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Fertility Lifetables of Glasshouse Whitefly *Trialeurodes vaporariorum* (Westwood) on French Bean cv. Contender at Different Temperatures

Jyoti Kapil[1*] and Manica Tomar[2]

[1]Dept. of Biotechnology, Kanoria P.G Mahila Mahavidyalaya, Jaipur, Rajasthan (302 004), India
[2]Directorate of Extension Education, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh (173 230), India

Corresponding Author

Jyoti Kapil
e-mail: jyotikapil31@gmail.com

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Abstract

Fertility Life tables and characteristics of the *Trialeurodes vaporariorum* (Westwood) were assessed on French bean cv. Contender at different temperatures 15, 20, 25 and 30 °C. The life table analysis showed that the females lived for a maximum of 58 days at 15 °C. The trend of oviposition showed a peak on 32nd day at 25 °C as the highest number of eggs produced per female per day was 9.98. The true Intrinsic rate of increase (r_m) values were 0.123 and 0.121 at 20 °C and 25 °C, respectively. The rate of natural increase (r_c) was 0.120 at 20 °C and 25 °C. The highest net reproductive rate (45.86) was obtained at 20 °C. The population doubling time (DT) was maximum (10.42 days) at 15 °C and minimum (5.64 days) at 20 °C. Generation time was 47.17 days at 15 °C which decreased to 24.82 days at 30 °C.

Keywords: Life-fertility Table, *Trialeurodes vaporariorum*, French beans

1. Introduction

Vegetables constitute an essential component of a balanced diet and play a vital role in the maintenance of good human health. Pest infestation and related diseases are major constraints in vegetable production. The warm temperature of spring and summer brings a flush of new foliage growth which attracts a wide variety of pestslike sap suckers foremost being whiteflies which can cause serious damage to crops worldwide (Peric, 1994).

The whiteflyis an important insect pest on a global scale, attacking a wide variety of agricultural commodities especially in vegetable and ornamental crops including citrus, squash, poinsettia, potato, cucumber, grape, tomato, hibiscus etc. (Van Lenteren and Martin, 2000). *Trialeurodes vaporariorum* (Westwood) commonly known as glasshouse whiteflyis a polyphagous pest. It was first described as *Aleurodes vaporariorum* (Westwood, 1856) from whiteflies collected from tomato in glasshouses throughout Europe (Quaintance, 1900). In India, it was reported at Thumantty (Nilgiris) infesting potatoes (David, 1971). The nymphs and adults suck the vital sap from the foliage which reduces photosynthetic activity of the plants (Yamada et al., 1979). The damage is inflicted by yellowing of leaves which later fade and dry away (Baker, 1922). The honeydew secreted by nymphs and adults of whitefly results in sooty mould which makes plants unsightly and valueless (Garman and Jewett, 1992; Johnson et al., 1992; Omar et al., 1992; Liu et al., 1993) and also reduces photosynthetic activity of the plants (Yamada et al., 1979; Tosh and Brogan, 2015).

Although whiteflies themselves can cause significant crop damage, *T. vaporariorum*-vectored viruses can cause losses that are much more economically damaging than those resulting from vector feeding alone (Byme et al., 1990). The viruses have been found to be transmitted by *Trialeurodes*, all within the genus Crinivirus (Wisler et al., 1998; Wisler and Duffus, 2001).

The whitefly species like *Bemisia tabaci* (Gannadius) and *T. vaporariorum* are serious pests of large cultivated crops throughout the world and in India, it poses potential threat to the cultivation of highly remunerative crops like tomatoes, beans and cucurbits. Since French bean is a short duration (85-90 days) crop, it fits as a component of intercropping and sequence cropping in many of the agro-climatic zones.In India, French bean is cultivated in 137.54 thousand hectare with production of 1370.21 thousand tones and productivity of 478 kg ha^{-1} (Saxena et al., 2015). The pests that attack French beans at different growth stages include white flies, pod borers and leaf miners (Lohr, 2006). Since, the construction of life

fertility tables is vital for determining the inherent capacity of an insect to increase in numbers and understanding population dynamics of a species (Phadke,1982). Hence, keeping in view the serious nature of the pest and potential threat it poses to the cultivation of highly remunerative crops like tomatoes, beans and cucurbits, an attempt was made in the present study to critically assess the reproductive potential of *T. vaporariorum* on French bean cv. Contender. The calculation of growth rate statistics is, therefore, a value for determining the growth potential of whitefly population under a given set of environmental conditions. The present study will enable us to know their potential in different temperature conditions.

