STUDIES ON SEASONAL ABUNDANCE OF DIAMONDBACK MOTH *PLUTELLA XYLOSTELLA* (LEPIDOPTERA: YPONOMEUTIDAE) ON CAULIFLOWER CROP

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Abstract: The studies on seasonal abundance of diamondback moth *Plutella xylostella* were conducted in two years 2004–2005 and 2005–2006. Survey data of three localities of Aligarh district showed that initial infestation by *P. xylostella* occurred when the farmers started transplantation of cauliflower seedlings, the density of *P. xylostella* ranged between 0.90 to 2.38 and 0.27 to 5.84 larvae and pupae/plant in I week of July, 2004 and 2005, respectively, and the rate of parasitization was quite low. Temperature and humidity recorded maximum and minimum i.e. 24.15° to 32.91°C and 68.60 to 91.30 percent, respectively. Population build up is usually observed in II to IV week of September. *Cotesia plutellae* was found to be a dominant larval parasitoid while, *Oomyzus sokolowskii* parasitized relatively few pupae of *P. xylostella*. 34.77°C significantly ($p < 0.01$) enhanced the population of DBM also on 8th September, 8th October, 2004 and 26th January, 2005. Rainfall negatively affected the DBM population in 2004–2005 and 2005–2006.

Key words: *Plutella xylostella*, diamondback moth, cauliflower

INTRODUCTION

Population seasonality refers to a regular ecological event that always occurs at the same time of the year. A priori, the phenomenon is not necessarily connected with conventional climatic seasons (Campos *et al*. 2006). In tropical populations and communities of insects, seasonal cycles were frequently attributed to variations in plant availability caused by alternating dry and rainy seasons (Pinheiro *et al*. 2002; Hopkins and Memmott 2003).

Diamondback moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae) is recorded as a major and oligophagous pest with the larvae feeding specially on the members of the family cruciferae (Thorsteinson 1953), cabbage, Chinese cabbage, cauliflower, broccoli, knol khol, radish, turnip and mustard. It has been recorded since 1746 (Harcourt 1962) and believed to have originated in Mediterranean region (Harcourt 1954), which is also the place of origin of some of the important crucifer crops (Tsunoda 1980). It has now been recorded from at least 128 countries or territories of the world and believed to be most universally distributed of all Lepidoptera (Talekar and Shelton 1993). In India, diamondback moth was first recorded on crucifer vegetables in 1914 (Fletcher 1914) and now it is distributed all over India wherever crucifers are grown and outbreak of *P. xylostella* was reported by (Ahmad *et al*. 2009) at Aligarh, India.

Seasonal incidence of *P. xylostella* was studied in different agro-climatic conditions of India (Sachan and Srivastava 1972; Jayarathnam 1977). High build up larval population has been reported during February and March (late-winter) and April–August (summer and mild rainy season) (Sachan and Srivastava 1972). However, Jayarathnam (1977) and Nagarkatti and Jayanth (1982) found significantly high build up population during rainy season (July–September) as compared to other seasons. DBM can be found on crucifers throughout the year provided that the host crop is planted continuously. Heavy rain is also one of the important factors affecting DBM's abundance (Leu and Lee 1984; Talekar and Lee 1985).

MATERIALS AND METHODS

Survey of local area

Seasonal abundance of *P. xylostella* and its parasites were studied in three cauliflower cultivated area of Aligarh. Survey was conducted from the month of July 2004 to April 2005 and the same time in 2005–2006 at Mathura Road, G.T. Road and Punjipur village. Three fields were selected from each locality and at least ten samples were taken randomly from each field at an interval of 10 days.

Population sampling

Collected materials were brought to laboratory from each field and the number of larvae and pupae of *P. xylostella* and cocoons of parasitoids were counted. Larvae

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and pupae were kept separately in glass jars and were provided with fresh leaves of cauliflower till pupation. Sick and sluggish larvae were sorted out and kept for parasitoid emergence. Cocoons of parasitoid were also kept separately in jars for their emergence. The emerged adults of parasitoids were then identified.

Statistical analysis

The data was analyzed statistically by the application of SPSS and Minitab version 10 for correlation, Analysis of variance (ANOVA) and further subjected to test of significance. Meteorological data was also collected from Meteorological Station, Department of Physics, Aligarh Muslim University Aligarh, India.

RESULTS

Seasonal abundance of *P. xylostella* was determined on cauliflower from July 2004 to April 2005 and July 2005 to April 2006 at district Aligarh. Three localities were surveyed i.e. Mathura Road, G.T. Road and Punjipur village, which are major cultivating areas where the farmers are taking three consecutive crops of cauliflower from July to April.

