Effect of Intercropping on the Infestation of Diamondback Moth, *Plutella xylostella* (L.) (Lepidoptera:Plutellidae) on Cabbage

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Abstract

Two consecutive field experiments were carried out at Taunggyi in winter and summer seasons, during the period of September 2015 to June 2016 to evaluate the infestation of diamondback moth (DBM) on cabbage between the two practices (intercropping and insecticide spraying). A field trial was set up in 4 x 2 factorial arrangements with four replications. Factor (A) ; sole cabbage (C), cabbage intercropped with tomato (C+T), cabbage intercropped with chilli (C+ Chi) and cabbage intercropped with wild radish (C+WR) and factor (B); insecticide (I) and no insecticide (I_0) were set up. The results showed that intercropping cabbage with tomato and chilli could reduce the DBM larva population significantly in both seasons. Insecticide (acephate) application has no significant impact on DBM infestation.

Key words: intercropping, insecticide, diamondback moth

Introduction

In Myanmar,cabbage - *Brassica oleracea* var. *capitata* L.(Brassicaceae) is one of the important vegetables and its production faces several constraints including insect pests. Diamondback moth (DBM) is the most deleterious pest of *Brassicae*crop in the world including Myanmar (Nilar Maung *et al*., 2010) and the annual cost for managing it is estimated to be U.S. $ 4-5 billion, globally (Kianpour *et al*., 2014). This pest is considered as a major pest because it's resistance to all insecticides used to control it (Travis and Rick 2007).

Intercropping is one of the cultural control methods. It involves the cultivation of two or more crops simultaneously in the same field. Intercropping can reduce pestpopulationbecause of the diversity of crops grown. Byusingintercroppingas alternativeto chemical, the infestation of diamondback moth can be reduced. This in turn, can also reduce the use of chemical insecticides and thus become decrease the adverse effect of the chemical pesticides (Sullivan 2003).

Some researchers have investigated the effect of intercropping to reduce infestation of DBM on cabbage (Asare-Bediako*et al*., 2010: Moses Brandford *et al*., 2011; Katsaruware Rumbidzai Debra and Dubiwa Misheck 2014; Karavina *et al*., 2014). They found that onion, tomato, garlic and chilli (pepper) can be used as intercrops to reduce DBM infestation on cabbage because of their repellent ability. Furthermore, mustard, Chinese cabbage and collard can also be used as trap crop (Singhamuni and Hemachandra 2013).

In Myanmar, there is no information about the effect of intercropping on the infestation of diamondback moth on cabbage. Therefore, this experiment was carried out to evaluate the infestation level of diamondback moth on cabbage between the two practices (intercropping and insecticide spraying).

Materials and Methods

Experimental Design

The field experiments were conducted at BantBwae village tract, Man Kyii Pin village, Taunggyi Township, Southern Shan State fromSeptember 2015 to June 2016 in winter and summer seasons.The experiment was set up in factorial arrangement in randomized complete block design with four levels of intercropping and two levels of insecticide application. Each plot was 3.9 x 3.9 m^2 in size and the whole experimental area was 44.7 x 23.1m^2. Each plot was replicated four times. The spacing for both intercrops and cabbage was 60cm x 60 cm in both seasons. The two adjacent plots were separated by 1.5 m fallow.

Treatment Combinations were:

Treatment	Treatment combination	
	Intercropping (cabbage) (A)	**Insecticide spraying (B)**
C+I	Sole cabbage	With
$C+I_0$	Sole cabbage	Without
C+T+I	Intercropped with tomato	With
$C+T+I_0$	Intercropped with tomato	Without
C+Chi+I	Intercropped with chilli	With
$C+Chi+I_0$	Intercropped with chilli	Without
C+WR+I	Intercropped with radish	With
$C+WR+I_0$	Intercropped with radish	Without

Plant Preparation

Tomato and chilli were used as repellent crops and wild radish as trap crop. Thirty-day old seedlings were used. The intercrops were transplanted 2 weeks ahead of cabbage. The planting ratio for cabbage : chilli and cabbage : tomato were 2:1 and cabbage : wild radish was 5:1. Each plot was occupied with four rows of cabbage that intercropped with tomato and chilli and five rows for wild radish intercropped. Each row consisted of seven plants and each plot contained 28 cabbage plants and 21 intercrop plants for tomato and chilli. For wild radish intercropped, each plot had 35 cabbage stands and 14 wild radish plants.

