Stone, A., C. W. Sabrosky, W. W. Wirth, R. H. Foote, J. R. Coulson, eds. A catalog of the Diptera of America north of Mexico. U.S. Govt. Printing Office, Washington, D.C. iv + 1696 pp.
TOFT, C. A. 1984a. Resource shifts in bee flies (Bombyliidae): interactions among species determine choice of resources. Oikos 43: 104-112.
TOFT, C. A. 1984b. Activity budgets in two species of bee flies (Lordotus: Bombyliidae, Diptera): a comparison of species and sexes. Behav. Ecol. Sociobiol. 14: 287-296.

POTENTIAL OF TEFLUBENZURON FOR DIAMONDBACK MOTH (LEPIDOPTERA: PLUTELLIDAE) MANAGEMENT ON CABBAGE IN SOUTHERN FLORIDA

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ABSTRACT

The potential of the chitin synthesis inhibitor, teflubenzuron (CME 13406), for managing populations of diamondback moth (DBM), *Plutella xylostella* L., on cabbage was assessed during two consecutive growing seasons in southern Florida. In the first year, the effectiveness of two rates of teflubenzuron at managing DBM populations was compared with those of three commonly used insecticides, fenvalerate, methamidophos, and methomyl in combination with *Bacillus thuringiensis* var. *kurstaki*, applied at recommended rates. In the second year, the effects of different treatment intervals (7, 14 or 21 days) of teflubenzuron on DBM management were assessed. Teflubenzuron was more effective than other insecticides at suppressing DBM populations and protecting plants. The percentages of marketable cabbage heads were 98, 98, 83, 80, and 50% on plants treated with teflubenzuron at 0.022 and 0.044 kg ai/ha, methomyl in combination with *B. thuringiensis*, fenvalerate, and methamidophos, respectively, and was 17% in nontreated plots. In the second year, teflubenzuron (0.033 kg ai/ha) was consistently more effective than other insecticides at suppressing DBM populations. DBM populations and the percentages of marketable heads did not differ among plants treated with teflubenzuron at 7-, 14-, and 21-day intervals, suggesting that the negative effects of teflubenzuron on DBM were persistent. The potential importance of teflubenzuron in DBM management programs in Florida is discussed.

RESUMEN

El potencial del inhibidor de la síntesis de quitina, teflubenzuron (CME 13406), para administrar poblaciones de alevillas de *Plutella xylostella* L., fue evaluado durante dos temporadas del cultivo de repollo en el sur de la Florida. En el primer año se comparó la efectividad de dos proporciones de teflubenzuron en administrar poblaciones de *P. xylostella* con tres insecticidas comunmente usados, fenvalerate, metamidofos, y metomil en combinacion con *Bacillus thuringiensis* var. *kurstaki*, aplicados a la proporción recomendada. Se evaluaron en el segundo año los efectos de diferentes intervalos de tratamiento (7, 14, o 21 dias) de teflubensuron en la administración de *P. xylostella*. Teflubenzuron fue más efectivo que otros insecticidas en suprimir poblaciones de *P. xylostella* y en protejer las plantas. El porcentaje de cabezas de repollos vendibles fue 98, 98, 83, 80, y 50% en plantas tratadas con teflubenzuron a 0.022 y 0.44 kg (ai)/ha, metomil en combinación con *B. thuringiensis*, fenvalerate, y metamidofos, respectivamente, y fue 17% en las parcelas no tratadas. En el segundo año, teflubenzuron (0.033 kg ai/ha) fue consistentemente más efectivo que otros insecticidas en suprimir poblaciones de *P. xylostella*. No hubo diferencia en poblaciones de *P. xylostella* y el porcentaje de cabezas vendibles entre plantas tratadas con teflutenzuron a intervalos de 7, 14, o 21 dias, sugeriendo que los efectos negativos de teflubenzuron en *P. xylostella* fueron persistentes. Se discute el potencial de la importancia de teflubenzuron en programas de administración de *P. xylostella*.

