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Genetic Basis of Resistance to Brown Plant Hopper (*Nilaparvata lugens* Stal) in Local Landraces of Rice

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A B S T R A C T

Three brown planthopper (BPH) resistant (Ratnachoodi, Rajamudi, JBT 36/14) and two susceptible donors (TN 1 and Jaya) of rice was studied at Department of Agricultural Entomology, ZARS, V. C. Farm, Mandya. The reaction of F_2 populations of the crosses *viz.*, Jaya × Rajamudi, Jaya × Ratnachoodi and TN 1 × JBT 3614 segregated in the ratio of 3:1 revealed that the resistance is governed by single dominant gene, while, Jaya × JBT 3614 and TN 1 × Ratnachoodi segregated in 13:3 interaction and TN 1 × Rajamudi in 9:7 indicating inhibitory and complementary gene action respectively. The parents Ratnachoodi, Rajamudi and JBT 36/14 can be used as source for easy incorporation of BPH resistance into susceptible high yielding rice varieties.

Introduction

Rice is an important staple food in Asia. More than 90 % of the world's rice is grown and consumed in Asia, where 60 % of the world's population lives. Rice accounts for about 35-60 % of the caloric intake of three billion Asians (Guyer *et al.*, 1998). In India, rice is grown over an area of 42.86 mha with a production of 104.3 mt (Anon. 2014). Karnataka occupies a prominent place in rice map of India accounting for 1.54 mha with a production of nearly 4.18 mt (Anon. 2014). Among the various constraints in the rice production biotic stress *i.e.* insect pest attack is the most important constraint. Therefore, breeding for the insect resistance is very important since rice is attacked by various insect pests during different growth stages. Among the several insect pests of rice, brown planthopper (BPH), (*Nilaparvata lugens* Stal) is known to cause economic losses in one or several rice growing areas of Asian countries.

Severe infestation of BPH causes typical symptom of hopper burn resulting in losses up to 100 *per cent*. The BPH is also known to transmit different viral diseases (Krishnaiah 2014). Severe outbreak of BPH was recorded in Karnataka, in Cauvery and Tungabhadra command areas during *Kharif* 2009 (Sidde Gowda and Gubbaiah 2011).

As the popular rice varieties are susceptible to planthopper, farmers depend solely on chemical pesticides for controlling this insect, which is expensive in terms of labour, cost and also pose environmental hazards. To overcome this problem and to manage this insect most economical and eco-friendly manner, the best approach is cultivation of BPH resistant varieties. In breeding crucial step is identification of appropriate donors by studying the number, nature and diversity of genes controlling resistance. Traditional landraces popularly called as local or farmer varieties are generally considered to be a rich source of genetic variation. Such landraces are important reservoirs of valuable genes responsible for medicinal properties, nutrition, taste, aroma, tolerance to drought and varying level of resistance to insect pests and diseases (Hanumaratti *et al.,* 2008). Identification of new donors and work out of their BPH resistance genetics is a continuous process to breed new BPH resistant varieties which can show resistance to newly evolved BPH biotypes. Hence, the present investigation was carried out to work out the genetics of BPH resistance in Ratnachoodi, Rajamudi and JBT 36/14 of rice.

Materials and Methods

Reaction to BPH of parents, F_1 and F_2 populations of six crosses during seedling stage

The present study consisting experimental material resistant lines (Ratnachoodi, Rajamudi and JBT 36/14) and susceptible lines (Jaya and TN-1). The brown planthopper population was maintained using standard artificial rearing in the cages (plate 1). Study involving resistant X susceptible crosses a total of six F_1 were generated from which F2 population was developed by selfing F_1 plants. The F_2 populations of the crosses were evaluated for their reaction against brown planthopper in glasshouse conditions (Plate 2 & 3).

Seeds of parents, F_1 and F_2 populations of the crosses were sown in modified seed bed in glasshouse conditions. The modified seed beds were filled with enriched puddled soil. Seeds were sown in 40 cm long-rows demarcated width-wise and spaced 5 cm among rows. Within a row, the seeds were placed equidistant (3 cm) apart. There were 10 rows of F_2 population, one row each of parents and one row of F_1 population. When the seedlings were 7 days old (at 3-leaf stage), 2^{nd} instar nymphs of BPH were released and all test seedlings were assessed individually for damage at 7 days after infestation, when Jaya and TN1 (susceptible checks) seedlings show >90% damage symptoms (damage score 9). The Standard evaluation system for rice (IRRI, 2014) was used to score the seedlings for BPH damage. Chi-square test was performed to fit a ratio to workout genetics of resistance to brown planthopper.

