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Determination of thermal constant and developmental threshold of chilli thrips, *Scirtothrips dorsalis* Hood

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ABSTRACT: Temperature is one of most important abiotic factors that play an important role in population dynamics of insects. It directly influences the rate of development of insects. Experiment was conducted to assess the effect of temperature on rate of development of chilli thrips, *Scirtothrips dorsalis* Hood, an important sucking pest which causes serious loss to chilli crop. Rate of development of *S. dorsalis* was studied at three temperature regimes i.e.19± 1°C, 21± 1°C, 25± 1°C, 29± 1°C, 32± 1°C and 35°C ± 1°C. A direct relationship between temperature and rate of growth of different life stages of *S. dorsalis* was observed. Whereas, an inverse association with developmental period of different life stages of *S. dorsalis* was found. The regression equation between temperature and development rate were developed for each stage of the insect. Thermal constant for egg, larva and pupa were determined as 147, 142.85 and 43.47 degree days (DD), respectively with corresponding developmental threshold being 16, 7.14 and 16.13°C. Accordingly 332 DD are required for *S. dorsalis* to complete one generation. The developed thermal constants will be useful in estimating *S. dorsalis* development and would help in timely action for effective management pest.

Keywords: Chilli, thrips, thermal constant, thermal degree days, threshold development.

INTRODUCTION

Chilli (*Capsicum annuum* L.) is one of the important commercial vegetable crops of India. It is cultivated throughout the country in summer and rainy seasons in Andhra Pradesh, Orissa, Maharashtra and Karnataka states with annual production of 14 lakh tones (Geetha and Selvarani, 2017; Manjunatha *et al*., 2018). Insect pests are the major constraint in chilli production and productivity. *Scirtothrips dorsalis* (Hood) (Thysanoptera: Thripidae), is the most important pest of chilli which causes a significant loss ranging from 74 to 75% (Dadasaheb, 2013; Manjunatha *et al*., 2018). Both adult and nymphs of *S. dorsalis* suck the cell sap of leaves, causing upward curling of leaf. *S. dorsalis* outbreak has been well documented during summer when the temperatures prevails higher. Whereas, in winter the populations are under minimal as temperatures usually goes down (Manjunatha *et al.,* 2018). The seasonal variation of the pest is controlled by temperature as it's a most important crucial abiotic factor that influences the rate of growth and development of an insect (Taylor 1981). It has a significant effect on adult longevity, fecundity, fertility, colonization, distribution, abundance, behavior, life history and fitness of insects (Yang et al. 1994; Hoffman *et al.* 2003). The temperature effect thus enumerated by developmental rate of an organism (Yadav and Chang, 2014). The daily and seasonal dynamic rhythms of insects are also regulated by temperature (Zheng *et al*. 2008). Generation of information on thermal requirements thus will be useful in pest forecasting, monitoring, timing of insecticide applications, analyzing distribution and abundance of insect populations and predicting effect of climate change on population dynamics (Messenger, 1958; Zalom *et al*., 1983; Kang *et al*. 2009). The present study was therefore conducted to understand the effect of temperature on developmental stages of chilli thrips.

MATERIALS AND METHODS

An experiment was conducted in the laboratory at the Division of Entomology and Nematology, ICAR-Indian Institute of Horticultural Research (IIHR), Bengaluru, India. Chilli thrips collected from the field were reared in the lab on tender capsicum (10-12 days old) for 2-3 generations to get homogenous population (Latha *et al*., 2015).

Temperature effect on thrips biology

Ten pairs of freshly emerged adults from above were released on tender capsicum kept in BOD incubators at different constant temperatures *viz*., 19± 1°C, 21± 1°C, 25± 1°C, 29± 1°C, 32± 1°C and 35°C ± 1°C with 70-80% RH, 12 hrs L: D. Further each temperature was replicated five times. Observations were made at developmental time on life stages of *S. dorsalis* such as duration of egg, duration of larva (pooling I instar and II instar), pupa and adult by observing under microscope.

Determination of thermal constant and developmental threshold of different life stages of thrips

Egg, larva and pupal developmental rate (R) were calculated as inverse of their corresponding developmental duration (D) such that R = 1/D. Development threshold (T0) and thermal constant (K) were then calculated by regressing development rate on temperature (Kipyatkov and Lopatina, 2010), as per the rule of the constant sum of effective temperature are as below.

Thermal constant = (Temperature - Development threshold) x Development duration. The K was estimated as reciprocal of regression coefficient (b) between development rate and temperature. K = 1/b T_0 was determined ratio regression intercept (a) and (b) = T0 = - a/b

RESULTS AND DISCUSSION

An inverse relationship between duration of development of *S. dorsalis* and temperature was observed. As the temperature increased from 19 ±1°C to 35±1°C, development of life stages of *S. dorsalis* decreased. The incubation period for eggs was more (5.5 days) at 19 ±1°C and less (2.5 days) at 35±1°C. Similarly, both first and second instar larva completed their period in 5.5 days at 19 ±1°C and 3 (I instar larva) to 4 days (II instar larva) at 35±1°C. The pupal duration (7 days) was highest at 19 ±1°C, whereas lowest (2.5 days) when they reared at 35±1°C. Likewise, developmental period of *S. dorsalis* adults was 5 days at 19 ±1°C and 2.5 days at 35±1°C. Completion of a total life cycle of *S. dorsalis* was found to be 28 days at 19 ±1°C and 14.5 days at 35±1°C (Table 1). The significant effect of temperature was observed in the present study. Temperature thus plays a crucial role in development of organisms (Taylor, 1981). Each organism has its own lower lethal temperature, upper lethal temperature and temperature preferendum (optimum); which keeps that organism at general equilibrium. Lower lethal is the one at which the growth starts such way that as temperature increases the growth rate also increases and time require to complete that particular stage/ life cycle decreases. Once it's reaches upper lethal then the growth seizes. Similar observations were made in the present study for chilli thrips, *S. dorsalis.* At lower temperatures the developmental period prolonged i.e at 19 °C time taken to complete each stage was more than at 35 °C (Fig 1). This is because of the amount of heat units required to complete each developmental stage at 19 °C (lower temperature) takes more time than at higher temperature.

