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Effect of Brassica Vegetable Hosts on Biology and Life Table Parameters of *Plutella xylostella* under Laboratory Conditions

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Abstract: Different bracissca vegetables such as *Brassica oleracea botrytis, B. oleracea capitata, B oleracea italica, B. napus, B. compestris, B. chenisis perkensis* and *Raphanus sativa* were provided to newly hatched larvae of *Plutella xylostella.* The shortest and longest larval period of 9.45 and 10.95 days were recorded on *B. oleracea botrytis* and *Raphanus sativa*, respectively. Percent larvae pupating did not differ significantly, the lowest and highest percent survival to adult stage was recorded 58.3 and 76.7% on *B. napus* and *B. oleracea italica.* Whereas shortest and longest pupal period was recorded as 6.48 and 5.84 days on *B.napus* and *B.oleracea capitata* fed larvae. Pupal mass and fecundity of female showed that highest pupal mass and fecundity was recorded on *B. oleracea* fed larvae as compared to other Brassica vegetable crops. Similarly *P. xylostella* females preferred to lay more eggs on *B.oleracea botrytis* as compared with other hosts. Result also showed that females preferred to lay eggs on lower side as compared to upper side of the leaves. The life table parameters showed that net reproductive rate (Ro), was highest (89.71) when *P.xylostella* fed on *B. olaracea botrytis*, while the lowest Ro value of 26.77 was recorded when larvae were fed on *B. napus.* The intrinsic rate of increase (rm) and finite rate of increase ($_e$rm) were highest and lowest on *B. olaracea botrytis* and *B.compestris*, respectively.

Key words: Brassica, life table, vegetables, fecundity, host-plant

INTRODUCTION

The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is the most destructive pest insect of cruciferous plants throughout the world. It has been recorded since 1746 (Harcourt, 1962) and is believed to have originated in the Mediterranean region (Harcourt, 1954) which is also the place of origin of some of the important crucifer crops (Tsunoda, 1980). Virtually, *P. xylostella* occurs wherever crucifer crops are grown, however, it has now been recorded from at least 128 countries or territories of the world and is believed to be the most universally distributed of all lepidoptera (CIE, 1968; Salinas, 1972; Lim, 1986; Talekar and Shelton, 1993). The annual cost of controlling *P. xylostella* on a worldwide basis is estimated to be around US$ 1 billion (Talekar and Shelton, 1993; Lasota *et al*., 1996). Abro *et al.* (1992) have found *P. xylostella* a very serious pest on cruciferous vegetables in the Southern Sindh, Pakistan. *P. xylostella* feeds only on plants of cruciferae. Many of the plants of this family are cultivated as vegetables and oil seed crops. There are numerous crucifer plants which are not consumed by man, are considered as weeds and consumed by *P. xylostella* when its favoured hosts are absent and provide crucial link in maintaining *P. xylostella* populations (Talekar and Shelton, 1993 and Begum *et al*., 1996).

Brassica vegetables specially cabbage, *Brassica oleracea* var. *capitata*, cauliflower, *B. oleracea* var. *botrytis* and radish, *Raphanis sativus* are important vegetable crops of province of Sindh, Pakistan. The climate of southern Sindh (Hyderabad and Karachi regions) is mild and cruciferous vegetables are grown almost throughout the year, around towns and cities. *P. xylostella* has become a very serious problem and causes great economic loss to farmers. *P. xylostella* attack is some times so catastrophic that farmers are unable to save their crops even with the cocktails of most toxic chemicals and are compelled to uproot their cruciferous vegetables and grow other non host crops like onions, garlic and tomatoes to save themselves from complete economic wreck.

MATERIALS AND METHODS

Biological studies: Studies on the effect of host plants on some biological parameters were carried out under laboratory conditions, at the department of Entomology, Sindh Agriculture University Tandojam during 1996-97. Different Brassica vegetable crops that is, cauliflower, *Brassica oleracea botrytis*; cabbage, *Brassicae oleracea capitata*; radish, *Raphanis sativa*; turnip, *Brassica napus*; Chinese cabbage, *Brassica chinesis perkensis*;

broccoli, *Brassica italica* and mustered, *Brassica compestris* were sown in a completely randomized block design on ridges. The leaf discs approximately 5.0 cm diameter of each host plant were kept in petridishes (10.0 cm dia) separately and 10 newly hatched larvae were introduced with fine hair brush in to each petridishes. The experiment was replicated five times. Fresh food was provided daily and old food removed till pupation. One day after pupation, pupal weight of randomly selected 25 pupae of each host plant were weighed on electrical balance (Ohas, Galexy 160). After adult emergence one male and female were paired and kept in glass chimney.(17.0 cm high) for egg laying. A small leaf of cauliflower was kept in vial containing water for egg laying and 10% (w/v) glucose solution in a beverage bottle lid impregnated on to cotton wool was provided to adult as food. Obsevations on egg laying were recorded daily till the end of oviposition or death of females.