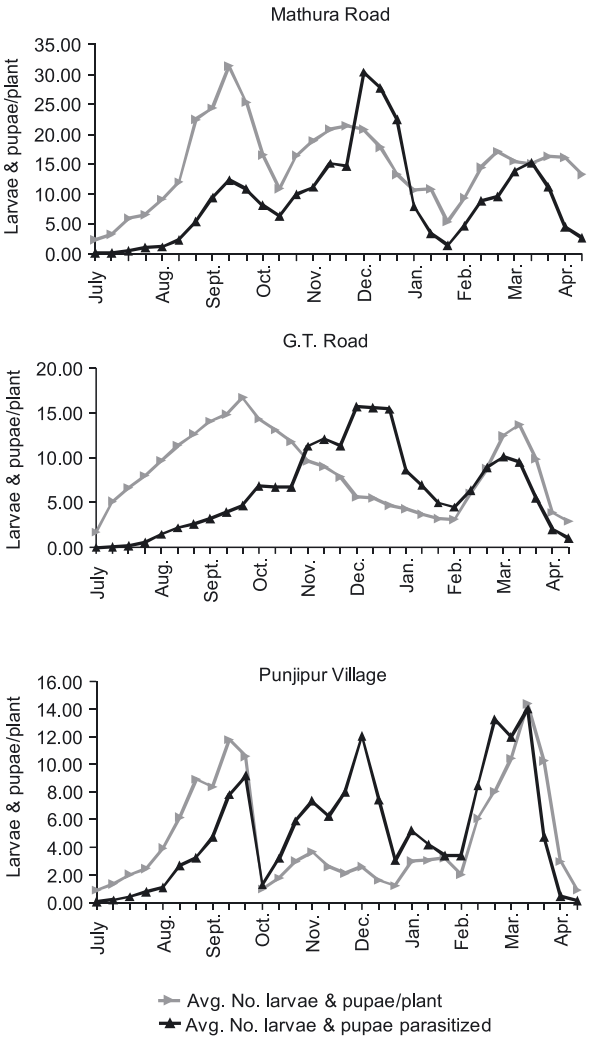

Fig 1. Seasonal abundance of *P. xylostella* on cauliflower (2004–2005)

The initial infestation of *P. xylostella* occurred in the above mentioned localities on transplanted cauliflowers in I week of July 2004 and 2005 where an average density of *P. xylostella* ranged between 0.90 to 2.38 and 0.27 to 5.84 larvae and pupae/plant, respectively and the rate of parasitization was quite low. During this period the temperature fluctuated between 24.15 to 32.91°C with relative humidity 68.60 to 91.30 percent. Rainfall during 10 days was 56.25 to 88.24 mm in 2004 and 2005, respectively (Fig. 1, 2).

