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Short Communication

Study of the Interactions among Cruciferaceae Crops, Cabbage Feeding Lepidopterans and their Egg Parasitoids

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ABSTRACT: *This study was conducted to examine the host preference by adult crucifer feeding insects and their egg parasitoids in relation to crops of family Cruciferaceae. Radish (Raphanus sativus L.), cabbage (Brassica oleracea L. var. captata), mustard (B. juncea L.) and knol-khol (B. oleracea var,.Gongylodes) crops were cultivated at the University Experimental Station at Dodangolla, Sri Lanka in 5 m x 5 m plots, separated by 5 m wide non-crop natural vegetation. Crops were established on different planting dates in order to get synchronized vegetation. Eggs of crucifer feeding caterpillars were collected at weekly intervals from 10% of plants in each plot. Collected eggs were incubated separately until the emergence of adult parasitoid or the host caterpillar. Plutella xylostella, Crosidolomia pavonana, Trichoplusia ni, and Spodoptera litura were recorded as pest caterpillars. Their oviposition preference significantly varied with the host crop. The total egg parasitism of Trichogramma species significantly varied with the crops. The highest parasitism of T. ni was found in cabbage (57.1%) followed by knol-khol (30.4%).*

Keywords: *Oviposition, parasitism, Plutella, Trichogramma, Trichoplusia*

INTRODUCTION

Crucifers are cultivated over 4,155 ha across the country. Crucifer cultivation is associated with many different production limitations such as crop damage by insects, pathogens and weeds, less crop tolerance to the adverse weather and high input requirements (fertilizer, agrochemicals and irrigation). Insect pest attack is one of the major limitations in crucifer production, particularly cabbage caterpillar complex which includes, diamondback moth (*Plutella xylostella*), cabbage semi looper (*Trichoplusia ni*), cabbage cluster caterpillar (*Crosidolomia pavonana*), and cabbage web worm (*Hellula undalis*) (Kudagamage, 1998). In addition, aphids (*Brevicoryne brassicae*), sap feeding bugs (*Bagrada cruciferarum*), cutworm (*Agrotis* spp.) are of a concern among farmers. Insecticide spraying has been the common practice among commercial farmers to manage cabbage caterpillar complex and ten different insecticides have been recommended by the Department of Agriculture, Sri Lanka (DOA, 2010). Chlorfluazuron 5% EC, Quinalphos 25% EC and Profenophos 50% EC are commonly used insecticides. Several applications of insecticides on crucifers are common among commercial farmers (FAO, 2005). Excessive use of chemicals leads to development of insecticide resistance in pest populations, secondary pest outbreaks and pest resurgence (Robert *et al.,* 1985). As a result, pest management becomes more difficult. In addition,

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many ecological and health problems are associated with insecticide applications. Pollution of soil and water is a significant concern among general public and health workers. Insecticide residues in harvested produce also lead to many health issues. Destruction of natural enemies is another consequence of insecticide application which reduces the level of natural control of pest populations demanding more and more application of insecticides. As a result of all these consequences, reduce use of insecticides has been proposed with the suggestion to implement integrated pest management (IPM) approach. Biological control of insect pest has been well recognized as a strong component of IPM and it is relatively permanent, safe, economical and environmental friendly (Debach, 1964). Cabbage caterpillar complex can be potentially controlled by using egg, larval, and pupal parasitoids (Klass & Dirig , 1981). However, the major limitation of using larval and pupal parasitoids is that, the cabbage feeding caterpillars continue to attack the crop before they are being controlled. Hence, use of egg parasitoids for controlling cabbage caterpillar is a better option as the pest is destroyed at egg stage before they start attacking the crop. In order to use the egg parasitoids efficiently, it is required to understand the interactions among host plants, pest species and the egg parasitoids.

Several factors are involved in host plant use by the phytophagous insects. Visual stimuli such as colour and intensity of the reflected light, tactile stimuli and chemical stimuli are used by insect in host plant selection (Renwick & Chew, 1994). Crucifer-feeding adult insects usually respond to glucosinolates (GS) and some of their breakdown products, e.g isothiocyanates (ITC) (Pivnick *et al*., 1994; Renwick & Lopez, 1999) in host plant selection. Under natural conditions, insects face up to many external stimuli, their own internal physiological stimuli, and a series of environmental constraints (Badenes *et al*., 2004). This makes it very difficult for the insect to distinguish the relative importance of chemical, visual and tactile stimuli from host and non-host plants (Hooks & Johnson, 2001). However, it is generally assumed that the host selection process in insects is directed primarily by volatile chemical signals, later by visual stimuli, and finally by non-volatile chemical signals (Hooks & Johnson, 2001; Santiago *et al*., 2006).

