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DUONG TRAN DINH[1,2], CHIEN TRAN DINH[3], CONG NGUYEN MINH[4]

[1]Department of Entomology and Environmental Protection
Poznań University of Life Sciences
[2]Department of Insect Ecology
Vietnam Academy of Science and Technology
[3]Department of Entomology
Vietnam National University of Agriculture
[4]Division of Vegetable Product Quality Management
Hanoi Plant Protection Sub-Department

A STUDY ON THE POSSIBILITY TO USE PHEROMONE TRAPS TO CONTROL THE DIAMONDBACK MOTH [*PLUTELLA XYLOSTELLA* (L.)] – A CABBAGE PEST IN HANOI, VIETNAM

BADANIA NAD WYKORZYSTANIEM PUŁAPEK FEROMONOWYCH W OGRANICZENIU WYSTĘPOWANIA TANTNISIA KRZYŻOWIACZKA [*PLUTELLA XYLOSTELLA* (L.)] – SZKODNIKA KAPUSTY W HANOI W WIETNAMIE

Abstract
Background. The diamondback moth [*Plutella xylostella* (L.)] is a major insect pest of cruciferous vegetables due to its infestation and resistance to pesticides. Pheromones have highly specialised advantages for each species and they leave no chemical residues. This study was an attempt to improve the understanding of the pheromone trap technique, a necessary step to produce safe vegetables in Vietnam.
Material and methods. The investigations were conducted on cabbage (*Brassica oleracea* L. var. *capitata*) in Hanoi. Pheromone traps were used to catch adult diamondback moths every day and to count larvae on cabbage every 7 days. The data were analysed with Microsoft Excel 2007 and Irristat 4.0.
Results. The highest number of diamondback moths in the first season was 21.2 larvae per 1 m^2 in the trapping variant and 22.1 larvae per 1 m^2 in the non-trapping variant; in the second season it was 17.5 and 19.5, respectively. The F parameter significance between the number of adult insects in the trap and the larval density was linearly proportional, i.e. $F = 0.000202$ (< 0.05) in the first season and $F = 0.000146$ (< 0.05) in the second season. The use of pesticides required higher investment, but yielded lower profit than the pheromone trap (552 €/ha vs 572 €/ha).

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Conclusions. The larval density in the formula with pheromone traps was always lower than in the one without traps. Pheromone traps affected the density of larvae in the field. Not only do they bring more economic benefits than the use of pesticides only, but they also protect the environment and ensure the sustainability of ecosystems.

Keywords: cabbage, pheromone trap, *Plutella xylostella,* safe vegetable production zone, Hanoi

Introduction

The diamondback moth [*Plutella xylostella* (L.)] is a major insect pest of cruciferous vegetables due to its infestation and resistance to pesticides. Diamondback moth larvae damage cruciferous plants at all stages of development, from planting to harvesting. They decrease productivity and the commercial value and reduce the economic value of cruciferous vegetables. However, the scale of damage depends on the density of pests in the field, which is controlled by natural enemies such as syrphid flies, rove beetles, ladybirds, parasitic wasps and spiders. The number of larvae changes over time, depending on the number of adults appearing at an earlier time.

Pheromones are substances produced by insects, which have specific effect on the members of their own species (Bartell, 1977). Due to the fact that they have special advantages for each species, inhibit the development of pesticide resistance in pests, and leave no chemical residues, they are safe for natural enemies and the environment. Therefore, pheromones are widely used for plant protection to detect, monitor and control pests in agricultural crops in many countries, especially those with highly developed agriculture, such as the US, European countries, Japan and Taiwan.

In Vietnam applied research on pheromones began only in 2002 through cooperation programmes under the protocol resulting from the agreement between Vietnam and China, the protocol between Vietnam and Korea of 2005, or the protocol between Vietnam and America of 2007. Studies on pheromone traps have been conducted on the pests of many crops, such as fruit trees, food crops and vegetables, e.g. the rice yellow stem borer (Giang et al., 2012), sweet potato weevil (Linh et al., 2012; Son et al., 2012), rhinoceros beetle (Hao et al., 2003; Hien et al., 2005), pink bollworm (Ut and Tho, 1997). Several techniques were applied, such as: trap density, trap height, trap type (Trinh and Au, 2005; Trinh et al., 2005) and the sex pheromone component (Vang et al., 2008). The results mostly focus on assessment of the potential usage of pheromones in pest control. This study was an attempt to produce safe vegetables in Vietnam.