The thermal degree days for completion of egg stage of *S. dorsalis* was found to be 147 DD which was achieved in 5 days at 19 °C and within 2.5 days at 35 °C (Fig 1a). The time taken in achieving the required DD for each developmental stage at higher temperature was lesser than at lower temperatures (Fig 1). Within favourable temperature range, development rate of an organism increases but it decreases beyond upper temperature threshold (Thakur *et al*., 2017).

The thermal constant and developmental threshold was determined using regression method. The equation was developed by regressing temperature on developmental rate. The developed regression equations for each stage are as below

Egg: Y=0.0069x+0.096 (R^2=0.47)

Larva: Y=0.0072x+0.0581 (R^2 = 0.84)

Pupa: Y = 0.0106x - 0.0467 (R^2=0.66)

The developmental threshold was determined for egg, larva and pupa to be 16, 7.14 and 16.13°C, respectively with corresponding thermal constant being 147.05, 142.85 and 43.47 DD (Table 2).Total thermal requirement to complete one generation was found to be 322 DD which was very close to 265 DD for *S. dorsalis* (Tatara, 1994). Difference in DD from the earlier study might be due to host effect, where host plants also play a crucial role on development of an organism (Venu Gopal *et al* ., 2019). The developed regression models can be used to predict the thermal constants and threshold development of *S. dorsalis* at various temperature regimes. Similar models are available for many insect pests such as *Sesamia inferens* (Selvaraj *et al*., 2014), jute indigo caterpillar (Thakur *et al*., 2017). The thermal constants can be used to predict likely the time of completion of *S. dorsalis* developmental stages which will ensure to predict further outbreaks of the thrips population and the rate of spread of viral diseases which are transmitting by *S. dorsalis*. The interventions made during immature stages may likely reduce the further spread of viral diseases like *Tomato spotted wilt virus* within and between fields. In addition, the thermal information helps in developing phenology based simulation model for the pest forewarning, assessing impact of climate change on the pest and prediction of thrips borne viral diseases on chilli. Development of different growth stages of *S. dorsalis* could be predicted using the developed thermal constants. Besides, thermal information would also be

Table 1. Effect of temperature on development of different stages of chilli thrips, *Scritothrips dorsalis*

Temperature (°C)	Developmental Period (days)				Total life span (days)
	Egg	I & II instar Larvae	Pupa	Adult	
19 ± 1°C	5	5.5	7	5	22.5
21 ± 1°C	4.5	4.5	6	4.5	19.5
25 ± 1°C	3	4.5	5	3.5	16.0
29 ± 1°C	3.5	3.5	7.5	4	18.5
32 ± 1°C	2.75	3.25	3.75	3	12.75
35 ± 1°C	2.5	3.5	2.5	2.5	11

Table 2. Determination of threshold temperatures and thermal constant for different developmental stages of chilli thrips, *Scirtothrips dorsalis*

Developmental stage	Regression equation	Thermal constant (K) (K=1/b)	Temperature threshold (To) (To=a/b)	R^2
Egg	Y=0.0069x+0.096	147.058	16	0.47
Larva (I & II)	Y=0.0072x+0.0581	142.86	7.14	0.84
Pupa	Y = 0.0236x - 0.37	43.47	16.13	0.53

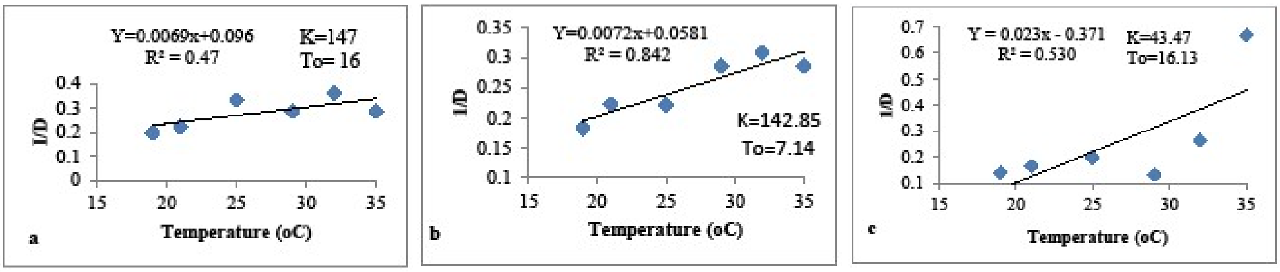

Fig 1. Regression between different temperature and mean duration of development stages of *S. dorsalis* (a=egg, b= larva, c=pupa) at various temperatures regimes

useful to predict the rate of spread of thrips borne viral diseases on chilli. The phenology based prediction model could be developed to use in insect pest management (IPM) programmes.

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