Research Article

Biology of Diamondback Moth, *Plutella xylostella* (Lepidoptera: Plutellidae) of Cauliflower under Laboratory Conditions

Muhammad Ramzan, Unsar Naeem-Ullah*, Mahreen Hanif, Muhammad Nadeem, Mirza Abdul Qayyum, Muhammad Javaid

Institute of Plant Protection, Muhammad Nawaz Shareef University of Agriculture, Multan Punjab, Pakistan

Abstract | Diamondback moth, *Plutella xylostella* is the serious and cosmopolitan pest for crops and vegetables especially cauliflower all over the world. The larvae feed on foliage and cause severe damage. Present study was carried out under laboratory conditions to elicit information about every stage like egg, larva, pupa and adult of *Plutella xylostella* on natural diet. The study revealed that incubation period of eggs varies from 3.2-4.3 hours. There are four larval instars of *Plutella xylostella*. The first, second, third and fourth instar larva survived for 3-5,3,1-4 and 2-3 days respectively while pupal and prepupal period lasted for 5-3 days, respectively. Adults lived for 4 to 5 days and life period under laboratory condition varies from 13 to 23 days.

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***Correspondence** | Unsar Naeem-Ullah, Institute of Plant Protection, Muhammad Nawaz Shareef University of Agriculture, Multan Punjab, Pakistan; **Email:** naeem1130@yahoo.com
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1. Introduction

Cauliflower (*Brassica oleracea*) is an important winter vegetable and known as the main source of income for the farmers in the world and especially in Pakistan (FAO, 2008). The vegetables belonging to family Brassicaceae have medicinal value having glucosinolates and anticancer substances used for the treatment of cancer (Cohen et al., 2000; Lampe and Peterson, 2002; Keck and Finley, 2004). It is an important component of human diet (Shelton, 2004) in temperate and tropical regions of the world. There are various limiting factors including biotic and abiotic factor but the insect pests are the major reason for limiting cauliflower production (Nyambo and Pekke, 1995) also the quality of crop is affected during severe infestation of pests (Sánchez and Vergara, 2014). Insect pests and diseases which attack on cauliflower are army worm, aphids, cabbage worms, flea beetles and club root and black rot, respectively (Nyambo and Pekke, 1995).

Among the insect pests, Diamondback moth, *Plutella xylostella* (Linn.) (Lepidoptera: Plutellidae) is the serious, cosmopolitan pest of cauliflower and caused about 90% damage globally (Verkerk and Wright, 1996; Sarfraz et al., 2006; Tufail et al., 2008; Sandström et al., 2011; Karlsson et al., 2013; Furlong et al., 2013). This pest being the main cause of low production (Talekar and Shelton, 1993; Sarfraz et al., 2006) is distributed throughout the world especially in those places where crucifers are cultivated (Shelton, 2001).

Majority of crops like radish, cabbage, broccoli, turnip, cauliflower and many others are the hosts of Diamondback moth (DBM) (Talekar and Shelton,

1993). When host is unavailable cruciferous weeds are also attacked by this pest. The host's leaves, seed pods, flowers, buds and outer layer of stem is attacked by the pest (Oke, 2008). During earlier stages of crops, larvae of DBM mine the crops and later stages feed on the leaves. Irregular patches appear on the leaves due to severe attack of larvae and 62 to 78 % leaves are consumed by a single larva (Gangurde and Wankhede, 2009). Whole leaf is fed by larvae except veins, last instars are voracious feeders than earlier instars (first three) giving the leaves a sieve-like appearance. Plant growth is stunted due to excessive feeding of larvae of DBM which attack from seedling to harvesting stage resulting in the reduction of quantity as well as quality of crops (Gangurde and Wankhede, 2009). Last three stages feed on the plant surface and are mostly found inside the leaves. The developmental time depend upon the abiotic factors like temperature and humidity. The rate of development is faster in warm and slower in cool conditions. Generations of DBM overlap and all stages are present in the field during warm temperatures (Zhu et al., 2018).

