Studies on Brown planthopper resistance in Rice (*Oryza sativa* L.)

ABSTRACT

In India, Rice is a major food crop and consumed by majority of Indian population. The crop often encounters various pests and diseases. Hence, development of Resistant varieties or resistant donors is a continuous process to reduce the losses due to the pests and diseases. Keeping in view of the above, a Research programme was carried out with an objective to study the Brown planthopper (BPH) (*Nilaparvata lugens* Stal) resistance reactions in the resultant hybrids when crosses were attempted with different sources of resistance against BPH. The current study was carried out at Agricultural Polytechnic (APT), Polasa, Jagtial. Eight lines and three testers were crossed line x tester mating design during *Kharif*, 2021 and the resultant 24 hybrids were evaluated in Randomized Block Design during *Rabi*, 2021-22. Among the hybrids, the damage score ranged from 3.2 (CMS 23A x JGL33124 and CMS 46A x JGL 33124) to 9.0 (CMS 23A x KNM 7787, JMS 11A x RNR 21278 and JMS 18A x RNR 21278). Ten hybrids exhibited moderately resistant reaction, one was moderately susceptible, ten were susceptible and three hybrids exhibited highly susceptible reaction. The cross, CMS 46A x JGL 33124 which recorded on par grain yield per plant over the hybrid check, 27 P 31 displayed moderately resistant reaction to BPH.

Key words: Paddy, lines, Testers, hybrids, Brown planthopper, resistance

1. INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food in majority of the Asian countries. India is the major producer of rice with a production of 122.27 Mt and a productivity of 2713 kg ha^{-1}. Rice and value added products accounts for nearly 22% on national economies (Bandumula, 2018) [1]. Globally, Rice is cultivated around 167.20 Mha in the world with a production of around 769.60 Mt and with a productivity of 4600 kg ha^{-1} (FAO, 2019) [2]. In Telangana, it is cultivated in an area of 2.31 Mha with production and productivity levels of 7.70 Mt and 3327 kg ha^{-1} respectively (Directorate of Economics and Statistics, 2021) [3].

Rice crop being cultivated in warm, humid and tropical climatic conditions, is often prone to high insect pest infestation. Biological factors (insects, diseases, weeds, and other pests) are expected to cause significant losses Brown planthopper (BPH) [*Nilaparvata lugens* (Stal.)] is one of the most damaging rice pests, causing enormous yield losses all over the world. Development of resistant varieties against BPH is very crucial since the biotypes change their behaviour over time and previously released resistant rice varieties often become susceptible to the pest. Hence,identification of novel sources of resistance and confirmation of resistance reactions are very crucial. (Guo, Liao & Chuang, 2019) [4].

2. MATERIALS AND METHODS

The present study was carried out at Agricultural Polytechnic College, Polasa, Jagtial is located at an altitude of 243.4 m above mean sea level on 18°49'40" N latitude and 78°56'45" E longitudes inthe Northern Zone of Telangana State. The selected parents were planted in the experimental plots.

All the parents were sown in three staggerings at 10 days interval to achieve synchronous flowering so as to obtain sufficient quantity of crossed seed. 28 days old seedlings were transplanted at a spacing of 15x15 cm during *Rabi,* 2021-22. Recommended crop management strategies were followed and maintained a healthy crop during the entire period of field evaluation.

Healthy CMS lines with newly emerged panicles were uprooted from the field during the flowering stage tagged and potted in earthen pots that were filled with mud inthe morning hours of the day, which were then transferred to the net house. Clipping and hybridization method was followed during crossing programme in line x tester mating design. The resultant experimental hybrids thus obtained during *Kharif*, 2021 were evaluated along with parents and checks to screen the resistant reaction against BPH.

Identification of better parents and superior hybrids with Brown planthopper (BPH) resistance.