Egg laying preference: For egg laying preference, newly emerged (10 pairs) male and female adults were released in a egg laying chambers. Fully expanded leaves of different host plants in a vial containing water were placed individually in a chamber for egg laying. Leaves were replaced daily and the eggs laid on subsequent days were considered as replications.

Egg laying distribution: The experiment was conducted on egg laying distribution. Newly emerged adult pairs were introduced in a cage,.cauliflower leaves were provided for egg laying. Eggs laid on upper and lower leaf surfaces were counted daily. The experiment was replicated 12 times.

Life table parameters: To study the effect host plants on life table parameters of *P. xylostella* under laboratory conditions, the fresh laid eggs were collected from the culture and kept for hatching. After hatching, 50 neonate larvae (10.0 h old) were transferred with fine camel hair brush onto different host pants leaf discs in Petridishes (10.0 cm dia). Each petridish contained 10 larvae (5 replications). The leaf discs were changed daily till all larvae went into pupation. The emerged adults were paired and released in separate cages for egg laying. The fecundity of the females on subsequent days was noticed daily till all the females died. The life table parameters under laboratory conditions were constructed as suggested by Southwood (1978).

Net reproductive rate= $Ro. = \sum Lxmx$

The mean length of generation , $T = \dfrac{\sum XLXMX}{Ro}$

The intrinsic rate of population increase (rm) = $\dfrac{LogeRo}{T}$

The finite rate of population increase = ($_e$rm).............

RESULTS

Biological parameters: The effect of host plants on some biological parameters of *Plutella xylostella* showed the effect of different Brassica vegetables crops on larval and pupal period, percent larvae pupating and percent survival to adults (Table 1) .There was significant effect (F=173.01,DF=6,12; P<0.001) of host plants on larval development of *P. xylostella*. The shortest and longest larval period of 9.45 and 10.95 days was observed on cauliflower, *Brassica oleracea botrytis* and *radish, Raphanus sativa*, respectively. However, pupal periods were significantly different from each other. The percent larvae pupating did not differ significantly (F=1.61, df=12; p>0.05). The lowest and highest survival to adult stage was recorded as 58.3 and 76.7% on turnip, *Brassica napus* and broccoli, *Brassia oleracea* italics, respectively and it was significantly different (F=60.11, df=6,12; P< 0.001) from each other.

The effect of different host plants on pupal mass and fecundity are shown in Table 2. which indicated that there

Table 1: Biological parameters of *P.xylostella* on different host species in a detached leaf bioassay[1]

Host species	Larval duration (days)	Rate of larval pupating/%	Pupal duration /d	Rate of survival to adult/%
B. oleracea botrytis	9.45±0.08b	88.3±1.7a	6.00±0.15e	75.0±0.58d
B. oleracea capitata	9.63±0.10b	78.3±4.4a	5.84±0.15a	63.3±1.116b
B. oleracea italica	10.68±0.11c	90.0±2.9a	5.89±0.13b	76.7±1.16d
B. napus	10.57±0.19c	78.3±6.0a	6.48±0.15f	58.3±0.58a
B. compestris	10.90±0.15d	78.3±1.7a	5.94±0.19d	60.0±1.16a
B. chinesis Pekinesis	9.13±0.18a	85.0±2.9a	6.00±0.19e	68.3±0.17c
R. sativa	10.95±0.13d	76.7±6.0a	5.92±0.15c	63.3±1.16
LSD 0.05	0.20	-	0.01	2.84

1) Mean ± SE followed by the same letter within a same column are not significantly different from each other (P< 0.05; LSD) method)

Table-2: Effect of different host species on pupal mass and fecundity of *P.xylostella* under laboratory conditions[1)]

Host	Pupal mass mg^{-1}	Fecundity per female
B. oleracea Botrytis	6.08±0.13f	212.3±23.8b
B. oleracea capitata	5.89±0.11e	190.0±6.6b
B. oleracea italica	5.58±0.08d	97.7±18.5a
B. napus	5.50±0.09c	82.0±20.5a
B. compestris	4.95±0.15a	118.7±19.3a
B. chinesis Pekinesis	4.94±0.13a	83.7±11.6a
R. sativa	5.04±0.16b	88.3±20.0a
LSD 0.05	0.04	38.06