Data Collection

Ten cabbage plants were randomly selected for data collection. The outermost rows from every plot were not counted for sampling. Sampling was started at one week after transplanting (1 WAT) and it was continued until harvest at 6 days interval. In each plot, DBM larvae, pupae and natural enemies were recorded.

Insecticide Application

Acephate was used to control DBM in this experiment. The application of insecticide for the control of DBM was carried out based on the economic threshold (ET) level > 37/10 plants developed by Jusoh *et al.*, 1982 in Malaysia.

Weather Conditions

Meteorological data (rainfall) was obtained from Department of Agriculture (DOA), Taunggyi Township. Maximum and minimum temperatures and relative humidity were recorded in the experimental field by using Hygrothermometer for both seasons.

Data Analysis

The data were statistically analyzed by using statistic software (Version 8). Mean comparison was done by Tukey' HSD test at 5% level.

Results and Discussion

Season-long mean number of DBM affected by intercropping in winter and summer seasons

In winter season, season long mean number of DBM larvae was highly significantly different among intercropping practices (Table-1). The highest mean number of DBM larvae (27.77 larvae/10 plants) was found in C (sole cabbage) followed by C+WR (cabbage intercropped with wild radish) (26.013 larvae/10 plant). The lowest number of larvae (5.99 larvae/10 plants) was observed in C+T (cabbage intercropped with tomato) followedby C+Chi (cabbage intercropped with chilli).

In summer season, populations of larvae were also highly significantly different among intercropping practices (Table-1). Peak population of DBM larvae (53.36 larvae/10 plants) was found in C (sole cabbage) and it was not significant different from C+WR (cabbage intercropped with wild radish) (47.23 larvae/10 plant). The lowest mean number (22.16 larvae/10 plants) was observed in C+Chi (cabbage intercropped with chilli followed by C+T (cabbage intercropped with tomato) (22.56 larvae/10 plants).

Present studies showed that intercropping of cabbage with non-host crops reduced the infestation of DBM in study area. This result was in agreement with the finding of Asare-Bediako*et al.*, 2010 they reported that significantly lower population of DBM were recorded in cabbage plant intercropped with other non-host plants due to the confusing olfactory and visual cues received from that.

Season-long mean number of DBM affected by insecticide in winter and summer seasons

The insecticide application has no significant effect on number of DBM larvae in winter season (table-1). The lowest mean number of larvae (16.23 larvae/10 plants) was recorded in I(insecticide application) and it was not significantly different from that of I_0 (without insecticide application) (18.20 larvae/10 plants).

Table 1 Season-long mean number of diamondback moth larvae/10 plants in winter and summer seasons

Treatments		Mean ± SE	
		Winter	Summer
Intercropping (A)	Sole cabbage	27.77 ± 1.33 a	53.36 ± 2.13 a
	Cabbage + tomato	5.99 ± 1.40 b	22.56 ± 1.72 b
	Cabbage + chilli	8.89 ± 1.03 b	22.16 ± 1.77 b
	Cabbage + wild radish	26.01 ± 1.11 a	47.23 ± 1.36 a
Insecticide (B)	With	16.23 ± 0.12 a	36.81 ± 0.06 a
	Without	18.20 ± 0.12 a	35.84 ± 0.06 a
P>F	A	**	**
	B	ns	ns
	A x B	ns	ns
CV %		17.00 %	18.07 %

In summer season, insecticide application had no obvious effect on the infestation of DBM larvae ($P > 0.05$) (table-1). The lower mean number of larvae (35.84 larvae/10 plants) was recorded in I_0 (without insecticide application). However, it was not significantly different from that of I (insecticide application).