2.1 Raising and Maintenance of Potted Rice Plants for Mass Rearing of BPH.

UNDER PEER REVIEW

Healthy seeds of the rice variety, Taichung Native 1 (TN1) which is susceptible to BPH were sown in plastic trays filled with fertilizer enriched soil. 20 days old rice seedlings were transplanted into three-litre plastic pots filled with fertilizer-enriched puddled soil at 3-4 hills per pot. For mass rearing of BPH population, the potted plants were watered regularly and kept in good condition. These plants were grown in a separate glasshouse where they were kept safe from other insect's attack.

2.2. Mass rearing of Brown planthopper on susceptible cultivar (TN1)

Since the study requires several instars of BPH nymphs as well as adults, mass rearing of BPH was carried out to ensure an adequate supply of nymphs throughout the study period. BPH was mass-reared on the susceptible rice variety, TN1 and xenic culture was maintained in insect rearing cages in the polyhouse.

The average temperature was maintained from 22.2 to 35°C, with a relative humidity of >70±5 % during the study period, which was ideal for BPH growth and development. The 50-60 days old TN1 plants were inoculated with BPH gravid females at a rate of 5-6 gravid females per hill for oviposition. To restrict the escape of gravid females, the pots holding the inoculated plants were placed within the insect rearing cages (70 cm x 62 cm x75 cm). Eight to ten days after oviposition, BPH nymphs started emerging and constantly drain the sap of potted TN1 vulnerable plants, causing the TN1plants to wilt. Wilted plants were replaced periodically with fresh plants to maintain a continuous supply of the BPH population. When the emerged nymphs/adults reachedthe appropriate age, they were used in screening of the genotypes. All the necessary precautions were undertaken to keep the culture safe from predators.

UNDER PEER REVIEW

2.3. Screening of experimental material for Brown planthopper resistance inpolyhouse condition

2.3.1. Plant material

The 24 experimental hybrids generated by crossing eight female lines with three male testers along with their parents and checks (one susceptible check (TN 1) and one resistant check (PTB 33)) were screened for BPH resistance reaction using the Standard Seed box Screening Technique (SSST) developed by International Rice Research Institute (IRRI, 1988) during *Rabi,* 2021-22 in the available Polyhouse.

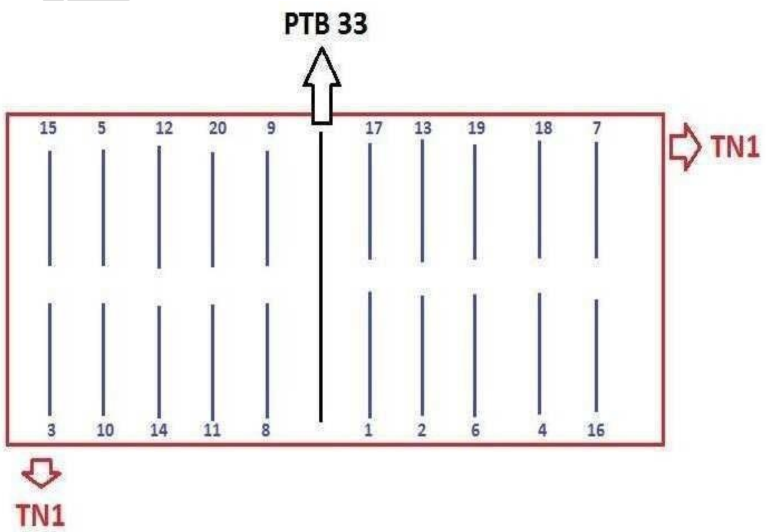
2.3.2. Standard seed box screening technique (SSST)

The rice genotypes were screened under polyhouse conditions by adopting Standard Seed box Screening Technique (SSST). The seeds of rice genotypes were soaked in petriplate with required amount of water for 24 hours then, the water was drained out and the soaked seeds were left in the same petriplate for an additional 24 hours to ensure proper germination. Later the germinated seeds of the experimental hybrids, their parents along with checks were planted in the plastic trays of size (45 x 35x 10 cm). The trays were filled with the puddled soils supplemented with the required amounts of Zinc, $FeSO_4$, Carbendazim, Mancozeb @ 2g/kg soil before sowing. Each genotype was dispersed randomly throughout the tray, the germinated seeds were then planted in the trays using a preset arrangement. After sowing, the seeds were covered with a thin layer of soil and watered at regular intervals.