Material and methods

The experiments were conducted in safe vegetable production zones in Hanoi, Vietnam, in September and December 2011, and from January to April 2012. In both seasons, cabbage (*Brassica oleracea* L. var. *capitata*) seedlings and pheromone traps were placed in an area of approximately 5,400 m^2 at a density of 100 traps per 1 ha. In total, 108 traps were used for two seasons. The cabbage was transplanted into 30 plots of

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10 m × 18 m each with a spacing of 2 m between the plots. In each plot there were 10 raised-bed ridges of approximately 1.2 m in width and 10 m in length. The spacing between the ridge beds was 60 cm. There were three rows in each ridge bed with plants spaced at 40 cm. Thus, a total of 750 cabbage seedlings were transplanted into each plot.

Pheromone traps for diamondback moths were made in plastic bowls with a diameter of 18–22 cm. Three-four small holes were perforated to hang them on racks. The plastic bowls contained water and glycol to keep the samples stable (Fig. 1). All pheromone baits were placed in a cylindrical cage (2.5 × 5 cm in size) with holes to increase the dispersal of active ingredients of pheromones. The baits contained 2 mg of (Z)-11-hexadecenal, (Z)-11-hexadecenol and (Z)-11-hexadecenyl acetate (Fig. 2). The pheromone traps attracted adult males of *Plutella xylostella*. The pheromone baits were replaced every 20 days to keep the power of attraction for moth adults.

Fig. 1. Model pheromone traps used in the field

Fig. 2. Pheromone baits

Dead moths were counted and removed from each trap every day. Then water was added. The density of larvae was estimated in 7 days' time, following the national technical regulation on investigation methods to detect plant pests issued in 2010. The ten-point cross-angle method was used for investigations in the area under study. Five cabbages were chosen at each point and all the larvae on them were counted.

The data were analysed with Microsoft Excel 2007 and Irristat 4.0. Descriptive statistics and regression were used to determine mean, standard errors (SE) and regression equations. Variable Y referred to the larval density, variable X referred to the number of adult insects in the trap.

Results and discussion

Table 1 shows the results of experiments on the effect of pheromone traps on the number of adult diamondback moths and larvae.

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Table 1. Differences in the density of diamondback moth [*Plutella xylostella* (L.)] larvae and adult insects between the two formulas (with and without the pheromone traps) applied to cabbage grown in two seasons between 2011 and 2012

Days after planting	September-December 2011			January-April 2012		
	trap used		non-trap, larvae (per 1 m^2)	trap used		non-trap, larvae (per 1 m^2)
	adult insects (per trap per day)	larvae (per 1 m^2)		adult insects (per trap per day)	larvae (per 1 m^2)	
7	0.3	0	0	0	0	0
14	3.2	1.5	4.4	0.9	1.3	2.2
21	4.3	3.7	5.2	2.5	2.8	4.3
28	5.7	4.8	7.1	5.1	3.9	5.6
35	4.2	6.2	17.4	6.3	5.2	7.8
42	9.3	11.5	15.3	8.6	8.4	14.6
49	15.9	16.2	21.3	13.3	13.7	18.6
56	13.1	21.2	22.1	10.5	17.5	19.5
63	11.4	19.5	14.4	8.8	11.5	11.8
70	9.3	8.9	10.7	6.4	7.6	8.1
Average	7.67 ±1.56	9.35 ±2.37	11.79 ±2.37	6.24 ±1.35	7.19 ±1.79	9.19 ±2.12
Standard error	1.556424	2.372961	2.374796	1.345296	1.792977	2.119028

The results showed that in both seasons the fluctuations in the larval density were similar and the number of larvae in both seasons gradually increased. During the early stages of seedlings all larval densities amounted to zero. They reached the peak value within approximately 56 days after planting. The greatest density of the pest in the first season was 21.2 larvae per 1 m^2 for the trapping formula and 22.1 larvae per 1 m^2 for the non-trapping formula. In the second season it was 17.5 and 19.5, respectively. It is noteworthy that we obtained adult samples at early stages of investigation in the first season, which can be explained by movement from the early season to the main season. Pest infestation may be low if precautionary measures are taken at this time.

There were differences in the number of larvae between the trapping and non--trapping plots – the density in the former was always lower than in the latter. In the first season the density of larvae in the variant with pheromone traps was 9.35 ±2.37 larvae per 1 m^2, whereas it was 11.79 ±2.37 larvae per 1 m^2 in the non-trapping formula. In the second season the densities were 7.19 ±1.79 and 9.19 ±2.12, respectively. It showed the benefits of pheromone traps, which affected the density of larvae in the field.

The correlation between the number of adult insects in the trap and the density of larvae is an important indicator showing the potential of pheromone traps (Figs. 3, 4). In both seasons the correlation between the two variables was relatively tight-structured, i.e. R = 0.838 in the September-December 2011 season and R = 0.850 in the January--April 2012 season.