The lower efficacy of insecticide in this research could be due to the fact that development of insecticide resistance by DBM. The excessive use of insecticide has resulted in widespread resistance of*P. Xylostella* to almost all major groups of pesticides (Furlong *et al.*, 2013) including organophosphates and arising to failure in its control (Sayyed *et al.*, 2002). RaccardoBommarco *et al.*, 2011 also found that diamondback moth population densities were not affected or became somewhat higher in fields treated with insecticides.

Mean number of DBMLarvae as affected by intercropping and insecticide in winter and summer seasons

In winter season, insecticide application was done three times (figure-1). The first spraying was conducted at 9 WAT as the number of larvae reached economic threshold (ET) level in C+I (26 larvae) and C+WR+I (32 larvae) plots. Then, the number of larvae increased again and reached ET level at 11 WAT and 12 WAT in C+I (>40 larvae) and C+WR+I (>50 larvae).

In summer season, insecticide application was started from 2 WAT until 10 WAT. Among the insecticide treated plots, the insecticide application was carried out 8 times (2-9 WAT) in C+I, 3 times (5,8& 10 WAT) in C+T+I, 3 times (7,8 & 10 WAT) in C+Chi+Iand 9 times (2-10 WAT) in C+WR+I respectively (figure-2).

In both seasons, although insecticide was applied, the number of larvae was not reduced in all insecticide treated plots especially in cabbage sole crop and cabbage intercropped with wild radish plots. The lower efficacy of acephate could possibly be due to the development of resistance by DBM because it was the commonly used insecticide in experimental area by farmers without consideration of frequency and dosage. The result was similar to the report of Andy J Cherry (2004) who observed that the extent of acephate used among the growers is likely to have led to significant resistance in DBM.

In case of intercropped (cabbage with chilli or tomato) for both seasons, the number of DBM larvae was maintained below the ET level throughout the growing season. According to this result, intercropping of cabbage with non-host crops such as tomato and chilli can be used to reduce DBM infestation. The results of present study are in line with the finding of James *et al.*, 2010 who reported that intercropping cabbage with non-host crop could reduce the incidence of pest attack.

Seasonal changes of diamondback moth larvae in winter and summer seasons

In winter season, the number of larvae was very low (<10 larvae per 10 plants) from 2 to 6 WAT. Then, the pest number was gradually increased from 7 WAT until 14 WAT. The highest pest population (47.44 ± 3.78) was observed on 14 WAT (figure 3). This result was similar to the finding of Sachan and Srivastava 1972 who reported that high built-up of larval populations was during February and March (late winter) in India. High temperature and low rainfall might increase in the number of diamondback mothand cabbage aphid (Baidoo*et al.,* 2012).

In summer season, the population of insect pests was initiated to speedily increase at 2 WAT and that was continuously increased until 10 WAT. After that the population was declined drastically till the final sampling date (14 WAT). This may be due to unusually heavy rain occurred in the experimental area during this period (figure4). Badioo*et al.,* 2012 reported that the heavy rains were an important abiotic mortality factor that washing off the eggs and larvae from the leaves.The peak population number (72.97 larvae/10 plants) was observed at 8 WAT and that was not significantly different from those of 7 and 10 WAT. This result was in agreement with the finding of Zhao *et al.*, 2011 who reported that the peak point of DBM population has been occurred during March to May. The smallest mean number (3.72 larvae/10 plants) was collected at 1WAT and that was not significantly different from that of 11, 12, 13 and 14 WAT.

Abundance of natural enemy in winter and summer seasons

In both seasons, four species of natural enemies such as *Cotesia plutellae* (Hymenoptera:Ichneumonidae), spiders (Araneae), Ants (Hymenoptera: Formicidae) and hoverfly (Diptera:Syrphidae) were recorded (Table 2). Among them, *C. plutellae* was the most abundant species in both seasons.

The number of insect in summer season (14.34) was higher than that of winter season (6.34) (figure 5). It may be due to the availability of more prey (density) in summer season. Ali *et al.*, 2013 documented that the abundance of natural enemy was depending on their prey density.

