

## Life Table of the Diamondback Moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) on Five Cultivated Brassicaceous Host Plants

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### ABSTRACT

The development, survival, and reproduction of diamondback moth (DBM), *Plutella xylostella* (L.), were studied in laboratory at 25±1°C, 65±5% RH and a 14L: 10D hours photoperiodism on five host plants of: cauliflower (*Brassica oleracea* L. var. *botrytis*), two varieties of cabbage (*B. oleracea* L. var. *capitata*) namely 'Globe Master' and 'Scarlet Ohara', kohlrabi (*B. oleracea* L. var. *gongylodes*), and canola (*B. napus* L.). DBM larvae successfully survived on all host plants, although survival rate was lowest on canola (70.56%). The developmental time of immature stages ranged from 13.76±0.15 d on kohlrabi to 15.06±0.22 d on canola. The reproduction period and adult longevity were longest on cauliflower and common cabbage cultivar 'Globe Master' without any supplemental food while the highest fecundity of *P. xylostella* being also observed on these two host plants. The highest and lowest net reproductive rates were detected on cabbage cultivars, 'Globe Master' and 'Scarlet Ohara', respectively. Mean generation time was the longest on cabbage cultivar 'Globe Master'. The respective descending order of intrinsic rates of population increase was on cauliflower, cabbage cultivar 'Globe Master', kohlrabi, cabbage cultivar 'Scarlet Ohara' and canola. Cauliflower and cabbage cultivar 'Globe Master' were recognized as the most suitable host plants for DBM.

**Keywords:** *Brassica*, Crucifers, Demography, Plant resistance.

### INTRODUCTION

The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is the most important pest of cultivated brassicas worldwide, sometimes causing more than 90% crop loss (Talekar and Shelton, 1993; Verkerk and Wright, 1996). *P. xylostella* is regarded as an oligophagous insect, with the larvae feeding specifically on members of the family Brassicaceae which contain mustard oils and glucosides (Gupta and Thorsteinson, 1960). This diverse plant group ranges from cultivated crops to numerous wild plants including weed

species. In general, the vegetables, cauliflower *B. oleracea* L. var. *botrytis*, cabbage *B. oleracea* L. var. *capitata* and kohlrabi *B. oleracea* L. var. are commonly available in various crucifer-growing areas in Tehran region. Canola, *Brassica napus* L. is also annually planted in this region. *P. xylostella* also occurs annually throughout the province wherever brassicaceous crops are grown, causing substantial crop losses.

Insect development, survival, reproduction and life table are parameters affected by kind of host plant (Tsai and Wang, 2001; Morgan *et al.*, 2001; Kim and Lee, 2002; Liu *et al.*, 2004; Yaşar and Güngör, 2005; Kumar *et al.*, 2009). Host plant quality traits

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are the key determinants of the fecundity of herbivorous insects affecting such insect reproductive strategies as: egg size and quality, allocation of resources to eggs, the choice of oviposition sites, and egg or embryo resorption. In some herbivore species, host plant quality during larval growth and development is a key determinant of both fecundity and fertility of adults (Awmack and Leather, 2002).

Life table and population studies showed that rainfall, temperature, natural enemies, as well as host plants influenced the survival and reproduction of DBM (Wakisaka *et al.*, 1992; Haseeb *et al.*, 2001). A development of life tables for DBM on different host plants will help to assess the relative contribution made by the various hosts to the local adult population pool, and to answer other relevant questions associated with DBM.

Plant species differ greatly in suitability as hosts for specific insects when assessed in terms of survival, development and reproductive rate. Shorter developmental time along with greater total reproduction of insects on a host indicate greater suitability of a host plant (van Lenteren and Noldus, 1990). Although developmental rate and reproduction provide important clues concerning the ability of a host to support an insect's complete life cycle, these data should be linked to other parameters (such as mortality) before a definitive conclusion can be drawn concerning host suitability (Liu *et al.*, 2004). Some demographic studies of *P. xylostella* have been done on different host plants (Wakisaka *et al.*, 1992; Salas *et al.*, 1993; Ramachandran *et al.*, 1998; Sarfraz *et al.*, 2007) showing that development and reproduction of DBM can be affected by host plant as well as by the geographic source of the *P. xylostella* population (Umeya and Yamada, 1973; Sarnthoy *et al.*, 1989; Shirai, 2000). These differences show that caution must be taken when comparing results among different regions.

Despite extensive literature documenting the effects of host plant quality traits on

performance of DBM, few publications have reflected directly on its life table and population growth parameters. The main purpose of this study is to determine the impact of some important *Brassica* crops annually cultivated in Tehran region on the performance and life table parameters of DBM. A knowledge of life table parameters of DBM and the resistance-susceptibility characteristics of *Brassica* crops will enable growers to employ the most appropriate control tactics towards integrated crop management (ICM) of a particular *Brassica* crop.

