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Effect of Different Host Plants on the Biology of Diamond-Back Moth, *Plutella xylostella* Under Laboratory Conditions in Northern Punjab, Pakistan

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ABSTRACT

Plutella xylostella is an oligophagous pest of several host plants belonging to the family Cruciferae (cauliflower, cabbage, canola). This is widely distributed in all those areas where its hosts exist and cause severe crop losses. The current study was conducted to check the effect of host plants such as cabbage, cauliflower and canola on the biology of *P. xylostella*. The effect on incubation period, growth, development time, fecundity, oviposition, % survival and % egg viability was studied on canola, cabbage and cauliflower. The developmental time from 1st instar to adult emergence was longest (18 days) on canola while shortest on cauliflower (15 days). Fecundity was recorded maximum (259 eggs) on cauliflower and minimum (159 eggs) on canola. Percentage survival of each stage was recorded maximum on cauliflower (84%) followed by cabbage (73%) and canola (69%). A significant difference was observed in the intrinsic rate of increase, r_m with host plants. The intrinsic rate of increase (0.290) and finite rate of increase values (1.35) were obtained on cauliflower while 0.283, 1.30 and 0.239, 1.23 on cabbage and canola, respectively. Cauliflower was found to be the most preferable host for *P. xylostella* due to higher percentage of survival, higher fecundity, higher % egg viability and shorter developmental period. The study provides knowledge about the host plants that prove helpful in enhancing the *P. xylostella* population.

INTRODUCTION

Agricultural crops such as cabbage, cauliflowers, canola, mustard and many other crops are playing a key role in the economy of Pakistan. Cruciferous crops are not only the main source of income for farmers but also for poor peoples in the country. The production of these crops is reducing as compared to other countries due to various biotic and abiotic factors (Grzywacz *et al.*, 2010, Zalucki *et al.*, 2012). The main problem of low crop production is due to the attack of sucking as well as chewing insect pests such as cabbage aphid (*Myzus persicae*), whitefly (*Bemisia tabaci*) (Shuaib *et al.*, 2007) cabbage butterfly

(*Pieris brassicae*), armyworm (*Spodoptera litura*), cabbage looper (*Trichoplusia binotalis*) and diamond-back moth, (*Plutella xylostella*) (Aslam *et al.*, 2007; Aslam and Razaq, 2011; Ramzan *et al.*, 2019a).

Among all these mentioned insect pests, diamond-back moth, (*Plutella xylostella*) belong to order Lepidoptera and family Plutellidae is considered a serious pest of cabbage (Sarfranz *et al.*, 2010; Furlong *et al.*, 2013) which become the cause of more than one billion crop losses per year throughout the globe (Furlong *et al.*, 2008; Sandström *et al.*, 2011; Karlsson *et al.*, 2013). This destructive pest is widely distributed (Shelton, 2004; Abro *et al.*, 1994; Khaliq *et al.*, 2007) and has been recorded from more than 128 countries of the world.

Several host plants of *P. xylostella* have been reported in Pakistan such as cabbage, turnip, mustard, canola, broccoli, cauliflower, radish and many more (Khaliq *et al.*, 2007; Ramzan *et al.*, 2019b). The biological parameters (fertility, fecundity, longevity and total developmental period or life cycle) of insect pests are highly attached to the phenology of host plants (Sayyed *et al.*, 2008a). Host plant quality and quantity can also affect the behaviour, feeding potential and reproductive potential of herbivores (insect pests).

Different management approaches have been adopted against this pest such as Push-pull, use of insecticides and biological fauna. Authentic information about the effect of host plants on herbivores is required which will be helpful in their management. The immature stages (eggs, larvae, pupae) of *P. xylostella* were collected from different cabbage fields and reared on different hosts under laboratory conditions. The aim of the current study was to check the host plants impact on the biological parameters of *P. xylostella*.

MATERIALS AND METHODS

Study Area:

The experiment was conducted at the University of Agriculture Faisalabad, Department of Entomology.

Source of the Host Plant, Collection of Immature Stages and Insect Rearing:

The seed of four different host plants was purchased from a nearby seed shop and grown in plastic pots (6x10x20cm). The detailed information about hosts is given in Table 1. A survey was conducted to collect the immature stages such as eggs, larvae and pupae of *P. xylostella* and each stage was kept in separate plastic containers. Larvae were reared on cabbage leaves till pupation. The insect rearing cages were prepared in the laboratory and a newly emerged one pair adult was released into each cage. Separate host plant leaves were kept into a separate cage for oviposition and cotton wools soaked in 10% honey solution as adult food. Eggs were collected from each host and kept in a plastic container with respective host leaves as food for emerging larvae. The rearing of the insect was performed under laboratory conditions (26±2°C L: D (14:10 h) by using Ramzan *et al.* (2019) and Syed and Abro (2003) procedure.

