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Effect of Temperature on Growth and Development of *Thrips tabaci* Lindeman in BT Cotton

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A B S T R A C T

The effect of temperature on growth and development of *Thrips tabaci* Lindeman was studied on Bt cotton at different constant temperature (25, 30 and 35°C) and 60 per cent relative humidity. Among all the three constant temperatures, significantly the lowest duration (days) of incubation period (2.39), 1st instar (2.29) and 2nd instar (3.03) nymphs, total nymphal period (5.10), pre-pupal period (1.28), pupal period (1.85), total development period (10.00), adult longevity (8.21) and total life cycle (18.13) were observed at 35°C, and these were highest (4.58, 4.23, 5.78, 9.93, 2.12, 3.21 and 19.56, 22.19 and 41.72, respectively) at 25°C. Maximum fecundity-cum-viability (21.70 nymphs/female) and nymphal survival (78%) were observed at 25°C, respectively and these were the minimum at 35°C i.e. 7.80 nymphs per female and 34 per cent, respectively. Maximum growth index was observed at 30°C and it was minimum at 35°C i.e. 7.92 and 6.70, respectively. It can be concluded that with the increase in temperature from 25 to 35°C there was significant decrease in the duration of various developmental parameters, adult life parameters, total life cycle and per cent survival of *T. tabaci*. Optimum temperature for the growth of T. tabaci is 30°C as growth index was maximum at this temperature.

Introduction

Cotton fibre is an important raw material to the textile industries and plays a key role in national economy in terms of employment generation and foreign exchange. India ranks first in area and fourth in production on global basis. In India, cotton was grown on an area of 12.66 million ha with the production of 40.00 million bales and average lint yield of 537 kg/ha during 2014-15. In Punjab, it was cultivated on an area of 0.45 million ha with total production of 1.4 million bales and average lint yield of 570 kg per ha during 2014-2015 (Anonymous, 2015). Despite the large area, the productivity in India is very low. One of the major constraints responsible for the lower production of cotton is direct damage caused by vast array of insect pests. The extent of losses caused by sucking pests, bollworms and both sucking pests as well as bollworms have been recorded up to 12, 44 and 52 per cent, respectively on hirsutum cotton (Dhawan *et al.*, 1988). With the introduction of Bt cotton, use of broad spectrum insecticides have been reduced to a

greater extent. As a result of this, non-target insect pests with piercing-sucking mouth parts such as leaf bugs, whiteflies, thrips, spider mites and aphids cause serious damage to the cotton crop (Xu *et al.,* 2008).

Thrips tabaci Lindeman (Thysanoptera: Thripidae) is the emerging pest of cotton crop under Punjab conditions. This pest has the potential to cause yield reduction of about 30 to 50 per cent (Cook *et al.,* 2011). Thrips are deleterious during high temperature and scanty rainfall (Vennila *et al.,* 2007). The total variability in thrips populations in crops is determined by the natural growth of population and the influence of weather on activity and rate of multiplication (Kirk, 1997). Weather variables including temperature, relative humidity and rainfall have been reported as important factors that significantly affect thrips population (Waiganjo *et al.,* 2008). In addition to their effect on thrips activity, temperature and relative humidity further influence the intrinsic rate of natural increase of thrips (Murai, 2000). A basic understanding of the relationship of these factors with thrips population is important in developing an integrated control strategy for thrips in cotton and in determining the potential pest control needs for a given climatic trend. The objective of the present study was to study various biological parameters of *T. tabaci* under different constant temperature conditions.

