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THE DISTANCE EFFECTS OF (Z)-9-TETRADECENYL ACETATE AND (Z)-11-HEXADECEN-1-OL ON THE SEXUAL COMMUNICATION OF DIAMONDBACK MOTH *PLUTELLA XYLOSTELLA* L.

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Yuh-Meei Lin, Yien-Shing Chow, Hwa-Jen Teng, Chiarn-Baau Hurng and Shung-Shiang Wang (1984) The distance effects of (Z)-9-tetradecenyl acetate and (Z)-11-hexadecen-1-ol on the sexual communication of diamondback moth *Plutella xylostella* L. *Bull. Inst, Zool., Academia Sinica* **23**(2): 187-192. Fifty μg of the synthetic sex pheromone in the ratio of 3:7:0.1 of (Z)-11-hexadecenal (Z11-16:Ald), (Z)-11-hexadecenyl acetate (Z11-16:Ac), and (Z)-11-hexadecen-1-ol (Z11-16:OH) significantly caught more adults than other blends in the Sang Chung cabbage field. The sticky traps with this ratio of synthetic sex pheromone were used as monitoring tools for evaluating the disruptive effect. Z11-16:OH and Z9-14:Ac reduced 58-69% captures of diamondback moth in the pheromone trap. Both Z9-14:Ac and Z11-16:OH showed the disruptive effect on the sexual communication of *Plutella xylostella* at 0.7 m, however significantly more adults were caught when comparing with the pheromone traps at 0 m. So, when using these two chemicals as disruptants for controlling diamondback moth, the spacing between disruptants shorter than 1.4 m was suggested.

Disruptive effects of synthetic sex pheromone components or related compounds have been successfully conducted on many species of lepidopterous pests in the field (Kaae *et al.*, 1974; Mitchell *et al.*, 1974; Taschenberg *et al.*, 1974; Cameron *et al.*, 1975; Grant, 1978; Schmidt *et al.*, 1980; Landolt *et al.*, 1981; Sower *et al.*, 1982; Tingle and Mitchell, 1982; Steenwyk and Oatman, 1983). Diamondback moth is a major problem for vegetable growers in Taiwan. The sex pheromone of *Plutella xylostella* L. has been identified as a combination of (Z)-11-hexadecenal (Z11-16: Ald) and (Z)-11-hexadecenyl acetate (Z11-16: Ac) (Tamaki *et al.*, 1977). (Z)-11-hexadecen-1-ol (Z11-16: OH) and (Z)-9-tetradecenyl acetate (Z9-14: Ac) increased the attractiveness of sex pheromone to diamondback moth in the field (Koshihara and Yamada, 1980; Chisholm *et al.*, 1983). The disruptive effect of its synthetic sex pheromone

components have been demonstrated by Fujiyoshi *et al.* (1979) first in the laboratory and later in the field by Chow *et al.* (1984). The objectives of the present study were concentrated on the distance effect of Z9-14: Ac and Z11-16: OH on the sexual communication of diamondback moth as disruptants mainly. Since population-dependent variation of male response to female sex pheromone of this insect was found in Taiwan (Maa *et al.*, 1983, 1984), a study on the optimal ratio of synthetic sex pheromone in field was also carried on.

MATERIALS AND METHODS

Chemicals

Pheromones used were synthesized by an acetylenic route from 1, 10-decanediol as starting material (Lin and Chow, 1983). (Z)-9-tetradecenyl acetate was synthesized by the Wittig condensation between valerylaldehyde and the ylid derived from 9-hydroxynonyltriphenyl phosphorium bromide (Lin *et al.*, 1980). The purity was ca. 95% by gas-liquid chromatography.