First time DBM was originated from North America in 1854 (Saravaiya and Patel, 2005). DBM has been considered as a periodic migrating pest and became an important pest for farmers all over the world (Sandström et al., 2011; Karlsson et al., 2013). The majority of farmers plough down their fields due to severe losses caused by DBM. In tropical and subtropical regions of the world, more than 10-21 generations are reported in a year (Oke et al., 2010) while these are 4 - 20 in temperate regions (Vickers et al., 2004). There are 7-14 generations of this pest in Pakistan and India (Talekar and Shelton, 1993; Vickers et al., 2004).

This insect is an important pest of all crucifers globally especially in southern parts of Pakistan (Abro et al., 1992). Economic threshold level of DBM is 0.05/plant (Verkerk et al., 1957). It has been reported that pest cause about 100% yield losses (Abro et al., 1994) while 90% losses in Pakistan (Verkerk and Wright, 1996).

Due to importance of this pest, the current study was carried out to determine the biological cycle of DBM under laboratory conditions.

2. Material and Methods

2.1 Rearing of diamondback moth

The biological study of DBM was carried out under laboratory condition at 26 ± 5°C and 60% temperature and relative humidity, respectively, in MNS-University of Agriculture, Multan, Pakistan during 2019. The adults and fourth instar larvae were collected from nearby cultivated cauliflower fields and released with cauliflower leaves and cotton swab with 10% sugar solution into plastic jars, top of which was covered with muslin cloth for aeration and further egg laying.

After egg laying, eggs were collected from jars with the help of forceps and camel hair brush and shifted into petri dishes for biological records. For this purpose, 30 petri dishes were used and one egg was kept in each petri dish. After hatching, new and fleshy leaves were provided to larvae on daily basis for pupation. Newly emerged adults were counted and shifted into new jars for further reproduction. The culture was multiplied and maintained for three generations. All the information such as egg to larva and pupa to adult of pest was recorded during the whole study.

3. Result and Discussion

3.1 Biology of DBM

During the experiment all four stages of the DBM were observed *i.e.*, egg, larva, pupa and adult. Quality and quantity of cruciferous crops reduce due to severe attack and feeding of first instar larvae of *P. xylostella* from seedling to harvesting of crops (Gowri and Manimegalai, 2016). The wing span (length and width) of each female and male was different from each other. It has been observed that female wing span was larger than males.

The descriptions of the recorded stages have been provided below.

3.1.1 Adult

Adults were grayish brown in color with distinct antennae. These were small, slender and 6 mm long. There was no difference in length between both sexes (male and female). Adult male and female longevity was 9.0±0.69 and 13.0±0.73 days, respectively (Åsman et al., 2001). The moths were weak fliers and active at both, night and dusk. The wings length of female was larger than male. The mating mostly occurs during

dusk. After mating as host available female laid eggs on the same day of mating (Åsman et al., 2001). The similar results had been reported by earlier studies (Gowri and Manimegalai, 2017).

3.1.2 Egg

Within few hours of emergence, mating takes place which continued about 1-2.5 hours. Males mate more than two times while females only once in their life cycle (Wang et al., 2005). Eggs were yellow and pale green in color. During the study it has been observed that female laid about 200-210 eggs on the lower surface of leaves, for protection from wind and rain (Talekar and Shelton, 1993). The similar findings had been observed by other scientists (Justus et al., 2000) whereas our findings are dissimilar with the findings of Yamada and Kawasaki (1983). Female lays eggs up to10 days after emergence while reported by Yamada (1978) that female lays egg up to 5 days after emergence, which is dissimilar to our findings. The eggs were laid on the groove surface of the leaves not on the smooth surface of plants (Silva and Furlong, 2012). Eggs can be seen with the help of hand lens (CABI, 2015). The female of diamondback moth laid eggs singly or in small group near the midrib or on the lower surface of leaves or container wall surface. The incubation period of eggs varied from 3.2-4.3 days with average of 3.5± 0.54 days as represented in Table 1, while incubation period observed by other scientists was 2 days (Gowri and Manimegalai, 2017), 3 to 4 days (Gangurde and Wankhede, 2009), 3.33 ± 0.42 days (Dhaduk, 2007) and 3.0 to 5.25 days (Ramegowda et al., 2006) as mentioned in Table 1. Variations in incubation period were due to various factors like food and climate change.