Second or third instar nymphs of BPH @ 6-7 per seedling were released at 15 days old seedlings or seedlings at the three-leaf stage, by gently tapping the pot holding BPH nymphs over the plastic trays containing seedlings of rice genotypes and ensured for treating the seedlings evenly. The responses of these rice genotypes to BPH were monitored. The trays were turned 180 degrees at regular intervals to ensure an even reaction since the susceptible genotype seedlings showed quick reaction than the resistant ones. The infected seedlings were observed until the susceptible check (TNI) seedlings exhibited 90% mortality. Scoring was recorded on a 0-9 scale using Standard Evaluation System (SES) given by International Rice Research Institute (IRRI, 1988).

PTB33- Resistant check, TNI- Susceptible check. 1 to 20- Treatment lines

Figure 1. Layout of Standard Seed box Screening Test (SSST)



The assessment was mostly based on the BPH-related symptoms of foliar damage. The score was given by the Standard Evaluation System (SES) on a scale from 0 to 9 based on the severity of the damage caused by BPH which has been described in Table 1.

UNDER PEER REVIEW

Table 1. Classification of resistance based on damage reaction

Reaction of plants	Score	Resistance classification
None of the leaves yellow or dead	0	Highly Resistant
One bottom leaf yellow	1	Resistant
One or two leaves yellow or leaf dried	3	Moderately Resistant
One or two leaves dried or one leaf healthy	5	Moderately Susceptible
All leaves dried or yellow but stem green	7	Susceptible
Plant dead	9	Highly Susceptible

3. RESULTS AND DISCUSSION

Keeping in view of the importance of this pest, studies were undertaken to screen the best parents and hybrids for brown planthopper resistance in RARS, Jagtial, Telangana state. Eleven parents and their 24 hybrids along with a susceptible check (TN-1) and resistant check (PTB-33) were screened for brown planthopper resistance by using Standard Seed box Screening Technique (SSST) by releasing 5-6 BPH nymphs per plant. Scorings were given to the entries 0-9 scale of the Standard Evaluation System (SES) developed by IRRI, 1988 for brown planthopper. Therefore, based on the pest scoring, the genotypes are classified as resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible types for brown plant hopper.

Perusal of data revealed that the damage score ranged from 3.0 to 9.0. Among lines, three lines *viz.,* JMS 11A, JMS 17A and JMS 18A showed moderately resistant reaction whereas two lines (CMS 23A and CMS 46A) showed moderately susceptible reaction and three lines (CMS 59A, JMS 13A and CMS 64A) exhibited susceptible reaction. Among testers, JGL33124 showed resistant reaction whereas KNM 7787 exhibited moderately resistant reaction and RNR 21278 exhibited susceptible reaction.

Among the hybrids, the damage score ranged from 3.2 (CMS 23A x JGL33124 and CMS 46A x JGL 33124) to 9.0 (CMS 23A x KNM 7787, JMS 11A x RNR 21278 and JMS 18A x RNR 21278). Ten hybrids exhibited moderately resistant reaction, one was moderately susceptible, ten were susceptible and three hybrids exhibited highly susceptible reaction (Table 2). It was observed that most of the parents showing susceptible or moderately susceptible reaction, gave rise to moderately susceptiblenatured hybrids. It was also observed that certain resistant parents, gave rise to moderately susceptible hybrids. Similar screening experiments were conducted foridentification of bph resistant lines and the results were reported by Kale et al. (2021)[5] and Meshram et al.(2022) [6]. The resistance mechanism might be attributed to the higher silica deposition thereby reduced digestibility of the host plant tissues. Some of the biochemical factors, non- nutritional chemicals that affect feeding habit of the insects might also played a role in governing resistance reaction Han et al., 2015) [7]. The studies indicated that inclusion of at least one of the resistant parents provided moderate resistance in the resultant hybrids.

