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The strategy of trap cropping for reducing the populations of diamondback moth in common cabbage

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Plutella xylostella (L.) (Lepidoptera, Plutellidae) is one of the most destructive pests of cruciferous crops throughout the world. In recent years, diamondback moth has had outbreak in Isfahan province and has caused many damages. The use of usual insecticides in multiple suggested doses was not able to control this pest. Furthermore, high residue of used poisons in crops such as cabbage has multiplied the importance of studying different methods of controlling this pest. One of the alternative methods for controlling diamondback moth is trap cropping that has been the conventional tool of pest management and in recent years the use of it has increased considerably. The goal of this research is to study and compare the several host plants' efficiency (as trap crop) in decreasing population of this important pest in main crop. Following the mentioned subjects, cabbage as main crop and white mustard, Chinese cabbage, turnip and black radish as trap crops in Pirbakran in Isfahan province have been sampled every two weeks. From two weeks after seedling to the end of growth season, once in every two weeks, sampling was done in two forms: larva and pupa on main crop were counted from the sampling of selected 10 plants and adults on trap crop were counted from the sampling of selected three plants. The achieved results showed the number of diamondback moth adult on trap crop has significant difference in different treatments. In the bases, the highest and the lowest mean number of diamondback moth adult per plant at each sampling were observed in white mustard (8.74) and treatment control (1.00), respectively. According to the achieved results, it can be said that white mustard is an efficient and effective trap crop when compared with other experimenting plants for diamondback moth management.

Keywords: *Plutella xylostella*; crucifers; trap crops

Introduction

The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera, Plutellidae), is the most destructive pest of crucifers crops throughout the world and at present this pest is everywhere where its host is found and has the most dispersion among Lepidoptera (Talekar & Shelton 1993; Sarfraz et al. 2005). This pest is an olighophagous and feeds on crucifers family such as cabbage (*Brassica oleracea* var. *capitata*), cauliflower (*B. oleracea* var. *botrytis*), broccoli (*B. oleracea* var. *italica*), radish (*Raphanus sativus* L.), turnip (*B. rapa* L.), brussel sprouts (*B. oleracea* var. *gemmifera*), kohlrabi (*B. oleracea* var. *gongylodes*), Chinese cabbage (*B. pekinesis*), mustard (*B. juncea*),

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rapeseed (*B. napus*) and collard (*B. oleracea* var. *acephala*). And in case of lack of cultivated host, many of cruciferous weeds can be planted (Talekar & Shelton 1993). The ability of this pest to migrate to long distances, its high reproduction rates and lack of natural enemies like parasitoids are the main reasons for its outbreak worldwide (Lim 1992; Talekar & Shelton 1993).

In recent years, diamondback moth has caused so many problems in Iran. Due to the increased damage caused by this pest in the district, the farmers preferred the use of chemical insecticides in doses higher than recommended amounts which led to environment pollution, danger to human health, non-economical production of crucifers crops, negative effects on natural enemies population and also pest resistance to many insecticides (Afiunizadeh et al. 2010; Karimzadeh & Heidary 2012). So with regard to mentioned cases and lack of successful control of this pest, many efforts have been done for performing integrated pest management efficiently, securely and constantly by replacing the conventional insecticides with better and more modern techniques (Karimzadeh & Heidary 2012). In this case, it can be pointed that planting of trap crop has been a conventional instrument of pest management and in recent years, its usage has had considerable increase (Shelton & Badenes-Perez 2006). The first concept of trap cropping in ecological framework emphasises the use of agriculture ecosystem for pest management (Landis et al. 2000). Trap crops are plants which are used for attracting insects and for protecting the crop against pest attack, preventing the pest from reaching near the crop and/or concentrating the pest in certain district of the field for making economical control (Talekar & Shelton 1993). Main specification of trap crop includes diverse and natural attraction for oviposition and feeding. Successful position of trap crops in a field depends on main specifications of trap crop, distance specifications, dynamic and behavioural patterns of pest, agricultural and economical conditions of production system. So, usage of trap crop when compared with many pest management forms is a more conscious method (Shelton & Badenes-Perez 2006). Different studies have been done in the case of planting of trap crops in diamondback moth management. First, a review was done about planting of trap crops in pest management (Hokkanen 1991). Then using of Indian mustard for diamondback moth management was reported (Srinivasan & Krishna Moorthy 1992; Charleston & Kfir 2000). In this direction, some scientists found that Indian mustard is not an attracting plant for diamondback moth (Silva-Krott et al. 1995). But the results of other researches indicated that Indian mustard is an attracting plant for diamondback moth (Charleston & Kfir 2000). Also using of Chinese cabbage, radish and Indian mustard as trap crops for cabbage pests in diamondback moth management and other crucifer pests was reported too (Silva-Krott et al. 1995; Muniappan et al. 1997). Asman (2002) studied the effect of planting Indian mustard and collard on oviposition behaviour of diamondback moth and leek moth (*Acrolepiopsis assectella*). Also, it can be pointed to trap crops' assessment for diamondback moth (Badenes-Perez et al. 2004), concept and application of trap cropping in pest management (Shelton & Badenes-Perez 2006), testing and improving the effectiveness of trap crops for management of the diamondback moth (George et al. 2009), and effect of Indian mustard on feeding, larval survival and development of diamondback moth at constant temperatures (Ansari et al. 2011). It is necessary to cite that no research has been done for using trap crops for controlling diamondback moth in Iran. In this direction regarding the development of incorporative management programmes of pest for selecting suitable host (trap crop) and due to decreasing population density and damage by this important pest, a research was done for showing the effect of planting trap crops for optimum and healthy management of diamondback moth in Esfahan province.