Field Test

The following experiments were performed at the cabbage fields, Tao Yuan District, Agricultural Improvement Station, Sang Chung. The sticky traps baited with 50 μg of sex pheromone in the ratio of 5:5:0.1 were set up around the experimental field for preventing the input of the diamondback moth during the experimental period for each experiment. All the traps were hanged above the cabbage crops. The tested disruptant and baits were put into the plastic microtube (PM) with one-side open. Renew the traps and chemicals at each capture for each experiment. All the data were analyzed by the Duncan's multiple range test.

The optimal ratio of the synthetic pheromone

Five ratios, 7:3:0.1, 6:4:0.1, 5:5:0.1, 4:6:0.1, and 3:7:0.1 of Z11-16:Ald, Z11-16:Ac, and Z11-16:OH were tested to find the optimal ratio to be used as baits for following experiments. The sticky traps baited with 50 μg of sex pheromone at different ratio were hanged by 8 m apart in a 5×5 latin square. Moth captures were recorded every 4-5 days from Oct. 11-24, 1983.

The disruptive effect of the disruptants

Z11-16:OH (1 mg in 1 PM and 10 mg in 10 PMs) and Z9-14:Ac (5 mg in 1 PM and 10 mg in 2 PMs) were tested as disruptants. The sticky traps were baited with the disruptant and sex pheromone (3:7:0.1) at the same trap. Sex pheromone in the ratio of 3:7:0.1 was served as a control. Traps were hanged by 8 m apart in a 5×5 latin square. The number of captures was recorded every 3-4 days in the period of Nov. 1-25, 1983. Each capture was separated in time by 2-3 days interval for redistributing moths.

The distance effect of the disruptants

Test 1

Z9-14:Ac (10 mg in 2 PMs) was used as the disruptant. The sticky traps baited with sex pheromone (3:7:0.1) were hanged at 0 m, 6 m, 12 m, and 18 m from the disruptants as treatments. Randomized completely block design (RCBD) with 10 blocks were used and the treatments were randomized each time for 3 times. The number of captures was recorded every 5 days (Dec. 23, 1983-Jan. 10, 1984). Each record was separated by 2-4 days interval for redistributing the adults. Each treatment was separated by 6 m.

Test 2

Z9-14:Ac (10 mg in 2 PMs) was used as the disruptant. The sticky traps baited with sex pheromone (3:7:0.1) were hanged from disruptants at 0 m, 2 m, 4 m, and 6 m separately as treatments. The number of captures was recorded every 5 days. Each record was separated by 3 days interval. The test period was in Jan. 13-31, 1984. RCBD with 3 blocks was used. Treatments with 12 m apart were randomized each record.

Test 3

Z9-14:Ac (10 mg in 2 PMs) was used as

the disruptant. The sticky traps baited with synthetic sex pheromone in the ratio of 3:7:0.1 were hanged at 0 m, 0.7m, 1.4 m, and 2 m from disruptants separately. RCBD with 12 blocks were used with 6 m apart in the treatments. The number of captures was recorded every 3-4 days in the period of Feb. 20-27, 1984. Each record was separated by 2 days interval. The traps were randomized each time.

Test 4

Z11-16:OH (10 mg in 10 PMs) was used as the disruptant. The sticky traps baited with 3:7:0.1 of sex pheromone were hanged at 0 m, 2 m, 4 m, and 6 m from disruptant separately. RCBD with 3 blocks were used. The treatments with 12 m apart were randomized each time. The number of captures was recorded every 3-4 days in Feb. 6-17, 1984. Each record was separated by 2 days interval.

Test 5

Z11-16:OH (10 mg in 10 PMs) was used as the disruptant. The sticky traps baited with sex pheromone in the ratio of 3:7:0.1 were hanged at 0 m, 0.7 m, 1.4 m, and 2 m from disruptants separately. RCBD with 12 blocks were used with 6 m apart between treatments. The number of captures was recorded every 3-4 days in the period of March 5-11, 1984. Each record was separated by 2 days interval and the treatments were randomized each time.

