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RESEARCH ARTICLE

Influence of temperature on egg hatching and development time of brown plant hopper

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ABSTRACT

Temperature is probably the most important environmental factor influencing the insect behaviour, distribution, development, survival and reproduction. Climate change, especially temperature increase, will affect insect physiology, behaviour, and development as well as species distribution and abundance, evidenced by changes in the number of generations a year, increasing survival rates in winter, and the earlier appearance of some insects. An investigation was taken up to understand the effect of different constant temperatures (28.3°C, 30.6°C, 32.7°C, 34.3°C and 36°C) on the egg hatching and development time of brown plant hopper (BPH). The results revealed that the temperature above 32.7°C was detrimental for the oviposoition by BPH females. Eggs hatching also decreased drastically with increase in temperatures. The development time taken by different stages of BPH varied significantly at different temperatures. Development time taken by different stages decreased considerably when the temperature increased. Longevity of the male and female adults also decreased with increasing temperature.

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INTRODUCTION

Rice (*Oryza sativa* L.) forms the stable food for more than half of the world's population. Among various constrains in rice production, losses due to insect pests are the major concern and Brown planthopper (BPH), Nilaparvata lugens (Stal.), is the most important insect pest on rice. Insects flourish in all climates. Improved techniques for managing pests require weather and insect data from thoroughly maintained monitoring as well as climate information and forecast to determine their suitability (Lee *et al.,* 2009). As insects are ectothermic organisms, the temperature of their body changes approximately with the temperature of their habitats. Therefore, among all the climatic factors, temperature is probably the most important environmental factor influencing their behaviour, distribution, development, survival and reproduction (Bale *et al.,* 2002).

The earth's climate has warmed by approximately 0.74°C over the past 100 years with two main periods of warming, between 1910 and 1945 and from 1976 onwards. The last assessment report from the Intergovernmental Panel on Climate Change (IPCC) predicts an increment in mean temperature from 1.1 to 6.4°C toward the year 2100 (IPCC, 2007). Climate change, especially temperature increase, will affect insect physiology, behaviour, and development as well as species distribution and abundance, evidenced by changes in the number of generations a year, increasing survival rates in winter, and the earlier appearance of some insects (Huang *et al.,* 2010).

The duration of the immature stages and the time required to complete the cycle from egg to adult of *Plutella xylostella* were decreased linearly with the increase of temperature (Marchioro and Foerster, 2011). With temperatures within their viable range, insects respond to higher temperature with increased rates of development, more number of generations with less time between generations (Das *et al*., 2011). Adult *Nilaparvata lugens* remain active from 10 to 32 °C. *N. lugens* adults usually live for 10-20 d in summer and 30-50 d during autumn indicated that the development time was inversely related to increase in temperature (Pathak and Khan, 1994). Hence, an investigation was undertaken during 2011-2013 to understand the effect of elevated temperature on development time of different stages of brown plant hopper (BPH), *Nilaparvata lugens* (Stal).

MATERIAL AND METHODS

Climate control chamber :

Experiments were carried out in Climate Control Chamber (CCC) established at Agro Climate Research Centre, Tamil Nadu Agricultural University which is situated 11° N latitude and 77° E longitude and is at an elevation of 427 m above the mean sea level. Temperature CCC was controlled using fogger and a mist fan. Temperature is recorded by the sensor and this sensor is connected to a data logger. For this investigation, five different constant temperatures (28.3°C, 30.6°C, 32.7°C, 34.3°C and 36°C) were maintained during the study period.

Insect culture :

BPH was mass reared separately on the susceptible variety ADT 43 as outlined by Heinrichs *et al*. (1985). Initial population was collected from the rice fields at Paddy Breeding Station, TNAU, Coimbatore. Adults were confined on 30 day old potted plants of ADT 43 placed in wooden wire netted and glass topped oviposition cages. The insects were removed three days after oviposition and the potted plants with eggs were collected and placed in separate cages to allow the eggs for nymphal emergence. The emerged nymphs were transferred to 15 day old ADT 43 rice seedlings raised in germination trays and these in turn were placed in galvanized iron (GI) trays (62 x 47 x 15 cm) containing 5 cm depth of water. ADT 43 seedlings in trays were changed periodically and thus continuous pure cultures of planthoppers were maintained.

Development time :

Thirty day old rice plants in a pot were placed on the floor of the insect cage (height - 2 ¾ feet, width - 2 ½ feet, length – 2 ½ feet, netted in three side). One gravid female adult BPH was released into the insect cage for egg laying under different temperature regimes. The total numbers of eggs laid were recorded under different temperatures daily, until released BPH female died. The eggs were counted using a magnifying glass. Observations were made on these eggs till they hatched and the incubation period of these eggs were determined under different temperatures. Date of hatching and percentage of egg hatched were recorded under five different temperatures. The nymphs of BPH were fed with fresh rice plants and reared in the insect cages at different temperature regimes. They were regularly monitored and observed for calculating the development time for each stage. For the study of longevity of adults, freshly emerged male and female moths were kept together in insect cage provided with rice seedlings. By observing the period between the emergence and death of the adults, the longevity period was calculated.