The diamondback moth (DBM), *Plutella xylostella* L., is the most important insect pest of cole crops during the winter growing season in southern Florida (Jansson, personal observation). Current management programs rely on chemical and biological insecticides. Recently, several insecticides, including methamidophos and fenvalerate, were ineffective at managing DBM populations in certain commercial cabbage, *Brassicae oleracea* L., fields in southern Florida. Insecticide-resistant DBM populations are known to occur in many areas of the world (Sudderuddin & Kok 1978, Liu et al. 1981, Cheng 1986, Miyata et al. 1986, Sun et al. 1986, Tabashnik et al. 1987), including central Florida (G. L. Leibee, personal communication). For this reason, alternative tactics are needed to improve current DBM management programs in Florida.

One approach that has potential is the use of chitin synthesis inhibitors, benzoylphenyl ureas (e.g., teflubenzuron [CME 13406]), for DBM management. This group of compounds has been evaluated for its potential at managing insecticide-resistant DBM populations in several countries (Becker 1986, Kohyama 1986, Lim & Khoo 1986, Sagenmueller & Rose 1986). Currently, cross-resistance between conventional insecticides and these compounds has not been documented (Perng & Sun 1987). However, certain DBM populations in southeast Asia have developed resistance to benzoylphenyl ureas (Perng et al. 1988). The present study determined the effectiveness of teflubenzuron at managing DBM populations on cabbage in southern Florida, and determined the effects of different application intervals (7, 14, or 21 days) of teflubenzuron on DBM population suppression and corresponding field plant protection. This information will help develop an application strategy for teflubenzuron on cabbage in Florida and subsequently minimize the number of applications needed per growing season, delay teflubenzuron resistance, and reduce environmental contamination.

MATERIALS AND METHODS

Two experiments were conducted during the 1986-1987 and 1987-1988 growing seasons in southern Florida. Rockdale soil was fumigated with Terr-O-Gas (75% methyl bromide, 25% chloropicrin; 242 kg/ha) and covered with black (1986) or blue (1987) plastic mulch one to two weeks before planting; mulch was perforated on 17 November 1986 and 9 December 1987. Certified seeds of 'Rio Verde' cabbage were incorporated into a germination mix (Pro-Mix®) and direct seeded at the University of Florida's Tropical Research and Education Center on 18 November 1986 and 14 December 1987. Plants were spaced 0.3 m apart within each of two rows that were 0.76 m apart on 1.83-m center beds. In the 1986-1987 growing season, treatment plots were 2 rows (1 bed) wide by 10.7 m long. A 1.5 m buffer of nontreated plants separated treatment plots. In the 1987-1988 growing season, treatment plots were 4 rows (2 beds) wide by 12.2 m long. A 3 m buffer of nontreated plants separated each replicate and one nontreated bed and a 1.8 m alleyway separated treatment plots.

In the first year, 1,120 kg/ha of granular (6:12:12 [$N:P_2O_5:K_2O$] and 672 kg/ha of liquid (7:16:8) fertilizer were applied; in the second year 1,680 kg/ha of granular (6:12:12) fertilizer were applied before planting. Plants were sprinkler irrigated (4.7-6.3 cm/ha/irrigation) twice per week. Maneb (Maneb 80) (Pennwalt Corp., Philadelphia, Pa.) was applied (3.36 kg ai/ha) weekly for routine management of various foliar plant pathogens.