Season-long mean number of natural enemies (NE) as affected by intercropping in winter and summer seasons

In winter season, mean population of NE were highly significantly different among intercropping practices (table 3). The lowest number of NE was found in C (sole cabbage). The highest number was observed in C+Chi (cabbage intercropped with chilli) followed by C+T (cabbage intercropped with tomato) and C+WR (cabbage intercropped with wild radish).

In summer season, mean number of NE were also highly significantly different among intercropping practices (table 3). The lowest number was found in C (sole cabbage). The highest number was observed in C+Chi (cabbage intercropped with chilli) followed by C+T (cabbage intercropped with tomato). The mean number of natural enemies from C+WR (cabbage intercropped with wild radish) was lower than C+T and C+Chi but larger than that of sole cabbage plot. Cai*et al.*, 2010 reported that intercropping systems favored the abundance of natural enemy population.

Season-long mean number of natural enemies (NE)as affected by insecticide in winter and summer seasons

Unlike the pest, season-long mean number of NE was significantly different among insecticide application in both seasons (Table 3). The highest number was recorded in I_0 (without insecticide application) and the lowest in I (insecticide application). This result was in dealt with the finding of Andy J Cherry (2004), who

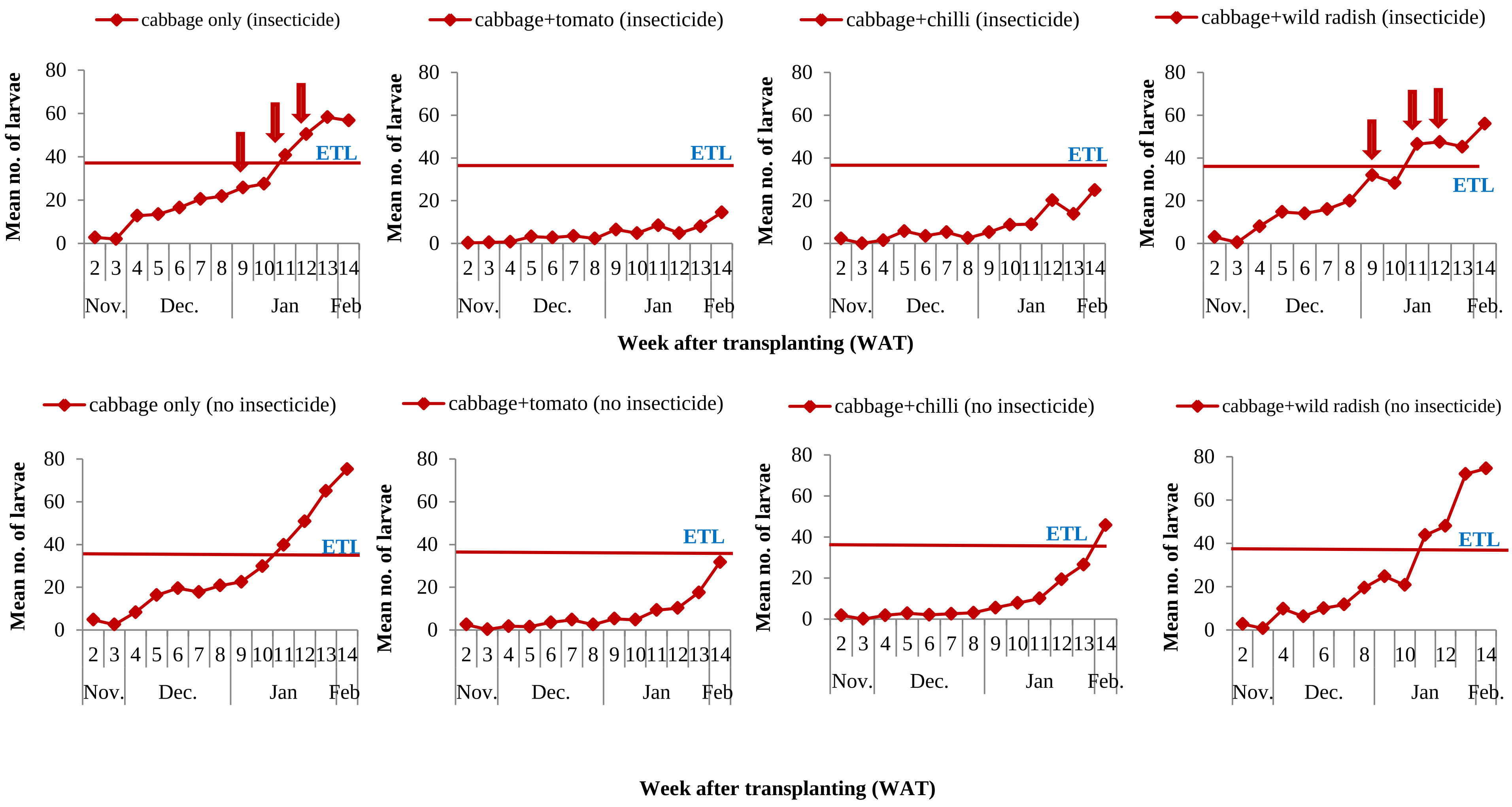


Figure 1 **Mean number of DBM larvae as affected by intercropping and insecticide application in winter season**