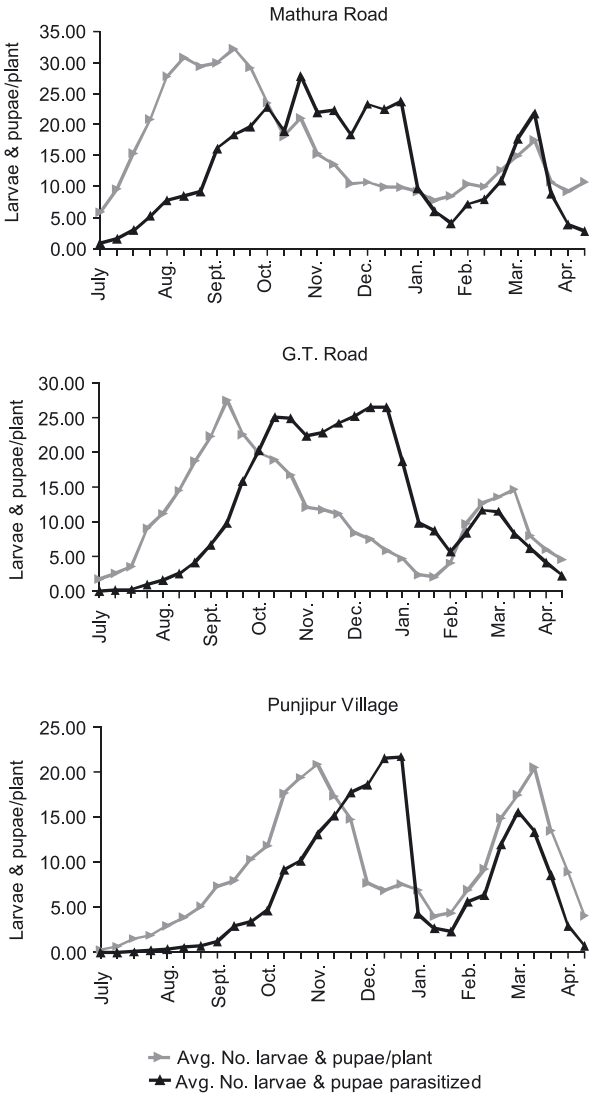

Fig. 2. Seasonal abundance of *P. xylostella* on cauliflower (2005–2006)

A significant increase of the population of *P. xylostella* i.e. 8.93 to 22.47 and 5.08 to 29.38 larvae and pupae/plant was observed on the last week of August 2004 and 2005, respectively. During this period temperature ranged from 25.20 to 35.00°C with relative humidity of 64.27 to 80.82 percent and the total rainfall during 10 days was 115.95 mm in 2004 and 26.59 to 35.46°C and 49.40 to 65.30 percent relative humidity and a very scanty rain of about 16.20 mm was in 2005. Peak population i.e. 31.43 larvae and pupae/plant was monitored in III week of September 2004 at Mathura Road, 16.72 larvae and pupae/plant on

30th September 2004 at G.T. Road and 11.78 in III week of September 2004 at Punjipur village but parasitization was found to be less than 10 percent (Fig. 1) at a temperature of 23.30 to 33.27°C with relative humidity of 70.50 to 79.00 percent and 14.00 mm rainfall was in 10 days during III week of September 2004 although scanty rainfall also occurred in II and IV week of September 2004.

Although, a significant increase in population of *P. xylostella* was also observed in II fortnight of August 2005 at both Mathura Road and G.T. Road while peak population occurred on III week of September and reaching to 32.23 larvae and pupae/plant at Mathura Road, 27.54 at G.T. Road and 17.63 at Punjipur village (Fig. 2). Moreover, rate of parasitization was 10 percent at different localities and at that time temperature ranged between 23.44 to 30.93°C and relative humidity of 71.60 to 89.20 percent, while 7.80 mm was the rainfall during this period of about 10 days. Population of *P. xylostella* decreased slowly from September to the harvesting of third crop in the first fortnight of April 2005.

Whereas, parasitism increased gradually and peak occurred in the II fortnight of December 2004 where it is about 35.52 percent at Mathura Road at a temperature of 10.18 to 22.51°C and relative humidity of 67.10 to 73.40 percent. At G.T. Road parasitism was 41.52 percent in IV week of December 2004 at 9.29 to 19.50°C and 72.90 to 80.00 percent relative humidity. The highest i.e. 41.33 percent parasitism was recorded in II week of December 2004 at Punjipur village where the temperature ranged between 10.47 to 22.57°C and 67.40 to 80.50 percent relative humidity. Rate of parasitization decreased gradually from the II fortnight of December 2004 to February 2005 and then another peak was obtained in III week of March 2005 at Mathura Road at temperature of 16.33 to 33.00°C and relative humidity of 40.20 to 88.10 percent with a scanty rain of about 1.20 mm. Parasitism did not increase further but decreased slowly to 5.20 percent at G.T. Road in III week of April 2005. At Punjipur village parasitism decreased from II week of December 2004 and then increased in III week of February 2005 where density of parasite was found to be 15.84 percent at temperature of 8.55 to 22.01°C and relative humidity ranged from 36.00 to 79.25 percent.

The highest population of DBM was found on 18th September 2005 and then began to decrease and an increase was monitored in III week of March 2006, where 17.49 larvae and pupae/plant were monitored at a temperature fluctuating between 13.41 to 24.84°C and relative humidity of 59.30 to 89.00 percent. *P. xylostella* continued to infest even after 15th April 2006 where temperature ranged from 22.38 to 38.43°C and relative humidity was 42.80 to 71.00 percent.