## MATERIALS AND METHODS

### Rearing Methods and Experimental Conditions

The initial population of DBM was collected from *Brassica* fields of the Horticultural Investigation Center of Tehran University in Karaj, a suburb of Tehran, Iran during October 2005. The stock culture of *P. xylostella* was initiated on different potted host plants and maintained at  $25\pm 1^\circ\text{C}$ ,  $65\pm 5\%$  RH and a photoperiodism of 14:10 (L: D) hours in a growth chamber.

Host plants, namely cauliflower, *B. oleracea* L. var. *botrytis* (cultivar 'Niagara'); two cultivars of cabbage, *B. oleracea* L. var. *capitata* (cultivar 'Globe Master' and 'Scarlet Ohara'), kohlrabi, *B. oleracea* L. var. *gongylodes* (cultivar 'Royal Sluis') and canola, *Brassica napus* L. (cultivar 'PF') were planted in pots in a greenhouse. Host plant seeds were sown in suitable soil and compost mixtures in seedling flats. After five weeks (plants having six to eight leaves) each seedling was transplanted in a 20 cm diameter plastic pot. Ammonium nitrate ( $3\text{ g l}^{-1}$ ) was applied once a week following transplanting. When host plants bore 10-12 leaves (about six weeks after transplant), they were taken for experimental use.

Experiments began following the rearing of two generations of *P. xylostella* under laboratory conditions on each host plant

used in the study. In order to obtain the same aged eggs of DBM, leaves of host plants were put inside an oviposition cage containing 150 pairs of both sexes of the moths reared on the corresponding host plants. After 5-10 hours, the host plant leaf was taken from the cage and the eggs picked up for experiments. The oviposition cage was a clear cubic Plexiglass container (35×35×35 cm), the top and sides of which were cut off and replaced with fine mesh gauze coverings. One side of the cage was modified so that it could be opened for either insertion or removal of plant leaves, moths as well as feed. One end of a 10 cm long cotton wick the other end of which was soaked into a 10% honey solution in a 100 ml flask was taken out of the flask to be placed in the oviposition chamber for feeding the adults.

#### Development and Mortality

Experiments were carried out in a growth chamber set at 25±1°C, 65±5% RH and a photoperiodism of 14:10 (L: D) hours. Developmental time of *P. xylostella* was determined on each host plant. Ten *P. xylostella* eggs were taken from a surface of the host plant leaf using a small brush and placed on a leaf disk in each of 20 Petri dishes (8.0 cm diameter), for a total of 200 eggs for each host plant. The leaf disk in each Petri dish was inserted in water soaked cotton to be fresh for a time (depending on temperature treatment). Lids of Petri dishes were cut off and replaced with fine mesh gauze for the needed ventilation. The Petri dishes were placed in a growth chamber, the eggs being checked daily, and the number of daily emerged larvae recorded. This regular checking of eggs either was continued until all eggs either hatched or collapsed.

Development of larvae and pupae was observed in the growth chamber at similar conditions provided for eggs. To evaluate the development on host plants, neonate larvae from the previous experiments were placed individually on the leaf disks of host

plants in 8.0 cm diameter Petri dishes. The base of each leaf disk was inserted in water soaked cotton to maintain its freshness. Fifty larvae were monitored on each host plant. All larvae were checked daily for their developmental stages recorded. Fresh foliage was provided every 1-2 days, until pupation stage. Survival rate and developmental time were recorded for all immature stages while the sex of emerged adults being also determined.

#### Reproduction and Population Growth Parameters

Fifteen pairs of male and female moths (each pair for one replicate) reared on each host plant were taken for the reproduction experiment. Each moth pair was placed in a cage (15×8×5 cm) for subsequent mating and egg laying. The top of the cage was cut-off and replaced with a covering of fine mesh gauze. Host plant leaves were replaced with fresh ones and the fecundity recorded daily. For this purpose, the male and female moths were placed in a new cage with fresh plant foliages, while all deposited eggs being recorded. Daily monitoring continued until death of adults. To obtain the sex ratio on each host plant, 200-250 deposited eggs on each host plant were placed on each corresponding host plant foliage and maintained until adult moth emergence. Such different parameters as pre-oviposition period, oviposition period, post-oviposition period, adult longevity and age-specific fecundity were also determined. The intrinsic rate of increase ( $r_m$ ), mean generation time (T), finite rate of increase ( $\lambda$ ), doubling time (DT) and net reproduction rate ( $R_0$ ) were assessed, using Carey's formulae (Carey, 1993).

#### Statistical Analysis

Statistical analysis was performed using the statistical program SPSS v. 13.0 (SPSS, 2004). Variables were tested for normality



using the Kolmogorov-Smirnov test. Effect of host plant on the duration of immature stages, the oviposition period and adult longevity were analyzed using one-way ANOVA. Means were compared by Tukey multiple range test. Differences in  $R_0$ ,  $T$ ,  $\lambda$ , DT and  $r_m$  values were tested through Jackknife procedure (Maia *et al.*, 2000).

