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Effect of mustard varieties on life table and development of diamondback moth, *Plutella xylostella*

Tufail Ahmad[1] and M. Shafiq Ansari[2]

[1]*Department of Plant Protection, Hamelmalo Agricultural College, Keren, State of Eritrea*
[2]*Department of Plant Protection, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, India*

ABSTRACT

The Life table and development of diamondback moth, Plutella xylostella, was studies on four mustard varieties, Brassica napus var. Neelam, B. campestris var. Pusa Kalyani, B. campestris var. BSH-1, B. juncea var. Pusa Bold in protected field conditions for two consecutive year 2004 and 2005. Mortality of immature stages was higher on Indian mustard during both cropping years than to other varieties. Maximum number of eggs laid by P. xylostella was on cauliflower and minimum on B. campestris BSH-1 in both cropping years of 2004-05 and 2005-06. Net reproductive rate (R_0) was smallest i.e. 8.36 and 10.36 females/female/generation on B. campestris var. BSH-1 in both cropping years. Intrinsic rate of increase (r_m) was smallest on B. campestris var. BSH-1 > Indian mustard > Pusa kalyani > Neelam > cauliflower. Generation time was prolonged on India mustard and BSH-1, therefore, egg, larval and pupal stages are more exposed to parasites than shorter generation. Doubling time is prolonged on Indian mustard and BSH-1. Development of immature stages was fast on cauliflower and prolonged to 38.1 days on B. campestris var. BSH-1. Greater degree days (DD) were required to complete immature development on BSH-1 and on B. juncea than Pusa Kalyani and Neelam. Similarly pupal development required more degree-days than other immature stage.

Kew words: Development, Life table, Degree days, Diamondback moth, *P. xylostella*

INTRODUCTION

Diamondback moth, *P. xylostella* (Linn.) (Lepidoptera–Yponomeutidae) is recorded as a major and oligophagous pest with the larvae feeding specially on the members of the family Cruciferae such as cabbage, Chinese cabbage, cauliflower, broccoli, knol khol, radish, turnip and mustard [20]. Diamondback moth believed to originate in Mediterranean region [8], which is also the place of origin of some of the important crucifer crops [21]. 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 [19]. In India, diamondback moth was first recorded on crucifer vegetables in 1914 [7] and now it is distributed all over India wherever crucifers grown.

Trap crops, important components of cultural control, are composed of one or more plant species grown to attract a pest species in order to protect a nearby cash crop [10]. Protection may be achieved by preventing the pest from reaching crop, or by concentrating the pest in a portion of field where it can be managed [16] and may serve as a resource for natural enemies that can then increase and suppress the pest populations [25]. Therefore, this technique has shown some potential to reduce the damage by *P. xylostella* in crucifers because Indian mustard was reported to be a host for *P. xylostella* [11]. According to Srinivasan and Krishnamoorthy (1992) the preference for oviposition on Indian mustard by *P. xylostella* as compared to cabbage and larval survival was significantly lower than other plant in laboratory. Charleston and Kfir (2000), observed in laboratory experiments that female *P. xylostella* prefers to lay more eggs on *B. juncea* than on other *Brassica* spp. which is consistent with previous laboratory and field studies of [1]. Further, Charleston & Kfir (2000), suggested that low larval survival on Indian mustard in the laboratory condition and low infestation in the field, which indicated that the reduced in the wax load of Indian mustard, may play an important role. According to Asman (2002), used Indian mustard as a trap crop and was reported to suppress the damage to cash crop. However, similar approaches have failed in Hawaii [12] and Texas [4].In a screen house assessment, adults of *P. xylostella* laid significantly more eggs on *B. vulgaris* than on the cultivated hosts; cabbage, broccoli, and *B. napus* and the larvae do not survive on *B. vulgaris* [16]. Larval feeding or survival may be reduced in normal bloom varieties through antixenosis and physically or nutritionally based antibiosis [23]. If larval period is longer then it can afford parasitoids and predators to have more opportunities to attack [23]. The effort has been made in the present study, how the life table parameters and development of *P. xylostella* were influenced in presence of mustard varieties with sole crop in order to use as potential trap crop.