Treatments were arranged in randomized complete blocks with four replications. In the 1986-1987 growing season, treatments evaluated were weekly applications of teflubenzuron (CME 13406, E. M. Industries, Hawthorne, N.Y.) (15 SC) (0.022 and 0.044 kg ai/ha), methomyl (Lannate 1.8L, E. I. du Pont Nemours & Co., Wilmington, Del.) (0.5 kg ai/ha) in combination with *Bacillus thuringiensis* var. *kurstaki* (Dipel 1X, Abbott Laboratories, North Chicago, Ill.) (0.28 kg/ha), methamidophos (Monitor 4L, Mobay Chemical Corp., Kansas City, Mo.) (0.56 kg ai/ha), fenvalerate (Pydrin 2.4EC, Shell Chemical Co., Houston, TX) (0.11 kg ai/ha), and a nontreated check. Since teflubenzuron was effective at suppressing DBM populations and protecting cabbage heads, in 1987-1988 we determined if the negative effects of teflubenzuron on DBM populations and on field plant protection were persistent. Treatments evaluated were teflubenzuron (CME 13406) (15 SC) (0.033 kg ai/ha) applied at 7-, 14-, and 21-day intervals, methomyl (Lannate 1.8L) (0.5 kg ai/ha) in combination with *B. thuringiensis* var. *kurstaki* (Dipel 2X) (0.28 kg/ha), fenvalerate (Pydrin 2.4EC) (0.11 kg ai/ha), and a nontreated check. An intermediate application rate (0.033 kg ai/ha) for teflubenzuron was selected because both the low (0.022 kg ai/ha) and high (0.044 kg ai/ha) rates used in the first year were equally effective at managing DBM populations. The methomyl in combination with *B. thuringiensis* and fenvalerate treatments were applied at 7-day intervals. In 1986-1987, treatments were applied on 7 dates: 8, 15, 22, and 29 January 5, 11, and 18 February 1987. In 1987-1988, teflubenzuron (7-day interval), methomyl in combination with *B. thuringiensis*, and fenvalerate were applied on 10 dates: 14, 21, and 27 January 3, 10, 17, and 24 February, and 2, 9, and 16 March 1988. Treatments of teflubenzuron at 14- and 21-day intervals were applied on 5 dates (21 January, 3 and 17 February, and 2 and 16 March) and 3 dates (21 January, 10 February, and 2 March), respectively. Treatments were applied with a tractor-mounted single-bed boom sprayer with two disc cone nozzles (D-4, no. 24) on each side of the bed and one nozzle over the center of each bed. The sprayer delivered 934.6 l/ha at 4.8 km/hr.

In 1986-1987, data were collected from the center 6 m of each treatment plot, and in 1987-1988 data were collected from the center 9 m of the two middle rows of each treatment plot. Numbers of DBM larvae and pupae, and other lepidopterous pests, including cabbage looper, *Trichoplusia ni* (Hubner), and cabbage budworm, *Hellula phidilealis* (Walker), were recorded on 8 plants per treatment plot on each of 8 dates in 1987 and 11 dates in 1988. In 1988, DBM larvae were categorized by size: small, medium, or large. Foliar damage was rated visually on 24 plants per treatment plot on 26 February 1987, on 8 plants per treatment plot on 4 and 11 March 1988, and on 24 plants per treatment plot on 21 March 1988 using a scale from 1-6 as follows: 1, no apparent insect feeding; 2, minor feeding on wrapper or outer leavs, 0-1% leaf area eaten; 3, moderate insect feeding on wrapper or outer leaves with no head damage, 2-5% leaf area eaten; 4, moderate insect feeding on wrapper or outer leaves with minor feeding on head, 6-10% leaf area eaten; 5, moderate to heavy feeding on wrapper and head leaves and a moderate number of feeding scars on head, 11-30% of leaf area eaten: 6, considerable insect feeding on wrapper and head leaves with head having numerous feeding scars, over 30% of leaf area eaten (Greene et al. 1969). The percentage of marketable heads was determined on 26 February 1987 and 21 March 1988 by calculating the percentage of heads with ratings ≤ 3.

Data were analyzed by the least-squares approach to analysis of variance (SAS Institute 1985b). Numbers of DBM larvae per plant and the percentage of marketable heads were transformed to ln(DBM + 1) and to the arcsin, respectively, to stabilize error variance. Normal probability plots and the Shapiro-Wilk statistic or the Kolomogorov D statistic were used to assess homogeneity of error variance (SAS Institute 1985a). The significance of differences among treatment means was assessed using the Waller-Duncan K-ratio t-test (SAS Institute 1985b). On several dates, the mean and variance for certain insecticide treatments of some insect counts were equal to 0. For this reason, these data could not be analyzed by least squares analysis of variance. These treatments were assumed to be significantly different from other treatments if 0 was outside the range of the 95% confidence interval of treatments with a mean > 0. To further assess the effects of teflubenzuron on plant protection from DBM, square-root transformed damage ratings were regressed on the application interval of teflubenzuron for each of the three dates that damage was rated (SAS Institute 1985b). Also, the percentages of marketable heads per replicate at harvest were regressed on the corresponding teflubenzuron application interval.

