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Potentiality of Chinese cabbage (*Brassica rapa* subsp. *pekinensis*) as a trap crop for diamondback moth (*Plutella xylostella*) management in cabbage

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ABSTRACT

Laboratory, net house and field experiments were conducted at Varanasi during 2003–07 to study a few biological parameters and ovipositional preference of diamondback moth (*Plutella xylostella* L.) among 6 crucifers for searching an effective and alternative host other than mustard (*Brassica juncea*) with potential of being used as trap crop for management of diamondback moth in cabbage (*Brassica oleracea* var. *capitata*). Although the larval weight was significantly more in Chinese cabbage, the larval period of diamondback moth was significantly more prolonged on Chinese cabbage (10.44 days) than other cruciferous hosts. In laboratory experiments, both no-choice and free-choice tests consistently showed almost two-fold preference by diamondback moth for oviposition on Chinese cabbage over cabbage. In the net house, under free-choice situation also the egg laying preference on Chinese cabbage was significantly higher (377 eggs/plant) than mustard (148.50 eggs/plant) and cabbage (114.50 eggs/plant). The larval population at two intervals after release (10 and 15 days) of adults among the test crucifers inside the field screen cage also confirmed maximum attractiveness of Chinese cabbage over mustard and cabbage for egg laying and larval survival. Considering these facts and better agronomic feasibility of Chinese cabbage as an ideal alternative to mustard for use as a trap crop in the management of diamondback moth of cabbage.

Key words: Crucifers, Ovipositional preference, *Plutella xylostella,* Trap crop

Among the pests of cruciferous vegetables, especially cabbage (*Brassica oleracea* var. *capitata*), diamondback moth (DBM) takes the prime position in causing serious crop losses worldwide. In India, cabbage and cauliflower suffer most from DBM attack, particularly during the primordial stage of the crops. A wide array of pesticides have been tested and are being used for the management of DBM, but mostly they failed to give effective control owing to development of resistance in the pest against many of the pesticides. Growing concerns on environmental issues and health hazards associated with pesticides coupled with pesticide resistance in insects have reoriented the management of pests using alternative methods such as trap crops (Hooks and Johnson 2003). Several trap crops, like Indian mustard [*Brassica juncea* (L.) czernj & coss.], collards (*Brassica oleracea* var. *acephala*) and yellow rocket [*Barberea vulgaris* (R.Br.)], a weed plant have been found to be effective in attracting *Plucella xylostella* adults more over the cabbage (Mitchell *et al*. 2000; Shelton and Nault 2004, Badenes-Perez *et al*. 2004). Trap crops need to be more attractive to the pest as either a food source or as an ideal oviposition site than the main crop. Preference for a particular host plant by a pest over others is due to either chemical stimuli (olfactory/ gustatory) and/or physical stimuli (tactile/visual). Diamondback moth, a specialist folivore on cruciferous vegetable crops seem to be attracted to the phytochemicals, like glucosinolates and their volatile hydrolytic products for its selective feeding and oviposition (Renwick 2002).

The study was undertaken to compare the preference of *P.xylostella* moths for oviposition and biology of the pest among 6 different crucifer crops namely cabbage (*Brassica oleracea* var. *capitata*), Chinese cabbage (*Brassica rapa* subsp. *pekinensis*), Cauliflower (*Brassica oleracea* var. *botrytis*), Broccoli (*Brassica oleracea* var. *italica*), Knolkhol (*Brassica oleracea* var. *gongylodes*) and Indian mustard (*Brassica juncea*) to identify a potential trap crop among them for diamondback moth management.

MATERIALS AND METHODS

Series of laboratory and field experiments were conducted

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during 2003–07 at the Indian Institute of Vegetable Research, Varanasi to study the comparative biology and egg laying preference of DBM, *P. xylostella* on 'Golden Acre' cabbage, 'Granat' Chinese cabbage, 'Pusa Snowball' cauliflower, 'Fiesta' broccoli, 'White Vienna' Knolkhol and 'Varuna' Indian mustard.

Biology of *P. xylostella* on 6 crucifer hosts was studied in the laboratory in completely randomized design by rearing the neonate larvae on the leaves of 45 day-old host plants which were grown in pots, kept under net in a pesticide-free condition. The leaves of respective crucifer were plucked, washed with distilled water and air-dried prior to cutting the leaf lamina identical to the inner bottom surface of 70 mm Petri-plates. The test insect was reared in the laboratory on pesticide free cabbage leaves and allowed to lay eggs on 45 day-old cabbage plants grown inside cage (30 cm×25 cm×30 cm). The neonates were collected from the plants with a camel hairbrush and released into the Petri-plates with the layer of leaf lamina of respective host plants. In each Petri-plate, 5 neonate larvae were released and there were 5 replicates for each treatment. The leaves were replaced on alternate days. The observation on larval period, larval weight and pupal weight was recorded.