Materials and Methods

Development of *T. tabaci* under different combinations of temperature was studied in the plant growth chamber installed at Entomological Research Farm, Department of Entomology, Punjab Agricultural University, Ludhiana. Biology of thrips was studied at three constant temperatures i.e. 25, 30 and 35oC and 60 per cent relative humidity. Incubation period was studied by releasing ten newly emerged females from leaf cage made on potted cotton plants placed in growth chamber at specific constant temperature. These females were released singly on each of ten potted cotton plants for oviposition. Serial transfers of these females were made daily for seven consecutive days. The time between the release of the female and appearance of the nymphs was considered as incubation period. Nymphs were observed daily to note the change of instar. This process was done till pre-pupal stage. The interval between two moultings was taken as duration of nymphal instar and the period between the time of release of a freshly hatched nymph and change into pre-pupal stage was taken as the total nymphal period. Pre-pupae were observed daily to note the change into pupal stage. When the second stage nymphs show sluggish movement, it was considered as beginning of pre-pupal stage. The colour of the pre-pupa was somewhat white-yellowish in colour and that of pupa was dark brownish in colours. The pupa when completely formed, the antennae folded back over the head and wing pads were well developed. Both the stages showed slight movement, when they were disturbed. The newly emerged adults from last experiment were transferred to new leaf cage made on potted cotton plants. The potted cotton plants were kept under observation daily for the emergence of the nymphs and survival of the adults. The nymphs from each female were counted and removed daily at the time of observation. The total number of nymphs emerged from one female represented the fecundity-cum-viability of the female. The female longevity was taken as the period from the adult emergence till the death. The survival percentage was calculated from the number of adults developed from the number of nymphs released. It was calculated by using following formula:

$$\text{Per cent nymph survival} = \frac{\text{Number of adults developed from nymphs}}{\text{Initial number of nymphs released}} \times 100$$

The means and standard error of means of different biological parameters were calculated. Data were statistically analyzed with analysis of variance (ANOVA) in completely randomized design. The different means were separated by critical difference (CD) at p = 0.05 (Gomez and Gomez, 1984).

Results and Discussion

Biological parameters of *T. tabaci* under various constant temperatures at 60 per cent relative humidity

Incubation period

The laboratory studies conducted during 2014 revealed that there was significant difference between the incubation periods of *T. tabaci* at different constant temperature conditions. It was significantly shortest at 35°C and highest at 25°C. It varied from 4 to 5 days at 25°C, 3 to 4 days at 30°C and 2 to 3 days at 35°C, respectively. The mean incubation period at different constant temperatures was 4.58±0.04, 3.18±0.04 and 2.39±0.04 days at 25, 30 and 35°C and 60 per cent relative humidity. It is evident from the studies that there was decrease in the incubation period with increase in the temperature from 25 to 35°C (Table 1).

Nymphal development

The difference in nymphal instars period of *T. tabaci* among different constant temperatures was significant. The nymphal duration of first instar was significantly shortest at 35°C followed by 30°C and it was longest at 25°C. The nymphal duration of first instar varied from 2 to 3 days with a mean value of 2.29±0.05 days, 3 to 4 days with a mean value of 3.63±0.04 days and 4 to 5 days with a mean value of 4.23±0.02 days at 35, 30 and 25°C, respectively. There was decrease in nymphal period of first instar with increase in temperature from 25 to 35°C (Table 1).

The nymphal duration of second in star of *T. tabaci* was significantly shortest at 35°C followed by 30°C and significantly longest duration of second instar nymph was observed at 25°C. The nymphal duration of second instar varied from 2 to 4 days with a mean value of 3.03±0.06 days at 35°C, 4 to 5 days with a mean value of 4.37±0.03 days at 30°C and 5 to 6 days with a mean value of 5.78±0.03 days at 25°C (Table 1).

There was significant difference between total nymphal periods of *T. tabaci* at all the constant temperatures i.e. 25, 30 and 35°C (Table 1). Total nymphal period was significantly minimum at 35°C followed by 30°C and significantly maximum total nymphal duration was observed at 25°C. Total nymphal period at 35°C was 5.10±0.08 days (4 to 7 days) followed by 30°C which ranged from 7 to 9 days with a mean value of 7.96±0.06 days and 9 to 11 days with a mean value of 9.93±0.05 days at 25°C.

Pre-pupal and pupal development

Difference in pre-pupal period under various constant temperatures and 60 per cent relative humidity was significant (Table 1). Significantly maximum pre-pupal period was recorded at 25°C which varied from 2 to 3 days with a mean value of 2.12±0.03 days, followed by 30°C which ranged from 1 to 2 days with a mean value of 1.52±0.03 days. Significantly minimum pre-pupal period was observed at 35°C with a mean value of 1.28±0.06 days (1-2 days). It is evident from the studies that with the increase in constant temperature there was decrease in pre-pupal period. Difference in pupal period of *T. tabaci* under various constant temperatures at 60 per cent relative humidity on Bt cotton hybrid,

RCH 650 was also significant. The maximum pupal period of 3 to 4 days was recorded at constant temperature of 25°C with a mean value of 3.21±0.03 days and significantly minimum pupal period ranged from 1 to 3 days with a mean value of 1.85±0.09 days at 35°C. Pupal period at 30°C was 2 to 3 days with a mean value of 2.32±0.03 days. Pupal period decreased when the constant temperature increased from 25°C to 35°C (Table 1).