Materials and methods

Planting of trap crops in greenhouse

For planting trap crops, first, seeds of plants including Chinese cabbage (*Brassica pekinensis*) cv.Yuki F1 (Sakata®, Uchaud, France), white mustard (*Sinapis alba*), turnip (*Brassica rapa*) and black radish (*Raphanus niger*) were planted in small earthen vases containing sterilised soil in an investigative greenhouse in Isfahan Azad University of Khorasgan Branch. Plants were reared in greenhouse conditions (25 ± 5 °C, 65 ± 5% RH and L:D 16:8 h) (Karimzadeh et al. 2004; Sarfraz et al. 2007). After two weeks, the vases were transferred out of greenhouse and after four weeks they were transferred to the field.

Planting of seedling of main crops with trap crops in the field

In this study, planting trap crops for controlling diamondback moth, a 2000 m^2 field locating in Pirbakran (Falavarjan county, Isfahan, Iran) which is one of the main districts for planting common cabbage (*B. oleracea* var. *capitata*) cv. Globe Master (Takiss" and Co., Kyoto, Japan) and in recent years due to severe pollution caused by diamondback moth, it has been considered as a selected site for experiment. And contemporaneous with transferring seedling of trap crops into the field, common cabbage seedling was planted in it. Experimental treatment includes: (1) planting of first two rows of plot with Chinese cabbage; (2) planting of second two rows with white mustard; (3) planting of third two rows of plot with turnip; (4) planting of fourth two rows of plot with black radish; and (5) planting of fifth two rows of plot with common cabbage (control treatment), so that experimental plots had dimensions of 12.5 × 8 m (with area of 100 m^2), the distance of plots in block was considered 2 m and the distances between block was considered 10 m. All treatments were performed in four repetitions (block) in completely random blocks form.

Sampling

From two weeks after seedling to the end of growth season, once in every two weeks, sampling was done in two forms: (1) Larva and pupa on main crop were counted from the sampling of selected 10 plants and (2) adults on trap crop were counted from the sampling of selected three plants.

Statistical analysis

Data were analysed by log linear analysis of deviance. Where there was overdispersion, instead of Poisson error the quasi Poisson was used and the comparison of mean was done by honestly significant different (HSD), Tukey's test. All statistical analyses were completed in R 2.10.0 (Crawly 2005, 2007).

Results

The mean number of diamondback moth adults per plant during growth season on different trap crops has been shown in Figure 1. The number of diamondback moth adults on trap crop has shown significant difference among different treatments ($t_{15} = 3.637$, $p < 0.01$). On this basis, the highest and the lowest mean number of diamondback moth