RESULTS AND DISCUSSION

The number of eggs laid by BPH increased with increase in temperature from 28.3°C to 32.7 °C. At 28.3°C the BPH laid 216 eggs. Highest number of eggs were laid under 30.6°C (231 eggs) followed by 32.7 °C (Table 1). At the same time, the number of eggs laid by BPH was considerably reduced at 34.3°C (196 eggs) and 36°C (116 eggs). From this, it is observed that the temperature above 32.7°C is detrimental for BPH oviposition. It is widely accepted that for most rice leafhopper and planthopper species, the optimum temperature is 25-30°C. Insects reared at higher temperatures do survive, but they are less fertile and often many eggs do not hatch (Pathak and Khan, 1994). The percentage of egg hatching was observed to decrease with increase in temperature. The highest percentage of hatching (90.7) observed at 28.3°C. But it was only 51.7 per cent at 36°C (Table 1). These results are in line with the Son and Lewis (2005), who reported that the temperature affected both *per capita* total egg production and egg viability. There was a significant reduction in egg production and egg viability per adult at extreme temperatures.

The duration taken by different stages of BPH varied under varying temperatures. Development time taken by different stages of the BPH decreased considerably with increasing temperature. The incubation period of BPH eggs was 8.25 days at 28.3°C whereas it took only 5.5 days at 36°C (Table 2). The development time taken by the five nymphal stages varied significantly with respect to the temperature. For example, the 1st, 2nd, 3rd, 4th and 5th nymphal stages took 4.75, 4.25, 3.25, 2.75 and 3.25 days, respectively at 28.3°C

Table 1 : Total number of eggs laid by BPH and its hatching percentage at different regimes

Particulars	28.3°C	30.6 °C	32.7 °C	34.3 °C	36.0 °C
Number of eggs	216.3 ± 19.3^{c}	231 ± 15.9^{b}	226.3 ± 24.1^{a}	196.5 ± 11.3^{d}	116.5 ± 13.2^{e}
Hatching (%)	90.7	87.9	81.0	59.7	51.7

Values are mean of four replications

In a row, means followed by a letter are significantly different at 5 % level of LSD

Table 2 : Development time taken by brown plant hopper at different temperature regimes

Stage	28.3°C	30.6 °C	32.7 °C	34.3 °C	36.0 °C
Egg	8.25±0.50[a]	7.5±0.58[b]	7.25±0.96[c]	6±0.82[d]	5.5±0.58[e]
Nymph I	4.75±0.96[a]	4.5±0.58[b]	3.75±0.96[c]	3.75±0.50[d]	3.25±0.50[e]
Nymph II	4.25±0.50[a]	3.75±0.96[b]	3.75±0.50[c]	3.25±0.50[d]	2.75±0.50[e]
Nymph III	3.25±0.96[a]	2.75±0.50[b]	2.5±0.58[c]	2.25±0.50[d]	2.25±0.50[e]
Nymph IV	2.75±0.50[a]	3±0.82[b]	2.5±0.58[c]	2.25±0.50[d]	1.75±0.50[e]
Nymph V	3.25±0.50[a]	3.25±0.50[a]	3.00±0.00[c]	2.75±0.50[d]	2.5±0.58[e]
Nymph	18.25±0.50[a]	17.5±0.58[b]	16±1.15[c]	14.25±0.50[d]	12.5±0.58[e]
Female adult	18.25±0.50[a]	17.75±0.50[b]	14.75±0.50[c]	13.50±0.58[d]	12.75±0.50[e]
Male adult	13.25±0.50[a]	12.50±0.58[b]	10.75±0.50[c]	10.50±0.58[d]	8.5±0.58[e]

Values are mean of four replications
In a row, means followed by a letter are significantly different at 5 % level of LSD

whereas it took 3.25, 2.75, 2.25, 1.75 and 2.5 days, respectively at 36°C. The developmental time of the cotton aphid significantly decreased with increasing constant temperatures ranging from 13.0 days at 15.0°C to 4.0 days at 30.0°C. Similarly, the green peach aphid developed significantly faster at warmer temperatures than at cooler temperatures (Satar *et al.*, 2008). In the same way, the longevity of adults also reduced with increase in temperature. Female BPH adult took 18.25 days from emergence to death at 28.3°C, but the same was only 12.75 days at 36°C. The longevity of adult male was 13.25 and 8.5 days at 28.3°C and 36°C, respectively (Table 2). Same results were reported earlier by Ju *et al.* (2010). They revealed that longevity of females was found to be the shortest, 17.7 days at 33° C and the longest, 58.9 days at 16° C.

It is clear that the hatching percentage was drastically reduced with increase in temperature due to the inability of eggs to hatch. The development time taken by YSB decreased considerably with increase in temperature which results in the increase in the number generations in the near future as the temperature is projected to rise. Insects develops faster and will oviposit early and hence the population will grow earlier than expected.

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