Total development period

Total development period of *T. tabaci* was significantly different at all three constant temperatures i.e. 25, 30 and 35°C. Significantly minimum duration of total development period was observed at 35°C with a mean value of 10.00±0.13 days ranging from 8 to 12 days followed by 30°C with a mean value of 14.43±0.10 days and significantly maximum duration was observed at 25°C which varied from 18 to 23 days with a mean value of 19.56±0.11 days (Table 1). It is evident from the study that with the increase in temperature there was decrease in total development period of *T. tabaci*.

Adult longevity

There was significant difference in adult longevity of *T. tabaci* at different constant temperatures on Bt cotton hybrid, RCH 650 BGII. The experiment conducted revealed that female longevity was significantly highest i.e. 17-26 days with a mean value of 22.19±0.16 days at constant temperature of 25°C. At temperature 30°C it ranged from 15-21 days with mean value of 17.13±0.26 days. Female longevity was significantly shortest i.e. 8.21±0.16 days with a range of 6-11 days at 35°C. There was decrease in the female longevity with increase in the constant temperature from 25 to 35°C (Table 2).

Fecundity-cum-viability

The fecundity-cum-viability of *T. tabaci* was found to differ significantly on different constant temperatures at 60 per cent relative humidity. It varied from 18 to 25 nymphs per female at 25°C, 12 to 17 nymphs per female at 30°C and 5 to 9 nymphs per female at 35°C, respectively. Fecundity-cum-viability was significantly highest with a mean value of 21.70±0.94 nymphs per female at 25°C followed by 14.60±0.58 nymphs per female at 30°C. At 35°C fecundiy-cum-viability was significantly lowest with a mean value of 7.80±0.42 nymphs per female. So, from these findings we can conclude that with the increase in temperature there was decrease in fecundity-cum-viability (Table 2).

Total life cycle

Total life cycle of *T. tabaci* i.e. incubation period, 1st instar nymph, 2nd instar nymph, pre-pupa, pupa and female longevity was recorded at different constant temperatures with 60 per cent relative humidity on Bt cotton hybrid, RCH 650 (BGII) (Plate 2). A significant difference between total life cycle at different constant temperature was observed. Significantly minimum duration of total life cycle with mean value of 18.13±0.27 days ranging from 14 to 22 days was recorded at constant temperature of 35°C. Significantly maximum duration was observed at constant temperature of 25°C followed by 30°C i.e. 41.72±0.20 days and 31.55±0.32 days, respectively. There was decrease in total life cycle with increase in constant temperature (Table 2).

Survival and growth index

The survival of nymphs was significantly highest at 25°C constant temperature on cotton which ranges from 70 to 90 per cent with a mean value of 78.00±2.00 per cent and it decreased to 63 per cent with a range of 50.

to 80 per cent and 34.00±1.63 per cent at 30°C and at 35°C, respectively. It is evident from the studies that with increase in temperature from 25 to 35°C there was decrease in per cent survival of nymphs (Table 3).

Growth index of *T. tabaci* under various constant temperatures and 60 per cent relative humidity was significantly highest at 30°C with a mean value of 7.92±0.37 which was at par with growth index at 25°C with a mean value of 7.85±0.20. Significantly lowest value of growth index was observed at 35°C with a mean value of 6.70±0.39 (Table 3). So, on the basis of growth index it may be concluded that 30°C was the optimum constant temperature with 60 per cent relative humidity for growth and development of *T. Tabaci*

Table.3 Survival and growth index of *T. tabaci* on Bt cotton under various constant Temperatures at 60 per cent relative humidity