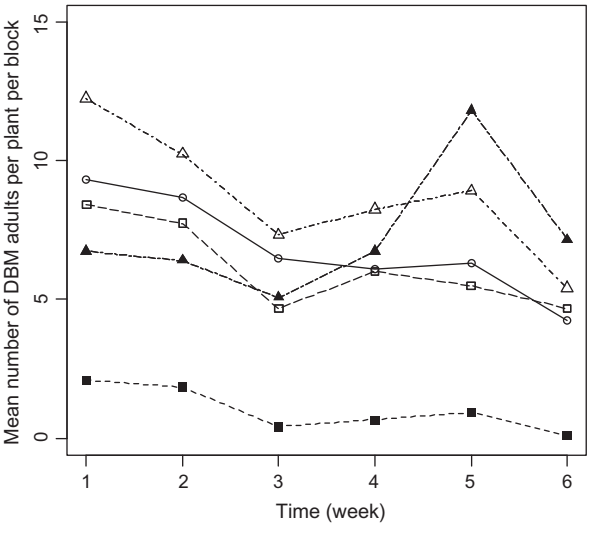

Figure 1. Mean number of *Plutella xylostella* adult per plant during the growing season (per two week) on the trap crop. ○ Chinese cabbage, Δwhite mustard, ■common cabbage, □turnip, ▲ black radish.

adults per plant in each sampling was observed on white mustard (8.74) and treatment control (1.00), respectively. Also, the mean number of diamondback moth adults on white mustard (8.74) was significantly more than black radish (7.33), Chinese cabbage (6.86), turnip (6.17) and common cabbage (1.00) treatment. In this direction, the mean number of diamondback moth adults per plant was significantly observed on black radish (7.33) more than common cabbage (1.00), and also mentioned treatment did not show significant difference with other treatments (Table 1).

The mean of total number of larva and pupa of diamondback moth during growth season on main crop has been shown in Figure 2. Total number of larva and pupa of diamondback moth on main crop (common cabbage) showed significant difference among different treatments ($t_{15} = 2.098$, $p < 0.01$). The highest and the lowest mean of total number of larva and pupa of diamondback moth per plant was observed on common cabbage (1.34) and white mustard (1.05), respectively. In this case, mean of total number of larva and pupa of diamondback moth per plant on common cabbage (1.34) observed more than white mustard (1.05), and also mentioned treatment showed significant difference with other treatment (Table 2).

Table 1. The mean number of *Plutella xylostella* adult per plant during the growing season on the trap crops.

	The number of *Plutella xylostella* adult per plant per sampling date (Mean ± SE; $n = 4$)				
Treatment	White mustard	Black radish	Chinese cabbage	Turnip	Common cabbage
	8.74 ± 0.27 c	7.33 ± 0.32 bc	6.86 ± 0.47 b	6.17 ± 0.41 b	1.00 ± 0.05 a[a]

[a]The different letters within the row are significantly different ($p < 0.05$, Tukey's HSD Test).

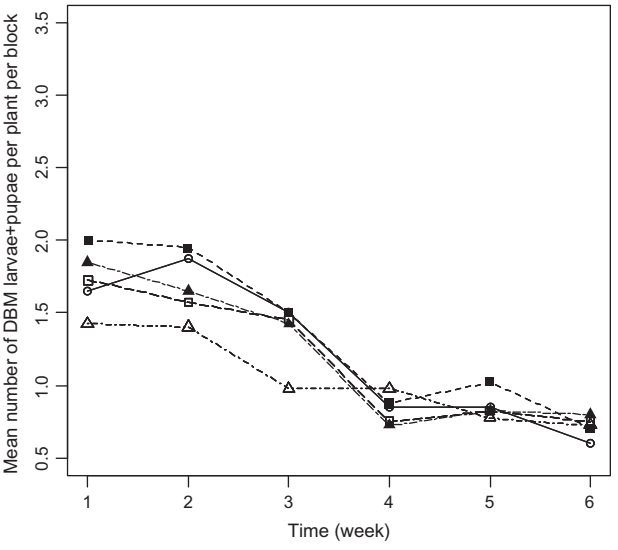

Figure 2. Mean number of *Plutella xylostella* larvae + pupae per plant during the growing season (per two week) on the main crop. ○ Chinese cabbage, Δwhite mustard, ■common cabbage, □turnip, ▲black radish.

Table 2. The mean number of *Plutella xylostella* larvae + pupae per plant during the growing season on the main crop.

	The number of *Plutella xylostella* larvae + pupae per plant per sampling date (Mean ± SE; n =4)				
Treatment	White mustard	Turnip	Black radish	Chinese cabbage	Common cabbage
	1.05 ± 0.04 c	1.18 ± 0.07 bc	1.21 ± 0.06 bc	1.22 ± 0.06 bc[a]	1.34 ± 0.07 ab

[a]The similar letters within the row are not significantly different ($p > 0.05$, Tukey's HSD test).