Results and Discussion

1986-1987 Growing Season

Abundance of DBM did not differ among most treatments on the first four sample dates; however, DBM were 1.5-26.0 times more abundant on nontreated plants than on plants treated with insecticides (Table 1). On the last four sample dates, DMB larvae were 2.3 to > 56.0 times more abundant on nontreated plants than on plants treated with insecticides. On 30 January and 9 February, fewer DBM larvae were found on plants treated with teflubenzuron (either 0.022 or 0.044 kg ai/ha) than on those treated with methomyl in combination with *B. thuringiensis*, fenvalerate, and methamidophos. On 16 and 23 February, DBM populations did not differ among most insecticide treatments; however, more DBM (although not consistently significant) were found on plants treated with methamidophos than on those treated with fenvalerate, methomyl in combination with *B. thuringiensis*, and teflubenzuron.

Damage ratings and corresponding percentages of marketable heads differed among most treatments (Table 1). Damage ratings of nontreated plants were 1.3-3.4 times greater than those of plants treated with insecticides. Plants treated with teflubenzuron (either 0.022 or 0.044 kg ai/ha) were least damaged. Damage ratings were 1.7, 1.8, and 2.6 times greater on plants treated with fenvalerate, methomyl in combination with *B. thuringiensis*, and methamidophos, respectively, than on those treated with teflubenzuron. Similarly, the percentage of marketable heads was 2.9-5.8 times greater on plants treated with insecticides than on nontreated plants. Teflubenzuron treatments resulted in the highest percentage of marketable heads (97.9%) followed in decreasing order by

TABLE 1. Mean numbers of DBM larvae per plant during the growing season, and damage ratings and percentages of marketable heads produced at harvest for cabbage plants treated with different insecticides at Homestead, Florida in 1987.

Insecticide treatment	Rate, Kg ai/ha	Mean no. DBM per plant[a]								Damage rating[b]	% marketable heads[c]
		2 Jan.	11 Jan.	16 Jan.	26 Jan.	30 Jan.	9 Feb.	16 Feb.	23 Feb.		
Methomyl +	0.50										
B. thuringiensis	0.28	0.5a	0.9a	0.3b	0.4b	0.7c	0.4cd	0.6bc	0.1c	2.2c	83.3b
Methamidophos	0.56	0.8a	0.9ab	0.5b	0.8b	1.1b	2.4b	1.2b	0.9b	3.1b	50.0c
Fenvalerate	0.11	0.7a	0.6b	0.4b	0.9b	0.8bc	1.1c	0.4c	0.2bc	2.1c	80.2b
Teflubenzuron	0.022	0.6a	1.0b	0.5b	0.1b	0.2d	0.1d	0.1c	0.0c	1.2d	97.9a
Teflubenzuron	0.044	0.7a	0.5b	0.3b	0.5b	0.1d	0.0d	0.0c	0.0c	1.2d	97.9a
Nontreated check	-—	0.2a	1.5a	1.7a	2.6a	3.4a	5.6a	3.9a	3.4a	4.1a	16.7d

[a]Data transformed to $ln(DBM + 1)$ to reduce error variance. Nontransformed means are presented. Means in the same column followed by the same letter are not significantly different (K-ratio = 100; Waller-duncan K-ratio t-test).

[b]Foliar damage was rated by the method described by Greene et al. (1969).

[c]Data transformed to the arcsin for analysis. Nontransformed means are presented.

TABLE 2. MEAN NUMBERS OF SMALL, MEDIUM, LARGE, AND TOTAL DBM LARVAE, AND DBM PUPAE DURING THE GROWING SEASON ON CABBAGE PLANTS TREATED WITH DIFFERENT INSECTICIDES AT DIFFERENT APPLICATION INTERVALS AT HOMESTEAD, FLORIDA IN 1988.