These studies will be further useful for identification of resistance locus. Yang et al. (2004) [8] identified Bph15 as a major gene governing resistance which was identified in an introgressed line, B5, that was mapped on chromosome 4 using restriction fragment length polymorphism markers and developed a high-resolution genetic map of Bph15 by positioning 21 DNA markers in the target chromosomal region. Jena *et al*, 2006 [9] in the studies on Genetic analysis reported the dominant nature of the Bph18(t) major gene which was non-allelic to Bph10 gene. The present results are in conformity with the earlier findings of Chacko et al, 2023 [10] where they reported the role of potential donors in governing durable resistance.

UNDER PEER REVIEW

Table 2. Reaction of parents, hybrids and checks against BPH.

S.No	Entry	Reaction to brown plant hopper (Score 0-9 scale)	Reaction
		Lines	
1	CMS 23A	6	Moderately susceptible
2	CMS 46A	5.8	Moderately susceptible
3	CMS 59A	8	Susceptible
4	JMS 11A	3.6	Moderately resistant
5	JMS 13A	7.2	Susceptible
6	JMS 17A	3.2	Moderately resistant
7	JMS 18A	3.8	Moderately resistant
8	CMS 64A	8.6	Susceptible
		Testers	
9	RNR 21278	7.4	Susceptible
10	JGL 33124	3.0	Resistant
11	KNM 7787	5.0	Moderately resistant
		Hybrids	
12	CMS 23A x RNR 21278	7.6	Susceptible
13	CMS 23A x JGL 33124	3.2	Moderately resistant
14	CMS 23A x KNM 7787	9	Highly susceptible
15	CMS 46A x RNR 21278	8	Susceptible
16	CMS 46A x JGL 33124	3.2	Moderately resistant
17	CMS 46A x KNM 7787	6	Moderately susceptible
18	CMS 59A x RNR 21278	7.6	Susceptible
19	CMS 59A x JGL 33124	7.2	Susceptible
20	CMS 59A x KNM 7787	8.4	Susceptible
21	JMS 11A x RNR 21278	9	Highly susceptible
22	JMS 11A x JGL 33124	3.4	Moderately resistant
23	JMS 11A x KNM 7787	4.6	Moderately resistant
24	JMS 13A x RNR 21278	7.6	Susceptible
25	JMS 13A x JGL 33124	4.4	Moderately resistant
26	JMS 13A x KNM 7787	7.8	Susceptible
27	JMS 17A x RNR 21278	3.8	Moderately resistant
28	JMS 17A x JGL 33124	3.4	Moderately resistant
29	JMS 17A x KNM 7787	4.8	Moderately resistant
30	JMS 18A x RNR 21278	9	Highly susceptible
31	JMS 18A x JGL 33124	4.8	Moderately resistant
32	JMS 18A x KNM 7787	8.6	Susceptible
33	CMS 64A x RNR 21278	8.0	Susceptible
34	CMS 64A x JGL 33124	4.1	Moderately resistant
35	CMS 64A x KNM 7787	8	Susceptible
		Checks	
36	TN-1 (Susceptible Check)	9	Highly susceptible
37	PTB-33 (Resistant Check)	2	Resistant

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Table 3. Brown Planthopper resistant hybrids identified in the present investigation

S.No	Cross	Reaction
1	CMS 23A x JGL 33124	Moderately Resistant
2	CMS 46A x JGL 33124	Moderately Resistant
3	JMS 11A x JGL 33124	Moderately Resistant
4	JMS 11A x KNM 7787	Moderately Resistant
5	JMS 13A x JGL 33124	Moderately Resistant
6	JMS 17A x RNR 21278	Moderately Resistant
7	JMS 17A x JGL 33124	Moderately Resistant
8	JMS 17A x KNM 7787	Moderately Resistant
9	JMS 18A x JGL 33124	Moderately Resistant
10	CMS 64A x JGL 33124	Moderately Resistant

CONCLUSION

The screening experiments indicated that 10 out of 24 experimental hybrids were moderately resistant to BPH, one cross was found moderately susceptible,10hybrids were susceptible and three were highly susceptible. Critical examination of the 10 moderately resistant hybrids indicated the role of inclusion of at least one resistant parent in governing the moderate resistance in the resultant hybrids.

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