MATERIALS AND METHODS

Cultivation of mustard varieties

The life table of *P. xylostella* was studied on *Brassica* varieties i.e. gobhi sarson (*B. napus* var. Neelam), yellow mustard (*B. campestris* var. Pusa kalyani), brown sarson (*B. campestris* var. BSH-1), Indian mustard (*B. juncea* var. Pusa Bold) and cauliflower (*B. oleracea botrytis* var. Pusa Snowball) (untreated control) under protected field condition (no-choice test) during December, 2004 to January, 2005 and December, 2005 to January, 2006. Seeds of above mentioned varieties were dibbled in pots (15cm) consist of soil with farm yard manure (FYM) in a ratio of 3:1 and then kept under protected condition to avoid insect infestation and plants (50 days after sowing) that were exposed to adults for egg laying.

Oviposition and rearing method

Five potted host plants were kept under the nylon cage (1x1x1m) and five pairs of newly emerged adults obtained from the stock culture were released in the cage. Sugar solution soaked in cotton was kept inside the cage for feeding the adults. The host plants were removed from the cage after 24 h of exposure and the experiment was replicated 10 times. 100 eggs were selected on the plants of known age for construction of stage specific life table. All parameter of life table were recorded till the emergence of adult. Emerged adults were taken out from the cage and were sexed and one pair of adult was released in a separate cage with potted plant of known age for calculation of female survivorship and fecundity of *P. xylostella*. Plant was changed every 24 h and a fresh potted plant was introduced into cage and this practice was done till the death of adults and also replicated 10 times.

Statistical analysis

Mortality and survival ratio, fertility table and life indices of *P. xylostella* were constructed as per method of [13] and [9]. Finally, the data was analyzed statistically by application of correlation, and ANOVA and further subjected to test of significance. Maximum and minimum temperatures were recorded during both cropping years.

Linear regression model

Effect of constant temperatures on the development of *P. xylostella* was analyzed by fitting (i) linear regression curve using Sigma Plot-Version 10. Rate of development is defined as the reciprocal of time required for completion of a life stage i.e. 1/d. Linear regression equation was adopted to express the relationship between the temperature (*T*) and rate of development (*D*).

$D = a + bT$……………………………………….………(1)

Where, D = Development rate, a and b are constants which were determined by least square method; T = Temperature

Lower thermal threshold T_{min} = 6.05 (base temperature) that calculated by putting D=0 in equation (1)

Thermal constant was calculated by the method of Wilson & Barnett (1983):

(Maximum temperature + Minimum temperature)/2 – Base temperature

RESULTS

Effect of mustard varieties on the life table of *P. xylostella*

The result showed that life table parameters are significantly (P<0.05) varied in one cropping season to another. Maximum *K-value* i.e. 0.638 was recorded on Indian mustard and lowest i.e. 0.260 on cauliflower in 2004-05 and similar observation was also found in second cropping season of 2005-06. Fecundity of female of *P. xylostella* decreased with advancing age and peak egg production was found on the beginning of pivotal age and then decreased with age and a variable post oviposition period was also observed on mustard varieties whereas 3 days were recorded in both cropping years on cauliflower. Mustard varieties significantly (P<0.05) affected the fecundity of *P. xylostella.* Maximum number of eggs was laid by *P. xylostella* on cauliflower and minimum on *B. campestris* BSH-1 in both cropping years of 2004-05 and 2005-06 (Fig1). Female survivorship of *P. xylostella* decreased with advancement of age and maximum occurred on cauliflower (control) and minimum on *B. juncea* and *B. campestris* var. BSH-1 in both the cropping seasons. Pre-oviposition period is 1-day on cauliflower but delayed to 4-days when larvae fed on *B. campestris* var. Pusa Kalyani. Oviposition period varied among the host plants tested as well as in different cropping years. Females obtained from the larvae fed on cauliflower continue to lay eggs for 10 and 11 days in 2004-05 and 2005-06, respectively but 6 days on *B. campestris* var. BSH-1, while 6 and 7 days on Indian mustard in 2004-05 and 2005-06, respectively.