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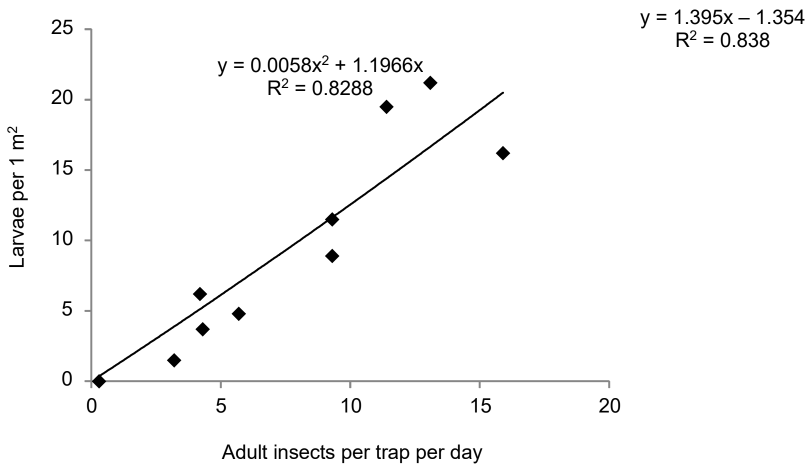

Fig. 3. The correlation between the density of diamondback moth [*Plutella xylostella* (L.)] larvae and adult insects in a cabbage plantation with pheromone traps used from September to December 2011

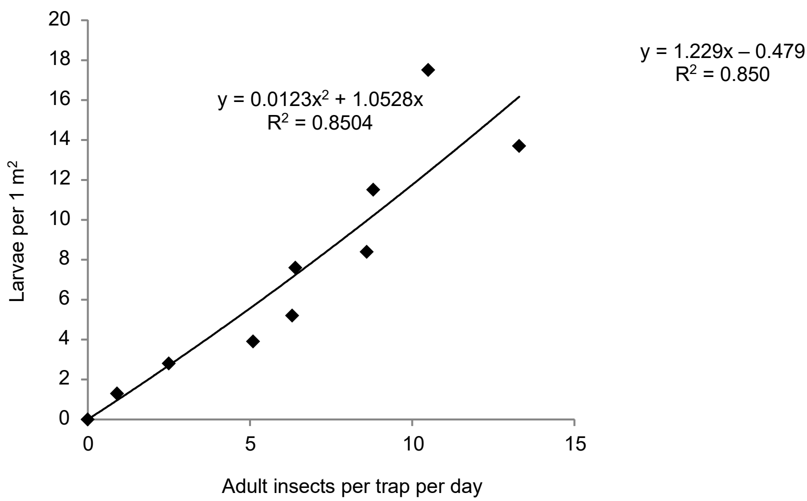

Fig. 4. The correlation between the density of diamondback moth [*Plutella xylostella* (L.)] larvae and adult insects in a cabbage plantation with pheromone traps used from January to April 2012

We built a regression equation to confirm the efficacy of traps in both seasons. In the first season the parameter significance F = 0.000202 (< 0.05), and in the second season F = 0.000146 (< 0.05). The results were reliable and the number of adult insects in the trap was linearly proportional to the larval density. This indicates that pheromone traps can be used to predict the peak of moths to prevent damage in the field.

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We know that chemicals boost agricultural productivity, but the use of pesticides has also raised concerns about its impact on humans, wildlife and sensitive ecosystems. Today in Vietnam there is a conflict between cheap and rather efficient plant protection with pesticides and the resulting pollution of water resources, but nevertheless, the price of pesticides or pheromones should not be equated with the economy of use. The opinion that pesticides are less expensive than pheromones and give more economic benefits needs to be reconsidered.

The results in Figure 5 indicate that the use, input costs and total income of pheromone traps was lower than in the second formula. However, the profit in the first formula was higher than in the other one. This can be explained by the fact that the use of pheromone traps on their own requires less investment capital but brings more profit. It should reduce the cost and volume of pesticide spraying by two-three times.

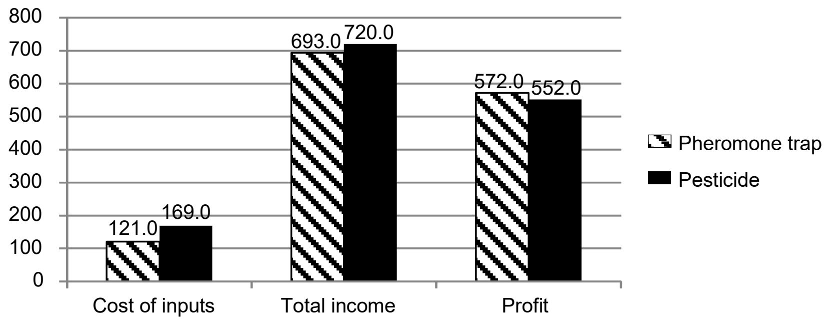

Fig. 5. The economic efficiency of using pheromone traps against diamondback moths [*Plutella xylostella* (L.)]

