ABSTRACT

Diamondback moth, *Plutella xylostella* (Linn.) (Lepidoptera: Yponomeutidae) is the most devastating insect pest and distributed throughout the world. It thrives under extremely varied climatic conditions prevailing in different parts of India. DBM is recorded as a major and oligophagous pest with the larvae feeding specially on the members of the family cruciferae i.e. cabbage, cauliflower, Chinese cabbage, broccoli, knol khol, radish, turnip, and mustard. DBM reproduces year round and completes 13-14 generations in a year.

Population dynamics in relation to abiotic factors prevailing in cropping season is an important component for proper management of the pests. Therefore, seasonal abundance of *P. xylostella* was studied on six varieties of cabbage, *Brassica oleracea* var. *capitata*; Field Man, F1 Deepti, Hybrid-1080, Golden Acre, Cabbage-NS-25 and Diamond Express from October 2007 to April, 2008 and October, 2008 to April, 2009 during Rabi season at 3 locations in the farmer’s fields of Aligarh district; Jalali, Mathura Road and G.T. Road which are major cultivating areas of cabbage. Number of larvae and pupae/plant ranged between 0.32 to 4.81 and 1.16 to 6.04 from 40 to 9 std. weeks in Field Man and F1 Deepti, respectively and percent parasitisation ranged between 2.44 to 43.70 and 7.31 to 59.33 from 41 to 9 std. weeks in F1 Deepti and Field Man, respectively in 2007-08 at a temperature fluctuating between 4.79° to 35.07°C with relative humidity of 50.71 to 84.14 percent with scanty rainfall i.e. 0.50mm and 11.60mm at 5 and 6 std. weeks, respectively. While, the density ranged between 0.95 to 5.79 and 0.76 to 5.27 from 40 to 9 std. weeks and percent parasitisation ranged between 2.62 to 57.61 from 40 to 9 std. weeks and 1.57 to 30.18 percent from 42 to 8 std. weeks in the same varieties and place in 2008-09 at 7.36° to 35.86°C and relative humidity of 30.43 to 94.14 percent with scanty rainfall i.e. 6.60mm and 3.20 mm at 47 and 7 std. weeks, respectively.

Number of larvae and pupae/plant ranged between 1.45 to 9.25 and 2.09 to 12.47 and percent parasitisation ranged between 2.99 to 45.45 and 1.18 to 29.0 percent from 47 to 13 std. weeks in Hybrid-1080 and Golden Acre, respectively in 2007-08 at a temperature fluctuating between 4.57° to 34.79°C with relative humidity of 51.0 to 85.0 percent with very scanty rainfall i.e. 0.50mm, 11.60mm, 0.60mm and 0.80mm at 6, 7, 11 and 12 std. weeks, respectively. However, the density increased from 1.28 to 11.66 and 1.08 to 12.56 and percent parasitisation was from 11.33 to 87.96 and 7.26 to 46.34 percent from 45 to 13 std. weeks in the same varieties in 2008-09 at Mathura Road at 7.14° to
32.50°C and relative humidity of 29.43 to 94.29 percent with scanty rainfall i.e. 6.60mm during 47, 3.20mm during 7 and 1.80mm during 13 std. weeks, respectively.

The density ranged between 1.75 to 19.67 and 2.15 to 25.80 larvae and pupae/plant from 50 to 17std. weeks and percent parasitisation ranged between 4.06 to 62.33 and 1.23 to 24.70 percent from 51to 15 and from 1 to 17 std. weeks in cabbage-NS-25 and Diamond Express, respectively in 2007-08 at 5.14° to 38.93°C with relative humidity of 42.29 to 82.57 percent and scanty rainfall i.e. 0.40mm, 11.60mm, 0.50mm, 0.60mm, and 9.60mm at 7, 8, 12, 13 and 15 std. weeks, respectively. Although the intensity of *P. xylostella* was ranging between 2.45 to 24.13 from 49 to 14 std. weeks and 2.55 to 24.50 from 52 to 17 std. weeks in the same varieties and percent parasitisation ranged between 17.81 to 59.52 and 10.35 to 46.63 percent from 52 to 14 and 4 to 17 std. weeks, respectively in 2008-09 at G. T. Road.

Oviposition of *P. xylostella* was studied on Brassica hosts in protected field conditions under choice and no-choice tests. Female of *P. xylostella* is significantly preferred to oviposit on cabbage as compared to Indian mustard in both choice and no-choice tests. While, Diamond Express of cabbage was more preferred than that of Hybrid-1080, Golden Acre, F1-Deepti and Field Man in both choice and no-choice tests. Pusa Bold of Indian mustard is more preferred over Varuna and Pusa Bahar in both choice and no-choice tests. Average number of eggs /5females ranged between 14.25 to 16.25 and 109.27 to 138.20 in both choice and no-choice tests, respectively on Indian mustard varieties which were significantly (*P<0.05*) similar during mean of both years, but significantly differed ranged from 25.01 to 73.31 in choice test on cabbage varieties. 204.09 to 623.66 eggs/5 females were ranged on cabbage varieties in no choice test, while F1-Deepti and Field Man were same but rest of the four varieties were significantly differed in no-choice test in mean of both years.

