



EFFECT OF TWO CABBAGE VARIETIES ON FITNESS OF *PLUTELLA XYLOSTELLA* UNDER CONTROLLED CONDITIONS

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ABSTRACT

The development, survival, and reproduction of diamondback moth (DBM), *Plutella xylostella* (L.), were studied under controlled conditions on two cabbage varieties Asha and Golden acre. Larvae of *Plutella xylostella* survived successfully on both cabbage varieties, although maximum survival percentage (85.42 %) was documented on Golden acre and minimum (75.25 %) recorded on Asha. Developmental period ranged from 15.09±0.25 d on Asha to 13.46±0.21 d on Golden acre. Longest adult longevity and reproduction period were recorded on Golden acre while maximum fecundity being also documented on Golden acre. Mean generation time was longest on Asha. In addition intrinsic rates of population increase was maximum on Golden acre and minimum on Asha. It is concluded that Golden acre variety were documented as most susceptible variety for *Plutella xylostella*.

1. INTRODUCTION

Cabbage belongs to family cruciferae considered as one of the oldest and extensively cultivated vegetable crops throughout the world (Sances, 2000). It is among the most popular food crop in Pakistan. It grows in many parts of the country from Southern Sindh to Gilgit Baltistan. However its production greatly retards by serious pests including Diamondback moth. The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) is the most important cosmopolitan pest of cultivated brassicas worldwide, sometimes causing more than 90% crop loss (Talekar and Shelton, 1993; Verkerk and Wright, 1996). It has been reported from more than 128 countries of world however it was first recorded in Indo-Pak subcontinent during 1914 (Tsunoda, 1980). In Pakistan, DBM is well-thought-out as the most important insect herbivores of cruciferous vegetables particularly in Southern parts of Sindh.

Development, reproduction, survival and life table are the parameters affected by variety of host plants (Tsai and Wang, 2001). Quality traits of host plant are the key factors which determines fertility and fecundity of insect herbivores (Awmack and Leather, 2002). Life table studies showed that host plants, temperature, rainfall and natural enemies greatly influenced the reproduction and survival of *Plutella xylostella* ((Wakisaka *et al*, 1992). Plant species fluctuate greatly in suitability as hosts for specific insects when assessed in terms of development, survival and reproductive rate. Shorter developmental period along with greater total reproduction of insects on a host indicate greater suitability of a host plant (Lenteren and Noldus, 1990). The main purpose of current study was to investigate the effect of selected cabbage varieties on fitness cost (Development, Survival, Reproduction and growth parameters) of *Plutella xylostella*.

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2. MATERIALS AND METHODS

Culture of cabbage varieties

Two cabbage varieties (Golden Acre and Asha) were used during current experimental studies. Each variety was grown in four seedling trays separately in glass house of Entomology Department, PMAS - Arid Agriculture University, Rawalpindi. After thirty five days of sowing, seedlings were transplanted into plastic pots filled with a mixture of compost and soil at 2:1 ratio. Transplanted cabbage plants from each variety (5-7 leaves stage) were utilized for further studies.

*Insect culture of *Plutella xylostella**

P. xylostella in all life stages (e.g. egg, larval, pupal and adult) were collected from farmers' field of cabbage crop located at Chak Shehzad, Islamabad. Specimens were collected in plastic jars covered with muslin cloth, provided with fresh leaves and honey solution soaked cotton plugs. Collected population was brought into bio-control laboratory of Entomology Department, PMAS - Arid Agriculture University, Rawalpindi. After that, it was transferred into rearing cages (45×30×35 cm) made up of transparent plastic sheet and ventilated through openings covered with muslin cloth. In rearing cages, potted cabbage varieties were placed singly for maintaining insect culture of *P. xylostella*. Culture was developed under controlled conditions at 25±2 °C, 60±5% RH and 16L: 8D photoperiod.