RESULTS

The Optimal Ratio of Synthetic Sex Pheromone

The optimal ratio of synthetic sex pheromone was 3:7:0.1 of Z11-16:Ald, Z11-16:Ac, and Z11-16:OH in the San Chung cabbage field (Table 1). The mean number captures per trap was significantly different from each ratio except 5:5:0.1 and 7:3:0.1. The captures were decreased by increase of the aldehyde and decrease of the acetate in general. However, 7:3:0.1 ratio were better than the 6:4:0.1 ratio.

TABLE 1
The attractiveness of synthetic sex pheromones in the different blends on diamondback moth

The ratio of synthetic sex pheromone[1]	Mean no. captures[2]/trap/3-4 days
3:7:0.1	37 a
4:6:0.1	27 b
5:5:0.1	18 c
7:3:0.1	17 c
6:4:0.1	8 d

1. (Z)-11-hexadecenal:(Z)-11-hexadecenyl acetate:(Z)-11-hexadecen-1-ol
2. Means followed by the same letter are not significantly different at P=0.05.

The disruptive Effect of Z9-14:Ac and Z11-16:OH

Moth captures were significantly reduced per trap to 58-69% when treated with Z11-16:OH and Z9-14-Ac (Table 2). However, two chemicals were not significantly different from each other.

TABLE 2
The disruptive effect of (Z)-11-hexadecen-1-ol (Z11-16:OH) and (Z)-9-tetradecenyl acetate (Z9-14:Ac) on diamondback moth

Disruptant	Mean no. captures/trap/2-3 days	% reduction
Control	348 a	—
Z11-16:OH (10 mg)	147 b	58
Z11-16:OH (1 mg)	145 b	58
Z9-14:Ac (5 mg)	110 b	68
Z9-14:Ac (10 mg)	107 b	69

Means followed by the same letter are not significantly different at P=0.05.

The Distance Effect

Test 1

The distances between disruptant and pheromone traps from 0-18 m were tested to show the disruptive effect (Table 3). The traps at 6 m from disruptants were significantly different from those at 12 m, 18 m, and 0 m from disruptants. Twelve meter and 18 m were not significantly different from each other

TABLE 3
The distance effect of (Z)-9-tetradecenyl acetate from 0-18 m on diamondback moth

Distance between disruptant and pheromone trap	Mean no. captures/trap/4 days
6 m	36 a
12 m	27 b
18 m	24 b
0 m	1 c

Means followed by the same letter are not significantly different at P=0.05.

in the mean number captures but were significantly different from 0 m.

Test 2

The mean number captures per trap at 2 m, 4 m, and 6 m from disruptants were not significantly different from each other but were significantly different from that at 0 m (Table 4).

TABLE 4
The distance effect of (Z)-9-tetradecenyl acetate (10 mg) from 0-6 m on diamondback moth

Distance between disruptant and pheromone trap	Mean no. captures/trap/4 days
4 m	26 a
2 m	25 a
6 m	21 a
0 m	1 b

Means followed by the same letter are not significantly different at P=0.05.

TABLE 5
The distance effect of (Z)-9-tetradecenyl acetate from 0-2 m on the diamondback moth

Distance between disruptant and pheromone trap	Mean no. captures/trap/2-3 days
2.0 m	44 a
1.4 m	41 a
0.7 m	28 b
0.0 m	3 c

Means followed by the same letter are not significantly different at P=0.05.

Test 3

The mean number captures per trap were increased by distances from 0-1.4 m (Table 5). No significant difference presented in the moth captures between 2 m and 1.4 m.

Test 4

Significantly the stick traps baited with the sex pheromone at 2 m, 4 m, and 6 m from disruptants caught more adults than the sticky traps baited with the sex pheromone and disruptant, Z11-16:OH. The mean number captures per trap at 2 m, 4 m, and 6 m were not significantly different from each other (Table 6).