2. Materials and Methods

All experiments were conducted at the Department of Entomology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh in climatic chambers operating under controlled conditions (15, 20, 25 and 30 °C). The culture of whitefly was raised in the laboratory on French bean cv. Contender. The French bean seedlings were grown in disposable cups and after 6-7 days of emergence, transferred to rearing cages (40×30×40 cm^3). The adults were released on the seedlings. The pots were taken out and leaves were observed under the microscope for egg laying activity of the insects.

After egg laying, the eggs were marked withpointed tip permanent Faber castle make markers,then the seedlings were taken out and covered with glass chimney (20×15 cm^2). The top of the chimney was covered with muslin cloth. The effect of temperature on the development of whitefly was studied in BOD incubators maintained at four constant temperatures i.e.15, 20, 25, 30 °C. A photoperiod of 14:10 (L:D) and relative humidity of 70% maintained at all the temperatures and replicated ten times. Daily observations at all temperatures were taken. The age specific survival (l_x) and age specific fecundity (m_x) at each pivotal age (x) were worked out daily for entire reproductive period to prepare fertility table as per the details given by Andrewartha and Birch (1954) and Southwood (1978).

Life table was constructed using the following column of parameters:

X: the pivotal of individuals (days)

l_x: the number of surviving individuals at age X

m_x : the number of living females born per female in age interval X(fecundity rate)

The reproduction rate: GRR =$\Sigma\, m_x$

Net reproduction rate of increase: $R_o = \Sigma\, l_x m_x$

Approximate generation time (in days) $T_c = \sum X\, l_x m_x / R_o$

True generation time (in days): $T = \log_e R_o / r_x$

The innate capacity for increase: $r_c = \log_e R_o / T_c$

True Intrinsic rate of increase: $r_m = \sum e^{7-r_m} X\, l_x m_x$

Finite rate of increase: $\lambda = \text{antilog}_e r_m$

Population doubling time: $DT = \log_e 2 / r_m$

Weekly multiplication rate: $WM = \text{antilog}_e r_m^{\,7}$

3. Results and Discussion

The age specific survival and age specific fecundity is illustrated graphically (Figure 1-4), the perusal of which revealed reproductive potential of *T. vaporariorum* at different temperatures. The whitefly had a maximumlife span of 58 days at 15 °C and pre-oviposition period was of 39 days. The oviposition started on 43rd day and maximum fecundity (6.80) was on 49th day (Figure 1). At 20 °C, lifespan was 42 days of which immature stage occupied 24 days. The oviposition started on 27th day and maximum age specific fecundity (9.66) was attained on 34th day, respectively (Figure 2).The fertility statistics at 25 °C revealed that oviposition lasted for 15 days and female contributed highest egg production (9.98) on 7th day of oviposition. The egg laying ceased on 41st day of pivotal age (Figure 3). At 30 °C, the total lifespan of *T. vaporariorum* was 32 days and immature stages lasted for 20 days. The oviposition started on 22nd day and lasted for 8 days, the maximum fecundity (4.35) was on 25th day (Figure 4). At all temperatures, the mortality mostly acts heavily on old individuals and was almost constant with time. Works done by