Insecticide Treatment	Rate, Kg ai/ha	Application interval, days	8 Jan.	15 Jan.	22 Jan.	29 Jan.	5 Feb.	12 Feb.	19 Feb.	26 Feb.	4 Mar.	11 Mar.	21 Mar.
			Mean no. of small DBM larvae per plant[a]										
Methomyl +	0.50												
B. thuringiensis	0.28	7	0.0a	0.1a	0.1a	0.1b	0.7b	0.1b	0.1b	0.1bc	0.1b	0.0b	0.0a
Fenvalerate	0.11	7	0.2a	0.0a	0.1a	0.1b	0.3bc	0.1b	0.2b	0.7b	0.6b	0.5ab	0.1a
Teflubenzuron	0.033	7	0.1a	0.0a	0.0a	0.0b	0.0c	0.0b	0.0b	0.0c	0.0b	0.0b	0.0a
Teflubenzuron	0.033	14	0.1a	0.2a	0.1a	0.2b	0.2c	0.0b	0.0b	0.0c	0.0b	0.0b	0.0a
Teflubenzuron	0.033	21	0.2a	0.2a	0.0a	0.1b	0.1c	0.1b	0.2b	0.1bc	0.1b	0.0b	0.0a
Nontreated check	—	—	0.1a	0.1a	0.1a	0.4a	1.7a	1.4a	3.5a	3.5a	4.5a	1.1a	0.0a
			Mean no. of medium DBM larvae per plant										
Methomyl +	0.50												
B. thuringiensis	0.28	7	0.1a	0.0a	0.0b	0.0b	0.2b	0.2b	0.1b	0.1b	0.0c	0.1c	0.1b
Fenvalerate	0.11	7	0.0a	0.1a	0.0b	0.1b	0.5b	0.1b	0.2b	0.4b	0.8b	1.0b	0.4a
Teflubenzuron	0.033	7	0.2a	0.0a	0.0ab	0.0b	0.0b	0.0b	0.0b	0.0b	0.0c	0.0c	0.0b
Teflubenzuron	0.033	14	0.1a	0.1a	0.0ab	0.0b	0.3b	0.0b	0.0b	0.0b	0.0c	0.1c	0.0b
Teflubenzuron	0.033	21	0.2a	0.1a	0.0ab	0.2ab	0.2b	0.1b	0.1b	0.1b	0.1c	0.0c	0.0b
Nontreated check	—	—	0.1a	0.1a	0.1a	0.4a	2.8a	1.1a	2.8a	3.7a	9.1a	3.7a	0.1b
			Mean no. of large DBM larvae per plant										
Methomyl +	0.50												
B. thuringiensis	0.28	7	0.1a	0.1a	0.0a	0.1a	0.1c	0.1b	0.1b	0.0b	0.0c	0.1c	0.0b
Fenvalerate	0.11	7	0.0a	0.0a	0.0a	0.0a	0.3bc	0.0b	0.0b	0.2b	0.7b	1.6b	0.4a
Teflubenzuron	0.033	7	0.1a	0.0a	0.0a	0.0a	0.0c	0.0b	0.0b	0.0b	0.0c	0.0c	0.0b
Teflubenzuron	0.033	14	0.1a	0.1a	0.0a	0.1a	0.5b	0.0b	0.0b	0.0b	0.0c	0.1c	0.0b
Teflubenzuron	0.033	21	0.1a	0.1a	0.0a	0.0a	0.1c	0.1b	0.0b	0.0b	0.1c	0.0c	0.0b
Nontreated check	—	—	0.1a	0.1a	0.1a	0.1a	0.9a	0.4a	1.8a	0.9a	5.3a	3.2a	0.2a
			Mean no. of total DBM larvae per plant										

