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Growth and reproductive responses of brown plant hopper to five rice cultivars

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Abstract: Growth and reproductive responses in terms of nymphal period, survival rate, growth index, oviposition, hatchability of eggs, fecundity and population growth of brown planthopper, *Nilaparvata lugens* (Stål.) to five rice cultivars were studied during March to September, 2006 in Entomology Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh. Brown planthopper nymphs caged on T27A, Swarnalata and ARC10550 had reduced survival while 100 percent nymphs survived on susceptible TN1. Growth index was lowest on T27A while it was highest on TN1. Maximum number of 48.8 eggs were laid on susceptible TN1 while the lowest was on resistant variety ARC10550 and T27A. TN1 favoured egg hatchability but T27A adversely affected the same. The highest fecundity of 493 eggs was recorded on susceptible TN1 and the lowest of the same was only 83 on resistant T27A followed by Swarnalata and ARC10550. Brown planthopper population development was highest on TN1 having 330 insects but Swarnalata and T27A had adverse effects on population increase having only 51 and 73 insects, respectively.
Key words: *Nilaparvata lugens*, nymphal development, growth index, fecundity, population growth.

Introduction

The brown planthopper, *Nilaparvata lugens* (Stål.) is a major rice pest in South and South-east Asia. It causes substantial damage to the rice crop by direct physical damage due to phloem sap removal (Sogawa, 1982) resulted in 'hopperburn', and by acting as a vector for the economically important ragged stunt, grassy stunt and wilted stunt viruses (Ou, 1985). Moreover, the feeding and ovipositional marks predispose plants to fungal and bacterial infection, and the honeydew secreted by nymphs and adults encourage sooty molds (Pathak and Khan, 1994).

The brown planthopper was formerly a minor pest in most tropical countries of Asia. Widespread adoption of high-yielding cultivars susceptible to *N. lugens*, application of high levels of nitrogen fertilizers, continuous cropping, and indiscriminate use of insecticides in the 1960's have been reported as causes for increased brown planthopper population and outbreak (Chelliah and Heinrichs, 1984).

Host plant resistance, which is relatively stable, inexpensive, causes no environmental pollution, and is generally compatible with other control methods, has been considered as a major control strategy against *N. lugens*. Natural resistance to brown planthopper exists in several rice varieties and wild rices (Heinrichs *et al*. 1985; Saxena, 1989). Susceptibility or resistance of plants is the result of a series of interaction between plants and insects which influence the ultimate degree of establishment of insect population on plants (Saxena *et al*. 1974; Saxena and Pathak, 1979). The factors which determine insect establishment on plants can be categorized into two groups such as insect responses to plants, and plant characters influencing insect responses. The insect responses included orientation, feeding, growth of nymphs to adult stage, adult longevity, egg production, oviposition and hatching of eggs. Unfavourable biophysical or biochemical plant characters may interrupt one or more of these insect responses, inhibit the establishment of an insect population on a plant and render it resistant to infestation and injury. It has been shown that resistant plants interrupt the behavior of *N. lugens* leading to the failure of establishment of the insect on its host rice. However, available information on the behavioral and physiological responses of *N. lugens* (biotype4) in rice is limited. In consideration of the above facts, the present study was undertaken to investigate the responses of brown planthopper to five rice cultivars.

Materials and Methods

The differential response of brown planthopper was studied on five selected rice cultivars. A series of experiments were conducted at the growth room under controlled environmental condition (27±2ºC temperature, 60-70% relative humidity with 12h photoperiod) in Entomology Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The rice cultivars were IR64 with bph1, ARC10550 with bph5, Swarnalata with bph6, T27A with unknown dominant single gene and TN1 having no resistant gene to brown planthopper. The response tests included nymphal growth and reproduction of female brown planthopper on different cultivars of rice. To obtain a regular supply of the insect of different stages, brown planthopper was mass-reared in the controlled growth room on susceptible rice variety TN1 following standard culture technique (Heinrichs *et al*. 1985).

The growth aspects of brown planthopper nymphs included its developmental period, survival rate and growth index on each of the five cultivars of rice. To determine the nymphal developmental period, 20-day old potted plants of the test cultivars caged with mylar film were infested with ten freshly hatched first instar nymphs and arranged in a completely randomized design. Five pots for each cultivar were used in this study, each pot represented one replicate. The duration of the test was extended to allow nymphs to reach the adult stage. Mean developmental period (1st instar nymph to adult) was calculated based on the daily adult emergence until all the surviving nymphs emerged to adults in each cage.