## RESULTS

Mean incubation period on kohlrabi was found to be the shortest and significantly different from that on cauliflower, canola, cabbage cultivar 'Globe Master' but not on cabbage cultivar 'Scarlet Ohara' (Table 1). No significant difference was observed between the total developmental time of larvae on cabbage cultivar 'Scarlet Ohara'

and kohlrabi that had shorter developmental time periods than the other three host plants evaluated ( $F= 14$ ;  $df= 4,184$ ;  $P< 0.05$ ) (Table 1). There was a significant difference observed between the development time of pupae on cabbage cultivar 'Globe Master' and cauliflower that had the shorter developmental time periods than the other three host plants ( $F= 22$ ;  $d= 4,184$ ;  $P< 0.001$ ) (Table 1). The longest total developmental duration was on canola ( $15.06\pm 0.22$  d), and the shortest on kohlrabi ( $13.76\pm 0.15$  d) ( $F= 8$ ;  $df= 4,184$ ;  $P< 0.05$ ) (Table 1).

The lowest and highest survival rates from egg to adult emergence were recorded as 70.56% on canola and 81.42% on cauliflower, the survival rate on canola being considerably lower than that on other

**Table 1.** Mean developmental time (day $\pm$ SE) of immature stages of *P. xylostella* on five brassicaceous host plants.

Stage	Host plant				
	Cauliflower	Cabbage cv. 'Globe Master'	Cabbage cv 'Scarlet Ohara'	Kohlrabi	Canola
Egg	2.86 $\pm$ 0.03a	2.87 $\pm$ 0.03a	2.74 $\pm$ 0.04ab	2.58 $\pm$ 0.04b	2.84 $\pm$ 0.03a
Instar I	1.83 $\pm$ 0.06b	1.96 $\pm$ 0.08ab	1.31 $\pm$ 0.07c	1.31 $\pm$ 0.07c	2.22 $\pm$ 0.09a
Instar II	2.16 $\pm$ 0.06a	2.09 $\pm$ 0.05a	1.70 $\pm$ 0.08b	1.49 $\pm$ 0.08b	1.57 $\pm$ 0.09b
Instar III	1.35 $\pm$ 0.08b	1.50 $\pm$ 0.08ab	1.60 $\pm$ 0.07ab	1.73 $\pm$ 0.07a	1.72 $\pm$ 0.08a
Instar IV	2.03 $\pm$ 0.03b	2.15 $\pm$ 0.06ab	2.12 $\pm$ 0.06ab	2.06 $\pm$ 0.05ab	2.30 $\pm$ 0.07a
Total larva	7.38 $\pm$ 0.144a	7.71 $\pm$ 0.15a	6.75 $\pm$ 0.11b	6.60 $\pm$ 0.11b	7.82 $\pm$ 0.20a
Prepupa	0.51 $\pm$ 0.09ab	0.62 $\pm$ 0.08a	0.41 $\pm$ 0.07ab	0.33 $\pm$ 0.07ab	0.30 $\pm$ 0.07b
Pupa	3.35 $\pm$ 0.12b	3.31 $\pm$ 0.11b	4.22 $\pm$ 0.08a	4.24 $\pm$ 0.08a	4.10 $\pm$ 0.08a
Total	14.12 $\pm$ 0.12bc	14.52 $\pm$ 0.18ab	14.13 $\pm$ 0.14bc	13.76 $\pm$ 0.15c	15.06 $\pm$ 0.22a

Means marked with the same small letter within the same row are not significantly different ( $P< 0.05$ ; Tukey).

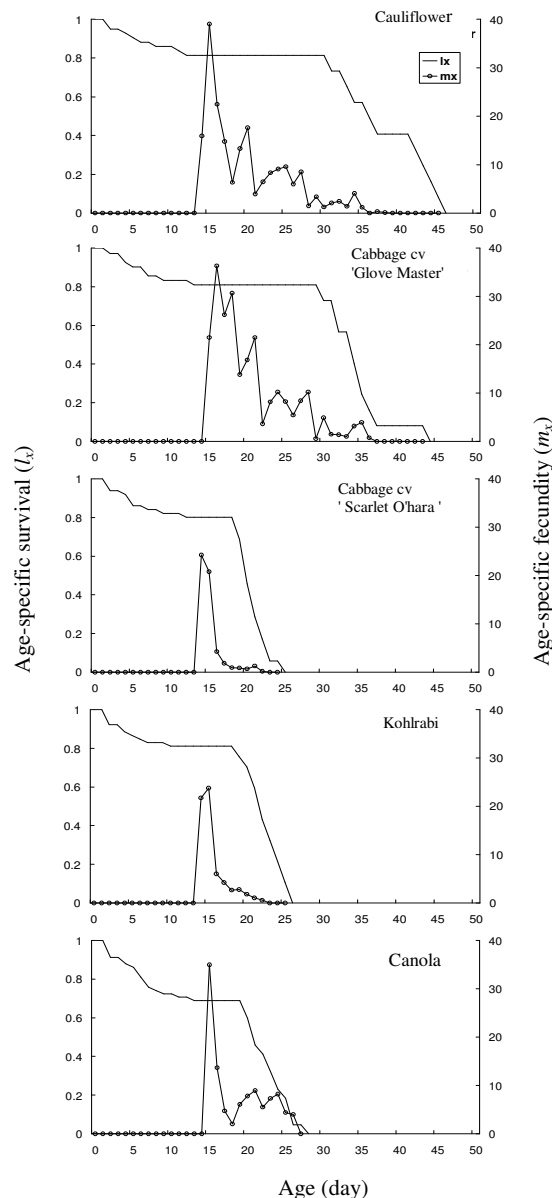
**Table 2.** Survival rate (%) of various stages and instars of *P. xylostella* on five brassicaceous host plants.