*Assessment of *Plutella xylostella* fitness on selected cabbage varieties*

Life table of *P. xylostella* was constructed to assess its fitness on two cabbage varieties (Golden Acre and Asha). Controlled conditions (i.e. 23±2 °C, 60±5% RH and 16L: 8D) were maintained to perform the experimental studies. To get the homogenized population data, adults were released in rearing cages containing cabbage varieties separately, for oviposition. Freshly laid eggs along with leaves section were placed in petri-dishes. A hole in the lid of petri-dishes was made for ventilation and it was covered with muslin cloth. Oviposition, developmental rate, survival rate, fecundity and adult longevity were recorded during the studies for each cabbage variety.

*Developmental period and survival rates of different life phases and Adult longevity of *Plutella xylostella**

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 period of different life stages of *Plutella xylostella* was investigated on each cabbage varieties. For this purpose eight *Plutella*

xylostella eggs were collected from each of cabbage leaf by using a camel brush and placed on a leaf disk in 10 Petri dishes, for a total of 80 eggs for each host plant. Top of Petri dishes were cut off and replaced with fine muslin sheet for ventilation. The Petri dishes containing eggs being checked on daily basis as well as larvae emerged. Larval and pupal developments were investigated in laboratory. To calculate the development on two cabbage varieties, neonate larvae were placed individually on leaf of cabbage host kept in petri dishes. Emerged larvae were checked on daily basis for their developmental stages recorded. Fresh leaves were provided every day until pupation. Developmental times as well as survival rate were recorded for all immature stages.

*Reproduction of *Plutella xylostella**

Four pairs of male and female *Plutella xylostella* reared on each cabbage varieties were then taken for reproduction experiment. Each pair of adult was placed in a cage (45×30×35 cm) for successive mating and purpose of egg laying. Cages are made up of transparent plastic sheet and ventilated through openings covered with muslin cloth. Leaves were substituted with fresh ones and fecundity was recorded on daily basis. For this purpose, the adult male and female were kept in a new cage with fresh plant foliage, while all deposited eggs was recorded. Different other parameters such as pre-oviposition, oviposition, post-oviposition period, adult longevity and fecundity were also investigated.

*Population growth parameters of *Plutella xylostella**

The life table parameters of *Plutella xylostella* including, net reproductive rate (R₀), the intrinsic rate of natural increase (r_m), finite rate of increase (λ), mean generation time (T) and doubling time (DT) on selected cabbage varieties were calculated by the formulae described by Birch (1948)

Statistical analysis

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.

3. RESULTS

*Assessment of *Plutella xylostella* l. fitness on selected cabbage varieties*

Research studies were performed to observe the fitness of *Plutella xylostella* on two cabbage varieties (i.e. Asha and Golden acre) under controlled conditions (23±2 °C, RH 65±5% and 16:8 L: D). Life tables were studied and different parameters such as oviposition, developmental rate, adult longevity,

survival rate and relevant population growth were studied on each cabbage variety. Findings of the relevant parameters are given as below.

Developmental period and survival rates of different life phases and Adult longevity of Plutella xylostella

Results revealed that immatures of *Plutella xylostella* reared on selected cabbage varieties. Mean period of incubation on Golden acre was quantified to be shortest and significantly different from that on Asha as shown in (Table 1). There is a significant difference was observed in between the total larval developmental period on Asha and Golden acre (Table 1). A significant difference was observed in between the developmental period of pupae on Asha and Golden acre (Table 1). Total development was maximum on Asha (15.09±0.25 d) while minimum was observed on Golden acre (13.46±0.21 d). The lowest survival rate of egg was monitored on Asha while highest on Golden acre. Survival rate of total larval period was found maximum on Golden acre and minimum on Asha. Highest pupal period was assessed on Asha and lowest on Golden acre. Total survival rate from egg to adult emergence was found maximum on Golden acre (85.42) and minimum on Asha (75.25) as shown in table 2.