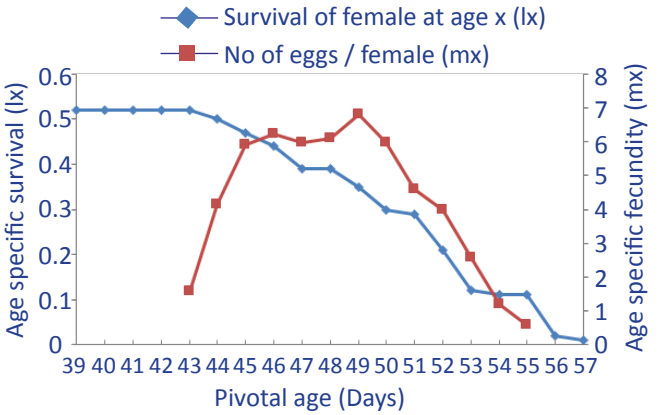

Figure 1: Daily age specific survival and age specific fecundity of *T. vaporariorum* on French beans cv. Contender at 15±1˚C

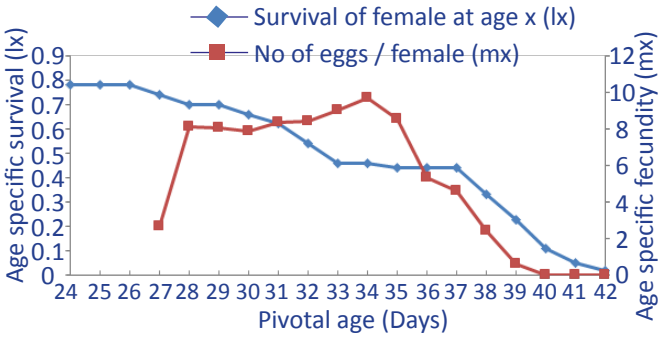

Figure 2: Daily age specific survival and age specific fecundity of *T. vaporariorum* on French beans cv. Contender at 20±1˚C

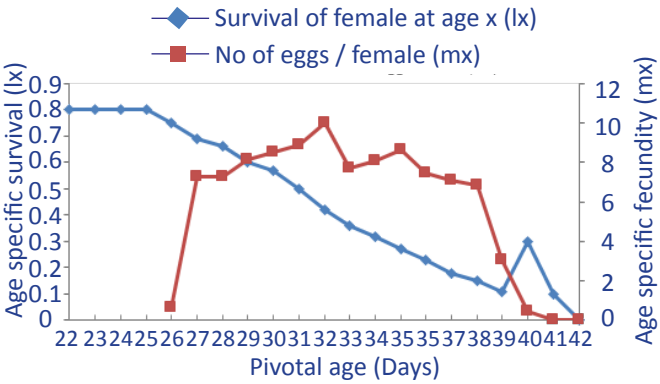

Figure 3: Daily age specific survival and age specific fecundity of *T. vaporariorumon* French beans cv. Contender at 25±1 ˚C

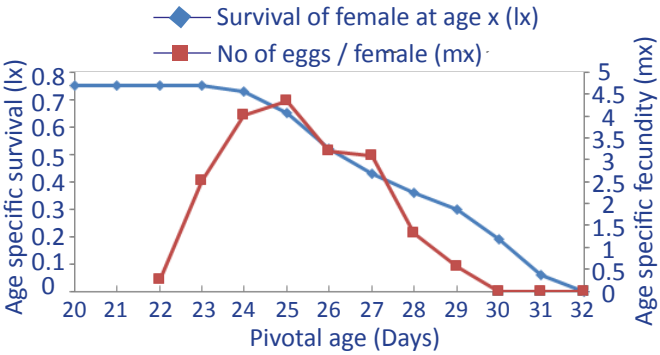

Figure 4: Daily age specific survival and age specific fecundity of *T. vaporariorum* on French beans cv. Contender at 30±1 ˚C

Verma et al. (1990) are in consonance with the present work.

Fertility table statistics of *T. vaporariorum* on French bean at different temperatures presented in Table 1 revealed that the higher net reproductive rate (R_o) was at 20 °C and 25 °C. The temperature below 20 °C and above 25 °C decreases the whitefly population. Rodriguez et al. (2005) made a generalization regarding climatic conditions that *T.vaporariorum* is absent in the area where RH is higher than 80% but other whitefly species like *Bemisia tabaci* (Gennadius) biotype B are present on vegetable crops.