Parasitoids use both physical and chemical cues originated from host plant and insect to locate their host. Chemical cues play more important role in this process (Vinson, 1976; Noldus, 1988; Rutledge, 1996). Most parasitoids use volatile chemicals associated with host insects and host plants as long range cues to locate the habitat of the host insect. When the parasitoids are in the habitat of the host insect, they use short-range cues to locate the host insect. These short distance cues are usually semi-volatile chemicals or physical cues from the host (Vet & Dicke, 1992; Boo & Yang, 2000) which work over distances of about 2 cm (Hendry *et al.,* 1973) or as far as 20 cm (Vinson, 1976; Boo & Yang, 2000). Parasitoids also show an association with crop plants of the host pest. Hence, it is important to understand the behaviors of pest species and their parasitoids among different crucifer vegetables to plan the use of parasitoids effectively in pest management. Therefore, the objective of this study was to examine the interactions among crop, pest insect, and egg parasitoid in crucifer ecosystem in relation to host plant preference by adult crucifer feeding moths and the host preference of egg parasitoids among crucifer crops.

METHODOLOGY

Field experiment was conducted at the University Experimental Farm, University of Peradeniya at Dodangolla during July - September, 2012. The experiment consisted with

5 x 5 m plots each containing one of the crops: radish at the spacing 30 x 15 cm (Japanese ball), cabbage at the spacing 50 x 40 cm (Green cornet), and mustard at the spacing 10 x 10 cm and knol-khol at the spacing 40 x 25 cm (Early white Vienna). Each plot was separated by 5 m wide non-crop natural vegetation. Crops were established on different planting dates in order to get synchronized crop vegetation, suitable for egg laying by crucifer pests. Crops were maintained following recommended agronomic practices without insecticide application. The crops were allowed to have natural insect pest infestation and naturally occurring egg parasitoid populations. Up on the infestation, randomly selected plants, which represent 10% of the plant population, were examined weekly to collect insect eggs in each crop.

Insect eggs were collected with a piece of leaf disk using a cork borer and placed in clear plastic vials (2.5 cm diameter, 5.5 cm height). During the egg collection, leaf number in which the eggs were present, the number of eggs and pest species were recorded. When there were eggs laid by different pest species, egg counts were taken separately.

Eggs, collected from different plots, were separately incubated in individual vials in the laboratory at the room temperature until the emergence of the adults of parasitoids or the host. Level of parasitism was calculated using the following equation given by Van Driesche (1983). The data were analyzed by using Chi square test in SYSTAT (ver 11).

$$Level\ of\ parasitism\ (\%) = \frac{No.of\ adult\ parasitoids}{No.of\ adult\ parasitoids + No.of\ unparasitized\ hosts} X100$$

RESULTS AND DISCUSSION

Four species of leaf feeding caterpillars, *Plutella xylostella, Crosidolomia pavonana, Trichoplusia ni,* and *Spodoptera litura* were recorded in the cruciferous crops. Their oviposition preference significantly varied with different crop species (χ^2 =5634 df=3 p<0.001). Mustard had the highest number of leaf feeding caterpillar eggs representing 63.1% of the total number of eggs (6430) followed by knol-khol (24.5%), cabbage (10.4%) and radish (2.0%) (Table 1).

Table 1.The oviposition preference of different cabbage feeding caterpillar species in terms of number of eggs laid among different crucifer crops.

Crop	*Number of eggs laid*			
	Plutella xylostella	*Crosidolomia pavonana*	*Trichoplusia ni*	*Spodoptera litura*
Cabbage	6	460	55	148
Knol-khol	2	1214	60	298
Mustard	75	3981	0	0
Radish	5	126	0	0
Total	88	5781	115	446

Mustard which has recorded the highest preference for the oviposition by leaf feeding caterpillars is being used by farmers as a trap-crop (Krishnamoorthy *et al.,* 2003). The oviposition preference of different cabbage feeding caterpillar species also varied with different crucifer crops. *P. xylostella* significantly preferred (χ^2 =170.63 df=3 p<0.001) to do oviposition on mustard than cabbage, radish and knol-khol. *C. pavonana* also showed variable preference of oviposition on different crops (χ^2 =6361.9 df=3 p<0.001) and the highest preference was given to mustard (68.9%) followed by knol-khol (20.9%), cabbage (7.9%) and radish (2.2%). These data further confirm the possibility of diverting *C. pavonana* to mustard, using it as a trap crop (Muniappan & Marutani, 1992; Silva-Krott *et al.*,1995 and Muniappan *et al.*, 1997). *T. ni* oviposited only on knol-khol and cabbage and both crops found equally preferred. Therefore, mustard is not suitable as a trap-crop for *T. ni* in cabbage cultivation. *S. litura* eggs were not found on mustard and radish which indicate both crops are not preferred by the pest in presence of cabbage and knol-khol. However, the results indicated that *S. litura* preferred knol-khol (66.8%) than cabbage (33.2%).The total number of eggs belongs to all recorded caterpillar species found vary with the sampling time (χ^2 =4718 df=9 p<0.001). The highest oviposition was recorded in the 6th week of the study period and it was common to all recorded caterpillar species. The comparative studies of the number of eggs laid with the weather pattern during the study period indicated the highest oviposition recorded under relatively dry and sunny weather. The lowest oviposition was recorded during the rainy weather. This further proves the well known fact that insects become very active on warm sunny days (Kobori & Amano, 2003) (Fig. 1).

