13

Evaluation of Communication Disruption Method Using Synthetic Sex Pheromone to Suppress Diamondback Moth Infestations

T. Ohno, T. Asayama and K. Ichikawa

Horticulture Institute, Aichi-Ken Agricultural Research Center, Nagakute, Aichi 480-11, Japan

Abstract

Field tests were conducted in 1987 and 1988 to evaluate the communication disruption method for the control of diamondback moth, *Plutella xylostella* (L.), on cabbage using a synthetic sex pheromone dispenser (SSPD) containing (Z)-11-hexadecenal: (Z)-11-hexadecenyl acetate (36:41). Fields for the SSPD setting were flat with strong winds in the Atsumi Peninsula and undulating mountainous area in Sitara, the northern district of Atsumi. The cabbage-growing season in Atsumi is from September to March, and in Sitara from June to October. The SSPD was set on the cabbage field when temperature was decreasing in Atsumi, and increasing in Sitara. The DBM adult population density in the field with SSPD treatment decreased by 92 to 97% in Atsumi and 95% in Sitara compared to that in the field without SSPD treatment. The mating rate in the SSPD-treated field in Atsumi was only 5.4 and 3.3% at 13 and 41 days after the SSPD setting, respectively, while that in untreated field was 50.9 and 30.4%. In Sitara, the former was only 0 and 5.3% at 20 and 63 days after the SSPD treatment, while the latter was 24.4 and 74.5%. In both of these SSPD-treated areas the larval population remained low. Total dose of the synthetic sex pheromone released from the dispenser was higher in summer than in winter. These results indicate that efficacy of DBM control by the communication disruption method using SSPD is not affected by meteorological or topographical conditions.

Introduction

Insecticide resistance of the diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae), caused by frequent field application of chemical insecticides has been a serious problem in the Atsumi Peninsula of Japan (Nishiwaki et al. 1988). We therefore tried to introduce the synthetic female sex pheromone as a DBM control agent.

Tamaki et al. (1977) reported (Z)-11-hexadecenal and (Z)-11-hexadecenyl acetate as the sex pheromone of the DBM, and showed that the male was attracted by 1:1 or 4:6 mixtures of these components. Fujiyosi et al. (1979) showed mating disruption of DBM using the 1:1 mixture in laboratory experiments. The purpose of our study was to evaluate synthetic sex pheromone to control DBM infestation in cabbage fields of the Atsumi Peninsula and Sitara.

Materials and Methods

Experimental fields

Cabbage fields in Atsumi and Sitara where the crop is cultivated successively were selected. These areas differed in cabbage transplanting time, temperatures during the growing

season and topography. Atsumi is situated in Atsumi Peninsula in the central district of the Japanese Archipelago. The cabbage field in Atsumi was a flat area near the sea with strong winds. Cabbages are transplanted in early autumn and harvested in late winter to spring. The temperature decreases as the season progresses. The Sitara cabbage field is in a mountainous region about 100 km north of Atsumi. The cabbage field is about 1000 m above sea level. Cabbage is cultivated in a sloping field, and are transplanted in early summer and harvested in mid summer to autumn. Here the temperature increases as the season progresses.

Synthetic sex pheromone dispenser

The synthetic sex pheromone dispenser (SSPD) used in the present study contained 36:41 mixture of (Z)-11-hexadecenal and (Z)-11-hexadecenyl acetate sealed in polyethylene tubes (Shin 'Etsu Chem. Co. Ltd). Ten thousand meters of SSPD (250 g AI/ha) was suspended over 0.1 ha cabbage field. SSPD was set on 17 September 1987 in Atsumi, and on 8 June 1988 in Sitara, 30-40 cm above the ground at 10-m intervals after the cabbage transplanting, and was maintained until cabbage harvest time.