Experiments on ovipositional preference of *P.xylostella* moths were conducted in no-choice (1 host at a time) and free-choice (6 host plants at the same time) situations in the laboratory and net house. Under no-choice test, single leaf of each of the 6 crucifer host plants was put in conical flask (250 ml capacity) separately, containing water with the leaf petiole dipped inside the water to keep the leaves fresh and attractive for egg laying. Each flask with the leaf of the host plant was kept individually in a screen cage (30 cm×25 cm×30 cm). Two pairs of freshly emerged male and female moth were released into the cage for oviposition. There were 4 cages representing 4 replications in a completely randomized design. In free-choice host preference study, the conical flasks (250 ml capacity) containing the leaf of all the test host plants separately were kept inside a single bigger screen cage (90 cm×90 cm×80 cm) in a completely randomized design. The positions of flasks containing different host plants in cages were randomized. Six pairs of moths were released into each cage. Observations on number of eggs laid on each of the host were recorded after 3 days of moth release in both the experiments.

Free-choice test involving all the host plants was conducted in outdoor net house to provide near natural conditions for the pest for oviposition. Twenty-days-old pest-free seedlings of the host plants were planted in earthen pots (20 cm upper diameter, 14 cm lower diameter, 20 cm height) containing mixture of farmyard manure, sand and soil (3: 2: 2). The potted plants were kept under net in a pest-free condition. Multiple screens were used, each of which was considered as replication. Six host plants were kept in a circular line with 60 cm radius inside a screen (1.8 m×1.6 m×1.2 m). The experiment was conducted in a completely randomized design with 3 replications. In each replication the position of pots were randomized. At 45 days after planting 60 pairs of laboratory reared, freshly emerged adults were released in each cage. After 3 days of oviposition, the adults were removed from the cage and number of eggs laid in each host plant was recorded. Further, the survival of the pest was observed by counting the number of pupae in each host plant after 25 days of release.

The experiment was conducted under a confined field screen-cage along with release of laboratory-reared adults to study the comparative egg-laying preference of *P. xylostella* in a near-natural and free-choice situation. Twenty-five days old pest-free seedlings of the host plants were planted in the beds (150 cm×40 cm×15 cm) and covered immediately with screen cages (2.0 m×1.2 m×1.2 m) to check egg laying by adults. The host plants were randomized in 3 beds representing the replications. Fifteen pairs of freshly emerged adults were released in each cage after 55 days of planting. The larval population was recorded at 10 and 15 days after release.

The data of all the variables were analyzed using analysis of variance (ANOVA). The means of significant variables were separated by least significant difference (LSD).

RESULTS AND DISCUSSION

Effect of cruciferous hosts on some biological parameters of P. xylostella

Studies on some biological parameters of *P. xylostella* indicated significant differences in larval period, weight of larvae and pupae of the insects fed on the cruciferous hosts. The larval period varied from 8.78 days in broccoli to 10.44 days in Chinese cabbage (Table 1). The larvae duration in Chinese cabbage (10.44 days) was significantly more than cabbage (9.16 days), mustard (9.10 days) and broccoli (8.78 days). However, the growth was most favoured in Chinese cabbage in terms of weight gain. The larval weight was significantly high (5.45 mg) in Chinese cabbage compared to other crucifers (2.37 – 2.83 mg). The pupal weights ranged from 5.49 to 6.41 mg. It was lowest in broccoli and highest in cabbage.

Table 1 Biology of diamondback moth on different crucifer species

Host plant	Larval period	Average weight of larvae (mg)	Average weight of pupae (mg)
Cabbage	9.16^{bc}	2.83^{b}	6.41^{a}
Knolkhol	9.70^{abc}	2.47^{b}	6.31^{a}
Broccoli	8.78^{c}	2.67^{b}	5.49^{b}
Cauliflower	9.56^{abc}	2.37^{b}	5.77^{ab}
Chinese cabbage	10.44^{a}	5.45^{a}	6.25^{a}
Mustard	9.10^{bc}	2.81^{b}	5.70^{b}
CD (P=0.05)	0.88	2.44	0.64

Ovipositional preference in the laboratory and net house

In no-choice test under laboratory conditions, the diamond back moth females laid significantly more number of eggs (26.67/plant) on mustard compared to all other test host plants (Table 2). However, Chinese cabbage was the second most preferred host with 23.00 eggs/plant, which was significantly higher than cabbage (12.33 eggs/plant) and other crucifers (1.00 – 3.33 eggs/plant).

Under free-choice condition in the laboratory, moths oviposited maximum number of eggs in Chinese cabbage (9.00/plant), being significantly more than mustard (2.33/plant), cabbage (4.67/plant) and rest of the hosts (Table 2). Although mustard indicated superiority as preferred host for egg laying in no-choice test, the egg laying preference study conducted both no-choice and free-choice tests in the laboratory consistently showed almost 2-fold preference for oviposition on Chinese cabbage compared to cabbage.

The egg-laying behaviour of *P. xylostella* adults in net house condition where the number of females were more than the laboratory test also confirms the highest preference of Chinese cabbage with 374 eggs/plant significantly more than mustard (148.50) and cabbage (114.25) (Table 3). In this free-choice test for egg laying on other crucifers, ie cauliflower, knolkhol and broccoli had significantly less number of eggs, ie, 98.58, 68.75 and 24.75/plant, respectively.