Another experiment was conducted to determine the survival of brown planthopper nymphs following same methodology and design as described for nymphal period. The cages were monitored daily and sixteen days after infestation, when the nymphs became adults on susceptible plants, data were recorded on the survival rates.

Growth study of *N. lugens* was initiated by infesting 30-day old potted rice plant of each cultivar caged by mylar film with ten first instar nymphs. The hoppers growth index on tested cultivars was calculated by the following formula (Saxena *et al*. 1974).

Growth index =

The reproductive aspects of brown planthopper females included its oviposition, hatchability of eggs, fecundity and population growth on each of the five cultivars of rice. Ovipositional response of brown planthopper was studied by releasing one pair of gravid females on thirty day old potted plant caged by mylar film represented one replicate. The females were allowed to oviposit for 24 hours after which the plants were removed. After five days, the number of eggs laid by the females was counted by dissecting the leaf sheath under a binocular microscope. The experiment was set up in a completely randomized design with five replications.

Hatchability of eggs of *N. lugens* was investigated following same design as that described for the ovipositional response test. Single pair of 5-day old gravid females reared on susceptible TN1 plants was caged on tested cultivars. The females were allowed to oviposit for 24 hour after which the hoppers were removed. The plants were left caged with mylar film for 10 days, which was longer than the insects normal incubation period. The total number of nymphs that emerged on the test plants was recorded. At the end of nymph emergence, unhatched eggs were counted by dissecting the leaf sheath under a bionocular microscope. The total number of eggs laid per plant was determined by summing the total number of nymphs and unhatched eggs. Then percent egg hatchability was calculated by the following formula:

% egg hatchability = x 100

To observe the fecundity of brown planthopper, rice plant caged with mylar film in a pot was infested with single pair of newly emerged males and females representing one replicate. The total number of nymphs emerged on plants was recorded and represent the number of viable eggs produced by the females during their lives. The experiment was set up in a completely randomized design with three replications.

Population growth of brown planthopper was studied in a separate experiment where 30-day old potted plants of each cultivar caged with mylar film (90cm x 10cm) were infested with three pairs of three-day old of brown planthopper females. Three pots for each cultivar were infested; each pot served as a replicate. The cages were checked at early hours of the day for dead hoppers, which were replaced. After 21 days of initial infestation, the adults were removed from the cages, and the progenies were collected with aspirator into a plastic container from each cage. The containers were frozen for 24 hours and then the nymphs were counted for populations build up of *N. lugens*. Data obtained from the experiments were analysed using computer package programme, MSTAT-C and means were ranked by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Nymphal period, survival and growth index: Rice cultivars did not have any significant influence on the nymphal period of *N. lugens* ranging from 12.8 to 13.4 days (Table 1). Similar results were reported by Kim *et al.* (1998) who found that resistant and susceptible cultivars did not exhibit significant differences in the nymphal period.

Percentage of nymphal survival differed significantly among the tested rice cultivars (Table 1). The highest percentage of *N. lugens* nymphs (100%) were survived on susceptible TN1, followed by IR64 (94.0%). On the other hand, nymphal survival was lowest on resistant T27A (66.0%) which was statistically similar with Swarnalata (78.0%) and ARC10550 (80.0%). This result was in agreement with that found by Senguttuvan *et al*. (1991), Nanda *et al.* (1997), Kim *et al*. (1998) and Zeng *et al*. (2000) who recorded higher survival rate of BPH nymphs on susceptible TN1 as compared to that on resistant varieties. Lower nymphal survival on T27A, Swarnalata and ARC10550 might be due to certain toxic or deterrent substances in the resistant cultivars which is responsible for non-preferences. When the nymphs were forced to feed on the resistant variety it may have had a detrimental effect on the survival of nymphs.

Table 1. Brown plant hopper nymphal development on five rice cultivars

Cultivars	Nymphal period (days)	Nymphal survival (%)	Growth index
IR64	13.4	94.0 b	7.0 a
ARC10550	13.8	80.0 c	5.8 b
Swarnalata	12.8	78.0 c	6.0 b
T27A	12.8	66.0 c	5.2 b
TN1	13.0	100.0 a	7.7 a

Means having same letter in a column did not differ significantly at 5% level of probability

Table 2. Effects of rice cultivars on oviposition, egg hatchability and fecundity of the brown plant hopper, *N. lugens*.