Stage	Host plant				
	Cauliflower	Cabbage cv. 'Globe Master'	Cabbage cv. 'Scarlet Ohara'	Kohlrabi	Canola
Egg	95	97.14	93.79	92.13	91.25
Instar I	95.25	92.85	91.66	92	88.67
Instar II	97.5	100	97.72	97.82	95.74
Instar III	97.43	94.87	97.67	100	95.55
Instar IV	100	97.29	100	97.77	97.67
Total larva	90.48	85.69	87.48	87.98	79.22
Prepupa	100	97.22	100	100	100
Pupa	94.73	100	97.61	100	97.61
Total	81.42	80.95	80.11	81.06	70.56

hosts (Table 2). This was due to a lower survival at egg as well as at first instar larva stages on canola. The age-specific survival rate ( $l_x$ ) of *P. xylostella* on five host plants is shown in Figure 1.

There was no significant difference observed among the pre-oviposition periods of females reared on all the five host plants ( $F= 0.54$ ;  $df= 4,59$ ;  $P> 0.05$ ) (Table 3). However, the oviposition periods were of

great difference and female adult longevities significantly different on different host plants ( $F= 81$ ;  $df= 4, 59$ ;  $P< 0.001$ ). On cabbage and cauliflower, female moths had a longer oviposition period than on the other three host plants ( $F= 74$ ;  $df= 4, 59$ ;  $P< 0.01$ ). The post-oviposition period on cauliflower was significantly higher than that on other plants and this was due to the significant difference between longevity on cauliflower



**Figure 1.** Age-specific survivorship ( $l_x$ ) and fecundity ( $m_x$ ) of *P. xylostella* on five host plants, at 25°C.



and cabbage. Male adult longevity showed a similar trend with its value being significantly higher than on cabbage and cauliflower than on the others (Table 3).

Fecundity was greatly influenced by host plant ( $F=68$ ;  $df=4, 59$ ;  $P<0.001$ ) (Table 3). On all host plants, a distinct peak of  $m_x$  (female offspring per female per day) showed a rapid initial increase in relation to the maximum and there being a more clearly defined peak in the early days of adult emergence (Figure 1). Maximum egg production was observed on cauliflower host plant (49.23 female eggs per female per day).

Population growth parameters of *P. xylostella* were significantly affected by host plants. The intrinsic rate of increase ( $r_m$ ) value was highest on cauliflower and lowest on canola respectively (Table 4). The net reproduction rate ( $R_0$ ) value on cauliflower

and cabbage cultivar 'Globe Master' was significantly higher than that on other hosts ( $F=73$ ;  $df=4, 59$ ;  $P<0.001$ ) (Table 4). The maximum and minimum values of  $R_0$  were obtained on cabbage cultivars, 'Globe Master' and 'Scarlet Ohara', respectively (Table 4). Mean generation times ( $T$ ) were longest on the cabbage cultivar 'Globe Master' ( $18.23\pm0.37$  d) and shortest on the cabbage cultivar 'Scarlet Ohara' ( $14.72\pm0.15$  d).

## DISCUSSION

Host plant availability and quality may play a role in pest population dynamics by affecting immature as well as adult performance. In the case of DBM, few life table studies as regards its various host plants have been published and only a few studies have examined the effect of host plants on the

**Table 3.** Oviposition period, adult longevity (days  $\pm$  SE) and fecundity (eggs per female) of *P. xylostella* on five brassicaceous host plants.