The highest leaf area consumed by the larva of *P. xylostella* was i.e. 15.05, 15.77 cm² and 14.97, 15.94 cm² and the lowest i.e. 6.21, 7.59 cm² and 6.03, 8.83 cm² on Diamond Express and Field Man in both choice and no-choice tests during 2007-08 and 2008-09, respectively. Whereas, feeding was statistically similar in Indian mustard varieties in both tests during both years. Hybrid-1080 and Cabbage-NS-25 were found similar, but other four varieties were significantly differed in both tests in 2007-08. F1-Deepti and Field Man were statistically similar, Cabbage-NS-25 and Golden Acre were also recorded similar in no-choice test in 2008-09. Whereas, larva of *P. xylostella*
preferred to feed more on Pusa Bold than Varuna and Pusa Bahar of Indian mustard in both tests during both years of study.

Larval survival was studied under protected field condition and at constant temperatures i.e. 10°, 15°, 20°, 25° and 30°C on *Brassica* hosts: 3 cabbage varieties i.e. Field Man, Golden Acre, Diamond Express and 3 Indian mustard; Pusa Bold, Varuna and Pusa Bahar. Larval survival was found to be highest i.e. 80.58 and 82.76 percent on Diamond Express and smallest on Pusa Bahar i.e. 30.84 and 47.76 percent in 2007-08 in both choice and no-choice tests, respectively. Whereas, it was 83.12 and 81.06 percent on Diamond Express and least i.e. 33.39 and 49.26 percent on Pusa Bahar in both tests, respectively in 2008-09. Among cabbage varieties, the lowest survival was on Field Man (40.37 and 50.24 percent) and (39.53 and 54.15 percent) in choice and no-choice tests, respectively during both years of study. Among the Indian mustard, larval survival was highest (35.23, 56.24 percent) and 41.68 and 53.47 percent on Pusa Bold and least on Pusa Bahar, respectively. Larval survival was highest on Diamond Express and the lowest on Field Man on cabbage varieties at all temperatures tested. Among the Indian mustard, survival of larvae was greater on Pusa Bahar at 20°C in comparison to Pusa Bold and Varuna. Larval survival was higher at 20°C on cabbage and Indian mustard varieties as compared to other temperatures.

Life table of *P. xylostella* was studied on *Brassica* hosts: three cabbage varieties; Field Man, Golden Acre, Diamond Express and three Indian mustard; Pusa Bold, Varuna and Pusa Bahar at 22±1°C and 70±5% relative humidity. Survivorship was greater on cabbage varieties than on Indian mustard. Highest number of eggs were hatched on cabbage i.e. Diamond Express followed by Golden Acre and Field Man as compared to Indian mustard. Mortality of egg was highest when *P. xylostella* reared on Pusa Bahar and lowest on Diamond Express. Pre-oviposition period lasted for one day in all the host plants. *P. xylostella* preferred to lay more eggs on cabbage varieties i.e. Diamond Express than other varieties of cabbage and Indian mustard. Total oviposition period was 8-days on Indian mustard while, 9, 10 and 11 days on Field Man, Golden Acre and Diamond Express, respectively. Female birth rate (*m*) was highest when *P. xylostella* fed on Diamond Express while, lowest on Pusa Bahar. Highest potential fecundity (*Pf*) occurred on Diamond Express i.e. 124.05 and lowest on Pusa Bahar i.e. 52.42 females/female/generation followed by on Golden Acre (90.56), Field Man (75.20), Pusa Bold (63.57) and Varuna (55.87). Net reproductive rate (*R*) is significantly (P<0.05)
differed on Field Man, Golden Acre, Diamond Express and Pusa Bold and not significantly differed on Varuna and Pusa Bahar. 7.78 females/female/generation were obtained on Varuna and highest i.e. 64.99 on Diamond Express. Highest Intrinsic rate of increase ($r_m$) occurred on Golden Acre (0.049) and lowest i.e. 0.027 females/female/day on Varuna followed by Diamond Express and Pusa Bold. $r_m$ is significantly (P<0.05) reduced when *P. xylostella* reared on Indian Mustard. Lowest finite rate of increase ($\lambda$) i.e. 1.027 females/female/day was found on Varuna and highest on Golden Acre i.e. 1.050. Corrected generation time of *P. xylostella* ($t$) was 38.01 days on Diamond Express followed by Golden Acre and Field Man. While, almost equal days required to complete one generation on Pusa Bold and Varuna. Population of *P. xylostella* will become double in 6.94 days on Pusa Bold while extended to 10.45 days on Pusa Bahar and 11.15 days on Varuna. *P. xylostella* multiplies fast on cabbage varieties as compared to Indian mustard.