[1)] Mean ± SE followed by the same letter within a same column are not significantly different from each other (P< 0.05; LSD)

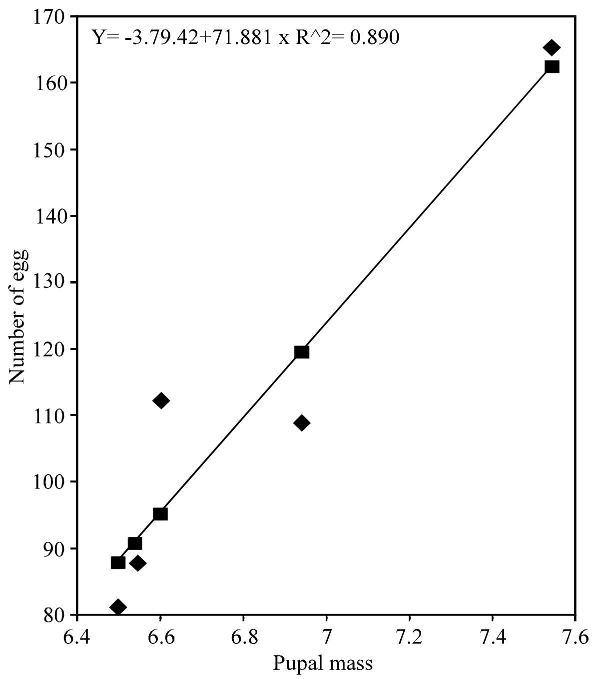

Fig. 1: Linear Regression between the eggs per female and average pupal mass of *P. xylostella* when larvae were reared on different host plants

was significant (F=13.75, df=6,54, P<0.01) effect of host species on pupal mass and the highest pupal mass was recorded from larvae reared on cauliflower (6.08 mg) followed by cabbage (5.89 mg). While the lowest pupal mass was found of larvae reared on Chinese cabbage (4.94 mg). Similarly, the highest fecundity of females was recorded when larvae were reared on cauliflower (212.3) followed by cabbage (190.0) which was significantly (F=8.82, df=6,12; P<0.01) higher than larvae reared on remaining host plants. The lowest fecundity of 82.0 eggs per female was recorded when larvae were fed on turnip as host. The correlation studies carried out between pupal mass and fecundity also indicated a highly significant (P<0.01) relationship (Fig. 1).

Egg laying preference: Host plant preference for egg laying by *P. xylostella* (Table 3) indicated that significantly (F=8.55, df=6,12; P<0.01) more eggs were laid on cauliflower leaf followed by cabbage indicating that cauliflower is preferred host of *P.xylostella* as compared with other hosts for egg laying.

Egg laying distribution: The egg laying distribution of *P. xylostella* on cauliflower leaves under laboratory conditions showed that more eggs were laid on lower leaf surface when compared with upper leaf surface, however, the difference was statistically non significant (Table 4).

Table 3: Egg-laying preference of *P.xylostella* females on different host species in a detached-leaf bioassay[1)]

Host	Eggs	%Eggs
B.oleracea botrytis	803.3±232.1b	47.7
B.oleracea capitata	233.3±23.9a	13.8
B.oleracea italica	154.0±10.0a	9.1
B.napus	127.3±49.1a	7.5
B.compestris	133.3±14.1a	7.9
B.chinesis pekinesis	126.7±43.6a	7.57
Raphanus sativa	106.7±35.9a	6.3
Total	1685.6	100
LSD 0.05	132.04	-

1) Means±SE followed by the same letter within a column are not significantly different from each other (P< 0.05; LSD)

Table 4: Egg distribution of *P. xylostella* on cauliflower leaves under laboratory condition

Treatment	n	X ± SE eggs	x %	t-a	P
Lower leaf surface	12	300.0+49.4	53.1		
				0.23	>0.05
Upper leaf surface	12	265.0+61.4	46.9		

a = Paired two tailed "t" test
p = figures are statistically non-significant (P>0.05)
n = Replications

Table 5: Effect of host plants on the life-table parameters of *P. xylostella* under laboratory conditions