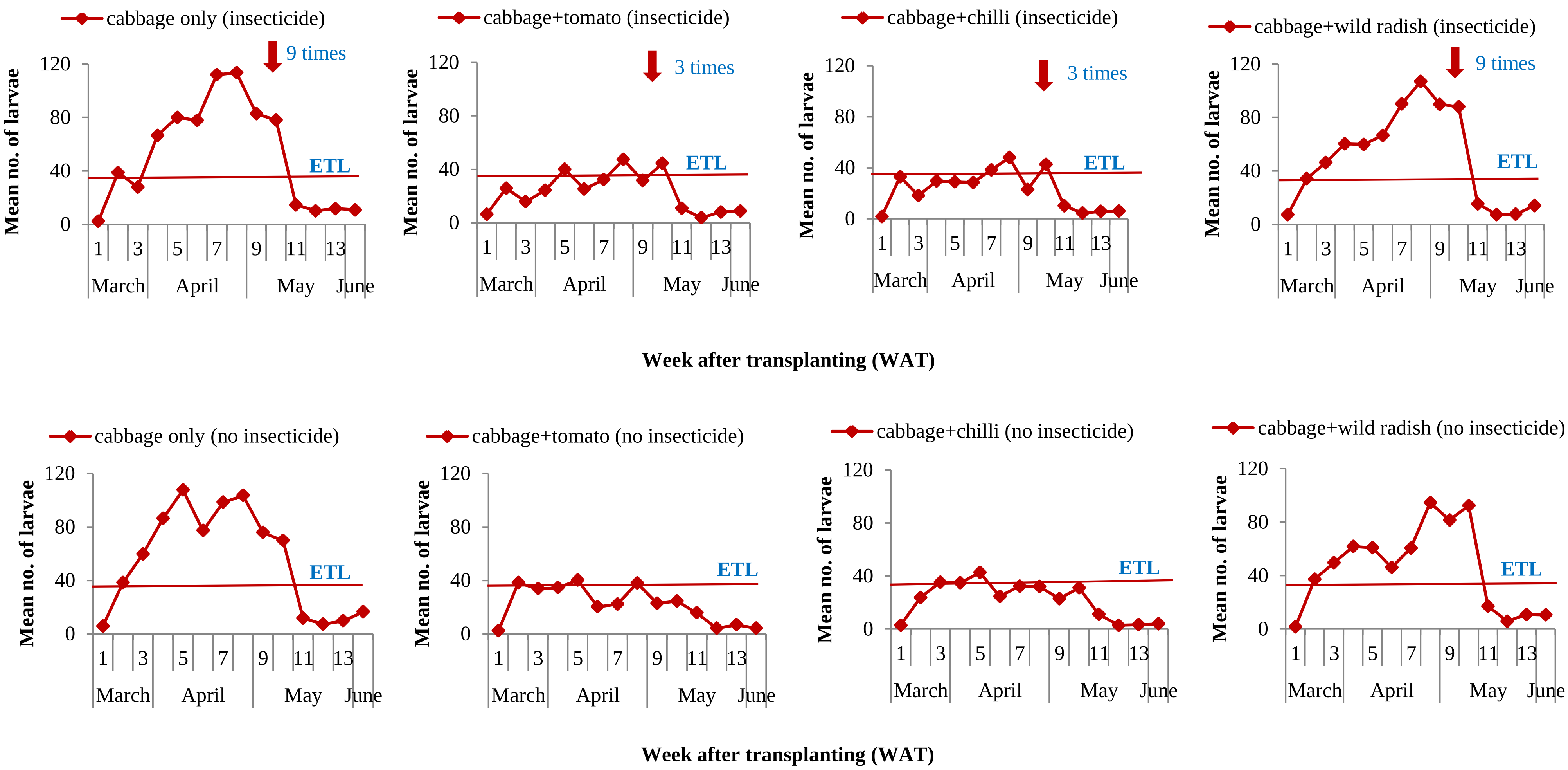


Figure 2 **Mean number of DBMlarvae as affected by intercropping and insecticide application in summer season**

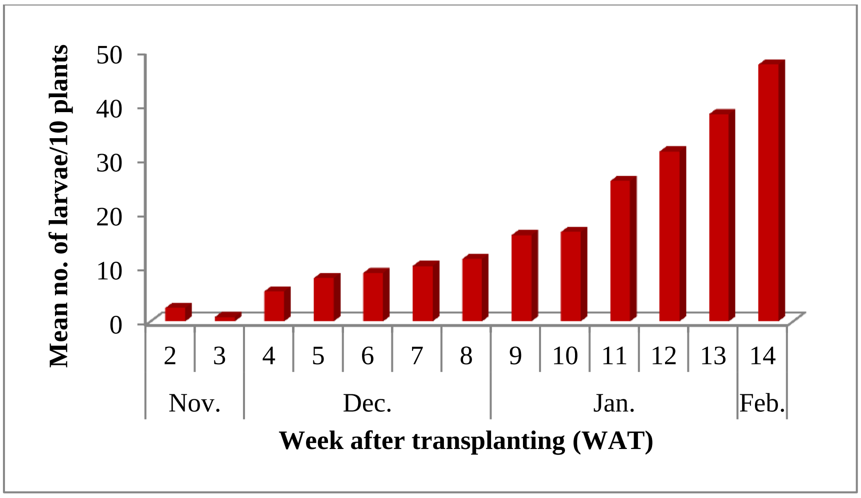


Figure 3 Season change mean number of DBM larvae in winter season.