Cultivars	Eggs laid/24 hr.	Eggs hatchability (%)	Total no. of eggs laid
IR64	41.3 a	77.4 b	287.3 b
ARC10550	28.6 b	65.6 b	184.0 c
Swarnalata	30.2 b	64.5 b	147.0 c
T27A	28.8 b	48.8 c	80.3 d
TN1	48.8 a	84.7 a	493.0 a

Means having same letter in a column did not differ significantly at 5% level of probability

Growth index of *N. lugens* differ significantly among rice cultivars (Table 1). The lowest growth index was found to be on T27A (5.2) while the highest was recorded on TN1 (7.7). Lower growth index on resistant cultivars might be due to absence of essential nutrients and higher growth index on susceptible ones was the presence of essential nutrients for *N. lugens* nymphs. The higher the growth index, the cultivar was found to be more suitable for *N. lugens* development. Similar results were also reported by Nanda *et al*. (1997a) and Soundararajan *et al*. (2003) who recorded the highest growth index on the susceptible TN1 compared to resistant varieties.

Oviposition, hatching, fecundity and population growth of *N. lugens*: Significant differences were observed in number of deposited eggs for 24 hours on the plants of five tested rice cultivars. The highest number of 48.8 eggs was laid on TN1 which was at par with that on IR64. The lowest number of 28.6 eggs was deposited on resistant cultivar ARC10550 which was statistically similar with T27A (28.8 eggs) and Swarnalata (30.2 eggs). Oviposition was inhibited on resistant cultivars, being only about 60% of that on susceptible TN1 (Table 2). Nanda *et al.* (1997b) also reported similar results recording lower oviposition on resistant rice plant than the susceptible rice plant.

The response of *N. lugens*, as measured by the percentage of egg hatchability differed significantly among the rice cultivars. The highest percentage of eggs hatched on susceptible TN1 (84.7%) followed by IR64 (77.4%) while hatchability of eggs was lowest on T27A (48.8%) (Table 2). This result was in agreement with that found by Velusamy *et al.* (1995), where they recorded significantly less number of eggs hatched on resistant wild rices as compared to that on TN1.

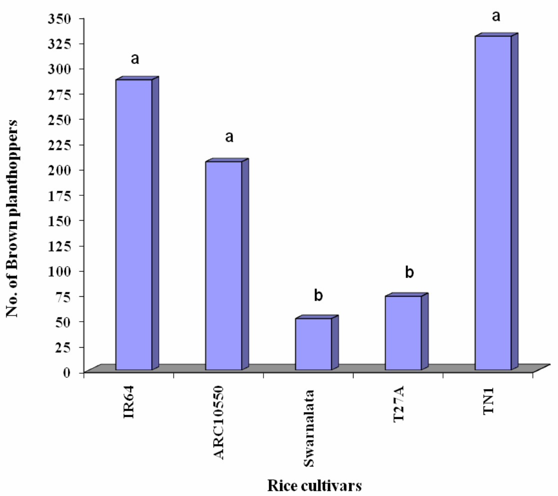

Fig. 1. Population growth of brown planthopper female as influenced by rice cultivars

Significant differences were also observed on the fecundity of brown planthopper on five rice cultivars. The female laid the highest number of 493 eggs on TN1, followed by IR64 (Table 2). T27A had the lowest number of 80 eggs, followed by Swarnalata (147eggs) and ARC10550 (184 eggs). Absence of sufficient nutrients in resistant plants, which might have caused lower the fecundity of the insect. Higher fecundity on susceptible variety or reduced fecundity on resistant varieties were reported by many workers in *N. lugens* (Senguttuvan *et al*. 1991; Nanda *et al*. 1997b). Kim *et al*. (1998) also found that the antixenosis to oviposition was higher on resistant cultivars than on susceptible cultivars.

Significantly lowest population growth of brown planthopper was recorded on Swarnalata (51 insects), followed by T27A (73 insects), about 4.0 to 6.5 times lower than that on other three cultivars (Figure 1). The population growth on TN1 (330 insects) was highest and identical with that on ARC10550 (206) and IR64 (287). Lower population growth on resistant cultivars might be due to the antibiosis effects of resistant cultivars. Senguttuvan *et al*. (1991) reported similar results recording significantly lower population on resistant variety PTB33, compared to a very high population in susceptible TN1. Kim *et al.* (1998) reported that resistant rice varieties inhibited population growth of *N. lugens* than susceptible one. Velusamy (1988) and Zeng *et al*. (2000) also found lower increase in population on all tested rice varieties having different resistance genes than that on susceptible TN1.

In conclusion, survival and growth index of brown planthopper nymphs are found to be reduced on resistant rice cultivars compared to susceptible TN1. The resistant cultivars had also very adverse effects on fecundity as well as on population growth while it was favoured by TN1.

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