Host plants	F*	Ro	T(d)	rm	e^{rm}
B. oleracea botrytis	212.3+22.8b	89.71	18.75	0.2398	1.27
B. oleracea capitata	190.0+6.6b	73.96	18.88	0.2288	1.25
R. sativa	88.3+20.0a	45.54	21.03	0.181	1.199
B. napus	82.0+20.5a	26.77	20.54	0.160	1.173
B. compestris	118.7+19.3a	31.797	21.69	0.159	1.173
B. chinesis pekinesis	83.7+11.6a	31.79	19.697	0.176	1.192
B. oleracea italica	98.7+18.5a	39.95	21.67	0.170	1.185

* = Mean+S.E

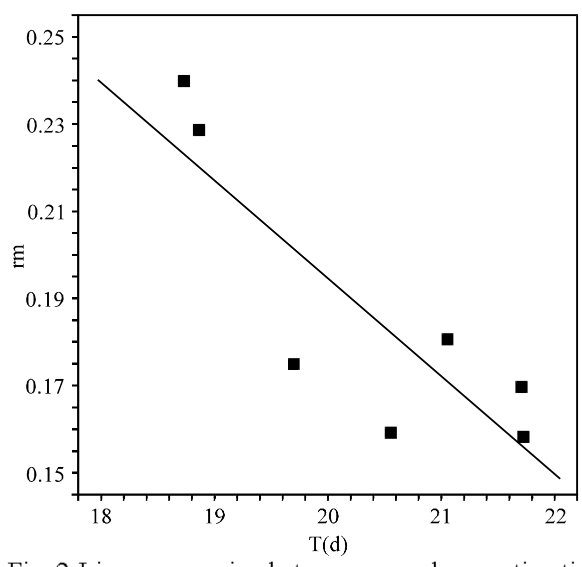

Fig. 2: Linear regression between rm and generation time of *P. xylostella* under laboratory conditions

Life table parameters: The life table parameters of *P. xylostella* on different host plants are shown in Table 5. The net reproductive rate (Ro) which is a product of mean

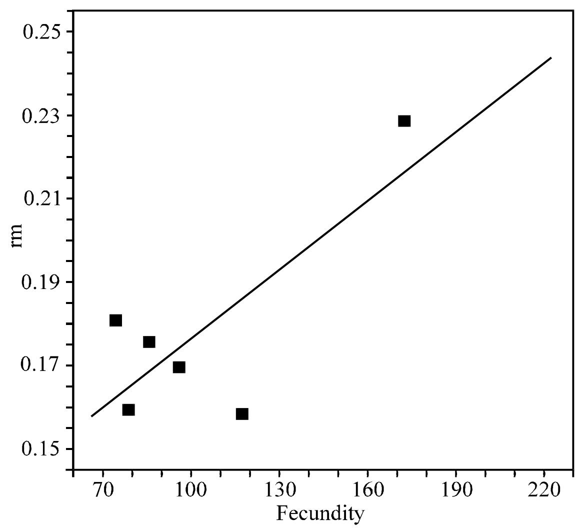

Fig. 3: Linear regression between rm and fecundity of *P. xylostella* under laboratory conditions

total fecundity, survival rate and sex ratio was the highest (89.71) expected females per female obtained with cauliflower as a host plant, while the lowest Ro value of 26.77 expected females per female was recorded when *P. xylostella* larvae were fed on turnip. There was some variation in the mean generation time T(d) of *P. xylostella* fed on different host plant. This value was (21.69 days) when individuals were fed mustard; T(d) was shorter (18.75) on cauliflower. The intrinsic rate of increase (rm) and the finite rate of increase (e^{rm}) were the highest (0.2398 and 1.27 respectively) when *P. xylostella* were fed cauliflower and lowest (0.159 and 1.173 respectively) on mustard as a host plant.

Multiple linear regression analysis between mean generation time (T) and mean total fecundity (independent variable) yielded R2=0.839 (P=0.05). The following equation was derived for *P. xylostella* at laboratory temperature rm=0.378 + 0.000146 F-0.0116G. This model indicated that 83.9% of the variance of the obtained rm values could be attributed to total fecundity and generation time. A higher total fecundity value would have a positive effect on the obtained rm value, where as, a higher value of generation time would have a negative effect on the rm value. (Fig. 1 and 2).

DISCUSSION

Life-cycle of diamondback moth varies considerably depending upon various factors such as the environmental conditions under which it develops and host plants (Ooi, 1986; Ko and Fang, 1979; Biever and Boldt, 1971; Shelton *et al.*, 1991). This difference in developmental time may be due to rearing of *P. xylostella* on different host plants. Differences in male and female developmental times and pupal weight observed in present studies were also reported by various workers (Kanervo, 1936; Umeya and Yamada, 1973).

