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Tolerance Mechanism of Resistance in Selected Rice Genotypes Against Brown Planthopper, *Nilaparvata lugens* (Stål)

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Abstract

The tolerance mechanism of resistance in selected rice genotypes against brown planthopper, Nilaparvata lugens (Stål) (Hemiptera: Delphacidae) was studied in the greenhouse condition in adult plant stage. The tolerance parameters viz., functional plant loss index (FPLI), tolerance index (TI) and plant dry weight loss index (PD loss) were assessed in selected 26 rice genotypes. The results revealed that FPLI was minimum in Ptb-33 (13.19%) followed by Mapillai Samba (22.96%), whereas susceptible check TN 1 recorded maximum FPLI (66.92%). The TI of rice genotypes ranged from 0.08 to 0.88. ADT-36 showed highest TI (0.88) followed by Vellai Kudavazhai (0.86) and Mapillai Samba (0.80). The plant dry weight loss index was more in the genotypes viz., White Ponni (889.93g), Ptb-19 (670.74g), Ptb-41 (470.62g). The susceptible check TN-1 had a plant dry weight loss of 57.79g and the resistant check Ptb-33 recorded low plant dry weight loss of 122.98g. The importance of assessing the tolerance parameters for relating seedling stage and adult plant resistance were discussed.

Key words: Brown planthopper, plant resistance, tolerance, functional plant loss index

Introduction

Host plant resistance is the most effective and environment friendly approach to control the damage caused by insects and increase yield potential of cereal crops especially in rice crop (Jena *et al*., 2006). Brown planthopper, *Nilaparvata lugens* (Stål) is still continuing as one of the serious insect pests of rice and causes considerable yield loss. The limitation to the success of resistant varieties is the potential threat of emergence of new biotypes of the insect. Most of the host plant resistance studies in rice against planthopper came out with the resistance confirmed at seedling stage screening or mass screening methods. The level of resistance at seedling stage may be not carried out at adult plant stage and vice versa. It is essential in recent times along with seedling screening, adult plant screening and mechanisms of resistance need to be studied (Soundararajan *et al.,* 2004). Tolerance is highly attractive concept possibly being superior to specific resistance suggested. Tolerance differs from antixenosis and antibiosis, because it provides a plant with the ability to produce satisfactory yield that would damage a susceptible plant whereas antixenosis and antibiosis interfere with insect behaviour and metabolism. Tolerance is mostly associated with polygenic resistance. The level of resistance is generally not very high and it does not exert strong selection pressure on the insect (Panda and Heinrichs, 1983). Therefore, it is believed that the limitations posed by biotypic selection can be minimized by the utilization of resistance sources having tolerance (Tingey, 1981). However, the breeding for tolerance has been very slow process. (Velusamy and Heinrichs, 1986).

Understanding tolerance is very difficult because it is a complex phenomenon, it requires a detailed knowledge on physiological basis of plant compensatory mechanisms upon insect attack and environmental conditions where it is expressed (Delaney and Macedo, 2001). There is a long history of attempts to quantify tolerance but each attempt had some limitations. Attempts have been made to develop techniques to measure tolerance precisely without the influence of antibiosis (Reese *et al.,* 1994). Thus, the search for resistance variation based on knowledge of resistance mechanisms provides a reliable indicator of the nature and extent of genetic variation for the trait. Different cultivars may possess the same levels of resistance with different mechanisms of resistance and/or levels of resistance components. In the present study, different tolerance parameters were assessed in selected rice genotypes under greenhouse conditions.

Materials and Methods

The experiments were conducted in Entomology greenhouse, Department of Rice, Tamil Nadu Agricultural University, Coimbatore, India. A set of 26 rice genotypes including identified BPH resistant varieties and promising lines from Department of Rice, TNAU, Coimbatore and gene differentials supplied by Indian Institute of Rice Research, Hyderabad through planthopper special screening trial were used to assess the level of tolerance to *N. lugens* at adult plant stage. Coimbatore population of Brown planthopper, *N. lugens* (BPH) was mass cultured in the greenhouse on the susceptible rice variety Taichung Native 1 (TN-1). Initial BPH population was collected from unsprayed rice fields of PBS, TNAU, Coimbatore and standard protocol was followed to multiply the insects for further experiments (Heinrichs *et al.,* 1985).

