Oryza Vol. 49. No. 4, 2012 (288-291)

Effect of high temperature on the multiplication of brown planthopper *Nilaparvata lugens* (Stal.)

Sucheta Rout and Mayabini Jena*
Central Rice Research Institute, Cuttack - 753006, Odisha

ABSTRACT

Brown planthopper, Nilaparvata lugens (Stal.) is a major pest of rice during both dry and wet season. Such occurrence made it necessary to know its chances of survival and multiplication ability during the intermediate summer period so that the possible incidence at later stage of crop period can be predicted. It was found that the insect thrived and multiplied well at a temperature of 30 ± 3ºC. Eggs hatched after 7 days of egg laying. The freshly emerged nymphs could complete their instar development within 11-14 days to become adults and 52.7% winged forms developed. With the rise in temperature, there was a gradual decrease in the number of eggs laid, the percentage of egg hatching decreased and the incubation period increased. At a temperature regime of 40-42ºC, there was no egg laying.

Key words: *rice, BPH, high temperature, ovipositionrate, egg hatching, instar duration*

The rice brown planthopper(BPH), *Nilaparvatalugens* (Stal) (Homoptera : Delphacidae) is one of the most notorious pests of rice throughout Asia during both dry and wet season.In the past few years, the rate of BPH infestation has increased in India and caused severe yield losses in several states like Tamil Nadu, Andhra Pradesh, Orissa, Punjab, Haryana, Kerala, Chhattisgarh, Madhya Pradesh, etc. Both the nymphs and adult BPHcause economic damage directly by feeding. Outbreaks often occur in rice from early to the heading and grain filling stages causing rice plants to dry and the symptom is known as 'hopper burn'. The damage caused due to BPH infestation is directly proportional to the rate of multiplication and resurgence of BPH.

The population increase of BPH is considered to be regulated by several ecological factors. Temperature being an important ecological factor, it has become necessary to know its effect on the survival and multiplication ability of BPH during the intermediate summer period so that the possible incidence at later stage of crop period can be predicted. Therefore experiments were carried out in the net house conditions of Central Rice Research Institute, Cuttack, to observe the effect of high temperature of dry season on the multiplication rate of BPH.

MATERIALS AND METHODS

Different stages of BPH reared on potted TN1 plants in the net house were utilized for different experimental purposes. Oviposition rate and nymphal emergence was studied by releasing of a pair of male and female BPH adults on forty-five days old potted plants of TN1 and kept confined as per the methods followed by Jena *et al.* (2000). The experiment was conducted under a series of temperature conditions ranging from 30 - 41^{0}C maintained in small chambers, during the oviposition and nymphal emergence. The insects were allowed to remain on the plant till death. The pots were regularly observed to record the emergence of nymphs. Observations were recorded everyday on the number of dead and alive nymphs till no more nymphs emerged. Then the leaf sheaths were closely observed to check the presence of oviposition marks, to ascertain whether egg laying has occurred and then dissected to count the no. of unhatched eggs. The data thus collected were subjected to analysis and the effect of high temperature on the oviposition and multiplication of BPH was worked out.

To study the growth and instar development of BPH, freshly hatched nymphs of BPH were released into cylinderical glass containers covered with nylon mesh containing 25-30 days old TN-1 plant with water level just above the root portion. This treatment was conducted at different temperatures with each temperature treatment having 50 insects per replications. Each temperature treatment was replicated thrice. Development and duration of instars was studied by observing the exuviae. The plants were regularly replaced by fresh plants in order to provide adequate food to the growing nymphs. These data were analyzed to study the variation in growth and instar development of BPH under high temperature conditions and also their percentage survival was worked out.

RESULTS AND DISCUSSION

The results revealed that at temperature as low as 19^0 C, there was no egg laying. With the increase of temperature to 22^{0}C and above, the number of eggs laid also increased. At a temperature range of 27-33^o C, maximum number of eggs were laid with the incubation period of 7-8 days. The percentage of egg hatching was absolute and almost all the freshly emerged nymphs survived. At a temperature level above 33^{0}C, the nymphal mortality increased considerably towards the temperature range of 34-35^{0}C. Higher temperature with high humidity (35ºC and 94% RH) even caused 100% mortality of the nymphs. However, with the increase of temperature range of 37-39^0 C, nymphal emergence was decreased with increase of nymphal mortality. Though some eggs were laid above 39^0 C, they failed to hatch and the egg laying was completely stopped above 40^{0}C. At 39.5^o C, no nymphs emerged and only a few oviposition marks were present and the unhatched eggs were found in bundles of 3-6 eggs each. At 40p C, oviposition marks were observed but no nymphal emergence occurred and unhatched eggs were absent indicating that eggs could not be laid in spite of probing by the female. At 41^o C, there was complete absence of oviposition marks indicating that oviposition was not attempted (Table 1).

