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Temperature dependent life table studies of diamondback moth, (*Plutella xylostella* L.) under laboratory condition

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Abstract
Different temperature has significant impact on the life cycle of *Plutella xylostella* (L.) and for effective management of diamondback moth (DBM) requires knowledge of effect of temperature on different stages of DBM. In current study survival rate from egg to adult emergence was found to vary from 80 to 69 %. Maximum survival was observed at 20±1°C (80 %), 25±1°C (77%) and 27±1°C (74%) whereas, minimum survival was observed at 30±1°C (69 %). The survivorship curves were observed to be type III curves. Indicate that the mortality at later stage of development like pupa or adult would have greater impact on population. In general, the force of mortality was high in first larval instar and pupal stage however, during third and fourth larval instar death rate curve was more or less steady during all temperatures. The overall mean death rate during 20±1°C was found to be low as compared to other temperatures.

Keywords: *Plutella xylostella* (L.), diamondback moth, life table, survivorship curve

Introduction
The diamondback moth is a major pest insect in more than 100 countries across the globe; this is one of the most serious and widely distributed pests of the cruciferous crops in many countries including India [2]. In the past 40 years, the diamondback moth has become one of the most difficult insects to control because of its intrinsic biology, ecology and its large host range. Hence, it would be beneficial to include ecological studies directed towards understanding of factors influencing pest population and identifying corresponding long-term control measures [8]. Life table study is a central theme in ecological research to understand the temporal and spatial patterns in population dynamics these tables can describe duration and survival at each life stage, which allow prediction of the population size and age structure of a pest insect at any time. Series of life tables of the pest increase understanding about pest dynamics and key mortality factors. It generates simple summary statistics such as life expectancy and reproduction rate [3, 4]. From a pest management standpoint, it is very useful to know when a pest population suffers high mortality. The life expectancy of insects can be calculated using control program which will help in predicting natural instar phase; further, this phase can be targeted to get maximum mortality by eco-friendly measures [4]. The purpose of this study is to examine the developmental rate of diamondback moth in laboratory over a different temperature range and to derive life table which will be helpful to combat with the pest in field in changing climate scenario. It will also predict the temperature range which will simulate the development diamondback moth.

Materials and Methods
Pure culture of diamondback moth (DBM), *P. xylostella* (L.) was initiated by collecting the pupae from farmer's field nearby Pune and was maintained in the laboratory at wire mesh cage measuring 60 cm^3 (Plate 1.). The DBM were raised for one generation to enable the field stock to acclimatize to laboratory conditions. The second-generation life stages were used for present study. In order to construct life table, freshly laid 100 eggs were collected with the help of wet camel hair brush, individually eggs were placed on cabbage leaf bits and kept in plastic container (4.5 cm x 5.5 cm x 4.5cm), lined with cabbage leaf bits and covered with a ventilated lid (Plate 2.) [9].

Then plastic containers were placed in incubators at four different temperatures (20℃, 25℃, 27℃ and 30℃, each ±1℃). All experiments were carried out at 65±10% RH and at 12:12 h (L: D) photoperiod. Freshly cut leaves of cabbage and cauliflower were provided to the larvae after every 1 or 2 days [3].

Eggs that failed to hatch by the end of the experiment were counted as dead and hatching per cent were calculated. Freshly cut leaves of cabbage and cauliflower were provided to the larvae after every 1 or 2 days. Survival and mortality of the larval, pre-pupal and pupal stage were checked and recorded stage wise until adult emergence. The study of life-table comprised of the following parameters [6, 7].

1. x = Stage at which the sample was taken; egg, larva and pupa.
2. lx = The number surviving at the beginning of the stage stated in the x-column.
3. dx = The number of dying within the age interval stated in the x – column.
4. d x f = The mortality factors responsible for dx.
5. 100 q x = Percent mortality (dx as percentage of lx).
6. Sx = Survival rate within the stage mentioned in the x column.