The life indices parameter, Potential fecundity (P_f) of *P. xylostella* obtained from the larva fed on cauliflower was highest i.e. 120.10 and 116.90 in both cropping seasons of 2004-05 and 2005-06, respectively and smallest on *B. campestris* var. BSH-1 in both years (Table 1). 64.20 and 68.50 eggs/female was obtained when larva fed on *B. juncea* in both cropping seasons, respectively. Net reproductive rate (R_0) was found to be smallest i.e. 8.36 and 10.36 females/female on *B. campestris* var. BSH-1 in both cropping years, respectively and 11.71 and 12.99 females/female was on Indian mustard in both the years respectively and R_0 was greatest when larva fed on cauliflower in both the years. Fractional difference was calculated between instantaneous rate of increase and intrinsic rate of increase of *P. xylostella* on mustard varieties in both consecutive years. *P. xylostella* adult obtained from the larva fed on cauliflower showed greatest r_m (0.1188 and 0.1215 females/female/day) in both cropping seasons. Whereas in *B. napus,* r_m was 0.0988 and 0.0969 females/female/day in both cropping seasons, respectively while, minimum (0.0537 and 0.0589 females/female/day) was on *B. campestris* var. BSH-1(Table 1). Intrinsic rate of increase was also tested by pseudo-jackknife test and result is given in the table that showed a significant difference in value of r_m on cauliflower in comparison to jackknife tested value in both years, respectively while, rest of host plants showed insignificant difference in tests during both experimental years. Finite rate of increase of cauliflower is significantly differed in comparison to other host plants. *P. xylostella* obtained from larva fed on *B. campestris* var. BSH-1 showed smallest (1.06 and 1.06 females/female/day) finite rate of increase in comparison to 1.13 females/female/day on cauliflower followed by 1.10 females/female/day on *B. napus* in both cropping seasons of 2004-05 and 2005-06. Mean length of generation (T_c) was found shortest i.e. 30.58 and 30.84 days on cauliflower during both years, respectively. While, T_c was delayed to 39.76 and 39.80 days on Indian mustard in 2004-05 and 2005-06, respectively. T_c on cauliflower was significantly different to other host plants tested in both years. T_c was not significantly different on *B. napus* and *B. campestris* var. Pusa Kalyani, as well as on Indian mustard and *B. campestris* var. BSH-1 during 2004-05. A significant (P<0.05) difference was found in T_c on *B. campestris* var. Pusa Kalyani in both the years and *B. napus* yielded a similar mean length of generation during both the cropping seasons. Fractional difference was obtained in corrected generation time (τ) and mean length of generation (T_c) on mustard host plants. Corrected generation time on cauliflower differed in comparison to other host plants tested. *P. xylostella* completed one generation in 39.75 days on Indian mustard during both years in comparison to 30.36 and 29.24 on cauliflower during 2004-05 and 2005-06, respectively. Doubling time (DT) significantly (P<0.05) differed on different host plants. *P. xylostella* obtained from larva fed on cauliflower become double in 5.83 and 5.70 days on in 2004-05 and 2005-06, respectively while, *P. xylostella* fed on *B. campestris* var. BSH-1 took 12.91 and 11.77 days to become double and 11.20 and 10.75 days on Indian mustard during both the years, respectively. Multiplication rate of *P. xylostella* fed on cauliflower was significantly faster than other host plants. However, ARI 6.79×10^{18} and 1.82×10^{19} individuals were produced on cauliflower during both the seasons, respectively.

Effect of mustard varieties on development of *P. xylostella*

Development of *P. xylostella* significantly (P<0.05) varied when the larvae fed on mustard hosts and also differed in two consecutive cropping seasons of 2004-05 and 2005-06 (Table 2). Development of egg of *P. xylostella* on cauliflower significantly (P<0.05) differed to that of Indian mustard and *B. campestris* var. BSH-1 during both the cropping seasons. Egg development was completed in 5.20 and 5.10 days on *B. campestris* var. BSH-1 during 2004-05 and 2005-06, respectively, while 5.10 and 2.90 days on Indian mustard. First instar remained in mine for 4.90 and 5.00 days on *B. campestris* var. BSH-1 and passed significantly longer time than that on cauliflower (control) during both cropping seasons, respectively. I instar completed the development in 4.80 and 4.70 days on Indian mustard while shorter time was observed on *B. napus* and *B. campestris* var. Pusa Kalyani. The development of II instar on cauliflower, *B. napus* and *B. campestris* var. Pusa Kalyani did not differed significantly with each other in the cropping season of 2004-05 and significantly prolonged on Indian mustard and *B. campestris* var. BSH-1. While during cropping season of 2005-06, development of II instar fed on cauliflower significantly differed to that of other mustard hosts. Likewise III and IV instar development significantly/non significantly varied among the mustard hosts. Pupal development varied when the larva were fed on cauliflower in comparison to mustard hosts as well as in both cropping seasons. Minimum developmental period was observed on cauliflower and maximum on *B. campestris* var. BSH-1 in both cropping seasons of 2004-05 and 2005-06, respectively. Total developmental period of immature stage (egg to emergence of adult) considerably (P<0.05) varied during both years of 2004-05 and 2005-