Methomyl +	0.50												
B. thuringiensis	0.28	7	0.2a	0.2a	0.2ab	0.2bc	1.0b	0.4b	0.2b	0.2c	0.1c	0.2c	0.1bc
Fenvalerate	0.11	7	0.2a	0.1a	0.1ab	0.2bc	1.0b	0.2bc	0.4b	1.4b	2.2b	3.2b	0.8a
Teflubenzuron	0.033	7	0.5a	0.1a	0.0b	0.0c	0.0c	0.0d	0.0c	0.0c	0.0c	0.0c	0.0c
Teflubenzuron	0.033	14	0.4a	0.3a	0.2ab	0.2bc	1.0b	0.0cd	0.0bc	0.0c	0.0c	0.2c	0.1bc
Teflubenzuron	0.033	21	0.5a	0.3a	0.0b	0.3b	0.4bc	0.2b	0.2bc	0.1c	0.2c	0.0c	0.0c
Nontreated check	—	—	0.2a	0.3a	0.4a	0.9a	5.5a	2.9a	8.1a	8.1a	19.0a	8.0a	0.3b
			Mean no. of DBM pupae per plant										
Methomyl +	0.50												
B. thuringiensis	0.28	7	0.0a	0.0a	0.1a	0.1a	0.2bc	0.1bc	0.1bc	0.1b	0.2b	0.2c	0.1a
Fenvalerate	0.11	7	0.0a	0.3a	0.0a	0.0a	0.2bc	0.3b	0.2bc	0.2b	0.4b	1.6b	0.6a
Teflubenzuron	0.033	7	0.0a	0.2a	0.1a	0.0a	0.0c	0.0c	0.0c	0.0b	0.0b	0.0c	0.0a
Teflubenzuron	0.033	14	0.0a	0.3a	0.1a	0.1a	0.6b	0.2bc	0.0c	0.1b	0.1b	0.0c	0.0a
Teflubenzuron	0.033	21	0.0a	0.2a	0.1a	0.0a	0.2bc	0.2bc	0.1b	0.1b	0.2b	0.4c	0.1a
Nontreated check	—	—	0.0a	0.1a	0.2a	0.1a	1.4a	1.0a	1.7a	1.6a	4.1a	3.3a	0.5a

[a]Data trasformed to ln(DBM + 1) to reduce error variance. Nontransformed means are presented. Means for each life stage within each column followed by the same letter are not significantly different (K-ratio = 100; Waller-Duncan K-ratio t-test).

methomyl in combination with *B. thuringiensis* (83.3%), fenvalerate (80.2%), methamidophos (50%), and nontreated plants (16.7%).

1987-1988 Growing Season

Abundance of small, medium, large, total larvae, and DBM pupae did not differ among most insecticide treatments on most dates; however, DBM were consistently more abundant on nontreated plants than on plants treated with insecticides (Table 2). In general, DBM were most abundant on nontreated plants followed in decreasing order by plants treated with fenvalerate, methomyl in combination with *B. thuringiensis*, and teflubenzuron (either 21-, 14-, or 7-day application intervals). In general, teflubenzuron treatments were more effective than other insecticides at managing DBM populations. Interestingly, abundance of DBM larvae and pupae did not differ among plants treated with teflubenzuron at 7-, 14-, and 21-day intervals on most sample dates.

Although the numbers of other lepidopterous pests were recorded on plants, few were found. For this reason, we could not evaluate the effectiveness of teflubenzuron at managing other pests of cabbage.

Foliar damage ratings differed among most treatments on the three dates that damage was assessed (Table 3). Plants treated with teflubenzuron every 7 days were least damaged. On 4 March, damage ratings were 3.4, 1.9, 1.9, 1.8, and 1.8 times greater on nontreated plants and plants treated with fenvalerate, teflubenzuron every 21 days, methomyl in combination with *B. thuringiensis*, and teflubenzuron every 14 days, respectively, than on plants treated with teflubenzuron every 7 days. On 11 March, damage ratings were 3.2, 2.1, 2.0, 1.8, and 1.8 times greater on nontreated plants and plants treated with fenvalerate, teflubenzuron every 21 days, methomyl in combination with *B. thuringiensis*, and teflubenzuron every 14 days, respectively, than on plants treated with teflubenzuron every 7 days. At harvest (21 March), damage ratings were 2.9, 2.2, 2.0, 1.8, and 1.8 times greater on nontreated plants and plants treated with fenvalerate, teflubenzuron every 21 days, methomyl in combination with *B. thuringiensis*, and teflubenzuron every 14 days, respectively, than on plants treated with teflubenzuron every 7 days. Square-root transformed damage ratings were significantly positively correlated with the application interval of teflubenzuron on 4 ($F = 58.96$; $P = 0.0001$; $df = 1,94$; $r^2 = 0.38$; $Y = -0.27 + 0.20X$), 11 ($F = 53.09$; $P = 0.0001$; $df = 1,94$; $r^2 = 0.36$; $Y = 0.42 + 0.23X$), and 21 March ($F = 216.77$; $P = 0.0001$; $df = 1,286$; $r^2 = 0.43$; $Y = 0.99 + 0.03X$). Thus, longer application intervals of teflubenzuron resulted in more DBM damage to plants.