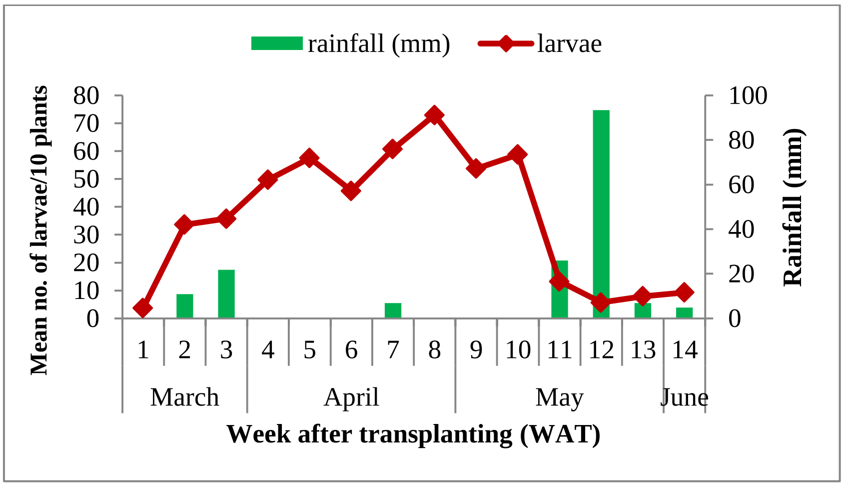


Figure 4 seasonal changes of *Plutella xylostella* larvae as affected by rainfall in summer season

observed that use of acephate significantly reduced the abundance of natural enemy groups found in cabbage field.