Field cage condition

In field cage condition, relative population of DBM larvae after 10 days of release on different cruciferous host plants varied significantly, which was maximum (5.66 larvae/plant) in Chinese cabbage (Table 4). There was no significant difference in surviving number of larvae on mustard (1.33) and cabbage (1.33). Later on at 15 days after release there was increase in number of larvae, which may be due to overlapping time of egg laying by the adults. The number of larvae on Chinese cabbage was 11.66/plant being significantly more than all other crucifers. The larval population in cabbage, mustard, cauliflower, broccoli and knolkhol was 4.16, 0.66, 3.50, 3.00 and 5.00, respectively. There was no significant difference in the level of larval population among these host plants.

The series of studies conducted in the laboratory, net house and field conditions confirmed the exclusive preference of diamondback moth for Chinese cabbage as the best host for oviposition and feeding. Although in no-choice test in the laboratory, the number of eggs laid in mustard was significantly more than Chinese cabbage, in all other conditions, Chinese cabbage was more preferred significantly over other hosts like cabbage and cauliflower. In another greenhouse experiment also mustard and Chinese cabbage were the preferred hosts for oviposition and larval feeding by diamondback moth. The biology of diamondback moth indicated that although Chinese cabbage favoured the growth of larvae in terms of weight gain and pupal weight, significantly longer larval duration over other host plants, particularly cabbage and mustard may delay the total life-cycle and indicating its suitability as a trap crop. The pattern of larval growth does not indicate high antibiosis effect of Chinese cabbage on immature stages of diamondback moth, an important character of an ideal trap crop. Hence, in case of its use as a trap crop, it needs periodical spraying of insecticide to kill the trapped larvae as suggested in case of mustard trap crop. Selectively higher attractiveness of Chinese cabbage for egg laying by other insects, viz head borer [*Hellula undalis* (F)], cutworm [*Spodoptera litura* (F.)], pepper maggot (*Delia radicum* L.) and *Crocidolomia pavonana* (Zeller) have proved Chinese cabbage to be ideal trap crop for these pests (Rousse *et al*.

Table 2 Egg-laying preference of diamondback moth on crucifer hosts under laboratory condition

Host plant	No. of eggs/leaf	
	No-choice	Free-choice
Cabbage	12.33^{c}	4.67^{b}
Knolkhol	1.00^{e}	4.00^{bc}
Broccoli	3.33^{d}	1.67^{d}
Cauliflower	2.33^{de}	3.67^{bcd}
Chinese cabbage	23.00^{b}	9.00^{a}
Mustard	26.67^{a}	2.33^{cd}
CD (*P*=0.05)	1.98	2.04

Table 3 Egg-laying preference and pupal population of diamondback moth on crucifer hosts (net house) under free-choice test

Host plant	No. of eggs/plant (3 DAR)	No. of pupae/plant
Cabbage	114.25^{bc}	20.00^{b}
Knolkhol	68.75^{cd}	10.75^{c}
Broccoli	24.75^{d}	18.75^{b}
Cauliflower	98.5b^{c}	4.75^{c}
Chinese cabbage	374.00^{a}	45.25^{a}
Mustard	148.50^{b}	21.00^{b}
CD (*P*=0.05)	61.04	7.30

Table 4 Diamondback moth larval population in different crucifers under field cage condition

Host plant	Larval population/plant	
	10 DAR*	15 DAR
Cabbage	1.33^{bc}	4.16^{b}
Knolkhol	2.50^{b}	5.00^{b}
Broccoli	1.16^{bc}	3.00^{b}
Cauliflower	2.66^{b}	3.50^{b}
Chinese cabbage	5.66^{a}	11.66^{a}
Mustard	1.33^{bc}	0.66^{b}
CD (*P*=0.05)	1.48	5.59

*DAR, Days after release

2003 and Smyth *et al*. 2003). The host selection and ovipositional behaviour of insect occurred in distinct stages, ie host patch selection, host attraction at short distance and assessment (Finch and Collier 2000). In free-choice test, *P. xylostella* adults have been released near suitable hosts, so that the stimuli used during last two stages, ie host attraction and assessment can be assessed. The difference in attraction of cruciferous hosts by diamondback moth is not influenced by total leaf area. Hence, host volatiles, leaf morphology and colour or a combination of these factors are likely to be the major cues responsible for manifesting ovipositional preference in *P. xylostella* (Badenes-Perez 2004). The present investigations confirmed the probability of using Chinese cabbage as a better trap crop over mustard as it constantly harboured more eggs of *P. xylostella*, besides the latter needs 2 sowings to prolong the attractiveness of the plant to the target pest which is not required in case of Chinese cabbage. Both Chinese cabbage and cabbage had similar phenological stages in terms of peak attractiveness of former (trap crop) and critical stage of latter (main trap). These facts strongly support the probability of use of Chinese cabbage as a trap crop for the management of diamondback moth in cabbage. Further field studies are underway to confirm different patterns of planting of Chinese cabbage as trap crop for management of diamondback moth.

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