Monitoring sex pheromone trap for adult population estimation

Sticky type of monitoring sex pheromone traps (Zoecon Corp.) were set 1 m above the ground in order to evaluate the effect on communication disruption. Each trap was baited with a rubber septum with a mixture of synthetic (Z)-11-hexadecenal. (Z)-11-hexadecenyl acetate and (Z)-11-hexadecenol (5:5:0.1) at a total dose of 0.1 mg (Takeda Chem. Ind. Ltd.). The pheromone traps were set in six plots in the SSPD-treated field and in two plots in the untreated field 7 days before SSPD treatment. Each trap was checked every week for 12 weeks from 17 September to 15 December 1987 in Atsumi, and 13 times in Sitara from 8 June to 31 August 1988.

Mating rate estimation

Estimation of mating rate was done using tethered female moths. In Atsumi, the estimation was conducted 13 days and 41 days after the SSPD setting. It employed 10 tethered female moths in six plots in the SSPD-treated field, and 30 tethered female moths in two plots in the untreated field. In Sitara, a similar procedure was followed at 20 and 60 days after the SSPD setting. Twenty tethered female moths were employed in three plots in the SSPD-treated field and 30 tethered female moths in two plots in the untreated field.

The procedure for mating rate estimation is as follows: Freshly emerged virgin female moths were collected. The forewing of each moth was tied with fine nylon thread 20 cm in length in the plastic tube (1 cm in diameter and 5 cm in depth). In the evening, the tethered female moths in the plastic tube is put randomly on the cabbage in the experimental field. They were recovered the next morning and transferred to the laboratory, and the eggs laid in the plastic tube were examined for hatchability.

Larval population density of the DBM

Larval population in the cabbage fields was counted once a week for 11 weeks from 17 September to 3 December 1987 in Atsumi, and for 12 weeks from 8 June to 31 August 1988 in Sitara. The number of larvae/20 cabbages at each plot were counted in six plots in the SSPD-treated field and at two plots in the untreated field.

Estimation of the evaporated dose of the synthetic sex pheromone

The dose of the synthetic sex pheromone that evaporated was estimated at Aichi-ken Agricultural Research Center located at Nagakute and Sitara. SSPD of 100 m (250 mg AI/m)

long was set 1 m from the ground in sunshine and shade. The weight was measured 12 times once a week from 18 September to 18 December 1987 at Nagakute and 11 times once a week from 22 June to 31 August 1988 at Nagakute and Sitara under only sunshine conditions.

Results and Discussion

1. Effect of SSPD at Atsumi

Occurrence and abundance of DBM adult population. Occurrence and abundance of captured DBM male adults by the monitoring sex pheromone trap between the SSPD-treated cabbage field and the untreated field in Atsumi are shown in Fig. 1. The male adult population density in the field with SSPD treatment decreased to 92 to 97% of that in the field without SSPD treatment during late October to mid November when adult population density peaks. During the experimental period, the total number of adult moths captured by the monitoring sex pheromone trap was 4538 adults/trap in the check field, and 213 adults/trap in the SSPD-treated field. These results showed that communication disruption of adult DBM certainly continued throughout SSPD treatment in the cabbage field.