Honeydew production of BPH on parents, F1 and F_2 populations of six crosses

The standard experimental set up was designed to measure the amount of honeydew excreted in 24 h by 1-day old brachypterous female were used (Heinrichs *et al.,* 1985). Parents, F1 and F2 populations were planted individually on 15 cm diameter in a clay pots. These plants were raised for 6-weeks. From the plant bases these seedlings were kept individually with in a feeding chamber (an inverted plastic cup).

A small hole was made in the centre of nine centimetre diameter of whatman number 1 filter paper and longitudinal cut was made from the margin towards centre of the hole. Small quantity of bromocresol green powder was added to ethyl alcohol solution in a beaker and mixed thoroughly. Then the

solution was taken in a petridish and the filter paper were dipped in it and then dried in shade. Card board sheets were taken and cut into square shapes of 12 × 12 cm size and a hole was made in the centre of the square. Six weeks old plants were inserted through the hole and the card board squares were kept at the base of the plants and the hole was plugged with non-absorbent cotton.

The treated filter paper circles were placed on the card board at the base of the plants. Small plastic cup without lid were taken and made a small hole at the basal portion of cup and the plant was inserted through the hole and the treated cups were place on the filter paper.

One day old 15 BPH females starved for two hours were released into the cup onto the filter paper through the hole and plugged the hole with non-absorbent cotton to prevent escape of the insects. The BPH adults were allowed to feed for 24 hours at the base of the stem. When the honeydew excreted by BPH comes in contact with the filter paper spots with blue tinged margins were formed. Then the filter papers were taken out and the area of the spots were measured by graph paper method. The area of all the honeydew spots were traced on a millimetre square graph paper and the number of squares within the spots were counted.

Honeydew measurements were taken on 3 plants, each for parents, F_1 and F_2 populations respectively. The area of all the honey dew spots were added and honey dew excretion was expressed as mm^2 per 5 females as method suggested by Paguia *et al.*, 1980.

Results and Discussion

Reaction to BPH of parents, F_1, F_2 populations of six crosses at seedling stage

Reaction of F_2 populations of the crosses between Jaya, TN 1, Ratnachoodi, Rajamudi and JBT 3614 against BPH were studied in glasshouse conditions. The F_2's of the crosses *viz.,* Jaya × Rajamudi, Jaya × Ratnachoodi and TN 1 × JBT 3614 indicated that the resistance to BPH due to monogenic dominant gene action(Table 1) and segregated in the ratio of 3:1, while, Jaya × JBT 3614 and TN 1 × Ratnachoodi segregated in 13:3, resistance is governed by two genes with inhibitory interaction and TN 1 × Rajamudi in 9:7 ratio with complementary gene action they were positively agreement with the work of Balakrishna and Satyanarayana (2013).

Honeydew production of BPH on parents, F_1 and F_2 populations of the crosses

Honeydew excretion on the resistant parents JBT 3614 (5), Ratnachoodi (5.33), Rajamudi (5.33) was lesser than the susceptible parents and F_1s were intermediate in honeydew excretion, where as much lesser on F_2 population of the crosses *viz.,* TN 1 × JBT 3614(4.67) Jaya × Rajamudi (5.0) and Jaya × Ratnachoodi (5.33) with 5.17 mean number of spots. The feeding rate (indicated as area) was more on Jaya (340 mm^2), TN 1(327.05 mm^2), the honeydew excreted on F_1 plants was intermediate to the parents with mean area of 242.5 mm^2. While, on the F2 population least honey dew production was recorded on TN 1 × JBT 3614 (136.9 mm^2), followed by Jaya × JBT 3614 (138.32 mm^2), TN 1 × Rajamudi (144.13mm^2) and TN 1 x Ratnachoodi (151.75 mm^2) (Figure 1).

In the present study all the F_2 populations showed the resistant reaction to BPH damage. The segregation pattern in the crosses Jaya × Rajamudi, Jaya × Ratnachoodi and TN 1 × JBT 36/14 revealed that the resistance is governed by single dominant gene, while in other crosses *viz*., Jaya × JBT 3614, TN 1 × Ratnachoodi and TN 1 × Rajamudi resistance is governed by two genes with inhibitory interaction and complementary gene action, respectively.