Intercropping of cabbage with non host plants viz., radish, carrot, tomato, garlic, cumin, fennel, coriander, berseem and marigold was studied in two cropping season of 2007-08 and 2008-09 at farmer’s field. Population of *P. xylostella* from 10 to 70 DAP then gradually decreases up to harvesting of the crop during both years. Peak population of *P. xylostella* was observed at 70 DAP (days after planting) on cabbage in 2008-09. 15:2 ratio of lines of cabbage+tomato was found to be superior in reducing the incidence of *P. xylostella* on cabbage as compared to 15:1, 25:1 and 25:2 ratio of lines of cabbage+intercrops; radish, carrot, garlic, cumin, fennel, coriander, berseem and marigold. It was followed by garlic, cumin, fennel and coriander. Spacing of cabbage (50x40cm) with intercrops holds more population of DBM larvae and pupae/plant than spacing of 60x45cm. 40-days old seedling of cabbage when planted along with intercrops showed a reduction in larval and pupal population of *P. xylostella* than planting of 30-days old seedling of cabbage in both years of study.

Higher parasitisation was recorded in 30-days old seedling of cabbage than 40-days old seedling and in 60x45 cm spacing than 50x40cm and also in 15:1 ratio than 15:2 during both cropping years. Similarly 25:1 ratio attracted more number of parasites than 25:2 ratios in both the seedling stages and in all the spacing schedules. Significantly highest parasitisation was observed in cabbage + tomato intercrop (23.64 to 60.71 percent) as compared to other cropping system during both years of study. Cabbage + berseem cropping system attracted a considerably lower number of parasites as compared to other intercropping system. Occurrence of parasitoids in cabbage intercropped with garlic,
cumin, fennel and coriander was significantly higher as compared to radish, carrot, berseem and marigold cropping system. *Cotesia plutellae* was observed dominant larval parasitoids in the experimental field during both the years.

The highest yield increase was in a range of 47.17 to 61.34 q\(^{-1}\) which was produced in cabbage + tomato cropping system and the lowest i.e. 6.30 to 15.00 q\(^{-1}\) in cabbage + marigold as compared to cabbage alone. 40-days old seedling of cabbage when planted produced greater yield than 30-days old in all ratios and spacing schedules during both years. Spacing of 60x45 cm with a ratio of 15:2 (cabbage + intercrops) produced higher yield of sole and intercrops than that ratio of 15:1 and also on the same way 25:2 produced maximum yield rather than 25:1. Minimum yield was recorded on cabbage + marigold cropping system in relation to stage of seedling, ratios and spacing. Maximum benefit in terms of rupees was estimated on cabbage + tomato cropping system i.e. Rs. 46440/- in 40-days old seedling of cabbage with 60x45cm spacing and 15:2 ratio during 2008-09. While, it was estimated as Rs. 40870/- in 30-days old seedling of cabbage with the same spacing and ratio in 2007-08 as compared to other cropping system. Cumin, fennel, garlic and coriander intercrops offered greater additional return as compared to radish, carrot, berseem and marigold during both years of study. Comparatively higher yield was recorded in 2007-08 than in 2008-09.

Weather parameters are significantly/non significantly, positively/negatively correlated in both years of study. Maximum and minimum temperature as well as average humidity and rainfall are non significantly (positively/negatively) correlated with ratios and spacing and both seedling stages during both seasons. The minimum temperature was also substantially affected the population of *P. xylostella* and there was negligible rainfall in experimental period of 2007-08. Rainfall substantially affected the population of *P. xylostella* in 2008-09. Maximum and minimum temperature significantly (*P* < 0.01, *P* < 0.05) enhanced the population of *Cotesia* in 30 and 40-days old seedling of cabbage.

Neem azal, neem excel, multineem, neemarin, ultineem, NSKE, cartap hydrochloride and dichlovos were tested against *P. xylostella* on cabbage crop. Neem azal 0.50% EC was significantly (*P*<0.05) the best treatment followed by neem excel 0.15% EC and cartap hydrochloride 50 SP in all the spraying schedules at 30, 50 and 70 days after transplantation (DAT) during both years of 2007-08 and 2008-09. Application of neem azal @ 0.25, 0.50 and 1.00% at 30, 50 and 70 (DAT) was found most effective registering 40.0-63.62%, 60.13-77.02% and 75.24-89.45% reduction in the population of
*P. xylostella* as compared to control in 2007-08. Whereas 41.79-65.36%, 60.46-76.97% and 75.16-91.86% reduction was obtained in larval population over control in all three round sprays, respectively in 2008-09. Neem azal and neem excel were similar in their efficacy during both years of study. All the treatments produced significantly (*P*<0.05) higher marketable yield of cabbage as compared to control during both years of study. Maximum yield was produced in neem azal i.e. 281.73 and and 275.62 qha⁻¹ in 2007-08 and 2008-09, respectively followed by neem excel, cartap hydrochloride and multineem. Lowest yield i.e. 212.43 and 207.60 qha⁻¹ of cabbage was recorded in control plot in 2007-08 and 2008-09, respectively. Yield of cabbage in ultineem and NSKE were statistically similar. Yield from neemarin and dichlorvos was also same statistically in both years of study. Neem azal exhibited the highest benefit cost ratio i.e. 13.55:1 and 14.02:1 in 2007-08 and 2008-09, respectively. Neemarin showed the lowest benefit cost ratio i.e. 7.81:1 and 7.61:1 during both years.