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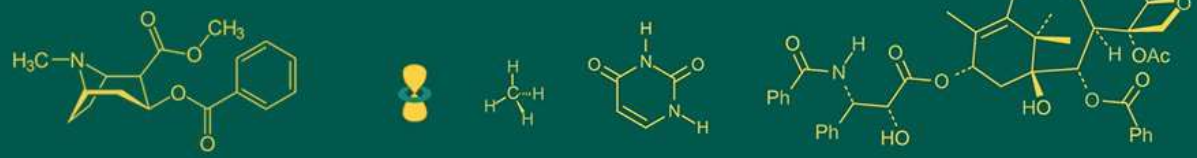

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Phenotyping and genotyping of rice genotypes for brown planthopper resistance

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Abstract
Brown planthopper (BPH), *Nilaparvata lugens* (Stal) is a destructive pest that poses a threat to the food security of rice producing countries. Finding highly resistant germplasm sources is essential to breeding rice varieties resistant to the BPH. The experiment was conducted at Agricultural Research Station (ARS), Gangavati during *kharif* 2021 with 78 traditional rice varieties and six popular local varieties with one susceptible check TN1. The results of field screening of traditional rice varieties against brown planthopper revealed that about 8 genotypes *viz*., Jeerige samba, Ratana Sagar, Ambe Mohar, Hasada, Karapu Kavalu, Nambari, Kusum kali-1 and Odissa -1 showed resistance to brown planthopper, 17 traditional rice varieties were showed moderate resistance, 27 rice varieties exhibited moderate susceptible, around 13 varieties were susceptible and 20 varieties showed highly susceptible reaction to brown planthopper. The BPH resistance genes in promising genotypes were molecularly characterized.
Results showed that Kempu battha, Nari kela, Burma black selection 2, and Mukanna ratna chudi specified positive bands for each of the six primers. Five primers yielded positive bands for Jaldi dhani-1, Bagiri jhulli, Bhajana, Ambe mohar, Hasada, Karapu kavalu, Nambari, Kusum kali-1, and Odissa -1. Mashuri, GNV-1089, Jeerige Sanna, and Kaagi Saale all produced positive bands for four primers. For three primers, Bangara sanna, MTU-1010, Malgudi sanna, and Jasmine black produced positive bands. Each of the three sambas—Jeerige, Ratana, and Andanoor—has two R genes. Only one primer for TN-1 exhibited amplifications. Both phenotypic and molecular studies revealed that Kempu battha, Nari kela, Burma black selection 2, and Mukanna ratna chudi these genotypes were found resistant to BPH. Additionally, by using MAS, these genotypes can be used in crop development or breeding programs to create novel cultivars that are resistant to BPH.

Keywords: Phenotyping, genotyping, rice genotypes, brown planthopper

Introduction
Rice (*Oryza sativa* L.) is one of the most important staple food for nearly 4 billion people around the world. Global rice demand is expected to rise from 479 million tons of milled rice in 2014 to 536-551 million tons in 2030, owing to expected population growth, income growth and a decrease in rice area (IRRI: Rice Today). Globally rice is cultivated around 162.7 million ha with the production 769.6 million tonnes of rice per year at a productivity of 4600 kg ha per ha (FAO., 2020) [2]. Globally, India is the second largest producer of rice after China. In India, rice is grown on 43.77 m ha, with an annual production of 117.47 million tonnes and productivity of 2570 kg per ha. In Karnataka, it is grown on 1.24 m ha, with an annual production of 3.54 million tonnes and a productivity of 2670 kg per ha (INDIA STAT 2019-20). Brown planthopper, BPH, *Nilaparvata lugens* (Stal), (Hemiptera: Delphacidae) is considered to be the most devastating biological constraint that impedes rice production across many countries in Asia (Park *et al*., 2008) [14]. It causes direct damage to the plants by sucking the phloem sap resulting in the drying of plants inciting hopperburn symptoms. The most common approach for controlling the pest is through the application of insecticides. The chemical method of pest control causes pesticide resistance in BPH and additionally it's being expensive and harmful to the environment (Cheng and Zhu, 2006) [4].
Landraces are referred to as "treasures of valuable genes" because they have grown in significance as sources of genetic variety in the hunt for genes causing tolerance and resistance to biotic and abiotic stresses.