Reproduction of Plutella xylostella

Four pairs of male and female *Plutella xylostella* reared on each cabbage varieties were then taken for reproduction experiment. The result revealed that no significant difference was observed in pre-ovipositional periods of female reared on two cabbage varieties (Table 3). However, there was significant difference among ovipositional periods and female adult selected cabbage varieties. Longer oviposition period observed on Asha while shortest on Golden acre. The post oviposition period on Asha (3.25±0.98) was significantly shorter than Golden acre (5.46±1.32) and this is due to significant difference in longevity on selected cabbage varieties. Male and female longevity was higher on Golden acre while minimum on Asha and the trend shows significant difference among Golden acre and Asha (Table 3). Host plants greatly influence fecundity rate (Table 3). There was significant difference in fecundity among two varieties. Female *Plutella xylostella* prefers to lay maximum eggs on Golden acre (152.63±22.54) while minimum eggs were observed on Asha (108.04±16.73).

Population growth parameters of Plutella xylostella

In our research, the lowest intrinsic rate of increase (rm) (0.198 ± 0.006 day⁻¹) and the lowest finite rate of increase (λ) (1.1232 ± 0.0005 day⁻¹) and highest (3.23 ± 0.129 days) doubling time (DT) of the

Diamondback moth were observed on Asha in comparison with Golden Acre. The rm, λ and DT are key demographic parameters used to compare the fitness of population across diverse food-related conditions (Smith, 1991). When the insect feed on the suitable host plant in their larval stages, they grow more rapidly and their generation time becomes shorter compared with less preferred host plants. The fecundity and population growth parameters are also highest on more suitable host (Price, 1997). The highest values of rm (0.403 ± 0.003 day⁻¹) and λ (1.312 ± 0.0003 day⁻¹) and the lowest DT (2.98 ± 0.012 days) were observed on Golden Acre, which indicates that this cultivar is the most suitable of the studied cabbage varieties for *Plutella xylostella*.

4. DISCUSSION

Hypothesis regarding to host selection process, it is expected that female choose hosts preferentially on which their offspring fitness will be better (Mayhew 1997). When choice was given among two cabbage varieties, *Plutella xylostella* preferred to lay maximum eggs on Golden acre and least oviposited on Asha during whole study. Offspring of *Plutella xylostella* fitness were also measured by survival rate of their developmental rate, immature stages (Egg, larva and pupa), longevity (male and female) were significantly different among cabbage varieties. Offspring survival rate is an important factor in management of pest. Overall survival of immature stages of *Plutella xylostella* was shortest on Asha, while longest on Golden acre. This findings showed that *Plutella xylostella* oviposited the minimum number of eggs on Asha. In compare, the overall survival rates of offspring were shortest on Asha, in spite of this variety received lowest number of eggs from the female moths. It is estimated that Asha variety will have lesser infestations due to lowest suitability for *Plutella xylostella* development. The incapability of *Plutella xylostella* to choose accurately for oviposit on host cabbage plants that support the maximum survival of the offspring is widely reported (Marchioro and Foerster, 2014). However, Zhang *et al*, (2012) investigated positive association between ovipositional preference and host acceptability and suitability for development of offspring in cases where moths do not have access to supplemental food. In the present study, Mean period of incubation on Asha was quantified to be longest and significantly different from that on Golden acre as shown in (Table 1). There is significant difference was observed in between the total larval developmental period on Asha and Golden acre that had shorter developmental time periods (Table 1). A significant difference was observed in between the