TABLE 6
The distance effect of (Z)-11-hexadecen-1-ol from 0-6 m on diamondback moth

Distance between disruptant and pheromone trap	Mean no. captures/trap/2-3 days
2 m	47 a
6 m	39 a
4 m	37 a
0 m	5 b

Means followed by the same letter are not significantly different at P=0.05.

Test 5

The mean number captures per trap were increased by the distance from 0-2 m (Table 7). However, 0.7 m were 1.4 m were not significantly different from each other in the mean number captures per trap.

TABLE 7
The distance effect of (Z)-11-hexadecen-1-ol from 0-2 m on the diamondback moth

Distance between disruptant and pheromone trap	Mean no. captures/trap/2-3 days
2.0 m	53 a
1.4 m	41 b
0.7 m	36 b
0.0 m	3 c

Means followed by the same letter are not significantly different at P=0.05.

DISCUSSION

Z11-16:OH and Z9-14:Ac used as the disruptants were only reduced 56-69% captures of diamondback moth. The dosages of 1 mg-10 mg of both disruptants made no difference in statistics. In Z9-14:Ac, the distance at 0.7 m showed the disruptive effect on the sexual communication of diamondback moth. However, comparing the mean captures with 0 m, significantly more captures presented at 0.7 m. In Z11-16:OH, the same situation happened in 0.7 m and 1.4 m. So, when using these two chemicals for controlling diamondback moth, the spacing between disruptants shorter than 1.4 m was suggested.

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REFERENCES

CAMERON, E. A., C. P. SCHWALBE, L. J. STEVENS, and M. BEROZA (1975) Field tests of the olefin precursor of disparlure for suppression of mating in the gypsy moth. *J. Econ. Entomol.* **68**(2): 158-160.

CHISHOLM, M. D., W. F. STECK, E. W. UNDERHILL, and P. PALANISWAMY (1983) Field trapping of diamondback moth *Plutella xylostella* using an improved four-component sex attractant blend. *J. Chem. Eco.* **9**(1): 113-118.

CHOW, Y. S., Y. M. LIN, N. S. LEE, and H. J. TENG (1984) The disruption effect of the synthetic sex pheromone and its analogues on diamondback moth *Plutella xylostella* L. in the field. *Bull. Inst. Zool., Academia Sinica* **23**(1): 119-122.

FUJIYOSHI, N., K. MIYASHITA, and K. KAWASAKI (1979) Mating inhibition in the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) with its synthetic sex pheromone. *Jap. J. Appl. Entomol. Zool.* **23**: 235-239.

GRANT, G. G. (1978) Field trials on disruption of pheromone communication of tussock moths. *J. Econ. Entomol.* **71**(3): 453-457.

KAAE, R. S., H. H. SHOREY, L. K. GASTON, and H. H. HUMMEL (1974) Sex pheromones of lepidoptera: disruption of pheromone communication in *Trichoplusia ni* and *Pectinophora gossypiella* by permeation of the air with nonpheromone chemicals. *Environ. Entomol.* **3**(1): 87-89.

KOSHIHARA, T., and H. YAMADA (1980) Attractant activity of the female sex pheromone of diamondback moth, *Plutella xylostella* (L.), and analogue. *Jap. J. Appl. Entomol. Zool.* **24**: 6-12.

LANDOLT, P. J., C. E. CURTIS, J. A. COFFELT, K. W. VICK, P. E. SONNET (1981) Disruption of mating in the navel orangeworm with (Z, Z)-11, 13-hexadecadienal. *Environ. Entomol.* **10**(5): 745-750.

LIN, Y. M., and Y. S. CHOW (1983) Synthesis of insect sex pheromone and their homologues II. Synthesis of the sex pheromones of the diamondback moth and *Spodoptera litura* F. The proceedings of the Symposium on the insect Control of vegetables in Taiwan. (in press).

LIN, Y. M., Y. S. CHOW, and STELLA C. L. HSU (1980) Synthesis of insect sex pheromones and their homologues I. (Z, E)-9, 11-Alkadienyl acetates. *J. Chinese Chem. Soc.* **27**: 107-111.