However, parasitism tended to increase from the month of October to December 2005 and peak was obtained on IV week of December 2005 where it reached 40.78 percent at temperature of 5.41 to 20.35°C and relative humidity ranged from 48.10 to 94.00 percent. The parasitism decreased to 14.31 percent in the I week of January 2006 at a temperature ranging from 3.87 to 16.00°C with a relative humidity of 44.20 to 94.60 percent and while another small peak (20.78 percent) was observed on III week of March 2005 at temperature of 13.41 to 24.84°C and relative humidity of 59.30 to 89.60 percent at Mathura Road. At G.T. Road, rate of parasitism found to be increased from 3.61 percent on II fortnight of September 2005 to 46.64 percent on the last days of December 2005 at temperature of 5.41 to 20.35°C with relative humidity of 48.10 to 94.00 percent, while parasites continued to parasitize the larvae of DBM throughout the month of January 2005 and even after in the months of February, March and April in 2006. At Punjipur village, parasitism was found increasing from IV week of September to III week of December 2005 where peak (37.33 percent) was obtained at temperature of 2.75 to 21.29°C and 48.00 to 88.60 percent relative humidity and about 3 percent decrease in parasitism was recorded after 10 days i.e. on 28th December 2005 and then a significant decrease was monitored from January to mid April 2006. *C. plutellae* Kurdjumov was found to be dominant larval parasitoid while *Oomyzus sokolowskii* Kurdjumov parasitized relatively few pupae of *P. xylostella*. Some larval and pupal parasitoids were also recorded in the present study but not yet identified.

Seasonal abundance of *P. xylostella* and its parasite was subjected to Pearson's correlation test that showed a positively/negatively significant/nonsignificant reaction with environmental conditions (Table 1, 2). In 2004–2005, high temperature caused a positively/negatively significant/non significant effect on the perpetuation of DBM. 34.77°C significantly ($p < 0.01$) enhanced the population of DBM also on 8th September, 8th October 2004 and 26th January 2005. An erratic correlation was computed in relation to minimum temperature. While, average temperature favourably/unfavourably affected the density of the *P. xylostella*. Higher range of humidity in the month of July and I fortnight of August caused a negative effect on population *P. xylostella*. However, minimum humidity did not considerably affect the population of DBM and almost the same result was obtained in relation to average humidity. Rainfall in the first 10 days of July 2004 and in II week of March 2005 caused a negatively significant ($p < 0.01$, $p < 0.05$) effect on the population of *P. xylostella*. Generally, rainfall negatively affected the DBM in 2004–2005. During 2005–2006, almost the same type of variable correlations were obtained for maximum, minimum and average temperature and relative humidity, while rainfall severely affected the population of *P. xylostella* on 20th August, 19th September and 9th October 2005, while insignificant correlation was calculated for the rest of observation period.

The rate of parasitization was correlated positively/negatively significant/non-significant to maximum, minimum and average temperature as well as maximum, minimum and average humidity during 2004–2005 and 2005–2006. Rainfall was sometimes favourable/unfavourable for perpetuation of parasites during both years of study (Table 1, 2).

Table 1. Correlation between abiotic factors and *P. xylostella* and its parasites (2004–2005)