The pheromone traps proved to be effective. 100 traps per hectare resulted in the density of 0.3–5.9 adult diamondback moths caught into each trap per day. The larval density rose from 0.3 to 21.2 individuals per 1 m^2. It resembles the results obtained by Trinh and Au (2005), where the corresponding numbers were 3.5–35.8 adult insects per trap per day and 0.3–20.1 larvae per plant. Trinh et al. (2005) also pointed out that if pheromone traps were used as a measure of integrated pest management, at a density of 100 traps per 1 ha in combination with probiotics, they would both make the prevention effective and save the costs. In our field experiments there were always differences in the larval density between the formulas. The density of larvae in the trapping formula was always lower than in the non-trapping one, which suggests that pest density can be fully constrained by pheromone traps.

Until now the materials used to capture insects, i.e. water and glycol, have been replaceable. Moreover, the trap is made only from a plastic bowl, so the price is low. A pheromone bait made from a Vietnam rubber tube (about €0.02 per tube) is as attractive as one prepared from Aldrich rubber tube (about €0.625 per tube) (Linh et al., 2012). This was proved in our experiments with pheromone traps: the investment cost is lower than the use of pesticides only. The input cost of a pheromone trap is €121 per 1 ha, whereas the cost of pesticide is €169 per 1 ha (Fig. 5). There is a relatively big gap in the amount of investment between the two formulas. Pesticides require higher in-

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vestment, but yield lower profit than a pheromone trap (€552 per 1 ha vs €572 per 1 ha). Not only are pheromone traps economically beneficial, but they are also safer to the environment and cleaner for people. However, our further investigation in Vanduc Commune, Hanoi, Vietnam, showed that pheromone traps were used only in 24 out of 300 households surveyed. This shows that farmers are not ready to apply new methods of agricultural production. They need more time and better results to switch to green, clean and sustainable agriculture.

Conclusions

1. There were different larval densities in two variants of the experiment. In both seasons the larval density in the formula with pheromone traps was lower than in the one without traps.
2. Pheromone traps affected the density of larvae in the field. They can be used by farmers for pest management to predict the peak number of moths in the field.
3. Not only are pheromone traps more economical than pesticides on their own, but they also protect the environment and ensure the sustainability of ecosystems.

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Abstrakt

Wstęp. Tantniś krzyżowiaczek [*Plutella xylostella* (L.)] należy do głównych szkodników roślin kapustowatych i jest gatunkiem odpornym na pestycydy. Feromony działają selektywnie w stosunku do gatunku i są bezpieczne dla środowiska. Celem badań było opracowanie technik stosowania pułapek feromonowych w strefie bezpiecznej produkcji warzyw w Wietnamie**.**

Materiał i metody. Badania prowadzono w Hanoi, na kapuście (*Brassica oleracea* L. var. *capitata*), stosując pułapki feromonowe. Motyle tantnisia krzyżowiaczka były odławiane każdego dnia. Larwy liczono co 7 dni. Do analizy wyników zastosowano Microsoft Excel 2007 i Irristat 4.0.

Wyniki. W pierwszym sezonie badań stwierdzono największą liczebność larw tantnisia i wyniosła ona 21,2 larwy na 1 m^2 uprawy ze stosowaniem pułapek fermonowych oraz 22,1 larwy na 1 m^2 bez zastosowania pułapek. Odpowiednio w drugim sezonie liczebność ta wyniosła 17,5 i 19,5. Równanie regresji F pomiędzy liczebnością motyli tantnisia odłowionych do pułapek feromonowych a zagęszczeniem larw miało charakter liniowy i w pierwszym sezonie jego wartość wyniosła 0,000202 (< 0,05), a w drugim 0,000146 (< 0,05). Stosowanie pestycydów wymagało większych nakładów finansowych i przyniosło mniejsze zyski niż stosowanie pułapek feromonowych (552 €/ha w porównaniu do 572 €/ha).

Wnioski. Zagęszczenie larw z zastosowaniem pułapek feromonowych było zawsze mniejsze niż bez użycia pułapek. Pułapki feromonowe zmniejszyły efektywnie zagęszczenie larw w uprawach. Stosowanie pułapek feromonowych nie tylko przyniosło korzyści ekonomiczne, lecz także przyczyniło się do ochrony środowiska i zapewniło zrównoważony rozwój ekosystemów.

Słowa kluczowe: kapusta, pułapka feromonowa, *Plutella xylostella,* strefa bezpiecznej produkcji warzyw, Hanoi

Corresponding address – Adres do korespondencji:
Duong Tran Dinh, Katedra Entomologii i Ochrony Środowiska, Uniwersytet Przyrodniczy w Poznaniu, ul. Dąbrowskiego 159, 60-594 Poznań, Poland, e-mail: duongflo@yahoo.com, boniecka@up.poznan.pl

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