Stage	Host plant				
	Cauliflower	Cabbage cv. 'Globe Master'	Cabbage cv. 'Scarlet Ohara'	Kohlrabi	Canola
Pre-oviposition period	0.40 $\pm$ 0.16a	0.50 $\pm$ 0.22a	0.21 $\pm$ 0.11a	0.26 $\pm$ 0.11a	0.40 $\pm$ 0.16a
Oviposition period	19.50 $\pm$ 0.93a	17.70 $\pm$ 0.89a	4.78 $\pm$ 0.58b	6.60 $\pm$ 0.53b	6.46 $\pm$ 0.80b
Post-oviposition period	5.30 $\pm$ 1.08a	1.70 $\pm$ 0.65b	2.14 $\pm$ 0.36b	2.00 $\pm$ 0.19b	1.46 $\pm$ 0.32b
Female longevity	25.20 $\pm$ 1.76a	19.90 $\pm$ 1.20b	7.14 $\pm$ 0.45c	8.86 $\pm$ 0.55c	8.33 $\pm$ 0.64c
Male longevity	23.00 $\pm$ 2.83a	19.70 $\pm$ 0.92a	6.78 $\pm$ 0.29b	6.86 $\pm$ 0.46b	6.40 $\pm$ 0.77b
Fecundity	408.10 $\pm$ 28.83a	440.90 $\pm$ 17.30a	106.21 $\pm$ 16.18b	124.46 $\pm$ 14.28b	158.73 $\pm$ 18.64b

Means marked with the same small letter within a same row are not significantly different ( $P<0.05$ ; Tukey).

**Table 4.** Population growth parameters of *P. xylostella* on five brassicaceous host plants.

Parameter	Host plant				
	Cauliflower	Cabbage cv. 'Globe Master'	Cabbage cv. 'Scarlet Ohara'	Kohlrabi	Canola
Intrinsic rate of increase ( $r_m$ )	0.293 $\pm$ 0.007a	0.285 $\pm$ 0.006ab	0.256 $\pm$ 0.009bc	0.261 $\pm$ 0.006bc	0.244 $\pm$ 0.006c
Net reproduction rate ( $R_0$ )	159.84 $\pm$ 11.29a	183.81 $\pm$ 7.21a	43.13 $\pm$ 6.54b	51.62 $\pm$ 6.00b	58.26 $\pm$ 6.84b
Mean generation time ( $T$ )	17.28 $\pm$ 0.31ab	18.22 $\pm$ 0.33a	14.71 $\pm$ 0.15c	15.10 $\pm$ 0.16c	16.64 $\pm$ 0.31b
Finite rate of increase ( $\lambda$ )	1.34 $\pm$ 0.01a	1.33 $\pm$ 0.00ab	1.29 $\pm$ 0.01bc	1.30 $\pm$ 0.00bc	1.27 $\pm$ 0.00c
Doubling time (DT)	2.35 $\pm$ 0.06c	2.42 $\pm$ 0.05bc	2.69 $\pm$ 0.10ab	2.64 $\pm$ 0.06abc	2.83 $\pm$ 0.07a

Means marked with the same small letter within a same row are not significantly different ( $P<0.05$ ; Tukey).

developmental stages or on the overall performance of this species.

Host plant has different effects on development and reproduction parameters of *P. xylostella* (Wakisaka *et al.*, 1992; Salas *et al.*, 1993; Ramachandran *et al.*, 1998; Sarfraz *et al.*, 2007). Life history of DBM can vary considerably depending upon such various factors, as environmental conditions and host plants (Ooi, 1986; Shelton *et al.*, 1991; Muhamad *et al.*, 1994; Syed and Abro, 2003). In the present study, the incubation period on kohlrabi was greatly less than that on the other host plants. This difference was probably a result of different food sources taken up by the parents during larval stage. Similar inference has been reported for *Copitarsia decolora* Hampson (Lep., Noctuidae) reared on asparagus and on artificial diet (Gould *et al.*, 2005). The longest and shortest developmental times of individuals from neonate to the end of pupal stage were recorded on canola and kohlrabi (15.06 and 13.76 days), respectively. The survival rate on canola was lowest as compared with that on the other hosts. This difference could be due to the presence of nutritional, phagostimulant factors (such as carbon and nitrogen) as well as defensive metabolites that directly affect potential and achieved herbivore development and fecundity (Awmack and Leather, 2002; Syed and Abro, 2003; Sarfraz *et al.*, 2006). Singh and Singh (1982) studied the influence of various cruciferous host plants on survival and development of *P. xylostella*. They found that DBM completed its larval and pupal development in the shortest time on cauliflower. In a study conducted by Syed and Abro (2003), the shortest and longest lasting larval periods of DBM were 9.45 and 10.95 days on cauliflower and radish (*Raphanus sativa*), respectively. They also reported that larval periods on cauliflower, cabbage and rapeseed were 9.45, 9.63 and 10.57 days, respectively, not similar to our findings (Table 1).

Differences between the results of studies could be attributed to differences among nutritional content of host plant cultivars. In

addition, variations could be due to differences among geographic populations of *P. xylostella* (Umeya and Yamada, 1973; Sarnthoy *et al.*, 1989, Shirai, 2000). Moreover, plant quality varies considerably depending upon external environmental factors (such as predictable changes between seasons and less predictable changes initiated from environmental stresses) and these could be cited as other reasons for the difference (Awmack and Leather, 2002).