06. Shortest developmental period was on cauliflower but prolonged (38.10 and 38.90 days) on *B. campestris* var. BSH-1 in both the cropping seasons, respectively. Time taken to complete the development in cauliflower was 28.10 days followed by *B. napus* 29.54 days during 2004-05 and 2005-06, respectively and 36.20 and 36.40 days on Indian mustard on both cropping seasons, respectively. Adults of *P. xylostella* live longer on cauliflower in comparison to mustard varieties during both years of study while, shortest 7 and 7.20 days occurred on *B. campestris* var. BSH-1. Correlation was significantly/non-significantly favourable/un-favourable for development of *P. xylostella* in both years of study on mustard varieties. The thermal constant estimated by linear regression (Table 3). The result showed that thermal constant varied in mustard varieties and in both years of study. Pupal development of *P. xylostella* required more degree days than that of individual stages of larva (Table 4).

DISCUSSION

In the present study, fecundity m_x was found to be highest on cauliflower (control) and the lowest on *B. campestris* var. BSH-1 in both cropping seasons. m_x was 88.45 and 90.45 when larvae raised on *B. napus* var. Neelam and 64.20 and 68.50 on *B. juncea* var. Pusa Bold in both cropping seasons, respectively (Fig 1). Syed and Abro (2003), reported that fecundity of *P. xylostella* was 118.7 and 82.00 on *B. campestris* and *B. napus*, respectively.

Life indices of *P. xylostella* were significantly (P<0.05) differed on mustard varieties. Highest R_0 occurred on cauliflower followed by *B. napus* var. Neelam and the smallest (8.36 females/female) on *B. campestris* var. BSH-1 (**Fig 1**) the [18] obtained a similar R_0 on *B. napus* but higher (31.79 females/female) on *B. campestris* as compared to present study. Intrinsic rate of increase varies substantially in two cropping seasons. r_m was 0.0992 and 0.0537 females/female/day on *B. napus* var. Neelam and *B. campestris* var. BSH-1, respectively. While, higher r_m was reported by [18] on these two mustard varieties. Mean generation time substantially differed in two cropping seasons and T_c on cauliflower also significantly differed in comparison to mustard varieties. *P. xylostella* required 39.65 and 39.76 days to complete a generation on *B. campestris* var. BSH-1 and *B. juncea* var. Pusa Bold, respectively, while 33.36 days on *B. napus* var. Neelam. (Syed & Abro 2003) reported that 20.54 and 21.69 days required by *P. xylostella* to complete one generation on *B. napus* and *B. campestris*, respectively. In the present study, development of immature stages was significantly fast i.e. 25.90 and 26.70 days on cauliflower in both cropping seasons of 2004-05 and 2005-06, respectively, but prolonged to 36.20 and 38.10 days on Indian mustard and *B. campestris* var. BSH-1, respectively. Female development was fastest on *B. juncea*, whereas male larval development faster on *B. napus* var. Liberty [15]. Ramegowada et al. (2006), reported that development of mature stage of *P. xylostella* was completed in 34.13 days. It was concluded by [22] that shortest development time and greater total oviposition (fecundity) on the host reflected suitability of the host plant. Degree day requirement for development *P. xylostella* varies in different years as showed in the present study. Minimum 196.60 degree days required when larva fed on cauliflower and maximum 351.72 degree days on *B. campestris* var. BSH-1 during cropping seasons of 2004-05. Degree-day requirement for development of *P. xylostella* depends on host plants and temperature and significantly greater degree-days was required to complete the development of *P. xylostella* at higher temperature than that of lower temperatures [2].