Comparison of the population of DBMlarvae in different growing seasons

The number of DBM larvae (17.17 larvae/10 plants) in winter season was lower than that of summer season (36.33 larvae/10 plants)(figure 6). This may be due to the impact of weather condition (temperature and relative humidity). In winter season, October to February the minimum temperature was 17˚C, maximum temperature was 23˚C and relative humidity (RH) 67 % (figure 7-a,b). This lower temperature and higher RH could reduce the multiplication rate of DBM. This results similar to the observation of Patra*et al*.2013 who accounted that cold temperature in November-February limited population dynamics of DBM.

In summer season, March to June, the minimum temperature was 23˚C, maximum temperature was 34˚C and relative humidity was 42 % (figure 7-a,b). These conditions could be favorable for multiplication of this pest. According to Tufail Ahmad and MohdShafiq Ansari 2010, the temperature 34.77˚C significantly enhanced the population of DBM. Moreover, Venkateswarlu *et al*. 2011 reported that relative humidity showed significant negative correlation with *P. xylostella* population.

Table 2 Natural enemies found in winter and summer seasons

Order	Common name	Winter season		Summer season	
		Individual	(%)	Individual	(%)
Hymenoptera	*Cotesia plutellae*	2.76	43.53	7.94	55.37
Araneae	Spider	1.17	18.45	2.00	13.95
Hymenoptera	Ant	1.33	21	3.00	20.92
Diptera	Hoverfly	1.08	17.03	1.40	9.76
Total		**6.34**		**14.34**	

Table 3 Season-long mean number of natural enemies/10 plants in summer season

Treatments		Mean ± SE	
		Winter	Summer
Intercropping (A)	Sole cabbage	3.84 ± 0.31 b	8.75 ± 0.30 c
	Cabbage + tomato	7.40 ± 0.13 a	17.35 ± 1.38 a
	Cabbage + chilli	7.55 ± 0.15 a	17.53 ± 1.40 a
	Cabbage + wild radish	6.55 ± 0.03 a	13.72 ± 0.92 b
Insecticide (B)	With	5.75 ± 0.07 b	11.61 ± 0.66 b
	Without	6.92 ± 0.07 a	17.07 ± 1.34 a
P>F	A	**	**
	B	*	**
	A x B	ns	ns
CV %		15.82 %	9.39 %