Date	Max. Temp.		Min. Temp.		Avg.Temp.		Max. R.H.		Min. R.H.		Avg. R.H.		Rainfall	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
01-07-2004	–0.26	0.140	0.12	–0.080	–0.22	0.12	–0.36	0.18	0.17	0.23	0.17	0.23	–0.714**	0.35
10-07-2004	–0.09	–0.210	0.07	–0.05	–0.02	–0.15	–0.15	0.03	–0.05	0.44	–0.210	0.32	0.43	0.27
20-07-2004	–0.660*	–0.130	–0.05	0.08	–0.43	–0.02	–0.39	0.3	.753**	–0.14	–0.14	0.32	–0.13	–0.13
30-07-2004	–0.39	0.04	0.03	–0.34	–0.21	–0.17	–0.35	–0.24	–.531*	–0.42	0.940	0.16	–0.070	–0.13
09-08-2004	0.710**	0.830**	–0.29	–0.170	0.3	0.509*	0.25	–0.23	.643*	0.44	0.14	0.32	–0.15	–0.31
19-08-2004	–0.35	–0.260	–0.46	0.050	–0.603*	–0.15	0.17	–0.22	0.45	0.41	0.39	0.16	–0.3	0.19
29-08-2004	0.22	0.420	–0.11	0.08	0.1	0.38	–0.14	–0.24	0.21	0.11	0.585*	–0.43	0.25	0.15
08-09-2004	0.574*	0.714**	0.684*	0.790**	0.717**	0.855**	–.815**	–0.862**	–0.2	–0.480	0.618*	0.26	–0.36	0.36
18-09-2004	–0.2	–0.39	–0.46	–0.36	–0.665*	–0.701*	0.05	0.16	–.507*	–0.510	0.41	0.17	–0.36	–0.12
28-09-2004	0.21	0.548*	–0.02	–0.04	0.16	0.44	–0.36	–0.46	–0.44	–.596*	0.14	0.01	–0.41	0.26
08-10-2004	0.526*	0.605*	–0.37	–0.520*	0	–0.08	–0.46	–0.5	–0.04	0.05	0.701*	–.873**	–0.37	0.330
18-10-2004	0.03	–0.16	0.537*	0.518*	0.47	0.37	–0.649*	–0.16	.660*	0.240	–0.38	–0.33	–	–
28-10-2004	0.04	–0.22	–0.05	0.14	–0.01	–0.06	–0.12	–0.31	0.47	0.04	–0.584*	0.775**	–	–
07-11-2004	0.16	0.44	–0.822**	–0.470	–.537*	–0.08	–0.755**	–0.350	0.37	0.2	–0.18	–0.11	–	–
17-11-2004	0.25	–0.12	0.33	0.531*	0.34	0.15	0.11	0.12	0.24	0.2	–0.08	0.050	–	–
27-11-2004	0.25	–0.12	–0.23	–0.22	–0.21	0.17	0.17	0.27	0.23	0.15	0.4	–0.09	–	–
07-12-2004	–0.09	0.29	–0.18	–0.18	–0.29	–0.35	–0.811**	–0.806**	–0.49	–0.550*	–0.44	–0.18	–	–
17-12-2004	–0.23	–0.3	–0.26	–0.4	–0.1	–0.26	0.558*	0.671*	0.39	0.49	0.31	0.28	–	–
27-12-2004	0.18	0.04	–0.22	–0.36	–0.551*	–0.610	0.518*	0.33	–0.09	–0.19	–0.13	0.29	–	–
06-01-2005	–0.48	–0.38	–0.24	–0.3	–0.582*	–.601*	–0.31	–0.07	0.37	0.120	0.801**	0.819**	–	–
16-01-2005	–0.44	–.617**	–0.25	–0.31	–0.41	–0.551*	0.496	0.15	–0.54	–0.47	0.500*	0.613*	–	–
26-01-2005	0.704*	0.584*	0.15	–0.41	0.563*	0.45	0.13	–0.13	–0.4	–0.22	0.48	0.22	–	–
05-02-2005	0.04	–0.720**	–0.11	–0.29	0.14	–0.811**	–0.25	–0.524*	–0.05	0.671*	0.23	0.1	–	–
15-02-2005	–0.26	–0.25	–0.44	0.41	–0.35	–0.44	0.697*	–0.12	.702*	0.13	0.24	0.33	–	–
25-02-2005	0.08	–0.2	0.39	0.505*	–0.16	0.04	–0.25	0.682*	–0.42	–0.030	–0.24	0.25	–	–
07-03-2005	0.41	–0.33	0.53	0.515*	0.39	–0.05	–0.19	0.588*	–0.2	–0.06	–0.24	0.26	–	–
17-03-2005	0.01	–.572*	0.06	0.24	–0.29	0.11	–0.46	–0.05	–0.34	0.719**	0.26	0.010	–	–
27-03-2005	–0.44	–0.14	0.16	0.22	0.120	0.16	–0.628*	–0.11	–0.29	0.579*	0.730**	0.535*	–	–
05-04-2005	0.05	0.04	0.46	0.06	0.618*	0.13	0.820**	0.13	–0.12	0.22	0.33	0.39	–	–
15-04-2005	0.180	0.080	0.23	–0.05	0.3	0.13	–0.45	0.510	–0.07	–0.21	0.630*	–0.665*	–	–

A – No. of DBM larvae and pupae/plant; B – percent parasitized; ** significant at 0.01 level; * significant at 0.05 level
Max. – Maximum; Min. – Minimum; Avg. – Average; Temp. – Temperature; R.H. – Relative Humidity

Table 2. Correlation between abiotic factors and *P. xylostella* and its parasites (2005–2006)