developmental period of pupae on Asha and Golden acre (Table 1). Total developmental time (days) was maximum on Asha (15.60 ± 0.25 days) while minimum was observed on Golden Acre (13.46 ± 0.21 days). The lowest survival rate of egg was monitored on Golden acre while highest on Asha variety. Survival rate of total larval period from first instars to fourth instars was found maximum on Asha and minimum on Golden acre. Highest pupal period was assessed on Asha and lowest on Golden acre. Total survival rate from egg to adult emergence was found minimum on Asha (75.25) and maximum on Golden acre (85.42). No significant difference was observed in pre-ovipositional periods of female reared on two cabbage varieties (Table 3). However, there was significant difference among ovipositional periods and female adult selected cabbage varieties. Longer oviposition period observed on Asha while shortest on Golden acre. The post oviposition period on Golden Acre was significantly higher than Asha and this is due to significant difference in longevity on selected cabbage varieties. Male longevity was higher on Golden acre while minimum on Asha and the trend shows significant difference among Golden acre and Asha (Table 3). Host plants greatly influence fecundity rate (Table 3). There was significant difference in fecundity among two varieties. Female *Plutella xylostella* prefers to lay maximum eggs on Golden acre (152.63 ± 22.54) while minimum eggs were observed on Asha (108.04 ± 16.73).

In addition, the intrinsic rate of increase of *Plutella xylostella* was higher ($0.403 \pm 0.003 \text{ day}^{-1}$) when larvae feed on Golden Acre as compared to Asha $0.198 \pm 0.006 \text{ day}^{-1}$. Lowest finite rate of increase (λ) ($1.1232 \pm 0.0005 \text{ day}^{-1}$) and highest (3.23 \pm 0.129 days) doubling time (DT) of the Diamondback moth were observed on Asha in comparison with Golden Acre. The highest values of r_m ($0.403 \pm 0.003 \text{ day}^{-1}$) and λ ($1.312 \pm 0.0003 \text{ day}^{-1}$) and the lowest DT (2.98 \pm 0.012 days) were observed on Golden Acre, which indicates that this variety is the most suitable of the studied cabbage varieties for *Plutella xylostella*

CONFLICT OF INTEREST

All authors have declared that there is no conflict of interest regarding publication of this article.

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Table 4.1: Developmental period (days) of different stages of *Plutella xylostella* on two cabbage varieties under laboratory conditions.

Host varieties	Eggs (days)	Larval Period (days)	Pupal Period (days)	Developmental time (days)
Asha	3.05±0.12a	8.26±0.212a	3.91±0.23b	15.09±0.25b
Golden Acre	2.71±0.06b	7.23±1.05b	3.28±0.98a	13.46±0.21a

Means sharing common letters in each column are not significantly different from each other.

Table 4.2: Survival rate (%) of different stages of *Plutella xylostella* on two cabbage varieties under laboratory conditions

Host Varieties	Egg (%)	Larva (%)	Pupa (%)	Total (%)
Asha	92.15	80.12	95.63	75.25
Golden acre	97	92.48	96.72	85.42

Table 4.3: Oviposition period (Pre and Post), adult longevity (Female and Male) (days ± SE) and fecundity of *Plutella xylostella* on selected host plants.

Host variety	Pre oviposition period	Oviposition period	Post oviposition period	Female longevity	Male longevity	Fecundity
Asha	1.32±0.15a	18.45±0.89a	3.25±0.98a	16.40±0.66a	15.42±1.83a	108.04±16.73a
Golden acre	1.01±0.16a	15.64±0.78b	5.46±1.32b	19.45±0.45b	17.03±0.46b	152.63±22.54b

Means sharing common letters in each column are not significantly different from each other.

Table 4.4: Population growth parameters intrinsic rate of increase (r_m), finite rate of increase (λ), net reproductive rate (R_0), doubling time (DT) and generation time (T) of *Plutella xylostella* on two cabbage varieties.

Host Varieties	r_m (day ⁻¹)	(λ)	R_0 (day ⁻¹)	DT (day)
Asha	0.198 ± 0.006 a	1.1232 ± 0.0005 a	26.45 ± 0.28 a	3.23 ± 0.129 bc
Golden acre	0.403 ± 0.003 b	1.312 ± 0.0003 b	29.32 ± 0.39 b	2.98 ± 0.012 abc