Determination of Biological Parameters:

Biological parameters such as duration of development of each larval instar, total developmental time, pupal period, total life period and % survival of tested pest were noted/recorded on each host plant. Five pairs of adults were released into a separate cage containing separate host plant leaves to calculate the reproductivity or fecundity of the pest. Eggs were collected separately from each host, kept into separate petri dishes and recorded their fertility up to 6 days. Unhatched eggs were considered died after 6 days of egg-laying. To check the development and growth of larvae, twenty (20) leaf discs of tested host plants were cut with the help of a leaf cutter. Discs were placed into petri dishes and each petri dish consist of one disc. A total of twenty discs were used to check the suitable host and further

parameters of the larva. Five number of neonate larvae were shifted into each petri dish. There were five replications of each host and each petri dish was considered as a replicate. to check growth rate full-grown 3rd instar larvae were randomly selected from reared culture and weighted them. The weighted larvae were reared separately on the respective host and change their food till pupation and then pupae were weighted. The mean relative growth rate (MRGR) was determined by using the following formula;

$$\text{MRGR} = [\ln W_2(\mu\text{g}) - \ln W_1(\mu\text{g})] \div T$$

where W1= initial larval (L3) weight and W2= initial pupal weights while T= time (days) from L3-pupal stage (Radford, 1967). The net replacement rate (R₀) and the intrinsic rate of population increase, r_m were also calculated by using a procedure of previous scientists (Sayyed and Wright, 2001).

RESULTS AND DISCUSSION

The environmental conditions and quality of hosts can affect the growth and development of mature and immature stages of insect pests (Syed and Abro, 2003). The host plants impacts on the biological parameters of *P. xylostella* have been studied by few experts throughout the world. The growth and developmental duration of *P. xylostella* can be increased or decreased depending on the species of host plants as reported by many researchers (Sarfraz *et al.*, 2007). In the current study, three different host plants were tested to check their effect on the biology of *P. xylostella* under laboratory conditions. The description of each host plants grown in the laboratory was elaborate (Table 1). The incubation period of the egg was recorded at 2.69, 2.75 and 2.80 days, respectively on cauliflower, cabbage and canola, respectively. The difference in the incubation period on each host is due to the consumption of food sources by parents at larval stages. Our study findings are in line with Gould *et al.* (2005) which had reported a significant difference in the incubation period.

Table 1: Description of host plants grown in the laboratory

Host plants	Scientific name
Cabbage	<i>Brassica oleracea</i> var. capitata
Cauliflower	<i>Brassica oleracea</i> var. botrytis
Canola	<i>Brassica napus</i>

First, second, third and fourth instars completed their growth on cauliflower within 2.34, 1.45, 1.07 and 1.02 days, respectively while 2.93, 1.50, 1.21 and 1.07 days on cabbage (Table 2). The total developmental period of larvae was completed at approximately 8 days. It was observed that *P. xylostella* completed their growth on cauliflower in a very short period of time than cabbage and canola. The larvae took maximum days to complete their development and growth on canola as compared to other tested host plants (cabbage and cauliflower). The time difference of larval growth and development on canola than cabbage and cauliflower hosts may be due to a lack of sufficient nutrients and metabolites that highly affect insect growth. The different characteristics of host plants can cause a significant difference in insect reproduction. More oviposition was done in an early stage of females on each host. The maximum (259) and minimum (158) fecundity was recorded on cauliflower and canola, respectively (Table 3). The mating duration and egg lying capacity or fecundity of those females were reduced that reared on canola at the larval stage. The study showed that canola is a nutritionally poor plant for *P. xylostella* growth and development or feeding. A significant difference in fecundity was recorded on each host. Hamilton *et al.* (2005) had reported that the egg-laying capacity of females fed on *Capsella bursa-pastoris* during the

larval stage was found low than Chinese cabbage *Brassica rapa* and *Brassica oleracea* variety *italica*. The chemical cues such as primary and secondary metabolites play a key role in host plant selection.

Table 2. Effect of host plants on the developmental duration of *P. xylostella* stages

Stages (days)	Host plants			LSD 5%
	Cauliflower	Cabbage	Canola	
	Mean±SE	Mean±SE	Mean±SE	
Egg				
Incubation period of egg	2.69±0.02a	2.75±0.04a	2.80±0.03a	0.10
Larva				
1 st instar	2.34±0.49c	2.93±0.61bc	3.00±0.26a	0.10
2 nd instar	1.45±0.50bc	1.50±0.60d	1.80±0.49cd	0.21
3 rd instar	1.07±0.31a	1.21±0.23c	1.45±0.51b	0.13
4 th instar	1.02±0.01d	1.07±0.53ab	1.30±0.50c	0.20
Total developmental period of larva	6.52±0.01b	7.32±38a	7.44±0.13a	0.11
Pupa				
Prepupa	0.28±0.05b	0.38±0.05ab	0.65±0.07ab	0.06
Pupa	4.00±0.30a	4.45±0.36a	4.98±0.65a	0.27
Total life period				
1 st instar-adult emergence	15.12±0.65b	16.20±1.23bc	18.23±0.37d	0.40

Note: Means sharing the same letter in a row are not significantly different to each other ($P > 0.05$).