MAA, C. J. WILLIAM, Y. M. LIN, and Y. S. CHOW (1983) Variation of pheromone response and antennal esterase activity of the male diamondback moth (*Plutella xylostella* L.) of Taiwan. Pages 157-165 in "Proceedings of the Seminar on Allelochemicals and Pheromones" ed., by Chou, C. H. and Waller, G. C. Monograph no. 5, Institute of Botany, Academia Sinica, Taipei, Taiwan, ROC.

MAA, C. J. WILLIAM, Y. M. LIN, and Y. S. CHOW (1984) Population-dependent variation of male response to female sex pheromone of diamondback moth (*Plutella xylostella* L.). in northern Taiwan. *Plant Prot. Bull.* **26**(3) (in press).

MITCHELL, E. R., W. W. COPELAND, A. N. SPARKE, and A. A. SEKUL (1974) Fall armyworm: disruption of pheromone communication with synthetic acetates. *Environ. Entomol.* **3**(5): 778-780.

SCHMIDT, J. O., W. D. SEABROOK, R. J. ROSS, S. DARVESH, and G. LONERGAN (1980) Spruce budworm: roles of pheromone components and analogues in male disruption and attraction. *Experientia* **36**(2): 222-223.

SOWER, L. L., D. L. OVERHULSER, G. E. DATERMAN, C. SARTWELL, D. E. LAWS, and T. W. KOERBER (1982) Control of *Eucosma sonomana* by mating disruption with synthetic sex attractant. *J. Econ. Entomol.* **75**(2): 315-318.

STEENWYK, R. A. VAN, and E. R. OATMAN (1983) Mating disruption of tomato pinkworm (Lepidoptera: Gelechiidae) as measured by pheromone trap, foliage, and fruit infestation. *J. Econ. Entomol.* **76**(1): 80-84.

TAMAKI, Y., K. KAWASAKI, H. YAMADA, T. KOSHIHARA, N. OSAKI, T. ANDO, S. YOSHIDA, and H. KAKINOHARA (1977) (Z)-11-hexadecenal and (Z)-11-hexadecenyl acetate: sex pheromone components of the diamondback moth (Lepidoptera: Plutellidae). *Appl. Entomol. Zool.* **12**: 208-210.

TASCHENBERG, E. F., R. T. CARDE, and W. L. ROELOFS (1974) Sex pheromone mass trapping and mating disruption for control of redbanded leafroller and grape berry moths in vineyards. *Environ. Entomol.* **3**(2): 239-242.

TINGLE, F. C., and E. R. MITCHELL (1982) Disruption of pheromone communication of the tobacco budworm in tobacco fields treated with pheromone components. *J. Econ. Entomol.* **75**(1): 50-56.

乙酸(順)-9-十四烯酯和(順)-11-十六烯醇對小菜蛾性費洛蒙訊息交換之有效干擾距離

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在桃園改良場三重分場之甘藍菜田中，小菜蛾之人工合成性費洛蒙 (順)-11-十六烯醛、乙酸 (順)-11-十六烯醇和(順)-11-十六烯醇，其比例以 3:7:0.1 (劑量爲 50 微克) 之誘蟲效果最好。故以此比例之費洛蒙爲本次干擾試驗效果之調查誘餌。乙酸 (順)-11-十四烯酯和 (順)-11-十六烯醇可減少 58-69%之人工合成性費洛蒙之誘蟲效果，此兩種化合物在 0.7 公尺之處，都有干擾效果存在。但在此之性費洛蒙誘蟲盒所捕捉之雄蛾數比干擾劑所在之性費洛蒙誘蟲盒所捕捉之雄蛾數爲多，故應用此兩種化合物當干擾劑來防治小菜蛾時，任兩干擾劑之距離應小於 1.4 公尺。