Survivorship and death rate curve

Survivorship curves have been drawn by plotting the numbers living at a given stage (lx) against the stage (x) while Death rate curves have been drawn by plotting age 'x' against 100 q x [9, 10].

Results and Discussion

Egg stage

The survival rates during egg stage were 96, 94, 93 and 91 per cent at 20±1℃, 25±1℃, 27±1℃ and 30±1℃ respectively (Table 1). Survival of egg stage was highest at 20±1℃ and lowest at 30±1℃ showing that the mortality of eggs increased with increase in temperature from 20±1℃ to 30±1℃.

20 to 25℃ temperature is more suitable for the hatching, where maximum survival has been observed [3]. Increase in temperature usually results in a concomitant reduction in the synthesis of yolk nutrition, it limits development of egg hence; increase in temperature can be directly detrimental to egg hatching [8].

Table 1: Stage specific per cent survival of *Plutella xylostella* (L.) at four different temperature

Temperature	Egg	1st instar	2nd instar	3rd instar	4rth instar	Pre-pupa	Pupa	Total
20^0 C	96.00	95.83	96.73	97.73	97.70	98.82	95.23	80.00
25^0 C	94.00	95.74	96.66	97.70	97.64	98.79	93.90	77.00
27^0 C	93.00	94.62	95.54	97.61	96.34	98.73	94.87	74.00
30^0 C	91.00	94.50	95.34	96.34	97.46	94.80	94.52	69.00

Larval stage

The observed survivals during first instar were 95.83, 95.74, 94.62 and 94.50 per cent; whereas, the survivals during second instar were 96.73, 96.66, 95.54 and 95.34 per cent at 20±1℃, 25±1℃, 27±1℃ and 30±1℃ respectively. The observed mortality of third instar was more or less constant throughout the experiment, constant survival was observed at 20±1℃ (97.73%), 25±1℃ (97.70%) and 27±1℃ (97.61%); whereas, slightly lower survival was observed at 30±1℃ (96.34%). As depicted in Table1, more or less constant survival of fourth instar larvae had been observed at 20, 25 and 30±1℃ i.e., 97.70, 97.64 and 97.34 per cent; whereas force of mortality at fourth instar was slightly higher at 27±1℃ i.e., 96.34 per cent during present study.

Survival trend of first, second and third instar indicated that, the survival rate at 20 and 25℃ remains nearly constant; whereas, temperature above 25±1℃ survival rate starts decline. It shows that 20 and 25±1℃ temperature is more favorable for all larval instars [1, 5].

Pre-pupal stage

It revealed from table no. 1. that the survival rate of pre-pupal stage was significantly constant at 20±1℃ (97.73%), 25±1℃ (97.70%) and 27±1℃ (97.61%) but more larvae were failed to transform itself into pre-pupal stage at 30±1℃ (94.80%).

The pre-pupal stage can accumulate a significant amount of development at 20±1℃, 25±1℃ and 27±1℃. However, temperature above 27±1℃ especially at 30±1℃, high mortality is observed [1].

Pupal stage

A maximum of 95.23%, 94.87% and 94.52% adult emergence were observed during this stage at 20±1℃, 27±1℃ and 30±1℃ respectively; whereas slightly lower adult emergence of 93.90% observed at 25±1℃ during present experiment.

The most favorable temperature for adult emergence is 20℃ [3]. The variations of adult emergence observed might be due to the influence of factors other than temperature such as nutrition, humidity and geographical individuality of initial culture [1].

Total survival rate

Total survival rate from egg to adult emergence was found to vary from 80 to 69 %. Maximum survival was observed at 20±1℃ (80 %), 25±1℃ (77%) and 27±1℃ (74%) whereas, minimum survival was observed at 30±1℃ (69 %).

As the temperature increases total survival is deceases gradually, survival trend shows negative correlation between temperature and populations [1, 5].