Table 1. Oviposition rate of gravid female BPH under higher temperature range

Mean temperature (º C)	Mean RH (%)	Incubation period (days)	No. of nymphs emerged	No. of nymphs died	No. of Unhatched eggs	Total no. of eggs	% of nymphal emergence	% of nymphs dead
19	39	0	0	0	0	0 (0.71)*	0	0
22	49	14	33	0	9	42 (6.52)	78.6	0
25	63	9	35	0	12	47 (6.89)	74.5	0
27	80	7	187	0	0	187(13.69)	100	0
27	68	7	189	0	6	195(13.98)	97.0	0
28	68	8	196	0	11	185 (13.60)	89.7	0
29	58	8	160	0	0	160 (12.66)	100	0
30	83	7	175	0	0	175 (13.24)	100	0
31	80	8	167	0	0	167 (12.94)	100	0
32.5	85	8	174	0	0	174 (13.21)	100	0
33	80	8	169	0	3	172 (13.13)	98.4	0
34	84	9	140	58	0	140 (11.84)	100	41.4
35	94	9	0	95	0	95 (9.76)	95	100
35	76	10	147	77	5	152(12.35)	96.7	50.7
37	71	9	21	15	77	98 (9.92)	21.4	23.8
39	73	9	20	20	60	80 (8.94)	93.8	80
39.5	73	0	0	0	14	14 (3.80)	0	0
40	72	0	0	0	11	11i(3.38)	0	0
40.5	73	0	0	0	18	10 (3.23)	0	0
41	72	0	0	0	0	0 (0.71)	0	0
CD at 5%				0.80				

Figures in parenthesis are transformed square root values

RH=Relative humidity, NH= Nymphs hatched, DN= Dead nymphs, UE= Unhatched eggs

At a mean temperature of 30^{0}C, the duration of nymphal growth was shortest and all the 1st instar nymphs reached adulthood confirming healthy growth and development. The instar durations started increasing with the increase of temperature so that the total period of development from 1st instar to adult increased from a range of 9-15 days at 27-33^{0}C to 15-26 days at 30-36^{0}C. Above this range, the nymphal duration became abruptly shorter for about 10% of the nymphs in the same temperature range of 31-38^{0}C so that they became adults even in 6 days. But they were found dead within one day of becoming adults. The growth period for others became more prolonged in each instar and the total period was covered in about 26-27 days. With further increase of temperature from 30 to 40^{0}C, the growth period also increased from 20 to 34 days. But beyond this temperature range, no nymphs could survive to grow beyond 2nd instar stage (Table 2). Nymphal survival and developmental period contributed mainly towards population increase. All the nymphs could survive to become adults at the temperature range of 27-33^{0}C. Nymphal survival gradually decreased with the increase of temperature and became almost 50% at 30-36^{0}C. With further increase, it was drastically reduced till no nymphs survived beyond 2nd instar at 41^{0}C. (Table 3).

Table 2. Instar duration of BPH nymphs under high temperature range

Temp (º C)	Mean temperature (º C)	Mean RH (%)	Nymphal duration (Days) 1st	2nd	3rd	4th	5th	Total duration
27-33	30	83	2 - 4	2	2	1 – 3	2 – 4	9 – 15
28-34	31	80	2 - 4	3	2 – 4	2 – 5	3 – 4	12 – 20
29-35	32	78	3 – 5	3 – 5	3 – 4	4 – 6	3-5	16 - 25
30- 36	33	70	3 –5	2 – 4	3 – 5	4 – 6	3 – 6	15 - 26
31- 38	34.5	70	2 – 5	1 – 3	1 – 7	1 – 5	1 – 7	6 - 27
33 – 40	36	72	1-5	2- 5	1-8	8	8	20-34
34 -41	37.5	75	2 – 4	1	dead			

The most favorable condition for the oviposition, nymphal hatching, and multiplication of BPH is the temperature range of 27º C-33º C and RH of 80- 85%. It was reported earlier that temperature between 25^{0}C and 30^{0}C was optimal for egg and nymphal development (Pathak, 1968; Ho and Liu, 1969; Bae and Pathak, 1970;

Table 3. Nymphal survival of BHP under high temperature range

Temp (ºC)	Mean temperature (ºC)	Mean RH (%)	% Nymphal instars survived* 1st	2nd	3rd	4th	5th	% of adults developed
27-33	30	83	100 (85.95)**	100 (85.95)	100 (85.95)	100 (85.95)	100 (85.95)	100 (85.95)
28-34	31	80	100 (85.95)	96 (78.77)	88 (69.78)	88 (69.78)	82 (66.45)	82 (66.45)
29-35	32	78	92 (73.65)	82 (64.92)	80 (63.92)	74 (59.35)	74 (59.35)	70 (56.80)
30- 36	33	70	74 (59.35)	66 (54.34)	56 (48.07)	56 (48.07)	54 (47.30)	52 (46.15)
31- 38	34.5	70	44 (41.55)	36 (36.87)	30 (33.61)	30 (33.61)	24 (29.32)	22 (27.96)
33 - 40	36	72	16 (23.55)	10 (18.38)	10 (18.38)	8 (!6.35)	8 (16.35)	6 (14.05)
34 -41	37.5	72	4 (6.77)	4 (6.77)	0 (4.06)	0 (4.06)	0 (4.06)	0 (4.06)
CD at 5%		2.61	3.21	2.50	2.65	2.28	2.29	