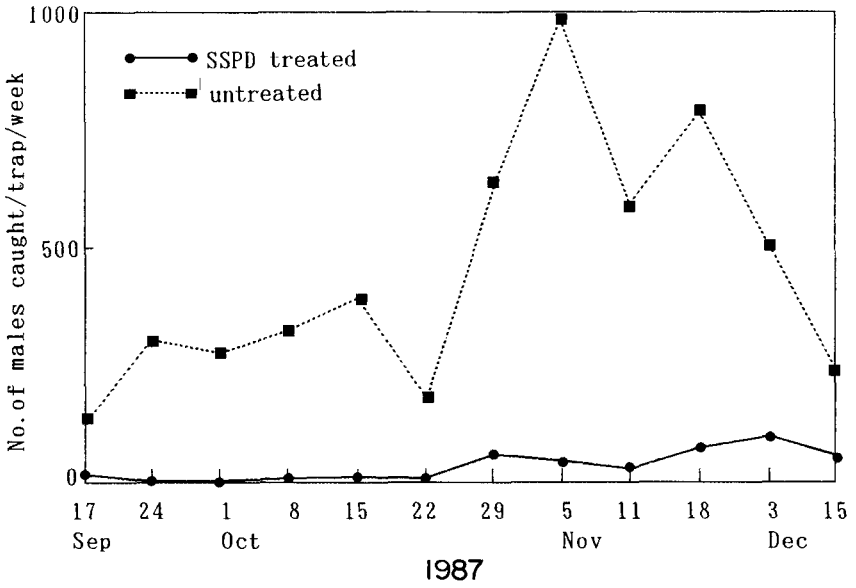

Fig. 1. Occurrence and abundance of captured DBM male adults by the monitoring sex pheromone trap between SSPD-treated and untreated cabbage fields in Atsumi.

Mating rate. The mating rates (number of females mated/number of females recovered alive) of the tethered female moths in the SSPD-treated field were 5.4% (3/56) and 3.3% (2/60) at 13 and 41 days after the SSPD setting, respectively, while those in the untreated field were 50.9% (27/53) and 30.4% (17/56), respectively (Table 1). It seems that these low levels of mating in SSPD-treated fields are the result of mating inhibition caused by the pheromone dispenser treatment.

Occurrence and abundance of DBM larval population. Suppression effects of SSPD treatment against DBM larval populations in the cabbage field in Atsumi are shown in Fig. 2.

Table 1. Mating rates of the tethered DBM female adults in SSPD-treated and control field.

SSPD	Atsumi 1987 Mating rate (%) after		Sitara 1988 Mating rate (%) after	
	13 days	41 days	20 days	63 days
Treated	5.4	3.3	0	5.3
Untreated	50.9	30.4	24.4	74.5

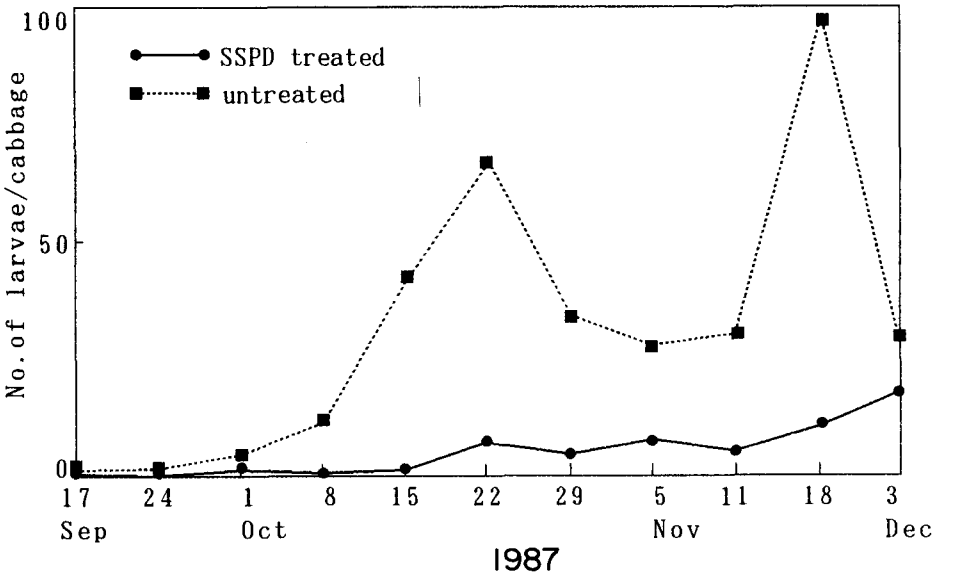

Fig. 2. Suppression effect of SSPD against DBM larval population in cabbage field in Atsumi.

The peak larval population was observed in late October and mid November when 66.5 and 98.1 larvae were found per cabbage plant in the SSPD-treated and check field, respectively. This decrease of DBM larval population resulted from the communication disruption, and mating inhibition of adult moths continued at an extremely low level throughout the period of the SSPD treatment.