The growth and development of *P. xylostella* varied considerably on different hosts plants in present study which may be due to presence of nutritional and phagostimulant factors in a most appropriate ratio for optimal growth and development of it in some of its host plants as compared with others. In present study cauliflower and cabbage were found to be better hosts for *P. xylostella* as larval period was completed in shorter time when compared with other hosts. Chand and Choudhary (1977) noted that *P. xylostella* attacked all the cruciferous plants, however, it exhibited a marked preference for cauliflower and cabbage. These two plant species possess fleshy succulent leaves that provide both olfactory and gustatory stimuli. Similarly, Singh and Singh (1982) studied the influence of various cruciferous host plants on survival and development of *P. xylostella* and found that pest completed its larval and pupal development in the shortest time on cauliflower. Harcourt (1957) studied the larval population of *P. xylostella* on various crucifers growing in the field and found the highest pest population on collards, cabbage and cauliflower crops as compared with other hosts. Ramachandran *et al.* (1998) also found significant differences in biological parameters of *P. xylostella* feeding on different *Brassica* spp. leaves. Present studies also show the highest *P. xylostella* survival when fed cauliflower followed by cabbage, almost similar observations were also recorded by other workers (Dube and Chand, 1977; Singh and Singh, 1982).

Highest number of eggs were laid by female *P. xylostella* when larvae were reared on cauliflower followed by cabbage (Table 4). Similarly, pupal weight of *P. xylostella* was also higher for those insect, which were fed cauliflower and cabbage in larval stage. Fecundity of an insect depends apart from other factors on pupal size (Wan, 1970). The fecundity-pupal weight regression equations obtained in present studies indicated that *P. xylostella* fecundity increased at a rate of 71.88 and 85.61 eggs for each milligram increase in pupal weight, regardless of the host on which female was reared. A correlation carried out between pupal weight and fecundity showed a significant positive relationship between two factors (Fig. 3). A significant correlation was noted between the fecundity of adults and pupal weight or length of *P. xylostella* (Wan, 1970). Similarly, Yamada and Umeya (1972) concluded that fecundity is determined by pupal size. The linear relationship of fecundity to body weight or size of pupa or both, has also been observed in other insects. Miller (1957) noted that fecundity of spruce budworm, *Choristoneusa fumiferana* Clemens, could be estimated on pupal weight or size, because both factors are related linearly. Williams (1963) observed that the correlation between pupal weight and fecundity was greater than that between pupal length and fecundity in *Chilo sacchariphagus* Bojer. Begum *et al.* (1996) showed that female *P.xylostella* grown on wild crucifers (*Rorippa indica* and *Lipidium virginicum*) was less fecund than those reared on cabbage. Moreover, fecundity, longevity, flight activity and morphological characters of adult were positively correlated with pupal weight.

In the present study more eggs were recorded on the lower leaf surface than upper leaf surface (Table 4). This difference in egg laying behaviour may be due to difference in leaf morphology including leaf waxes, contour (grooves) etc. supporting egg impaction on leaf surface. These findings are in agreement with Robertson (1939).

P. xylostella feeds on a wide range of cruciferous host plants (Harcourt, 1957; Dube and Chand, 1977; Singh and Singh, 1982; Siemens and Mitchellolds, 1996; Ramachandran *et al.,* 1998). The effect of host plants on development and reproduction of *P. xylostella* vary (Wakisaka *et al.,* 1992; Salas *et al.,* 1993; Begum *et al.,* 1996). Van Lanteren and Noldus (1990) have stated that shorter developmental times and greater total oviposition (fecundity) on a host reflected the suitability of the host plant. In present study, *P. xylostella* fed on cauliflower and cabbage showed higher intrinsic rates of increase (rm) resulting from faster development (shorter generation time), higher survivorship and higher fecundity rates. These two host plants are presumably more suitable hosts as compared to other hosts. Wakisaka *et al.* (1992) studied the rm value of *P. xylostella* on different host plants and found that 'rm' value ranged between 0.2778 and 0.1362 respectively on broccli and a wild crucifer, *Capsella bursa-postoris.* Salas *et al.* (1993) investigated the life table parameter of *P. xylostella* on different host plants and observed that the highest rm was on cauliflower. Also, there are many other studies where host plants have affected biology and life table parameters of many insects/organisms (Root and Olson, 1969; Bessin and Reagan, 1990; Fouly *et al.* 1995; Tsai and Wang, 1996).

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