The most practical and ideal way to control pests in crop plants is through plant resistance. Tolerance, antixenosis, and antibiosis are the main mechanisms underlying host plant resistance. Using plants' defensive mechanisms is a fascinating field of study that is being conducted globally to control agricultural diseases and pests (Painter, 1951) [13]. The emergence of biotypes has compelled researchers to find new sources of resistance from germplasms in order to create tolerant and resistant varieties that have desirable traits in addition to resistance characteristics, even though they have identified numerous sources of resistance from various cultivars and wild species.

Furthermore, the development of biotechnology allowed for the molecular characterisation of rice genotypes, which allowed researchers to examine the genetics of BPH resistance in donor lines using DNA markers. The advantage of using these DNA markers for molecular characterisation is that they are unaffected by environmental influences, allowing for exact accurate characterisation (Karkousis *et al*., 2003) [9]. Based on the aforementioned information, the current study was designed to identify the genotyping and phenotyping of BPH resistance genotypes in rice crops.

Materials and Methods

Field screening of traditional rice varieties against brown planthopper was carried out at BPH screening block. All the rice genotypes were screened under field condition at Agricultural Research Station, Gangavathi during *kharif* season 2021 (peak period) for brown planthopper incidence. Six popular rice varieties and 78 traditional rice varieties with susceptible check variety TN 1 (Table 1) made up the experimental material used for field screening of brown planthopper resistance. Nursery of traditional rice varieties was prepared as per the common practices. 30 days old healthy seedlings were transplanted in the experimental field to evaluate them against brown planthopper.

These traditional rice varieties were planted in the field in two rows of 4m length. All around the test entries, ten rows of susceptible check *viz*., TN 1 were planted. Transplanting was done with inter- row spacing of 20 cm and intra- row spacing of 15 cm.

All the recommended agronomical practices were adopted during crop cultivation. No crop protection measures were taken against BPH incidence.

Observations were recorded on number of brown planthopper and per cent hopper burn symptom from 45, 60 and 75 days after transplanting. The damage level of each variety was scored by using the rating scale provided by International Rice Research Institute (IRRI., 2020) [5] during the cropping period as given below.

The damage level of each variety was scored by using the rating scale provided by International Rice Research Institute (IRRI., 2020) [5] during the cropping period as given below.

Score	Damage level	Inference
0	No damage	Highly resistant
1	Slight yellowing of a few plants	Resistant
3	Leaves partially yellow but with no hopperburn	Moderately resistant
5	Leaves with pronounced yellowing and some stunting or wilting and 10-25% of plants with hopperburn, remaining plants severely stunted	Moderately susceptible
7	More than half the plants show wilting or with hopperburn, remaining plants severely Stunted	Susceptible
9	All plants are dead	Highly susceptible

The laboratory work for evaluating promising genotypes for presence of brown planthopper resistance genes was carried out in the breeding Laboratory, Indian Institute of Rice Research, Rajendranagar, Hyderabad. The promising genotypes were subjected to molecular identification of brown planthopper resistant genes and the DNA fingerprint was generated. Genomic DNA was extracted from fresh, healthy and young (20-25 days-old seedlings) leaves by CTAB (Cetyl-Tri Methyl Ammonium Bromide) method (Murray and Thompson, 1980) [12].

For achieving this objective, a set of markers randomly distributed over the entire rice genome were used. The primer sequences for the selected markers were obtained from www.gramene.org and other previously published research work on brown planthopper resistance genes with associated markers. The primer sequence was used and the oligos were synthesized from commercial facility (Eurofins, Bengaluru, India). The markers used were mentioned in Table 2.

Results and Discussion

Traditional rice varieties were the focus of field screening because they are landraces with genes that are resistant or tolerant to a variety of biotic and abiotic stressors. As a result, screening conventional rice varieties for resistance to brown planthoppers helps discover rice types that are resistant, and these resistant varieties can be used in environmentally and economically responsible integrated pest management.

A total of 84 genotypes were screened against planthopper complex in field condition during *kharif* 2021 (Plate 1). It was visualized that planthoppers were settled at the base of the crop genotypes. In general, the population of planthopper was recorded on the resistant and moderately resistant varieties less compared to susceptible varieties. Highest BPH population was recorded on Gandha saale (mean population 110.333/ 10 hill) hence it is recognized as susceptible cultivar as it recorded damage score 9, on the contrast the lowest BPH population was recorded on Nambari (mean population 40/ 10 hill) which showed resistance reaction with damage score 1. However, some of resistant genotypes had higher population BPH compared to be susceptible check TN1, they were found to be resistant, the variety Burma black selection- 2 which was resistant to planthoppers but supports higher planthopper population in the present study (mean of BPH 77.33/10 hill) than the susceptible variety TN1 (mean of BPH 67/10 hill). Though some of the lines had a higher population compared to susceptible check TN 1, they were found to be resistant to BPH as indicated in the damage score this might be due to inherent characteristics of the genotypes or biochemical properties of the host plant (Akshaya *et al*., 2011) [1].