Evaporation of the synthetic sex pheromone in SSPD. The dose of the synthetic sex pheromone that evaporated from SSPD in two different circumstances, sunshine and shade, were 2.91 and 2.77 mg/m/day, respectively, just after SSPD setting in mid September, and 0.63 and 0.45 mg/m/day, respectively, at 80 days after the SSPD setting (early December). These results indicated that the release rate of the synthetic sex pheromone from SSPD decreased with decreasing temperature. Total dose of the synthetic sex pheromone evaporated from SSPD was 107.5 mg/m under sunshine conditions, showing that 43.0% of active ingredient was evaporated during 91 days from September to December. There was no difference between sunshine and shade conditions in the dose evaporated.

2. Effect of SSPD at Sitara

Occurrence and abundance of DBM adult population. Occurrence and abundance of captured DBM male adults by the monitoring sex pheromone trap between SSPD treated cabbage

field and untreated field in Sitara are shown in Fig. 3. The male adult population density in the field with SSPD treatment decreased to 95 to 96% of that in the field without SSPD treatment, during mid July to early August when adult population density peaked. During the experimental period, the total number of adult moths captured by the sex pheromone monitoring trap was 789 adults/trap in the check field, and 72 adults/trap in the SSPD-treated field. These results showed that communication disruption of adult DBM certainly continued throughout SSPD treatment in the cabbage field.

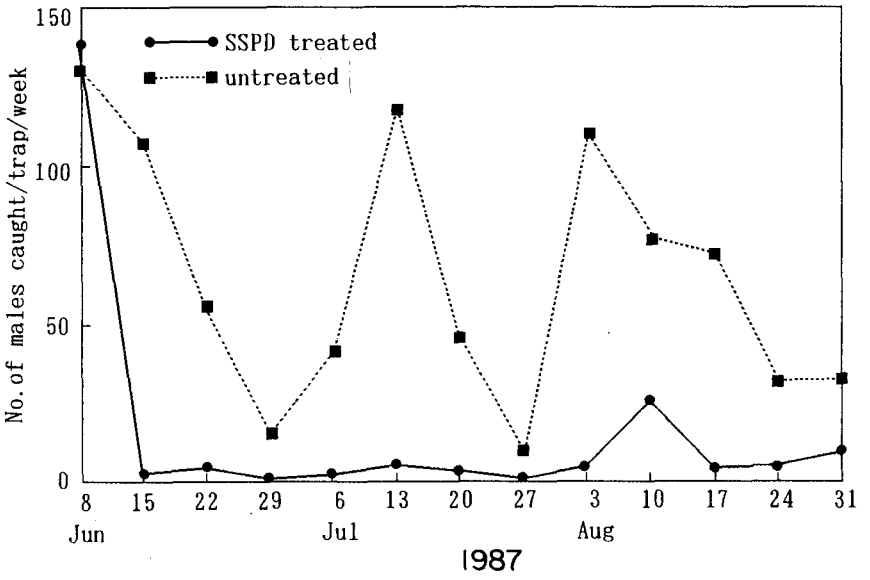

Fig. 3. Occurrence and abundance of captured DBM male adults by the sex pheromone monitoring trap between SSPD-treated and untreated cabbage field in Sitara.

Mating rate. The mating rates of the tethered female moths in the SSPD-treated field were 0% (0/46) and 5.3% (3/57) at 20 and 60 days after the SSPD setting, respectively, whereas those in the untreated field were 24.4% (10/41) and 74.5% (41/55), respectively (Table 1). These data showed that mating inhibition caused by the SSPD treatment was found also in the mountainous region.