Fig.1 Honeydew excretion test of parents, F1 and F2 population

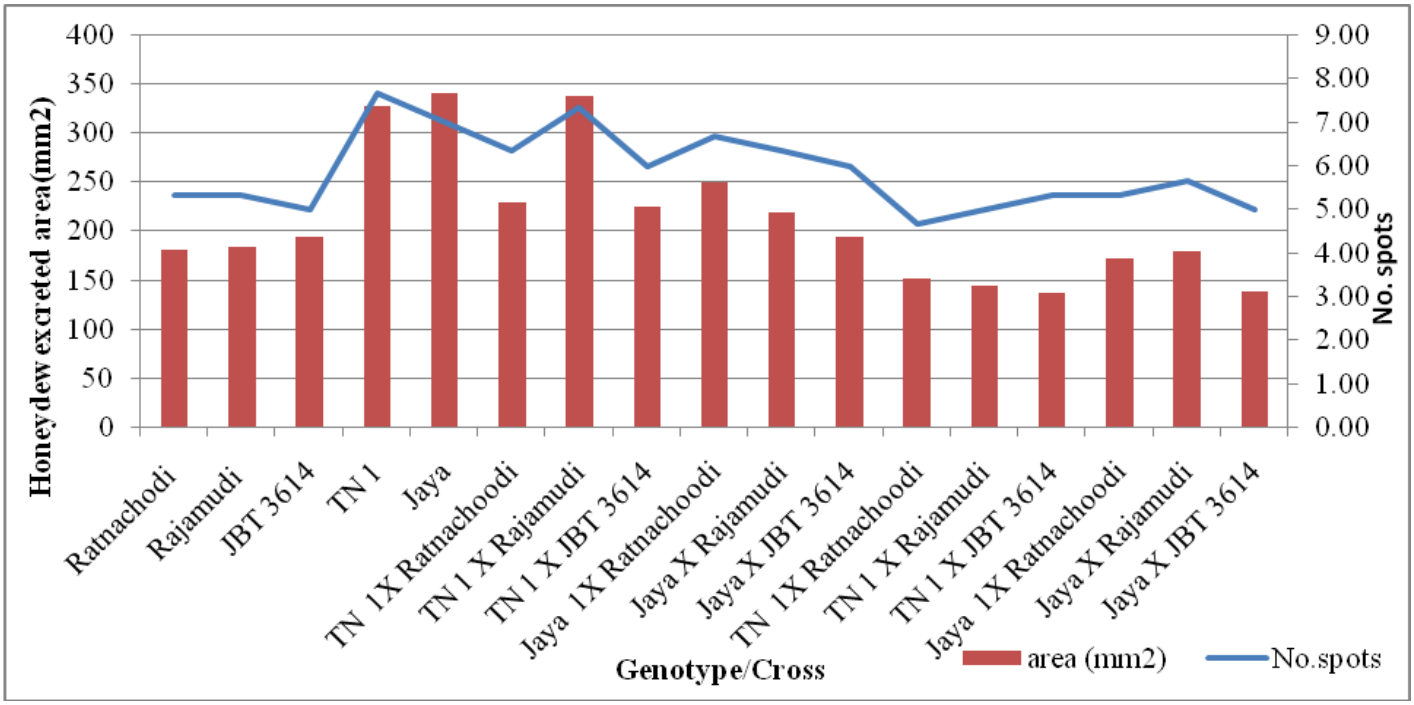

Plate.1 Culturing of BPH in cages

Plate.2 Crossing of Susceptible genotypes with resistant landraces

Plate.3 Screening of F_2 population in the glass house

Table.1 Chi-square test for goodness of fit F_2 populations of the crosses between four resistant and two BPH susceptible parents

Cross	Reaction of F_1 population (damage score)	F_2 population		Genetic ratio	χ^2 value
		Resistant	Susceptible		
Jaya × Rajamudi	5	228	67	3:1	0.82
Jaya × Ratnachoodi	7	228	67	3:1	0.82
TN 1 × JBT 3614	5	227	66	3:1	1.09
TN 1× Ratnachoodi	7	242	44	13:3	16.17
Jaya × JBT 3614	5	235	57	13:3	5.09
TN 1 × Rajamudi	9	179	116	9:7	32.27

The results of the study are in agreement with the studies of Balakrishna and Satyanarayana (2013). Decreased amount of honeydew Excreted on Ratnachoodi, Rajamudi and JBT 3614 than the susceptible checks Jaya and TN 1 and F1 population it was intermediate to the parents. Honeydew excreted on F_2 population was less as compared to the parents and F_1 population. This clearly indicates that a major gene and number of minor genes are responsible for BPH resistance (Fig 1). Similar results were also observed by the Nugaliyadde *et al.,* (2014) who reported that the more honeydew excretion on TN 1, F_1 populations but fewer amounts on PTB 33 and F_2 populations.

The cultivars found resistant to BPH cannot themselves be developed as improved as improved variety due to poor genetic back ground. But the genes possessed by them can be identified as a resistance source and can be incorporated into the agronomically superior rice genotypes. The cultivars which possess single dominant or recessive genes are of immense value for crop improvement. Hence with single gene inheritance of Ratnachoodi, Rajamud and JBT 36/14 is considered to be more advantageous than other traditional donors for easy incorporation of resistant traits into the susceptible high yielding varieties of rice by using back cross breeding methods and hybridisation. Further investigations can be focused on to confirm genetic ratios obtained in F_2 generation. Resistant F_2 plants from the six crosses may be advanced to isolate new genotypes with resistance to BPH and high grain yield.

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