Differences in reproduction period and in longevity of DBM on *Brassica* host plants in this study indicate that the characteristics of host plants not similar. The longest and shortest female longevities in this study occurred on cauliflower and on the cabbage cultivar 'Scarlet Ohara', respectively. Adult moth showed a prolonged longevity (up to three fold) on these two host plants (cabbage and especially cauliflower) as compared to the other three hosts (Table 3). Adult insects need carbohydrate-rich food as their main source of energy for longevity, fecundity and mobility. This is true for many herbivores including Lepidoptera (Winkler *et al.*, 2005). The sap secreted from the cut leaves of cabbage and cauliflower used up during adult oviposition in oviposition cage could be an additional food source and a basis for longer adult longevity on these host plants as observed in our study.

Total fecundity in the study ranged from 106.21 to 440.90 eggs on cabbage cultivar 'Scarlet Ohara' and 'Globe Master', respectively (Table 3). Cauliflower and cabbage, in general, appeared to be more appropriate to oviposition than the others. The low number of eggs laid on a plant could have been affected by the more indirect route of reduced fecundity arising from larval feeding on nutritionally poor plants (Verkerk and Wright, 1996; Hamilton *et al.*, 2005). Wakisaka *et al.* (1992) observed that females fed on *Capsella bursa-pastoris* L. during the larval stage laid a significantly smaller number of eggs than those reared on broccoli *Brassica oleracea* variety *italica*, chinese cabbage *Brassica rapa* and young cabbage. DBM fecundity figures reported by Syed and



Abro (2003) on cauliflower, cabbage and *B. napus* were 213.3, 190.0 and 82.0 eggs, respectively.

There was a significant difference observed in the intrinsic rates of increase ( $r_m$ ) with respect to host plants in our study (Table 4). Highest and lowest  $r_m$  values were obtained on cauliflower and canola (0.293 and 0.244), respectively. These by contrast were higher than those recorded in Syed and Abro's study (0.239 and 0.160 on cauliflower and canola, respectively). Wakisaka *et al.* (1992) studied the  $r_m$  value of *P. xylostella* on different host plants and found that  $r_m$  ranged between 0.2778 and 0.1362 respectively on broccoli and a wild crucifer namely *Capsella bursa-pastoris*. Salas *et al.* (1993) studied life table parameters of *P. xylostella* on different host plants and found that the highest  $r_m$  occurred when the insect fed on cauliflower. The differences between results of various studies could be attributed to cultivar differences as well as to strains of *P. xylostella*. Van Lenteren and Noldus (1990) stated that shorter developmental time and greater total oviposition (fecundity) on a host might be a reflection of the host plant suitability. In our study, mean generation time (T) on cabbage cultivar 'Globe Master' and cauliflower were longer than on cabbage cultivar 'Scarlet Ohara', kohlrabi and canola. The high value of net reproductive rate ( $R_0$ ) on cabbage cultivar 'Globe Master' and cauliflower is a reflection of high  $r_m$  values. Since intrinsic rate of increase ( $r_m$ ) is a reflective of many factors such as fecundity, survival and generation time and adequately summarizes the physiological qualities of an animal in relation to its capacity to increase, it would be a most appropriate index to evaluate the performance of an insect on different host plants as well as the host plant's resistance (Kocourek *et al.*, 1994; Southwood and Henderson, 2000).

In conclusion, the high  $r_m$  value on cauliflower and cabbage indicates that DBM has a greater reproductive potential and there are presumably more suitable hosts than the ones evaluated. Canola had the highest antibiosis resistance against *P. xylostella* and

was the least favorable of the hosts evaluated for DBM as indicated by the long developmental time, low survival of immature stages as reflected in a lower value of  $r_m$ . Such antibiosis effects could cause reductions in survival fitness of *P. xylostella*; for example, prolonged developmental time could increase the exposure of the insect to its natural enemies. A knowledge of how *Brassica* host plant quality influences the life table parameters of DBM can help one to understand the population dynamics and select for the proper measures in management of this insect.

## REFERENCES

1. Awmack, C. S. and Leather, S. R. 2002. Host Plant Quality and Fecundity in Herbivorous Insects. *Annu. Rev. Entomol.*, **47**: 817-844.
2. Carey, J. R. 1993. *Applied Demography for Biologists with Special Emphasis on Insects*. Oxford University Press, New York. P. 211.
3. Gould, J., Venette, R. and Winograd, D. 2005. Effect of Temperature on Development and Population Parameters of *Copitarsia decolora* (Lepidoptera: Noctuidae). *Environ. Entomol.*, **34**: 548-556.
4. Gupta, P. D. and Thorsteinson, A. J. 1960. Food Plant Relationship of Diamondback Moth (*Plutella maculipennis* (Curt.)). I. Gustation and Olfaction in Relation to Botanical Specificity of Larva. *Entomol. Exp. Appl.*, **3**: 241-250.
5. Hamilton, A. J., Endersby, N. M., Ridland, P. M., Zhang, J. and Neal, M. 2005. Effects of Cultivar on Oviposition Preference, Larval Feeding and Development time of Diamondback Moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), on some *Brassica oleracea* Vegetables in Victoria. *Aust. J. Entomol.*, **44**: 284-287.
6. Haseeb, M., Kobori, Y., Amano, H. and Nemoto, H. 2001. Population Density of *Plutella xylostella* (Lepidoptera: Plutellidae) and Its Parasitoid *Cotesia plutellae* (Hymenoptera: Braconidae) on Two Varieties of Cabbage in an Urban Environment. *Appl. Entomol. Zool.*, **36**: 353-360.