Discussion

In recent years, outbreak of diamondback moth has caused many damages to crucifers fields. The necessity of studying this research is the importance of crucifer crops, high economic value and vast planting of these plants. So, Chinese cabbage, white mustard, turnip and black radish were used as trap crop against diamondback moth in common cabbage field (main crop). The obtained results showed that white mustard can be effective as an efficient trap crop in decreasing diamondback moth population and its damage in common cabbage field. The pests identify trap crop in the basis of a series of continuous mechanisms and prefer them to other hosts; regarding to this, chemical (olfactory/gustatory) and/or physical (tactile/visual) stimuli have special importance for attracting pests toward certain plants (Badenes-Perez et al. 2004). Moreover, the quality effect of trap crop in its attractiveness is as nutritious source or oviposition place in comparison to main crop (Badenes-Perez et al. 2004). By considering these cases, the first condition of trap crop planting is the reference of pest for oviposition on the plant (Musser et al. 2005). In this study, the highest mean for diamondback moth adults was observed on white mustard and the lowest mean was observed on common cabbage. After white

mustard, the highest mean of population was observed on black radish, Chinese cabbage and turnip, respectively.

The studies have shown that the high rate of attractiveness in crucifers family is mainly arising from chemicals such as sulphur-containing glucosinolate or its metabolites, and allylisothiocyanates, which are available in plant of this family that causes attractiveness property and oviposition stimulation of diamondback moth (Talekar & Shelton 1993; Karimzadeh 2005). In this case, glucosides sinigrin, sinalbin and gluco-cheirolin have been reported as feeding stimulation of diamondback moth (Talekar & Shelton 1993).

White mustard seeds containing sinalbin (4-hydroxybenzyl glucosinolate) (Bodnaryk 1991; Vaughn & Berhow 2005). Regarding to this point, high-potential attractiveness of white mustard and more desirability of this plant is presumably due to high concentration of sinalbin in comparison with other trap crops (Vaughn & Berhow 2005). So, due to the difference in volatile chemical by investigated trap crops, there is different level of diamondback moth attraction on host plants. In fact, white mustard affect diamondback moth behaviour (George et al. 2009). In current study, white mustard also had more acceptable potential for management of this important pest and played an important role in selecting host by the pest. In the researches that have done, one of the most suitable hosts for diamondback moth is white mustard species. In this basis, Indian mustard (*Brassica juncea*) (Srinivasan & Krishna Moorthy 1992; Talekar & Shelton 1993; Charleston & Kfir 2000; Shelton & Badenes-Perez 2006; Ansari et al. 2011) and also white mustard (*S. alba*) (Talekar & Shelton 1993; George et al. 2009) have been used because diamondback moth preferred more to oviposit on these plants. In recent decades, dependence to short term and monomethod guidelines of control, specially the guidelines reliant to chemical insecticides has been increased so that it has caused the need for pest management (Karimzadeh & Farazmand 2011). Today, many efforts have been done in agriculture so that expenses decrease and quality and quantity of products increase. In this regard, it can be pointed to cultural control methods like using trap crops for pest management. Using trap crops before artificial insecticides was one of the methods of pest control; this method which is considered as an old method but as pest resistance to insecticides increased, using trap crops become a special choice. Nowadays, due to increase in the production expenses of crucifer crops and also increase in the cost of insecticides and unsuccessful control of diamondback moth, the farmers were interested in using cultural control methods especially planting of trap crops in producing crucifer crops. On the one hand, cultural control methods do not need any special proficiency and do not hurt human health, use of it is efficient and considerable in producing crucifer crops. It is necessary to cite that ecological pest management (EPM) is mainly distinct of composing pest management. In fact, composing of plant protection methods is compatible with each other and are not dangerous for humans and environment. It is said that EPM's main idea is supporting of natural constancy of arthropoda in agricultural ecosystem and their perimeter environment (Karimzadeh & Farazmand 2011). With appearance and incoming of biotechnology, new opportunities have been made for planting of trap crops for example there was intentionally manipulation of genes usingbiotechnology in trap crops, and its importance in improving and expanding trap crops has been increased (Shelton & Badenes-Perez 2006). In any case, developing and expanding trap crops need to be investigated and studied more so that it must be allocated to the programmes including efficient and optimum pest management and organic agriculture.

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