Table 1 Life indices of *Plutella xylostella* on mustard varieties

Host plant	P_f	R_0	r_c	r_m	r_j	λ	T_c	τ	R_0^2	*DT*	*A.R.I*
Cropping year (2004-05)											
B. napus var. Neelam	88.45b	27.01b	0.0988a	0.0992a	0.0954a	1.10a	33.36b	33.23b	729.54b	6.99d	5.31E+15a
B. campestris var. Pusa Kalyani	75.35c	16.73c	0.0838b	0.0839b	0.0832b	1.09a	33.61b	33.58b	279.89c	8.26c	1.99E+13a
B. campestris var. BSH-1	54.00c	8.36c	0.0536c	0.0537c	0.0522c	1.06b	39.65a	39.54a	69.89d	12.91a	3.25E+08a
B. juncea var. Pusa Bold	64.20d	11.71d	0.0618b	0.0619b	0.0617b	1.06b	39.76a	39.75a	137.12d	11.20b	6.49E+09a
Cauliflower	120.10a	36.85a	0.1180a	0.1188a	0.1103a	1.13a	30.58c	30.36c	1357.92a	5.83d	6.79E+18a
LSD P=0.05	0.910	0.960	0.0290	0.0280	0.0165	0.058	1.420	0.750	73.980	1.240	4.38E+13
df	4,14	4,14	4,14	4,14	4,14	4,14	4,14	4,14	4,14	4,14	4,14
F	92.660	75.230	14.850	15.28	42.86	187.63	80.410	202.970	0.040	114.770	1.720
R^2	0.162	0.113	0.115	0.118	0.176	0.111	0.102	0.125	0.212	0.001	0.499
r	-0.126	-0.092	0.071	0.066	0.138	-0.002	-0.219	-0.205	-0.246	-0.266	-0.522
Cropping year (2005-06)											
B. napus var. Neelam	90.05b	26.45b	0.0969b	0.0974b	0.0921a	1.10a	33.81c	33.63c	699.60b	7.12c	2.75E+15a
B. campestris var. Pusa Kalyani	76.20c	18.21c	0.0821c	0.0824c	0.0795a	1.09a	35.34b	35.22b	331.60c	8.41b	1.15E+13a
B. campestris var. BSH-1	58.60e	10.36e	0.0588d	0.0589d	0.0581b	1.06a	39.74a	39.69a	107.33e	11.77a	2.17E+09a
B. juncea var. Pusa Bold	68.50d	12.99d	0.0644d	0.0645d	0.0637b	1.07a	39.80a	39.75a	168.74d	10.75a	1.68E+10a
Cauliflower	116.90a	34.92a	0.1152a	0.1215a	0.0585b	1.13a	30.84d	29.24d	1219.41a	5.70a	1.82E+19a
LSD P=0.05	1.52	2.45	0.0080	0.0130	0.0130	0.11	0.93	1.14	49.25	1.15	2.80E+12
df	4,14	4,14	4,14	4,14	4,14	4,14	4,14	4,14	4,14	4,14	4,14
F	63.240	12.590	20.530	19.35	20.05	31.24	125.860	84.510	2.420	56.270	1.820
R^2	0.157	0.246	0.212	0.201	0.083	0.201	0.203	0.181	0.248	0.163	0.349
r	0.400	0.414	0.488	0.456	0.590	0.506	-0.525	-0.477	0.305	-0.603	0.066