Tolerance of the test genotypes was evaluated on the basis of plant weight loss by the feeding of *N. lugens* known as Functional Plant Loss Index (FPLI). Plant dry weight loss index (PD loss) by BPH population was one of the measures of tolerance in which the weight loss per mg dry weight of BPH produced. The tolerance index of each genotype was also calculated by comparing dry weight of insect produced on test genotypes with susceptible check (Panda and Heinrichs, 1983).

The test genotypes along with susceptible (TN-1) and resistant (Ptb-33) checks were raised in pots and allowed for normal development and experiments were replicated thrice. At 45 DAS, the plants in each pot were covered with a polyester film cage and infested with 50 freshly hatched nymphs. A control plant without releasing any insect was also maintained for all 26 rice genotypes. The insects were allowed to feed on the plants till the genotype or susceptible check showed wilting and drying symptoms. At that time, the live and dead insects on the plants were collected and weighed. All the plants were uprooted, roots were washed in water, air dried for two hours, dried in an oven at 70 ^{0}C for 72 h and then the dry weight was recorded. The FPLI was worked out using the following formula:

$$\text{FPLI} = 1 - \left[\frac{\text{Dry weight of infested plant}}{\text{Dry weight of uninfested plant}}\right] \text{X } 100$$

Tolerance index and Plant dry weight loss index were calculated for each replication based on *N.lugens* dry weight produced on the test lines.

$$\text{Tolerance index (TI)} = \frac{\text{N.lugens dry weight on test genotype}}{\text{N.lugens dry weight on TN-1}}$$

$$\text{Plant dry weight loss/ mg of BPH dry weight produced} = \frac{\text{Dry weight of uninfested plant - dry weight on infested plant}}{\text{Dry weight of BPH on infested plant}}$$

Results and Discussion

The results are presented in Table 1. The Functional Plant Loss index (FPLI) was minimum in resistant check, Ptb-33 (13.19%) followed by Mapillai Samba (22.96%) and ASD-7 (23.83%). Highest FPLI value was observed in Kattu Ponni (81.36%) followed by Ptb- 41 (79.47%) and Milyang 63 (79.27%), whereas susceptible check TN-1 recorded FPLI of 66.92%. The Tolerance Index (TI) of rice genotypes ranged from 0.08 to 0.88. ADT-36 showed highest TI (0.88) followed by Vellai Kudavazhai (0.86) and Mapillai Samba (0.80). The lowest TI value of 0.08 was observed in ASD-7 followed by White Ponni (0.11) and RP 2068-18-3-5 (0.15). The susceptible check TN 1 had a TI of 1.00 and the resistant check Ptb-33 had TI value of 0.08. The plant dry weight loss was more in the genotypes *viz*., White Ponni (889.93g), Ptb-19 (670.74g), Ptb 41 (470.62g), Mudgo (320.90g), Milyang 63 (297.68g), IR-64 (273.84g), Pokkali (237.58g), IR 71033-121-15 (218.17g). The minimum plant dry weight loss was recorded in ADT-36 (14.02g) followed by MTUNS-1 (23.87g) and Babawee (24.58 g). The susceptible check TN-1 had a plant dry weight loss of 57.79g and the resistant check Ptb-33 recorded low plant dry loss of 122.98g.

The phenomenon of tolerance is generally cumulative and is a result of interaction between insect feeding and plant growth responses. It includes general vigour, inter and intra plant compensatory growth, wound compensation, mechanical strength of tissues and nutrients and growth regulator partitioning. Tolerance is the capacity to produce a variety of high quality and yield despite insect infestation and this component of host plant resistance is less exploited. Several studies have documented different levels of resistance mechanisms to planthoppers among rice genotypes (Nalini and Gunathilagaraj, 1994; Cohen *et al.,* 1997; Alam and Cohen, 1998). Mishra and Misra (1992) found a significant difference in the Functional Plant Loss Index (FPLI %) between the resistant and susceptible accessions. FPLI was the highest in TN-1 (100.00) followed by Sankarjata (83.75) respectively, while it was lowest in resistant varieties Pundia (1.25) followed by Sunnabhai (54.25), respectively. FPLI of IET 10251 was lowest (14.2%) and the loss was only one fifth compared to the susceptible check TN-1 (78.21%). In the present study, FPLI was very low in Mapillai Samba, ASD-7, OM-4498, ADT-36 and RP 2068-18-3-5 compared to susceptible check TN-1. The genotype ASD-7 and RP 2068-18-3-5 were reported as resistant in the seedling stage (Thamarai and Soundararajan, 2017) had tolerance mechanisms at adult plant stage also. These findings are in accordance with the earlier reports made by Panda and Heinrichs (1983) who developed and elaborated FPLI method and identified rice varieties like Triveni, Kanchana and Utri Rajapan with tolerance as predominant component of BPH resistance. Harini *et al*. (2013) revealed that genotype Swarnalatha had more number of insects and Pokkali showed less to moderate count of live insects, including number of nymphs surviving on each genotype. All genotypes under control conditions were showing higher bio-mass compared to plants infested with insects. Ptb-33 has shown highest biomass while TN-1 has shown lowest biomass after infestation among the genotypes.