Date	Max. Temp.		Min. Temp.		Avg.Temp.		Max. R.H.		Min. R.H.		Avg. R.H.		Rainfall	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
01-07-2005	–0.11	–0.13	0.17	0.29	0.03	0.1	0.44	0.04	0	0.070	–0.21	0.23	–0.2	0.22
10-07-2005	–0.09	–0.19	0.49	–0.150	0.23	–0.24	–0.04	–0.18	–0.15	0.06	–0.28	0	–0.29	0.170
20-07-2005	–.573*	–0.18	0.060	–0.06	–0.29	–0.15	–0.562*	0.260	0.06	0.14	–0.1	0.25	–0.13	0.03
30-07-2005	0.32	0.39	0.470	0.05	0.46	0.25	0.17	0.08	–0.370	–0.17	–0.49	–0.27	–0.31	0.26
09-08-2005	–0.11	0.44	0.01	–0.070	0.380	0.3	–0.04	0.41	0.2	–0.07	0.100	–0.05	–0.210	0.24
19-08-2005	0.22	0.22	0.07	0.3	0.15	0.517*	–0.24	–0.668*	–0.551*	–0.14	–0.576*	–0.3	–0.592(*)	–0.34
29-08-2005	0.01	–0.07	0.05	0.26	0.24	0.48	–0.1	0.3	0.05	–0.05	0.010	–0.1	–0.12	0.19
08-09-2005	0.514*	0.506*	0.685*	0.36	0.686*	0.49	0.25	0.03	0.13	0.06	–0.47	–0.330	–0.24	–0.17
18-09-2005	0.16	0.46	0.24	0.1	0.05	–0.2	–0.150	0.33	–0.607*	–0.46	–0.28	–0.460	–0.552*	0.541*
28-09-2005	0.21	0.31	–0.08	0.05	0.25	–0.01	0.02	0.5	–0.24	–0.06	–0.3	–0.090	0.140	0.08
08-10-2005	0.520	0.54	–0.26	–0.603*	0.340	–0.21	0.05	0.17	0.15	–0.13	0.28	–0.05	–0.935**	0.573*
18-10-2005	–0.21	–0.43	–0.47	0.13	–0.44	0.1	0.32	–0.45	–0.3	0	–0.14	0.030	–0.449	0.34
28-10-2005	0.31	–0.04	–0.27	–0.39	–0.29	0.05	0.19	–0.39	–0.4	–0.4	–0.4	–0.43	–	–
07-11-2005	0.687*	0.507*	–0.26	0.21	–0.02	0.4	–0.14	0.49	–0.150	0	–0.23	0.04	–	–
17-11-2005	–0.03	0.03	0.528*	0.33	0.26	0.2	–0.526*	0.874**	–0.19	–0.15	–0.17	–0.17	–	–
27-11-2005	–0.16	0.32	0.04	–0.09	–0.09	0.16	–0.29	0.35	0.08	–0.12	0.080	–0.060	–	–
07-12-2005	–0.578*	–0.33	0.28	–0.020	–0.1	–0.23	–0.26	0.25	0.1	–0.29	–0.09	–0.721**	–	–
17-12-2005	–0.03	0.15	–0.4	–0.34	–0.29	–0.18	0.01	0.280	0.527*	0.29	0.581*	0.46	–	–
27-12-2005	–0.36	–0.16	–0.19	–0.3	–0.603*	–0.47	–0.579*	0.44	–0.26	–0.23	–0.04	–0.27	–	–
06-01-2006	–0.35	–0.613*	–0.2	–0.22	–0.330	–0.504*	0.44	0.04	–0.36	–0.01	–0.44	0.16	–0.01	0.24
16-01-2006	0.27	0.780**	–0.110	–0.693*	0.32	0.663*	–0.04	–0.18	–0.12	–.647(*)	–0.13	–0.547*	–	–
26-01-2006	0.15	–0.190	0.603*	–0.33	0.32	0.695*	–0.562*	0.260	0.06	–0.06	0.070	0	–	–
05-02-2006	0.380	–0.23	0.15	–0.39	0.35	–0.37	0.17	0.08	0.12	.641(*)	0.37	–0.17	–	–
15-02-2006	–0.03	0.03	–0.35	0.735**	–0.37	0.22	–0.04	0.41	0.34	–0.19	0.270	–0.33	–	–
25-02-2006	0.09	–0.22	0.17	0.4	0.44	0.35	–0.24	–0.778*	–0.340	0.27	–0.29	0.49	–0.23	0.18
07-03-2006	0.47	–0.04	0.27	0.09	0.25	–0.24	–0.1	0.3	0.13	0.160	–0.21	0.594(*)	–	
17-03-2006	0.160	–0.43	0.07	0.030	0.13	0.09	0.25	0.03	–0.08	0.584*	–0.34	0.53	–0.03	0.09
27-03-2006	0.08	0.07	–0.03	0.616*	0.01	0.584*	–0.150	0.33	0.15	0.25	–0.23	0.27	–	–
05-03-2006	0.060	0.4	–0.32	–0.21	–0.31	–0.24	0.02	0.5	–0.13	–0.16	–0.01	0.22	–	–
15-04-2006	–0.06	–0.09	0.01	–0.37	0.07	–0.2	0.05	0.17	–0.47	0.170	–0.637*	0.46	–	–