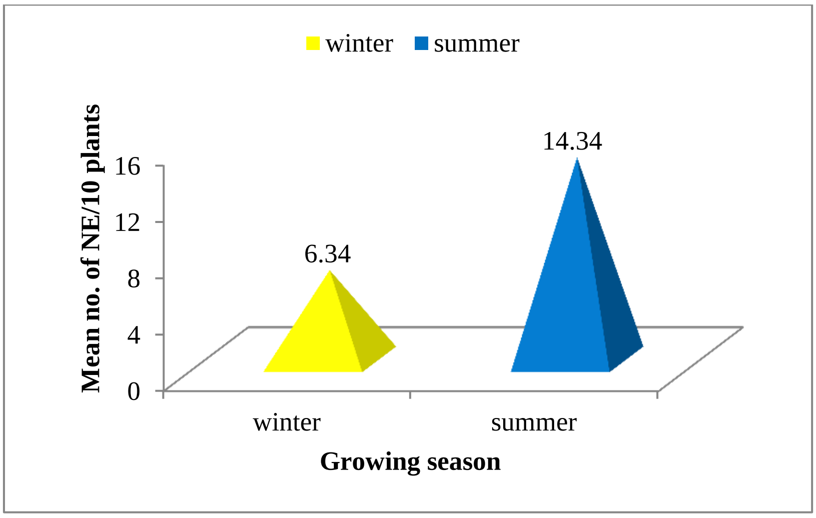


Figure 5 Population of natural enemies in winter and summer seasons

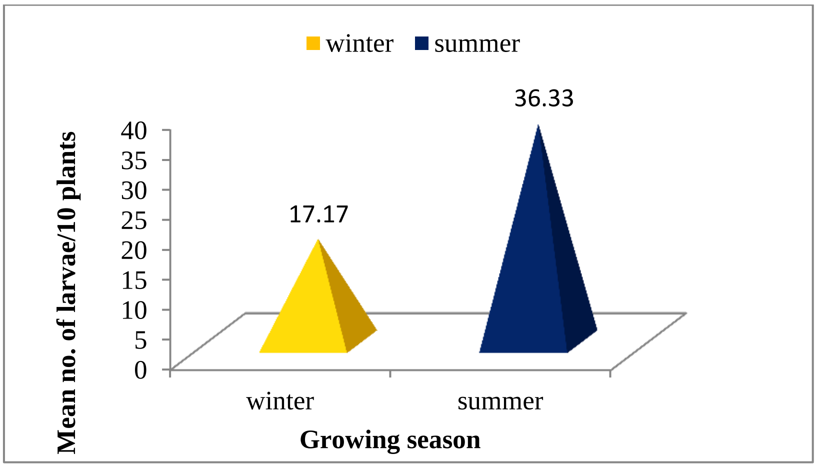
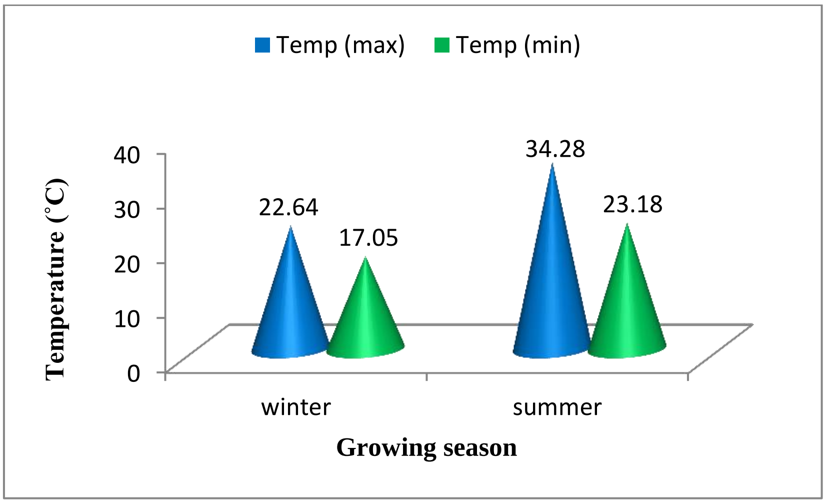


Figure 6 **Population of *Plutella xylostella*larvae in winter and summer seasons**

(a)



(b)

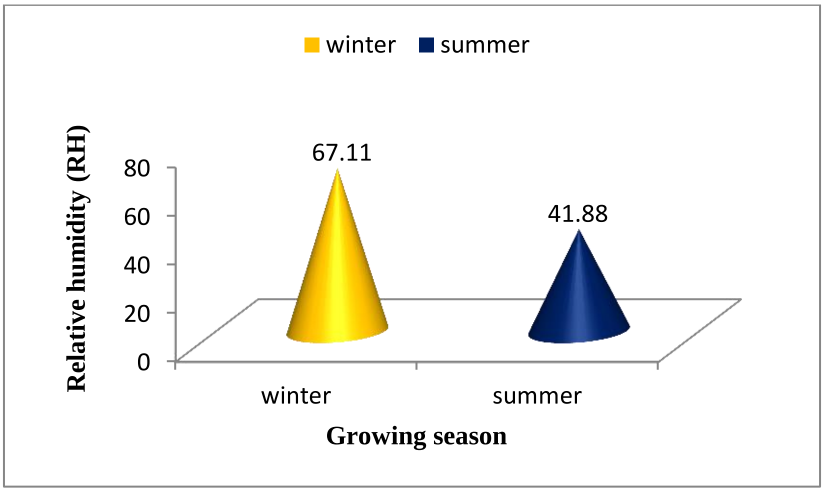


Figure 7 **(a) minimum and maximum temperature (b) relative humidity (RH) in winter and summer seasons**

Conclusion

The study showed that tomato and chilli when grown in intercrop repel DBM in cabbage. They may be good companion crops for cabbage in reducing DBM population. Therefore, intercropping cabbage with these crops could be a good practice desirable for integrated management of DBM.

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