More than 50 per cent of the test genotypes in this study showed low tolerance index and in these accessions antibiosis may operate as major resistance mechanism. ADT 36 showed high level of tolerance index (0.88). The genotype, Mapillai Samba had more tolerance index (0.70) was reported as moderately susceptible at seedling stage (Thamarai and Soundararajan, 2017). The functional plant loss index was less (27.33 & 22.96%) in these two genotypes indicating the mechanism of tolerance at adult plant stage.

The plant dry weight loss index (PD loss) measures the actual quantity of plant material used for development of insect and this parameter expressed as g/mg of insect weight produced. In the present study, more plant dry weight loss was recorded in White Ponni (889.93g) and Ptb-19 (670.74g) which shows that more plant biomass was required for the development of BPH (dry weight in mg) nymphs. It shows that these genotypes have more level of tolerance than the resistant check Ptb-33 in terms of PD loss index. In susceptible TN-1 the PD loss value was 57.79g which indicated that minimum plant biomass was sufficient for the development of BPH nymphs. Low FPLI and low PD loss was evident in tolerant varieties (Panda and Heinrichs, 1983). Alam and Cohen (1998) refined the tolerance parameter as DWL (dry weight loss) per unit dry weight of insect produced. Chen *et al.* (1978) reported that BPH population caused the reduction in plant dry weight. Significant differences were observed in the dry weight of insect, shoot length and root length produced through the feeding of *N.lugens* (Nalini and Gunathilagaraj, 1994). Ramaraju *et al.* (1996) reported that in field condition, the cultivar Triveni was more tolerant, the mean plant height and weight were only slightly reduced. It was suggested that Triveni could possibly survive and produce tillers at higher population levels of *N.lugens.* Rath and Mishra (1998) assessed the tolerance in terms of loss of plant biomass, where the loss of straw weight was the lowest in Ptb-33 (48.82%) and the highest in TN-1 (66.05%). Ptb 33 suffered the least grain weight loss (45.62%) and Suryamukhi and Bhuban had a grain weight loss of 54.40 and 62.33 per cent, respectively. An 80 per cent grain loss was observed in TN-1. The mean biomass loss indicated that Ptb-33 had suffered the least damage (47.22%). Suryamukhi had a biomass loss of 56.24 per cent and Bhuban lost 58.83 per cent. However, the highest biomass loss was in TN-1 (73.33%). Emmanuel 2001 and Emmanuel *et al.* (2003) found that FPLI was lowest in IET 15423 (11.87%) while it was maximum in TN-1 (76.45%). Sarao and Bentur (2015) assessed the tolerance studies *viz*., days to wilt, functional plant loss index and plant dry weight loss to BPH dry weight produced and found that RP 2068-18-3-5, Rathuheenathi and Ptb-33 performed better than the other test genotypes.

Conclusion

The tolerance parameters, functional plant loss index value (FPLI) was minimum in resistant check, Ptb-33 and in a local land race Mapillai samba. The plant dry weight loss (PD loss) was more in the genotypes White Ponni (889.93g) and Ptb-19 (670.74g). ADT-36 and Mapillai Samba showed high level of tolerance index. The resistance at seedling stage in some of the rice genotypes was confirmed in its adult plant tolerance. Assessing tolerance parameters in rice genotypes under controlled laboratory condition is one of the important evaluation processes for further field tolerance and yield correlation studies.

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