A – No. of DBM larvae and pupae/plant; B – percent parasitized; ** significant at 0.01 level; * significant at 0.05 level
Max. – Maximum; Min. – Minimum; Avg. – Average; Temp. – Temperature; R.H. – Relative Humidity

DISCUSSION

Seasonal abundance of *P. xylostella* on cauliflower was significantly/non-significantly affected by temperature, humidity and rainfall as well as parasites in three localities of Aligarh i.e. Mathura Road, G.T. Road and Punjipur village from July 2004 to April 2005 and in the same months in 2005–2006. A number of abiotic and biotic mortality factors interacting together that affect the natural intrageneration population dynamics of *P. xylostella* (Keinmeesuke *et al*. 1992; Syed and Abro 2003). A significantly high build up of larval population of *P. xylostella* was monitored during rainy season (July–September) as compared to other factors (Nagarkatti and Jayanth 1982). Climatic conditions, including higher temperatures and decreased rainfall were cited as major factors which regulate the population dynamics of *P. xylostella* (Harcourt 1986) while hot and dry conditions are known to be conducive for *P. xylostella* (Shelton 2001). Talekar and Shelton (1993) suggested that inversed temperatures can lead to the production of more generations per season. Although egg production and larval survival of *P. xylostella* are inhibited by temperature above 30°C (Yamada and Kawasaki 1983). Kuwahara *et al.* (1995) reported that *P. xylostella* maintained consistently high population density through the year even during hottest season of March to May. High temperature (Hawang 1970; Leu and Lee 1984), food availability and heavy rain (Leu and Lee 1984; Talekar and Lee 1985) are important factors affecting the DBM population. It was suggested by Campos *et al*. 2006 that seasonal growth in tropical population of *P. xylostella* may be largely dependent on annual pattern of atmospheric circulation. The present finding also showed that maximum humidity adversely affected the population of *P. xylostella.* Contrary to that Yamada and Kawasaki (1983) suggested that rates of hatching, pupation and adult emergence were not affected by the levels of humidity.

In the rainy season, larval population of *P. xylostella* decreased down and significantly/non-significantly unfavourable for the immature stages in the present study. It was confirmed by Talekar and Shelton (1993) that rain can dislodge the larvae of *P. xylostella* from the plants and can drow the larvae in the water in the soil. Iga (1985) reported that almost 100 percent mortality of I–II instars of *P. xylostella* and a range of 14.30 to 71.40 percent mortality of III–IV instar larvae might be due to rain. While, Sivaparagasam *et al*. (1988) found that rainfall generally washed off 38 percent eggs of *P. xylostella* and also I instars were found to be susceptible to drowning when they are trapped in water at the leaf axel. It was thoroughly studied and stated by Kobori and Amano (2003) that 1 hour of simulated rain resulted 95.30 percent drop off of I instar, 72.00 percent II instar, 60.70 percent III instar and 42.70 percent IV instar. Falling rate of eggs of *P. xylostella* are significantly higher on the upper surface than the lower surface of cabbage leaves, direct impact by rain drops, washing off by water flowing across the leaf surfaces and secondary impacts from drops hitting the soil and ricocheting soil and water particles back at the leaves. Ayalew *et al*. (2006) reported that rainfall and maximum temperature significantly influenced DBM numbers and parasitoid activity. Dennill and Pretorious (1995) demonstrated that high infestation levels by DBM are a result of excessive insecticide applications and also because of the history of *P. xylostella* resistance rather than favourable conditions (Shelton *et al*. 2000) while the DBM attacks are often attributed to the lack of effective of these natural enemies (Talekar and Shelton 1993). The same result is found in the present study that in II fortnight of September and I week of October, parasitization was insignificantly low and did not provide any control on the infestation level by DBM.