*average of 3 replications with Fifty 1st instar nymphs per replication.
** Figures in parenthesis are transformed Arcsin values

Chiu, 1970; Kulshreshthra *et al.*, 1974; Kalode 1976) and temperatures above 30^{0}C, i.e. 33^{0}C to 35^{0}C are unfavorable for insect survival (Ho and Liu, 1969; Bae and Pathak, 1970; Chiu, 1970; Kalode 1976). But, Jena *et al.* (2006) reported that 30±2^o C was suitable for oviposition and nymphal hatching. The present study indicated that 27 - 33^o C (30±3^{0}C) is the most favourable temperature for the multiplication and growth of BPH. This variation showed the gradual adaptation of BPH to higher temperatures.

Under optimal condition of 27-33^o C, 52.7% of the nymphs developed into winged adults; about 90% of the male and about 36% of the female BPH were winged.But, with the increase in temperature up to 36.5^o C, there was a gradual decline in the percentage of winged insects. With further rise in temperature, there was no development of winged forms. At higher temperature, all the macropterous BPH were males. Bae and Pathak (1970) reported that high temperature probably influences distribution or even seasonal abundance under favourable temperature range. The development of a high percentage of winged forms possibly indicated the dispersion and migratory phase of BPH, and thus it's increased multiplication and resurgence in suitable ecosystem.

Under field condition, the higher temperature conditions during the months of April and May did not fully support the multiplication of BPH in terms of oviposition, nymphal hatching, instar growth or survivility. With the rise in temperature, death of the unhatched eggs and nymphs took place due to protein denaturation, metabolic imbalance, disruption of ordered molecules and desiccation. At extreme high temperature, although the adult BPH survived for some days, it became stationary and was unable to move as it entered the heat stupor phase which resulted in a steady decline in oviposition and finally death of BPH. These results also indicated that eggs have greater tolerance for high temperature than nymphs and adults which is in agreement with the earlier findings (Bae and Pathak, 1970).

Thus, it was observed that temperature is the major ecological factor that directly affects the development, reproduction and survival of BPH. The rise in temperature above the optimum level (27-33^o C) decreased the movement of the insect, has an adverse effect on fecundity, with delayed and even arrested nymphal moulting ultimately leading to death of the nymph. So, the high temperature period during April, May or June, may not support high rate of multiplication of BPH leading to resurgence.

REFERENCES

Bae SH and Pathak MD 1970. Life history of *Nilaparvata lugens* (Homoptera :Delphacidae) and susceptibility of rice varieties to its attacks. Ann. Entomol. Soc. Am. 63: 149 – 155.

Chen JM, Yu XP, Cheng JA, Lu ZX, Zheng XS and Xu HX 2003. Evaluation for tolerance and compensation of rice varieties to infesting of brown planthopper, *Nilaparvata lugens*. Chin. J. Rice Sci. 17:265 – 269.

Chiu MD 1970. Ecological studies on rice brown planthopper [in Chinese]. Taiwan Agric. Q. 6(1) : 143 – 152.

Ho HS and Liu TH 1969. Ecological investigation on brown planthopper in Taichung district [in Chinese, English summary] Plant Prot. Bull (Taiwan) 11(1): 33 – 42.

Jena Mayabini, Dani RC and Rajamani S 2000. Efficacy of new insecticides against rice brown planthopper, *Nilaparvata lugens* Stal. *Oryza*. 37(3): 262-264.

Jena Mayabini, Sahu RK and Marandi BC 2006. Screening of rice varieties for resistance against brown plant hopper (*Nilaparvata lugens* Stal.).Oryza. 43 (4) ; 334-335.

Kalode MB 1976. Brown planthopper in rice and its control. Indian farming 27(5): 3 – 5.

Kulshreshtha JP,Anjaneyulu A and Padmanabhan SY 1974. The disastrous brown planthopper attack in Kerela. Indian Farming 24(9):5 – 7.

Pathak MD 1968. Ecology of common insect pests of rice.Annu. Rev. Entomol. 13: 257 – 294.

Sogawa K 1980. Feeding behavior of the brown planthopper and brown planthopper resistance of *Indica* rice "Mudgo" Bull. No. 4, Lab Appl. Entomol., Faculty of Agriculture Nagoya University, Chikusa, Nagoys, Japan.