The percentage of marketable heads was 15.0-18.8 times greater on plants treated with insecticides than on nontreated plants (Table 3). Plants treated with teflubenzuron every 7 days produced the highest percentage of marketable heads (97.9%) followed in decreasing order by plants treated with teflubenzuron every 14 (93.7%) and 21 days (88.5%), methomyl in combination with *B. thuringiensis* (88.5%), fenvalerate (78.1%), and nontreated plants (5.2%). These data were similar to those from the first year. The percentage of marketable heads was not significantly correlated ($F = 4.08$; $P > 0.05$; $df = 1.10$; $r^2 = 0.30$; $Y = 1.028\text{-}0.007X$) with the application interval of teflubenzuron, suggesting that the negative effects of teflubenzuron on DBM populations were persistent.

In summary, this study showed that teflubenzuron was more effective than fenvalerate, methomyl in combination with *B. thuringiensis*, and methamidophos at managing DBM populations on cabbage and protecting cabbage heads from DBM damage. Cabbage yields were similar among plants treated with teflubenzuron at 7-, 14-, and 21-day intervals. Teflubenzuron appears to have considerable potential for managing DBM populations in Florida. Current label restrictions for teflubenzuron limit its use to 6

TABLE 3. FOLIAR DAMAGE RATINGS ON THREE DATES AND THE PERCENTAGES OF MARKETABLE HEADS AT HARVEST FOR CABBAGE PLANTS TREATED WITH DIFFERENT INSECTICIDES AT DIFFERENT APPLICATION INTERVALS AT HOMESTEAD, FLORIDA IN 1988.

Insecticide treatment	Rate, Kg ai/ha	Application interval, days	No. of applications	Damage rating[a]			% marketable heads[b]
				4 Mar.	11 Mar.	21 Mar.	
Methomyl +	0.50						
B. thuringiensis	0.28	7	10	2.2b	2.4c	2.6c	88.5ab
Fenvalerate	0.11	7	10	2.3b	2.8b	3.1b	78.1b
Teflubenzuron	0.033	7	10	1.2c	1.3d	1.4d	97.9a
Teflubenzuron	0.033	14	5	2.2b	2.4c	2.6c	93.7a
Teflubenzuron	0.033	21	3	2.3b	2.6bc	2.8bc	88.5ab
Nontreated check	—	—	0	4.1a	4.2a	4.1a	5.2c

[a]As in Table 1. Means followed by the same letter within the same column are not significantly different (*K*-ratio = 100; Waller-Duncan *K*-ratio *t*-test).
[b]Data transformed to the arcsin for analysis. Nontransformed means are presented.

applications per growing season. The present study indicates that adequate control of DBM may be possible with as few as 5 and perhaps even 3 applications of teflubenzuron per growing season. Future studies should develop an application schedule for teflubenzuron so that teflubenzuron selection pressure on DBM populations is minimized and DBM resistance to teflubenzuron is delayed.

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REFERENCES CITED

BECKER, P. 1986. The potential use of CME-134 for the control of vegetable pests. pp. 257-263 *in* N. S. Talekar and T. D. Griggs [eds.], Diamondback moth management. Proceedings of the first international workshop. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

CHENG, E. Y. 1986. The resistance, cross resistance, and chemical control of diamondback moth in Taiwan. pp. 329-345 *in* N. S. Talekar and T. D. Griggs [eds.], Diamondback moth management. Proceedings of the first international workshop. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

GREENE, G. L., W. G. GENUNG, R. B. WORKMAN, AND E. G. KELSHEIMER. 1969. Cabbage looper control in Florida—a cooperative program. J. Econ. Entomol. 62: 798-800.

KOHYAMA, Y. 1986. Insecticidal activity of MK-139 (CME-134) against diamondback moth. pp. 265-269 *in* N. S. Talekar and T. D. Griggs [eds.], Diamondback moth management. Proceedings of the first international workshop. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

LIM, J. E., AND C. K. KHOO. 1986. The status and effectiveness of IKI-7899 in controlling diamondback moth in the lowlands and highlands of Malaysia. pp. 279-287 *in* N. S. Talekar and T. D. Griggs [eds.], Diamondback moth management. Proceedings of the first international workshop. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

LIU, M. Y., Y. J. TZENG, AND C. N. SUN. 1981. Diamondback moth resistance to several synthetic pyrethroids. J. Econ. Entomol. 74: 393-396.