Parasitism reached to 41.52 percent at temperature fluctuating between 9.29 to 19.50°C with relative humidity of 67.10 to 73.40 percent in 2004, while 46.64 percent parasitism at a temperature of 5.41 to 20.35°C and relative humidity ranging between 48.10 to 94.00 percent was observed in IV week of December 2005 in the present studies. It was reported by Mosiane *et al.* (2003) that *C. plutellae* was most abundant throughout the year and accounted for 55 percent parasitism of *P. xylostella. C. plutellae* was also found cause more than 16–70 percent larval parasitism in Gujarat (Yadav *et al*. 1975) and Bangalore (Jayrathanam 1977; Nagarkatti and Jayanth 1982) followed by *O. sokolowskii* causing 28–96 percent (Jayrathanam 1977). However, *C. plutellae* was the dominant larval parasitoid in several parts of India and probably capable of 85.70 percent parasitism (Chandramohan 1994). Chauhan and Sharma (2002) found that a total parasitization by all parasitoids varied from 13.4 to 78.3 percent in the period of 1993, 1994 and 1995 and also found that *Diadromus collaris* was the dominant species. Xu *et al.* (2001) reported 33.6 percent parasitism for III instar larvae and 53.6 percent for the IV instar larvae of *P. xylostella* mainly by *D. insulare* and *M. plutellae* in Geneva, New York. *D. fenestralis* was more active at a temperature of 15.27°C, while *D. collaris* at 27–32°C (Chauhan and Sharma 2002). Parasitism by *C. plutellae* and *O. sokolowskii* reached to 18–52.5 percent (Alam 1991) and an average of 75 percent DBM larvae were parasitized (Alam 1991). Navatha and Murthy (2006) observed a higher rate of parasitism (60.00 percent) during August on DBM in South Indian region. Among the parasitoid of DBM, only *Brachymeria excarinata* was reported as a potential pupal parasitoid (Lingappa *et al*. 2000).

CONCLUSIONS

1. Attempts were made in the present study to investigate the seasonal abundance of *P. xylostella* at Aligarh district by surveying three localities, which are major producers of cauliflower and farmers are, generally cultivating three consecutive crops of cauliflower from July to April every year.
2. Initial infestation of *P. xylostella* was in a range of 0.90–2.38 and 0.27–5.84 larvae and pupae/plant and rate of parasitisation was quite low in I week of July, 2004 and 2005, respectively in three localities i.e. Mathura Road, G.T. Road and Punjipur village.
3. Peak population i.e. 31.43 larvae and pupae/plant was recorded in III week of September 2004 at Mathura

Road. Whereas, rate of parasitization was less than 10 percent while, in the same week of September, 2005 maximum density i.e. 32.23 larvae and pupae/plant was obtained with about 10 percent parasitization

4. From September onwards during both years of study, density of *P. xylostella* decreased down slowly up to harvesting of third crop of cauliflower in the month of April 2005 and 2006. Parasitization was found to be highest i.e. 41.52 percent in IV week of December 2004 where the temperature ranged between 9.29 to 19.50°C with relative humidity of 72.90 to 80.00 percent.
5. Parasitization was found to be decreased down from January to April 2005 and the same was recorded in 2006. *C. plutellae* was recorded as a dominant larval parasitoids and *O. sokolowskii* parasitized a few pupae of *P. xylostella*.

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POLISH SUMMARY

BADANIE SEZONOWE PO NASILENIU WYSTĘPOWANIA TANTNISIA KRZYŻOWIACZKA *PLUTELLA XYLOSTELLA* (LEPIDOPTERA: YPONOMEUTIDAE) W UPRWIE KALAFIORÓW

Badania nad sezonowym po nasileniu występowania tantnisia krzyżowiaczka *Plutella xylostella* prowadzono w latach 2004–2005 oraz 2005–2006. Dane z lustracji w trzech lokalizacjach okręgu Aligarh (Indie) wykazały, że początkowe zakażenie występowało wówczas, gdy farmerzy rozpoczynali przesadzanie siewek kalafiora. Gęstość *P. xylostella* wahała się od 0,90 do 2,38 oraz od 0,27 do 5,84 larw i poczwarek na roślinę, w pierwszym tygodniu lipca 2004 i 2005 roku. Tempo pasożytowania było dość niskie. Maksimum i minimum temperatury i wilgotności wynosiło odpowiednio od 24,15 do 32,91°C oraz od 68,60 do 91,3°C. Wzrost populacji obserwowano w II i IV tygodniu września. Wykazano, że *Cotesia plutellae* Kurdjumov był dominującym parazytoidem larw, podczas gdy *Oomyzus sokolovskii* Kurdjumov pasożytował na niewielu poczwarkach *P. xylostella*. Temperatura 34,77°C ($p < 0,01$) pobudzała populację tantnisia krzyżowiaczka także 8 września, 8 października 2004 roku oraz 26 stycznia 2005 roku. Opady deszczu negatywnie wpływały na populację tantnisia krzyżowiaczka w latach prowadzonych badań.