7. Kim, D. S. and Lee, J. H. 2002. Egg and Larval Survivorship of *Carposina sasakii* (Lepidoptera: Carposinidae) in Apple and Peach and Their Effects on Adult Population Dynamics in Orchards. *Environ. Entomol.*, **31**: 686-692.
8. Kocourek, F., Havelka, J., Berankova, J. and Jarosik, V. 1994. Effect of Temperature on Development Rate and Intrinsic Rate of Increase of *Aphis gossypii* Reared on Greenhouse Cucumber. *Entomol. Exp. Appl.*, **71**: 59-64.
9. Kumar, S. Saini, R. K. and Ram, P. 2009. Natural Mortality of *Helicoverpa armigera* (Hübner) Eggs in the Cotton Ecosystem. *J. Agric. Sci. Technol.*, **11**:17-25
10. Liu, Z., Li, D., Gong, P. and Wu, K. 2004. Life Table Studies of the Cotton Bollworm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae), on Different Host Plants. *Environ. Entomol.*, **33**: 1570-1576.
11. Maia, A. H. N., Luiz, A. J. B. and Campanhola, C. 2000. Statistical Influence on Associated Fertility Life Table Parameters Using Jackknife Technique, Computational Aspects. *J. Econ. Entomol.*, **93**: 511-518.
12. Morgan, D., Walters, K. F. A. and Aegerter, J. N. 2001. Effect of Temperature and Cultivar on Pea Aphid, *Acyrtosiphon pisum* (Hemiptera: Aphididae) Life History. *Bull. Entomol. Res.*, **91**: 47-52.
13. Muhamad, O., Tsukuda, R., Oki, Y., Fujisaki, K. and Nakasuji, F. 1994. Influences of Wild Crucifers on Life History Traits and Flight Ability of the Diamondback Moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae). *Res. Popul. Ecol.*, **36**: 53-62.
14. Ooi, P. A. 1986. A Diamondback Moth in Malaysia. In: "Proceedings of First International Workshop on Diamondback Moth Management", (Eds.), Talekar, N. S. and Griggs, T. D., Shanhua, Taiwan, PP. 25-34.
15. Ramachandran, S., Buntin, G. D., All, J. N. and Raymer, P. L. 1998. Diamondback Moth (Lepidoptera: Plutellidae) Resistance of *Brassica napus* and *B. oleraceae* Lines with Differing Leaf Characteristics. *J. Econ. Entomol.*, **91**: 987-992.
16. Salas, M. D., Mendoza, B., Salazar, E. and Rivera, V. M. 1993. Survival and Reproduction of *Plutella xylostella* in some crucifers. *Turrialba*, **43**: 242-246.
17. Sarfraz, M., Dosdall, L. M. and Keddie, B. A. 2006. Diamondback Moth Host Plant Interactions: Implications for Pest Management. *Crop Prot.*, **25**: 625-639.
18. Sarfraz, M., Dosdall, L. M. and Keddie, B. A. 2007. Resistance of Some Cultivated Brassicaceae to Infestations by *Plutella xylostella* (Lepidoptera: Plutellidae). *J. Econ. Entomol.*, **100**: 215-224.
19. Sarnthoy, O., Keinmeesuke, P., Sinchaisri, N. and Nakasuji, F. 1989. Development and Reproductive Rate of Diamondback Moth *Plutella xylostella* from Thailand. *Appl. Entomol. Zool.*, **24**: 202-208.
20. Shelton, A. M., Cooley, R. J., Kroening, M. K., Wilsey, W. T. and Eigenbrode, S. D. 1991. Comparative Analysis of Two Rearing Procedures for Diamondback Moth (Lepidoptera: Plutellidae). *J. Entomol. Sci.*, **26**: 17-26.
21. Shirai, Y. 2000. Temperature Tolerance of the Diamondback Moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae) in Tropical and Temperate Regions of Asia. *Bull. Entomol. Res.*, **90**: 357-364.
22. Singh, S. P. and Singh, D. 1982. Influence of Cruciferous Host Plants on the Survival and Development of *Plutella xylostella* L.. *J. Res. Punjab Agri. Univ.*, **19**: 100-104.
23. Southwood, T. R. E. and Henderson, P. A. 2000. *Ecological Methods*. Third Edition, Blackwell Science, Oxford. PP. 575.
24. SPSS, 2004. *SPSS Base 13.0 User's Guide*. SPSS Incorporation, Chicago, IL.
25. Syed, T. S. and Abro, G. H. 2003. Effect of Brassica Vegetable Hosts on Biology and Life Table Parameters of *Plutella xylostella* under Laboratory Conditions. *Pak. J. Biol. Sci.*, **22**: 1891-1896.
26. Talekar, N. S. and Shelton, A. M. 1993. Biology, Ecology and Management of Diamondback Moth. *Annu. Rev. Entomol.*, **38**: 275-301.
27. Tsai, J. H. and Wang, J. J. 2001. Effects of Host Plants on Biology and Life Table Parameters of *Aphid spiraecola* (Homoptera: Aphididae). *Environ. Entomol.*, **30**: 45-50.
28. Umeya, K. and Yamada, H. 1973. Threshold Temperature and Thermal Constants for Development of the Diamondback Moth, *Plutella xylostella* L., with References to Their Local Differences. *Jpn. J. Appl. Entomol. Zool.*, **17**: 19-24.
29. Van Lanteren, J. C. and Noldus, L. P. J. J. 1990. Whitefly Plant Relationships,