Values not followed by same letter are significantly different (P=0.05) by DMRT

Table 2 Effect of mustard varieties on the development of *Plutella xylostella*

Host plant	Egg ± SE	I instar ± SE	II instar ± SE	III instar ± SE	IV instar ± SE	Pre-Pupa ± SE	Pupa ± SE	Immature stage (Egg to pupa) ± SE	Adult ± SE
Cropping year 2004-2005									
B. napus var. Neelam	4.20 ± 0.10a	4.20 ± 0.09ab	4.10 ± 0.12a	3.90 ± 0.05a	3.90 ± 0.08ab	1.00 ± 0.08a	6.80 ± 0.16b	28.10 ± 0.75b	12.10 ± 0.38d
B. campestris var. Pusa Kalyani	4.50 ± 0.10b	4.44 ± 0.10b	4.30 ± 0.08a	4.00 ± 0.14a	4.10 ± 0.14b	1.20 ± 0.05b	9.20 ± 0.44c	31.74 ± 1.18c	10.30 ± 0.32c
B. campestris var. BSH-1	5.20 ± 0.57c	4.90 ± 0.22c	5.20 ± 0.26b	4.30 ± 0.14b	4.80 ± 0.22c	1.50 ± 0.10c	12.20 ± 0.20e	38.10 ± 1.85e	7.00 ± 0.26a
B. juncea var. Pusa Bold	5.10 ± 0.10c	4.80 ± 0.24c	5.00 ± 0.33b	4.20 ± 0.14b	4.50 ± 0.22c	1.30 ± 0.11b	11.30 ± 0.16d	36.20 ± 1.77d	7.50 ± 0.32b
Cauliflower	4.00 ± 0.27a	4.20 ± 0.25a	4.00 ± 0.33a	3.90 ± 0.11a	3.70 ± 0.14a	1.00 ± 0.07a	5.10 ± 0.24a	25.90 ± 1.45a	14.20 ± 0.16e
LSD P=0.05	0.38	0.26	0.39	0.14	0.30	0.13	0.62	0.49	0.45
df	4, 14	4, 14	4, 14	4, 14	4, 14	4, 14	4, 14	4, 14	4, 14
F	28.75	25.84	17.44	41.08	19.49	48.60	15.07	52.38	36.59
R^2	0.955	0.909	0.916	0.916	0.980	0.938	0.820	0.983	0.971
r	0.191	-0.357	-0.618	-0.098	-0.107	-0.249	-0.331	-0.316	-0.422
Cropping year 2005-2006									
B. napus var. Neelam	4.10 ± 0.30a	4.44 ± 0.50a	4.30 ± 0.21b	4.20 ± 0.17a	4.10 ± 0.14b	1.20 ± 0.25b	7.20 ± 0.35b	29.54 ± 1.93b	12.50 ± 0.72c
B. campestris var. Pusa Kalyani	4.30 ± 0.18a	4.44 ± 0.20a	4.50 ± 0.15c	4.30 ± 0.14a	4.20 ± 0.12b	1.30 ± 0.52b	9.40 ± 0.40c	32.44 ± 1.71c	11.00 ± 0.95b
B. campestris var. BSH-1	5.10 ± 0.24b	5.00 ± 0.22b	5.30 ± 0.26e	4.90 ± 0.22c	4.70 ± 0.20d	1.60 ± 0.26c	12.30 ± 1.21e	38.90 ± 2.96e	7.20 ± 0.88a
B. juncea var. Pusa Bold	4.90 ± 0.29b	4.70 ± 0.30ab	5.10 ± 0.26d	4.60 ± 0.17b	4.50 ± 0.16c	1.50 ± 0.47c	11.10 ± 0.73d	36.40 ± 2.38d	7.80 ± 0.72a
Cauliflower	4.00 ± 0.27a	4.30 ± 0.14a	4.10 ± 0.12a	4.10 ± 0.20a	3.80 ± 0.34a	1.00 ± 0.24a	5.40 ± 0.91a	26.70 ± 1.43a	14.70 ± 0.91d
LSD P=0.05	0.35	0.45	0.18	0.21	0.12	0.16	0.38	0.53	0.97
df	4, 14	4, 14	4, 14	4, 14	4, 14	4, 14	4, 14	4, 14	4, 14
F	35.78	20.45	72.05	44.37	120.96	71.90	77.91	53.65	35.72
R^2	0.929	0.870	0.955	0.935	0.983	0.986	0.970	0.995	0.970
r	0.223	0.032	-0.044	-0.101	0.193	-0.306	-0.298	0.84	-0.163