Temperature (°C)	Number of nymphs released	Number of adults developed	Nymphal survival (%)*		Total nymphal duration (days)		Growth index (Mean±SE)
			Mean±SE	Range	Mean±SE	Range	
25	100	78	78.00±2.00 (62.23)	70-90	9.93±0.05	9-11	7.85±0.20
30	100	63	63.00±3.00 (52.67)	50-80	7.96±0.06	7-9	7.92±0.37
35	100	34	34.00±1.63 (35.61)	30-40	5.10±0.08	4-7	6.70±0.39
CD (p =0.05)			(4.24)		0.18		0.96

*Figures in parentheses are arc sine transformed values

Table.1 Developmental period of *T. tabaci* on Bt cotton under various constant Temperatures at 60 per cent relative humidity

Temp-erature (°C)	Incubation period (days)		Nymphal period (days)						Pre-pupal period (days)		Pupal period (days)		Total development period (days)	
			I instar		II instar		Total							
	Mean±SE	Range	Mean±SE	Range	Mean±SE	Range	Mean±SE	Range	Mean±SE	Range	Mean±SE	Range	Mean±SE	Range
25	4.58±0.04	4-5	4.23±0.02	4-5	5.78±0.03	5-6	9.93±0.05	9-11	2.12±0.03	2-3	3.21±0.03	3-4	19.56±0.11	18-23
30	3.18±0.04	3-4	3.63±0.04	3-4	4.37±0.03	4-5	7.96±0.06	7-9	1.52±0.03	1-2	2.32±0.03	2-3	14.43±0.10	13-17
35	2.39±0.04	2-3	2.29±0.05	2-3	3.03±0.06	2-4	5.10±0.08	4-7	1.28±0.06	1-2	1.85±0.09	1-3	10.00±0.13	8-12
CD (p=0.05)	0.11		0.11		0.12		0.18		0.12		0.17		0.33	

Mean of ten replications; 10 individuals in each replication

Table.2 Adult life parameters and total life cycle of *T. tabaci* on Bt cotton under various constant temperatures at 60 per cent relative humidity

Temperature (°C)	Adult longevity (days)		Fecundity-cum-viability per female (number)*		Total life cycle (days)	
	Mean±SE	Range	Mean±SE	Range	Mean±SE	Range
25	22.19±0.16	17-26	21.70±0.94 (4.76)	18-25	41.72±0.20	35-49
30	17.13±0.26	15-21	14.60±0.58 (3.94)	12-17	31.55±0.32	28-38
35	8.21±0.16	6-11	7.80±0.42 (2.96)	5-9	18.13±0.27	14-22
CD (p =0.05)	0.58		(0.24)		0.78	

Mean of ten replications; 10 individuals in each replication

*Figures in parentheses are the means of √n+1 transformation

Incubation period

Our findings are in agreement with the study of Kumar (2013) who reported that incubation period of thrips on cotton was 2-4 days with a mean value of 2.67±0.33 days when the mean temperature was 34.17±0.43°C and relative humidity was 46.10 per cent. Our results are in close proximity with the findings of van Rijn *et al.*, (1995) who reported that the incubation period was 3.92±0.32 days at 25°C on cucumber. Fekrat *et al.*, (2009) who conducted their study at 25°C and 50 per cent RH reported that the egg period of thrips varied from 3.5 to 6.5 days with a mean value of 4.97±0.07 days and 3.5 to 6 days with a mean value of 4.63±0.09 days on onion in the Khorasan Razavi and Golestan populations, respectively and 4 to 6 days with mean value of 5.11±0.07 days on tabacco in the Mazandaran population. Lall and Singh (1968) revealed that on onion it was 6.0 days at fluctuating temperature conditions with 23.4°C average temperature and 54.4 per cent average relative humidity and 4.8 at 30.8°C average temperature and 47.6 per cent average relative humidity, respectively.

Nymphal development

Our results are in close proximity with the findings of Kumar (2013) who reported that duration of first instar nymph varied from 2 to 3 days with a mean value of 2.50±0.22 days, second instar nymph was of 3 to 5 days with a mean value of 3.83±0.31 days and total nymphal period varied from 5 to 7 days with a mean value of 6.33±0.33 days, respectively on cotton plant when the average temperature was 34.17°C and relative humidity was 46 per cent. In contrast to our findings Murai (2000) repoted that first instar nymph and second instar was of 2.38±0.54 and 2.87±0.57 days, respectively at 25°C and 1.85±0.17 and 1.89±0.46 days, respectively at 30°C on pollen and honey solution. Van Rijn *et al.*, (1995) revealed that the first instar nymphal period was 2.13±0.45 days and second instar nymphal period was 3.17±0.45 days at 25°C on cucumber. The difference in the period may be due to difference in temperature and host species involved.