Survivorship and death rate curves

The survivorship curves obtained in the present studies (Fig 1.) were almost similar to type III curves [8]. Indicate that the mortality rates were nearly constant during all stages. Hence the mortality at later stage of development like pupa or adult would have greater impact on population while in death rate curves the force of mortality was found to act in different pattern at different temperatures on the 7 stage intervals of the pest (Fig 2.). In general, the force of mortality was high in first larval instar and pupal stage, however, during third and fourth larval instar death rate curve was more or less steady during all temperature. The mortality force revealed steep decline in curve at the earlier (Egg and first instar) and later stages (pupal) of the diamondback moth Mortality observed during egg stage were mainly due to the infertility in eggs only and this was found to be higher in hot conditions (30±1℃) compared to the low temperature (20±1℃). The overall mean death rate during 20±10C was found to be low

as compare to other temperatures; Mainly due to this is a pest of temperate region, hence the force of mortality is increasing with increase in temperature.

Earlier workers [1, 9, 10] reported more or less similar pattern of survivorship curves at different ecological conditions. Moreover, they had also been reported observed cure is type III curve and mortality rate were nearly constant in all stages. The survivorship curves indicated 20℃ as most favorable temperature for overall survival [7]. The mortality at later stage has greater impact on population [10].

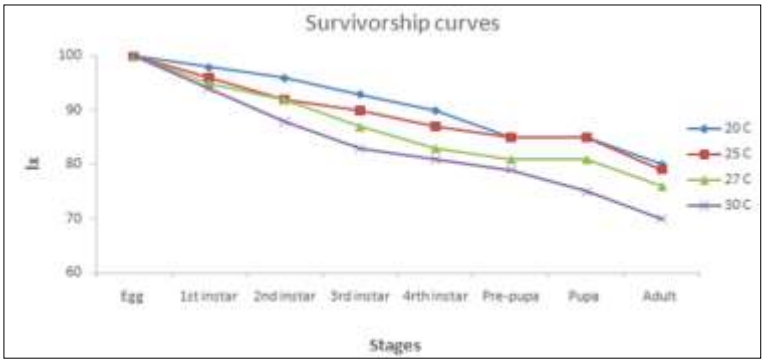

Fig 1: Survivorship curves of *Plutella xylostella* (L.) at different temperatures

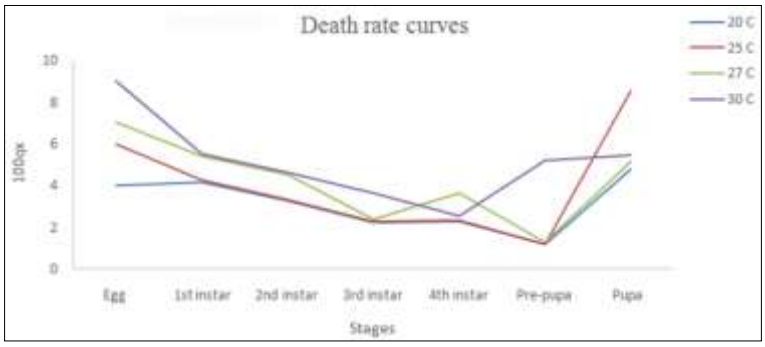

Fig 2: Death rate curves of *Plutella xylostella* (L.) at different temperatures

Plate 1: Rearing of *Plutella xylostella* (L.) on mustard seedling under laboratory condition

Plate 2: BOD incubator and Rearing of *Plutella xylostella* (L.) in ventilated plastic containers for life table study

Conclusions

The diamondback moth, *Plutella xylostella* (L.) has potential to grow at all four temperatures i.e., 20±1℃, 25±1℃, 27±1℃ and 30±1℃ but the most favorable temperature for diamondback moth is 20±1℃, where highest developmental period was observed. There was a significant negative correlation between temperature and DBM populations were observed at temperature range of 20 to 30±1℃. The higher force of mortality is observed during initial stages of DBM during all four temperatures. However, survivorship curve is observed to be of type III curve. So, it is recommended that farmers should plan management practices during initial (first and second instar) stages for better management of DBM.

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