The rate of parasitism of crucifer feeding caterpillar eggs by *Trichogramma* spp found significantly vary with the host plants (χ^2 = 63 df=3 *p*< 0.001) and the highest parasitism was found in cabbage (3.0 %). *T. ni* eggs were parasitized only in cabbage (57.1%) and knol-khol (30.4 %) (χ^2 = 2.34 df=1 *p*<0.126). *P. xylostella* eggs were parasitized only in mustard (14.6%). Very low level of parasitism was observed with *C. pavonana* and *S. litura* eggs by these parasitoids. *P. xylostella* and *T. ni* lay eggs singly or as very small egg clusters and distributed all over the crop; the eggs were also not covered or overlapped. Therefore, the egg parasitoids can easily locate the eggs and oviposit on them. This reflected by the high parasitism rate in the eggs of *P. xylostella* (14.2%) and *T. ni* (41.9%). On the other hand, *C. pavonana* and *S. litura* oviposit as egg masses and they were concentrated onto few plants of the crop making them difficult to locate by the parasitoids. Further, *C. pavonana* lay as masses of 10-140 eggs per mass and they overlapped with each other (DOAF, 2010). *S. litura* lays eggs as egg masses which contain 200-300 eggs per mass in two or three layers and covered by hairy mat (Espinosa & Hodges, 2012).

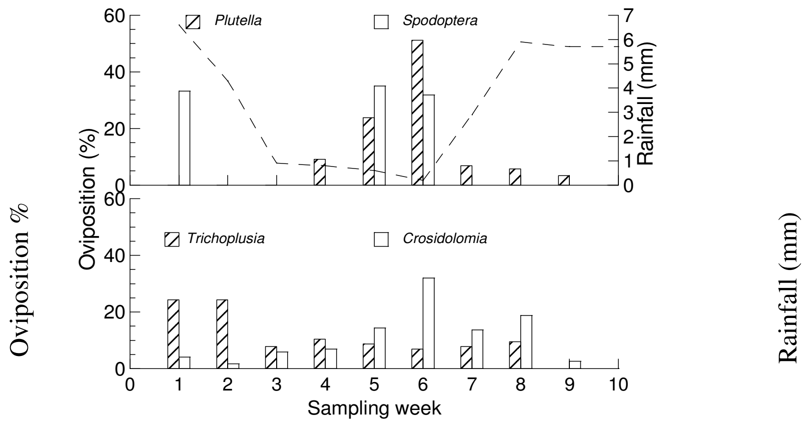

Fig.1. Egg laying activity of four crucifer feeding insect on cabbage, radish, knol-khol and mustard during July-September, 2012 at University experimental farm, University of Peradeniya at Dodangolla. Eggs were counted by examining randomly selected plants.

These adaptations may provide good protection for the eggs against parasitism. The very low rate of parasitism observed in this study by C. *pavonana* and *S. litura* clearly indicates the effect of these adaptations on parasitism of eggs. The different levels of parasitism of *T. ni* eggs by *Trichogramma* spp. in different crops indicated that the parasitoids have some association with the crop on their oviposition. Cabbage or knol-khol recorded similar number of eggs of *T. ni* but the level of parasitism significantly higher in cabbage (57%). Hence, it can be suggested that *Trichogramma* appears to prefer cabbage ecosystem than the knol-khol ecosystem.

CONCLUSIONS

Four species of leaf feeding caterpillars, *Trichoplusia ni*, *Crosidolomia pavonana*, *Plutella xylostella* and *Spodoptera litura* were recorded in the cruciferous crops and their oviposition preference significantly varied with different species of crucifer crop. Mustard found as the most preferred crop for *P. xylostella* and *C. pavonana;* hence, the suitability of mustard as a trap crop in cabbage cultivations is further confirmed. Oviposition by caterpillar pests of crucifer crops is high under dry and sunny weather and low under rainy weather conditions. The oviposition preference of egg parasitoid, *Trichogramma* species varied not only with the host pest species but also with the host crops. The highest oviposition preference of *Trichogramma* species was observed on *T. ni* in cabbage crop followed by *P. xylostella* in mustard and very low parasitism was observed in the eggs of *C. pavonana* and *S. litura.*

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