Pre-pupal and pupal period

Our results corroborate the finding of Kumar (2013) who reported that on cotton plant the pre-pupal period of *T. tabaci* was of 1 to 2 days with a mean value of 1.33±0.21 days and pupal period was of 1 to 3 days with a mean value of 1.83±0.31days, respectively when the average temperature was 34.17°C and relative humidity was 46 per cent.

Pre-pupal period varied from 1 to 2 days with mean value of 1.67±0.21days and pupal period varied from 2 to 3 day with a mean value of 2.67±0.21 days. Lall and Singh (1968) recorded the pre-pupal and pupal period of 1.40 days and 2.40 days, respectively at 30.8°C on onion. Similarly, Salas (1994) recorded that pre-pupal and pupal period of *T. tabaci* was 1.17 and 2.4 days, respectively at 32°C and 60 per cent relative humidity.

Total development period

Our results are in close corroboration with the findings of Salas (1994) who reported that thrips take 12.03 days from egg to adult at a temperature of 32°C and 60 per cent relative humidity on onion. In contrast to our findings van Rijn *et al.,* (1995) reported that that the development period from egg to adult stage was 12.90±0.89 during their comparative study on cucumber at 25°C.

Adult longevity

At fluctuating temperature , Kumar (2013) reported female longevity of 12 to 24 days with a mean value of 18.69±1.67 days on cotton when the average temperature was 34.17±0.43℃ and relative humidity was 46.10 per cent. Our results are in line with the findings of Murai (2000) who reported that female longevity was 25±10.2 at constant temperature of 25°C and 12.8±4.6 days at constant temperature of 30°C on pollen and honey solution. Our results are also in close proximity with the study of Salas (1994) who reported that at 32°C temperature and 60 per cent relative humidity, the longevity of thrips female was 21.5±3.69 days on onion. Salmasi *et al.,* (2003) found that the females lived for 16.15 days on onion at 27°C. However, van Rijn *et al.,* (1995) found that at similar constant temperature conditions i.e. 25°C females lived for 11.9 days on cucumber that is lower than our results. This difference in longevity of adult may be due to the difference in crop species involved and difference in environmental conditions.

Fecundity-cum-viability

Our results are in close proximity with the findings of Fekrat *et al.*,(2009) who conducted their study at 25°C, 50 per cent relative humidity and reported that the total fecundity varied from 12 to 41 with a mean value of 29.50±2.24 and 8 to 45 with a mean value of 27.71±2.83 on onion in the Khorasan Razavi and Golestan populations, respectively and 11 to 35 with mean value of 26.35±1.93 on tabacco in the Mazandaran population. Van Rijn *et al.,* (1995) found that each female of *T. tabaci* laid 27.5 eggs on cucumber at 25°C. Whereas, Murai (2000) revealed that total number of eggs per female was 165±84.8 at constant temperature of 25°C and 62.6±35.9 at constant temperature of 30°C on pollen and honey solution. Salas (1994) reported the fecundity of thrips was 37 eggs per female and fertility was 62.28 per cent on onion at 32°C temperature and 60 per cent relative humidity. The difference in the values of fecundity may be due difference in host species and due to difference in environmental conditions.

Total life cycle

Our results are not in accordance with the findings of Kumar (2013) who reported that the total life cycle of thrips was 30.86±3.25 days at 34.17°C and 46.10 per cent relative humidity. The difference in findings may be due difference in environmental conditions.

Survival and growth index

Our results are in partial agreement with Fathi *et al.,* (2011) who reported that there was 40 to 90 per cent survival of nymphs on different canola cultivars at 25°C. Murai (2000) reported 67.5 per cent survival both at 25 and 30°C on pollen and honey solution. Our findings are not in line with Kumar (2013) who revealed that at average temperature of 34.17°C, there was 75 per cent survival and at average temperature of 31.43°C, per cent survival of nymphs was 89 per cent on cotton plant. The difference in observations may be due to difference in environmental conditions.

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