Table 3: Effect of host plants on characteristics of *P. xylostella*

Life traits	Host plants		
	Cauliflower	Cabbage	Canola
	Mean±SE	Mean±SE	Mean±SE
% Survival	84±0.88b	73±0.89b	69±1.90a
Growth (mg/ml)	13.01±0.10b	14.00±0.13a	15.01±0.20c
Oviposition period	8.01±0.40ad	7.67±0.19ab	7.29±0.26bc
Pre-oviposition period	0.39±0.15a	0.49±0.20a	0.30±0.15a
Post-oviposition period	5.28±1.10a	1.68±0.61b	1.49±0.30b
Male adult longevity	21.01±2.79a	17.70±0.89a	8.38±0.74b
Female adult longevity	26.00±1.72a	20.90±1.18b	10.03±0.59c
Fecundity	259±6.02a	180±3.79b	158±0.49a
% Eggs viability	60.00±0.50a	46.01±0.34a	30.45±0.78b

Note: Means sharing the same letters in a row are not significantly different from each other ($P > 0.05$)

The highest fertility was observed on cauliflower while lowest on canola. The current study showed that cauliflower is a more suitable host for insect growth and female oviposition as compared to cabbage and canola. (Lu *et al.*, 2004; Badenes-Perez *et al.*, 2005) had reported that difference in egg lying is highly linked with host plants cues and conditions under which the hosts have grown either laboratory and field. More numbers of eggs were recorded under uncontrolled conditions as compared to controlled or laboratory conditions. The male and female longevity on cabbage was 21 and 26 days, respectively. It was observed that female was long lived than male on all tested hosts. Females can consume their eggs as

food during life period and lived more days as compared to male. Many researchers had reported that adults need protein and carbohydrates as energy for their flight, fecundity and longevity. Winkler *et al.* (2005) had reported that carbohydrates and proteins are the requirement of many herbivores especially lepidopteran insect pests. The sap secretion from damage leaves of host plants can consume by adults during oviposition, become the source of food and increase the longevity of adults. The survival rate of each stage was found minimum on canola while maximum on cauliflower. The variation in survival rate could be due to various factors such as nutritional values and defensive mechanism of plants that directly or indirectly influenced the biological parameters of insect pests (Sarfranz *et al.*, 2006). Low survival rate could be due to early mortality of insect. The geographical difference could be factors that indirectly influence the insect parameters. Awmack and Leather (2002) had given the same reasons about insect fecundity.

A significant difference was observed in the intrinsic rate of increase, r_m with host plants. In the current study, Intrinsic rate of increase, r_m (0.290) and finite rate of increase values, λ (1.35) were obtained on cauliflower while 0.283, 1.30 and 0.239, 1.23 on cabbage and canola, respectively (Table 4). Our findings of the intrinsic rate of increase and finite rate of increase values are similar to previous researcher's findings (Wakisaka *et al.*, 1992; Salas *et al.*, 1993). The high r_m values on cauliflower show that cauliflower is a suitable host for *P. xylostella* reproduction, survival, longevity and generation time as compared to other tested host plants.

Table 4: Effect of host plants on population growth parameters of *P. xylostella*

Life traits	Population growth parameters				
	r_m	λ	R_0	T	DT
	Mean±SE	Mean±SE	Mean±SE	Mean±SE	Mean±SE
Cauliflower	0.290±0.01a	1.35±0.01a	162.98±10.38a	18.00±0.30ab	3.31±0.07c
Cabbage	0.283±0.00ab	1.30±0.00ab	180.78±6.31a	17.19±0.29a	2.59±0.06bc
Canola	0.239±0.05c	1.23±0.00c	60.21±5.86b	14.89±0.23b	2.80±0.08a

Note r_m ; Intrinsic rate of increase. λ ; Finite rate of increase. R_0 ; Net reproduction rate. T; Mean generation time. DT; Doubling time. Means sharing with the same small letter within the same row are not significantly different from each other ($P < 0.05$; Tukey).

Conclusion

Cauliflower is the most suitable host plant for *P. xylostella* reproduction, survival and longevity as indicated by high r_m values. Among tested host plants, canola had greater antibiotic resistance as indicated by low survival of immature stages and long developmental time with low r_m values. More information about how plant characters can maintain the pest population below the economic injury level are need to study. That knowledge will be helpful in adopting an effective strategy to control insect pests.

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