Among 84 genotypes screened no variety was found immune with damage score 0. The varieties *viz*., Jeerige

samba, Ratana sagar, Ambe mohar, Hasada, Karapu kavalu, Nambari, Kusum kali-1 and Odissa -1 showed resistance reaction with damage score of 1.

Bangara sanna, Malgudi sanna, Jasmine black, Kaagi saale, Andanoor sanna, Mukanna ratna chudi, Kempu battha, Jeerige sanna, Nari kela, Burma black selection 2, Jaldi dhan-1, sanakathi, Mashuri, Bagiri jhulli, Bhajana, GNV-1089 and MTU 1010 exhibited moderate resistance with damage score of 3.

Sindhura madhusale, Navara, Arom rice, Jooliga, Chitti muthyalu, Gouri sanna 1, Sidda sanna, NMS2, Madras sanna, Raichur sanna, Ganga baali, Rajamudi, Phrandarvanki, Selam sanna selection, Aasana chudi, Gouri sanna 2, Kagga selection, masoori, Jaldi dhan-2, Chitti muthyalu, Black rice, mulamanji, Philippines black rice, Khudrath paddy, Basapathre, Kusum kali-2 and GNV-1109 showed moderately susceptible reaction with damage score of 5.

Asaleeya, Kaamadhali, Anthara saali, Doddigaselam, Burma black 1, Giddagouri, Ralugali, Bili chigi, Alooru sanna, Kari gajivili, Jaldi dhan-3, Godhavariiskaravalu and Gangavathi sona exhibited susceptible reaction with damage score of 7.

BPT-5204, Gandha saale, Jugal paddy, Anandi, High protein rice, kari jodya, Shandar saali, Navalisaali, karekallu, Gangavanthi sanna, New SH sona, Hmt, Sanna paddy, Daasmati, Mugada Sugandha, Athi kariya, China ponni, RNR15048 and check TN-1 showed highly susceptible reaction with damage score of 9.

The number of variants with different resistance reactions is listed in Table 3, and Fig. 1 shows graphically the percentage of rice genotypes that show differential reactions to brown planthoppers. Twenty conventional rice cultivars were highly vulnerable to BPH, whereas thirteen conventional rice varieties had a susceptible response. Seventeen were fairly resistant, and about eight of the conventional rice varieties that were being screened were showing resistant reactions. We observed twenty genotypes of traditional rice to be somewhat sensitive.

The reported molecular markers associated with these resistant genes were used in the current investigation to validate the presence of BPH resistance genes. The set of markers used in this study was carefully chosen following a comprehensive review of the literature and experience with their prior use. Six known gene-linked markers for brown planthopper resistance genes were used to screen these genotypes that demonstrated resistant and moderate resistant reactions in phenotypic scoring. Table 2 lists the markers used in this investigation.

In order to establish a relationship between phenotypic and genotypic observation, band analysis was performed and genotypes were graded using markers in the current study. The amount of intense bands that occurred in the test varieties' marker banding pattern for various markers linked to particular brown planthopper resistance genes—as illustrated in Plates 2 and 3—was used to score the genotypic data. Table 4 displays the genotypic data scoring based on the presence or lack of a band using primers unique to brown planthoppers.

The region linked to the brown planthopper R gene *Bph17* was amplified using the RM8213 primer and was visualized by a product of 150-230 bp (Plate. 2a). *Bph17* was detected in 23 rice varieties. The region linked to the BPH R gene *Bph3* yielded a 160-220 bp fragment when amplified with the RM589 primer (Plate. 2b) and was detected in 16 rice varieties. Region linked to the BPH QTL was amplified using the RM410 primer and visualized as an amplicon of 180-295 bp (Plate. 2c). 15 varieties contained the brown planthopper resistant QTL. The region linked to the brown planthopper R gene *Qbp3* was detected with marker RM154 (Plate. 3a) produced an amplicon of 170-230 bp and was detected in 20 rice genotypes. The region linked to the brown planthopper R gene *Qbph6* showed that 22 varieties produced a band of 120-140 bp when amplified with RM314 primer (Plate. 3b). The region linked to the brown planthopper R gene *Bph21* was amplified using the RM5479 primer and was visualized by a product of 180-260 bp (Plate. 3c). *Bph21* was only detected in 13 rice varieties (Table 5).