This observation is supported by findings of Burnett (1949) who reported the maximum fecundity between 18 and 21 °C and maximum female longevity at 15 °C with very short survival at 9°C and temperatures over 27 °C. These results are corroborated by the work done byVerma et al. who studied the life cycle of the whitefly and concluded that temperature ranges from 23 to 30 ˚C provided optimal conditions for development of *T. vaporariorum* .

The gross reproductive rate (GRR) of *T. vaporariorum* was 55.71, 87.69, 100.22 and 19.34 while net reproductive rate was 19.99, 45.86, 40.83 and 11.50 at 15, 20, 25 and 30 ˚C, respectively. The difference in gross and net reproductive rate may be attributed to mortality of the parent female before reaching the maximum reproductive age at the respective temperature. The whitefly completed one generation (T_c) in 34.78 days at 15 °C, 31.66 days at 20 °C, 31.03 days at 25 °C and 24.90 days at 30 °C. The temperature was inversely proportional to duration of development. Yano (1988) while working on survival rate of *T. vaporariorum* adults also found that at low temperatures the survival capacity of the fly reduced considerably.

The innate capacity of natural increase (r_c) gives the actual rate of a species with no overlapping of generation and is derived from survival rate and reproductive performance of a cohort of females. It was found that the r_c was maximum (0.120) at 20 and 25 °C. This was attributed to the fact that the intrinsic rate of increase (r_m) gives response of an organism to a particular set of environmental conditions and therefore, it gives a precise estimate of the reproductive capacity of a species (Birch, 1948; Bursell, 1964; Macfadyan, 1963 and Messanger, 1964). It was observed that maximum r_m value (0.123) was at 20 ˚C and the nearly same value of r_m (0.121) was at 25 °C. Calvitti and Buttarazzi (1995) also reported the similar r_m value (0.121) of *T. vaporariorum* population on marrows.

The higher rate of finite increase (λ) was 1.13 per female per day at 20 and 25 °C. The population multiplied weekly 1.57, 2.31, 2.33 and 1.99 times at 15, 20, 25 and 30 °C, respectively and doubling time was maximum at 15 ^{0}C (10.83) and minimum (5.64) at 20 °C. No such work appears to have been carried out at constant temperature. However, Yano(1989) studied the effect of two temperature regimes 24 and 30 °C during the day time and 10 and 25 °C during night on population growth of *T. vaporariorum* on tomato and concluded that low temperature regimes decreased survival rate of eggs and larva and the higher temperature increase the intrinsic rate of natural increase. Yano (1988) also found that survival rate of *T. vaporariorum* adults reduced at low temperature. Recently, it was found that *T. vaporariorum* possesses less tolerance to higher temperatures than *B. tabaci* biotype B, probably linked to the expression of heat shock protein genes

Table 1: Fertility table statistics of *T. vaporariorumon* French beancv. Contender at different temperatures.

Tempera-ture (± °C)	Growth rate parameter								
	GRR	R_o	T_c	r_c	r_m	T	λ	WM	DT
15	55.71	19.99	34.78	0.086	0.064	47.17	1.07	1.57	10.83
20	89.69	45.86	31.66	0.120	0.123	31.10	1.13	2.37	5.64
25	100.22	40.83	31.03	0.120	0.121	30.60	1.32	2.33	5.73
30	19.34	11.50	24.90	0.098	0.098	24.82	1.10	1.99	7.04

(Wan et al., 2009).

4. Conclusion

This study provides important data for understanding the population dynamics of *T. vaporariorum*, for development of potential population dynamic models and pest forecasting. Further, the whitefly population growth model can be used to evaluate effects of intended changes in the cropping system, e.g., of changes in climate and crop species or cultivar on whitefly development. Result of this study indicated that optimum temperature for population growth of *T. vaporariorum* was between 20 to 25 °C, so early sowing of French bean can help the crop escape the onslaught of this pest.

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