Occurrence and abundance of DBM larval population. Suppression effect of SSPD treatment against DBM larval populations at two different cabbage fields in Sitara is shown in Fig. 4. In the first experiment the field where cabbages were harvested in late July (top figure), in the check field the peak larval population was found in late June and mid July when 8 and 33 larvae/cabbage were found. In the second experiment where cabbages were harvested in late August (bottom figure), the peak of larval population was observed in late July and early August. In this experiment 24.9 and 52.7 larvae were found in a cabbage in the check field. In both cabbage fields, the larval population remained at a negligible level throughout SSPD treatment.

Evaporation of the synthetic sex pheromone in SSPD. The dose of the synthetic sex pheromone lost in Sitara and Nagakute was 1.43 and 2.63 mg/m/day, respectively, immediately after SSPD setting in late June. In mid July the peaks of the evaporated dose (2.5 and 3.14 mg/m/day) were seen in Sitara and Nagakute. The release rate of the synthetic sex pheromone

then decreased gradually, reaching a minimum of 1.07 mg/m/day in Sitara, and 1 mg/m/day in Nagakute at 77 days after SSPD setting (late August). Total dose of the synthetic sex pheromone evaporated was 115.1 mg/m, accounting for 46% of total active ingredient in Sitara, and 151.7 mg/m or 60.7% in Nagakute. It seems likely that higher evaporation of the synthetic sex pheromone in Nagakute is due to the higher average temperature (+3.1°C) as compared with that in Sitara.

These results indicate that efficacy of communication disruption with synthetic sex pheromone dispenser against DBM was not affected by meteorological or topographical conditions.

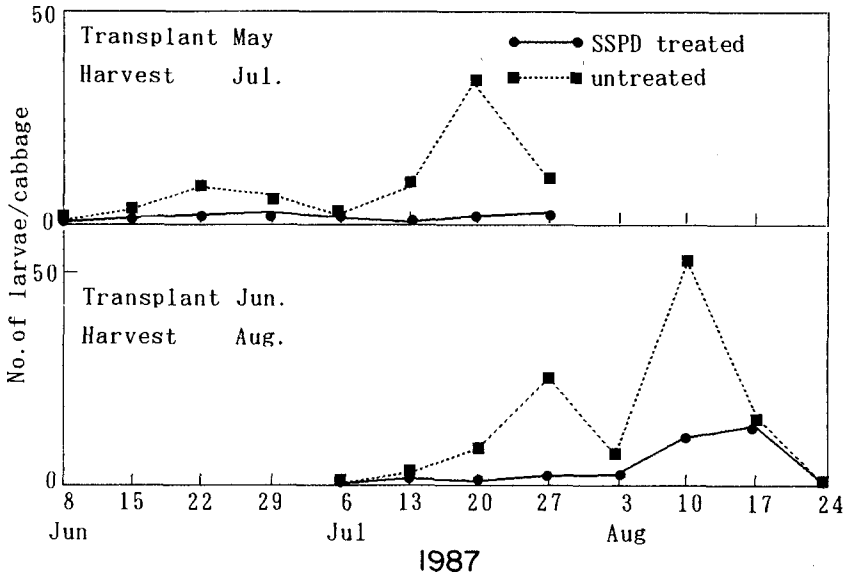

Fig. 4. Suppression effect of SSPD against DBM larval population in cabbage cultivation area in Sitara.

References

Fujiyoshi, N., Miyashita, K., and Kawasaki, K. 1979. Mating inhibition in the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) with its synthetic sex pheromone (in Japanese with English summary). Jpn. J. Appl. Entomol. Zool., 23, 235-239.

Nishiwaki, K., Itoh, K., Kokubo, H., Nomura, M. 1988. Insecticide resistance of diamondback moth in Atsumi Aichi-ken. (in Japanese). Proc. Kansai Plant Prot., 30, 105-106.

Tamaki, Y., Kawasaki, K., Yamada, H., Koshihara, T., Osaki, N., Ando, T., Yoshida, S., and Kakinohara, H. 1977. Z-11-hexadecenal and Z-11-hexadecenyl acetate: sex pheromone components of the diamondback moth (Lepidoptera: Plutellidae). Appl. Entomol. Zool., 12, 208-210.