- Behavioural and Ecological Aspects. In: "White Flies: Their Bionomics, Pest Status and Management". (Ed.): Gerling, D., Andover, Hampshire, England. PP. 47-89.
30. Verkerk, R. H. J. and Wright, D. J. 1996. Multitrophic Interactions and Management of the Diamondback Moth: a Review. *Bull. Entomol. Res.*, **86**: 205-216.
31. Wakisaka, S., Tsukuda, R. and Nakasuji, F. 1992. Effects of Natural Enemies, Rainfall, Temperature and Host Plants on Survival and Reproduction of the Diamondback Moth and Other Crucifer Pests. In: "Diamondback Moth and Other Crucifer Pests: Proceedings of the Second International Workshop", (Ed): Talekar, N. S., Shanhua, Taiwan, PP. 16-36.
32. Winkler, K., Wäckers, F. L., Stingli, A. and Van Lenteren, J. 2005. *Plutella xylostella* (Diamondback Moth) and Its Parasitoid *Diadegma semiclausum* Show Different Gustatory and Longevity Responses to a Range of Nectar and Honeydew Sugars. *Entomol. Exp. Appl.*, **115**: 187-192.
33. Yaşar, B. and Güngör, M. A. 2005. Determination of Life Table and Biology of Colorado Potato Beetle, *Leptinotarsa decemlineata* Say (Coleoptera: Chrysomelidae), Feeding on Five Different Potato Varieties in Turkey. *Appl. Entomol. Zool.*, **40**: 589-596.

**جدول زندگی شب پره پشت الماسی (*Plutella xylostella* (L.) (Lepidoptera: Plutellidae) روی پنج میزبان گیاهی از جنس *Brassica***

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**چکیده**

رشد و بقا و تولیدمثل شب پره پشت الماسی یا بید کلم (*Plutella xylostella* (L.)) در آزمایشگاه در دمای  $25 \pm 1$  درجه سلسیوس، رطوبت نسبی  $65 \pm 5$  درصد و دوره نوری ۱۴ ساعت روشنایی و ۱۰ ساعت تاریکی بر روی پنج گیاه میزبان کلم گل *Brassica oleracea* L. var. *botrytis*، دو رقم کلم پیچ (معمولی و قرمز) (*B. oleracea* L. var. *capitata*)، کلم قمری *B. oleracea* L. var. *gongylodes* و کلزا *B. napus* L. مورد بررسی قرار گرفت. لاروهای شب پره پشت الماسی با موفقیت بر روی همه گیاهان میزبان زنده ماندند، اگرچه که میزان بقا روی کلزا پایینتر از بقیه بود ( $70/56$ ٪). طول دوره نابالغی شب پره از  $13/76$  روز روی کلم قمری تا  $15/06$  روز روی کلزا طول کشید. بیشترین طول دوره تولیدمثل و طول عمر افراد بالغ بر روی کلم گل و کلم پیچ معمولی Globe Master بود. همچنین بیشترین باروری شب پره بر روی همین دو گیاه میزبان به دست آمد. بالاترین و پایین ترین نرخ خالص تولیدمثل ( $R_0$ ) بترتیب بر روی دو رقم کلم پیچ معمولی 'Globe Master' و کلم پیچ قرمز 'Scarlet O'hara' بود. میانگین طول نسل (T) شب پره روی کلم پیچ معمولی 'Globe Master' طولانی تر از سایر میزبانها بود. ترتیب کاهش نرخ ذاتی افزایش جمعیت ( $r_m$ ) به ترتیب بر روی کلم گل، کلم پیچ معمولی Globe Master، کلم قمری، کلم پیچ قرمز 'Scarlet O'hara' و کلزا بود. بر اساس نتایج به دست آمده، دو گیاه میزبان کلم گل و کلم پیچ معمولی Globe Master به عنوان گیاهان میزبان مناسبتر برای شب پره پشت الماسی تشخیص داده شدند.