Table 1: Incubation period of eggs.

Number of eggs observed	Incubation period (Days)		
	Min.	Max.	Ave. ± SD
30	3.2	4.3	3.51± 0.54

3.1.3 Larva

There were four larval instars of DBM. The newly emerged larva was very small in size. The head of newly hatched larvae was pale brown while fully grown caterpillar was light green and 10 mm long in length. The length and width of head capsule was 1.46 mm and 1.55 mm. The newly hatched larvae made very small holes on the plants leaves (Nirmala and Desh, 1995) like mines. The first instar larvae were leaf mining and difficult to see due to small in size. The first instar larvae were small about 0.05-0.1 cm in length and after 5-6 days change into second instar as shown in Table 2. The similar results had been reported by other scientists (Sharma et al., 1999; Kumar et al., 1999; Dhaduk, 2007). The sparse short erect hairs are also present on the whole body of the larval instars with small white patches. The five pairs of prolegs are also present in the newly hatched larvae. The second instars are very active and larger as compared to first and change into third instar after 3-4 days. The body and head capsule color of the larva were yellowish green and light brown, respectively and the width and length of head capsule was 3.12 mm and 2.65 mm. The second instar takes 3-4 days for its development into third instar larvae which are light yellow in color. The third instar feed more vigorously than first and second instar and after 4-5 days change into fourth instar. Head capsule of the larvae was 4.56 mm and 4.32 mm in length and breadth, respectively as shown in Table 3. There were similar habits of feeding in third and second instars but stop the feeding during pre-pupal stage. The fourth instar larvae were dark green in color, length and width of head capsule of the larvae was 4.99 mm and 4.98 mm. Our findings were similar with earlier studies (Capinera, 2000).

Table 2: Life cycle of diamondback moth, *Plutella xylostella* (Linn) on cauliflower under Laboratory condition.

Objects	Laboratory condition (26±5 C° and 60% R.H)
	Life cycle (Days)
1st instar	5.65 ± 0.62
2nd instar	3.57 ± 0.74
3rd instar	4.45 ± 0.65
4th instar	3.78 ± 0.96
Total	15.89 (12-17)
Pupal period (days)	4.77 ± 1.13
Pre-oviposition period	0.50 ± 0.24
Oviposition period	17.30 ± 0.81
Post-oviposition period	4.12 ± 1.12
Adult longevity (days)	
Male	11.0 ± 0.88
Female	13.0 ± 0.92

3.1.4 Pre pupa and pupa

There were two inactive phases of this pest i.e., pupa and prepupa. During the pre-pupal stage, larva showed sluggish movement and reduce the feeding which last for about 1 to 3 days with an average of

1.45 ± 0.65 days. At last, pre-pupa changed into pupal stage which last for 1 to 3 days (Stapathi, 1990; Kandoria et al., 1994; Kapadia and Koshiya, 1999; Gowri and Manimegalai, 2017) as describe in Table 4. Our current findings were similar with other studies (Ahmad et al., 2008; Ahmad et al., 2011).

Table 3: Average of head capsules length and width of different larval instars.

Stages	Head capsule	
	Length (mm)	Width (mm)
First instar	1.46	1.55
Second instar	3.12	2.65
Third instar	4.56	4.32
Fourth instar	4.99	4.98

Table 4: Pre-pupal and pupal period of DBM.

Number of larva	Pupal period			Pre-pupal period		
	Min.	Max.	Ave. ± SD	Min.	Max.	Ave. ± SD
30	3.50	5.50	5.05 ± 0.56	1.00	2.50	1.75 ± 0.65

Conclusion

P. xylostella is a serious threat to successful prophecy of cruciferous vegetables. knowledge of the biology of Diamondback moth effects the host plant quality and helps in the management of this insect.

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Author's Contributions

MR planned, conducted the experiment, recorded the data and wrote the manuscript. UNU provide technical guidance and reviewed the manuscript. ZR helped in data recording. GM and SHMB helped in data analysis.

Conflict of interest

Authors have no conflict of interest.

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