MIYATA, T., T. SAITO, AND V. NOPPUN. 1986. Studies on the mechanism of diamondback moth resistance to insecticides. pp. 347-357 *in* N. S. Talekar and T. D. Griggs [eds.], Diamondback moth management. Proceedings of the first international workshop. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

PERNG, F. S., AND C. N. SUN. 1987. Susceptibility of diamondback moths (Lepidoptera: Plutellidae) resistant to conventional insecticides to chitin synthesis inhibitors. J. Econ. Entomol. 80: 29-31.

PERNG, F. S., M. C. YAO, C. F. HUNG, AND C. N. SUN. 1988. Teflubenzuron resistance in diamondback moth (Lepidoptera: Plutellidae). J. Econ. Entomol. 81: 1277-1282.

SAGENMUELLER, A., AND E. ROSE. 1986. HOE 522 (CME 134), a new insect growth regulator for control of the diamondback moth. pp. 271-278 *in* N. S. Talekar and T. D. Griggs [eds.], Diamondback moth management. Proceedings of the first international workshop. Asian Vegetable Research and Development Center, Shanhua, Taiwan.

SAS INSTITUTE. 1985a. SAS procedures guide for personal computers. Version 6 edition. SAS Institute Inc., Cary, N. C. 373 p.
SAS INSTITUTE. 1985b. SAS/STAT guide for personal computers. Version 6 edition. SAS Institute Inc., Cary, N. C. 378 p.
SUDDERUDDIN, K. I., AND P. F. KOK. 1978. Insecticide resistance in *Plutella xylostella* collected from Cameron Highlands of Malaysia. FAO Plant Prot. Bull. 26: 53-57.
SUN C. N., T. K. WU, J. S. CHEN, AND W. T. LEE. 1986. Insecticide resistance in diamondback moth pp. 359-371 *in* N. S. Talekar and T. D. Griggs [eds.], Diamondback moth management. Proceedings of the first international workshop. Asian Vegetable Research and Development Center, Shanhua, Taiwan.
TABASHNIK, B. E., N. L. CUSHING, AND M. W. JOHNSON. 1987. Diamondback moth (Lepidoptera: Plutellidae) resistance to insecticides in Hawaii: intra-island variation and cross-resistance. J. Econ. Entomol. 80: 1091-1099.

A SURVEY OF STRUCTURE-INFESTING TERMITES OF PENINSULAR FLORIDA

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ABSTRACT

A total of 785 samples of termites was obtained from structures in central and southern Florida between February 1987 and March 1988. Eleven of the 15 termite species known from Florida were recorded including six drywood (Kalotermitidae) species and five subterranean (Rhinotermitidae) species. An unidentified species of Termitidae, new to Florida, was collected in St. Petersburg. The subterranean termites, *Reticulitermes flavipes* (Kollar) and *R. virginicus* (Banks), accounted for 57% of the 716 survey samples identified to species, while the drywood termites, *Cryptotermes brevis* (Walker) and *Incisitermes snyderi* (Light), accounted for 36%. Flight seasons for various species were determined from alate collections. Fumigation for drywood termite control cost building owners in central and southern Florida ca. $30 million in 1987.

RESUMEN

Se obtuvieron un total de 785 muestras de termes de edificios en el centro y el sur de la Florida durante el periódo febrero de 1987 hasta marzo de 1988. Se registraron 11 de las 15 especies conocidas para la Florida, incluyendo 6 especies de termes de madera seca (Kalotermitidae) y 5 especies de termes subterráneos (Rhinotermitidae). Se colectó en St. Petersburg una especie desconocida de Termitidae la cual es nueva para la Florida. De las 716 muestras identificadas al nivel de especie, 57% fueron termes subterráneos, *Reticulitermes flavipes* (Kollar) y *R. virginicus* (Banks), mientras las especies *Cryptotermes brevis* (Walker) y *Incisitermes snyderi* (Light) constituyeron la mayoría de los termes de madera seca y el 36% de los ejemplares. Se determinaron por ejemplares de termes aladas los vuelos estacionales de varias especies. La fumigación