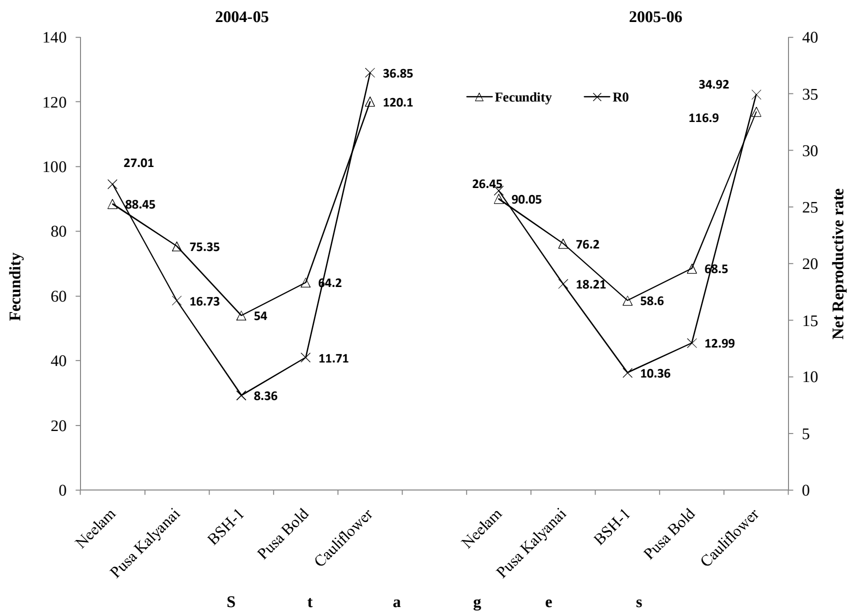

Figure 1: Effect of mustard varieties on fecundity and net reproductive rate of *P. xylostella*

Table 3 Estimates of linear regression of *P. xylostella* on mustard varieties

Host Plants	*a*	*b*	*R²*	*k*	*RSS*
Cropping year (2004-05)					
B. napus var. Neelam	0.1595	0.0451	0.1103	22.17	0.4598
B. campestris var. Pusa Kalyani	0.1764	0.0315	0.0813	31.75	0.4147
B. campestris var. BSH-1	0.1669	0.0218	0.0626	45.87	0.1992
B. juncea var. Pusa Bold	0.1573	0.0293	0.0804	34.13	0.2754
Cauliflower	0.1541	0.0494	0.1382	20.24	0.4256
Cropping year (2005-06)					
B. napus var. Neelam	0.1785	0.0324	0.0893	30.86	0.3004
B. campestris var. Pusa Kalyani	0.1867	0.0258	0.0661	38.76	0.2626
B. campestris var. BSH-1	0.1683	0.0189	0.0552	52.91	0.1715
B. juncea var. Pusa Bold	0.1739	0.0211	0.0605	47.39	0.1944
Cauliflower	0.1513	0.0486	0.1312	20.58	0.4373

Table 4 Degree days (Averaging method) for development of *Plutella xylostella* on mustard varieties

Host Plant	Egg	I instar	II instar	III instar	IV instar	Pre-pupa	Pupa	Immature stage (egg to pupa)
Cropping (2004-05)								
B. napus var. Neelam	42.74	40.05	43.25	39.90	41.68	9.85	60.30	277.77
B. campestris var. Pusa Kalyani	52.44	52.25	43.00	39.43	40.85	9.95	82.75	320.67
B. campestris var. BSH-1	52.44	52.25	53.95	38.18	49.05	14.00	91.85	351.72
B. juncea var. Pusa Bold	52.44	52.25	53.95	38.18	49.05	7.55	79.85	333.27
Cauliflower	42.74	40.05	43.25	39.90	41.68	9.85	51.35	268.82
Cropping year (2005-06)								
B. napus var. Neelam	25.95	31.15	28.05	24.70	22.55	6.35	46.35	185.10
B. campestris var. Pusa Kalyani	25.95	31.15	34.40	31.05	28.90	6.35	60.60	218.40
B. campestris var. BSH-1	32.65	38.70	34.05	28.55	30.90	11.45	81.90	258.20
B. juncea var. Pusa Bold	32.65	38.70	34.05	28.55	30.90	11.45	77.50	253.80
Cauliflower	25.95	31.15	28.05	24.70	22.55	6.35	30.85	169.60

Base temperature (T_{min}) = 6.05°C

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