Comparative study of molecular characterisation and phenotypic screening

From the comparative analysis of molecular identification and phenotypic screening for BPH resistance, it was found that Kempu battha, Nari kela, Burma black selection 2 and Mukanna ratna chudi showed moderately resistance reaction in phenotypic screening with a damage score of 3 and have six resistance genes in molecular profiling. Similarly, Jaldi dhan-1, Bagiri jhulli and Bhajana gave moderately resistant reactions in phenotypic screening with 3 damage score and have only five resistance genes in molecular profiling. Ambe mohar, Hasada, Karapu kavalu, Nambari, Kusum kali-1 and Odissa -1 also have five resistance genes for brown planthopper resistance but it showed a resistant reaction in the phenotypic scoring with damage score 1. Kaagi saale, Jeerige sanna, Mashuri and GNV-1089 have four resistance genes and they showed resistance in phenotypic reaction. Bangara sanna, MTU-1010, Malgudi sanna and Jasmine black have three resistance genes against BPH and showed resistant reaction in the phenotypic scoring. Jeerige samba, Ratana sagar and Andanoor sanna have two R genes and Jeerige samba, Ratana sagar has shown resistant reaction with phenotypic damage score 1, while Andanoor sanna shown moderately resistant reaction in the phenotypic scoring with damage score 3. TN-1 has shown a highly susceptible reaction in the phenotypic scoring with a damage score of 9 with one R gene.

By considering above investigating data clearly showed that field screening of traditional rice varieties against brown planthopper results revealed that about 8 genotypes *viz*., Jeerige samba, Ratana sagar, Ambe mohar, Hasada, Karapu kavalu, Nambari, Kusum kali-1 and Odissa -1 showed resistance to brown planthopper, 17 traditional rice varieties were showed moderate resistance, 27 rice varieties exhibited moderate susceptible, around 13 varieties were susceptible and 20 varieties showed highly susceptible reaction to brown planthopper.

Molecular characterisation of brown planthopper resistance genes in promising genotypes indicated that out of 6 primers, Kempu battha, Nari kela, Burma black selection 2 and Mukanna ratna chudi specified positive bands for all six primers. Jaldi dhani-1, Bagiri jhulli, Bhajana, Ambe mohar, Hasada, Karapu kavalu, Nambari, Kusum kali-1 and Odissa -1 gave positive bands for five primers. Subsequently, Kaagi saale, Jeerige sanna, Mashuri and GNV-1089 gave positive bands for four primers. Bangara sanna, MTU-1010, Malgudi sanna and Jasmine black showed positive bands for 3 primers. Even in Jeerige samba, Ratana sagar and Andanoor

sanna have two R genes each. For TN-1 only one of the primer shown amplifications.

In conclusion, analyzing phenotyping and genotyping for the BPH resistance feature in closely related crop germplasm will contribute to the wise use of genetic resources. The study conducted by Chakravathy and Rambabu (2006) [3] highlights the significant role that genetic variation analysis plays in breeding material selection, monitoring, and genetic gain prediction. Kempu battha, Nari kela, Burma black selection 2, Mukanna ratna chudi shown all six resistance genes/QTLs namely *Bph17*, *Bph3*, *QTL*, *Qbp3*, *Qbph6* and *Bph21* when amplied using gene linked markers RM8213, RM589, RM410, RM154, RM314 and RM5479 respectively. These genotypes were found resistant in both phenotypic and molecular study. Further these genotypes can be utilized in the crop improvement or breeding programme for developing new cultivar with BPH resistance through MAS.

The capacity of BPH to quickly become virulent on novel plant genotypes and to generate new biotypes for the breakdown of resistant varieties, however, significantly increased the difficulties of breeding for resistance. Resistance of rice to BPH has been reported several times and most of the resistant donors have been identified in traditional varieties (Kalode and Krishna, 1979; Jena *et al*., 2006) [8, 7].

Table 1: List of traditional rice genotypes used in the study

Sl. No.	Genotypes	Sl. No.	Genotypes
1	Sindhura madhusale	40	Hmt
2	Jeerige samba	41	Sanna paddy
3	Bangara sanna	42	Ralugali
4	Gandha saale	43	Bili chigi
5	Ratana sagar	44	Alooru sanna
6	Malgudi sanna	45	Rajamudi
7	Jugal paddy	46	Phrandarvanki
8	Anandi	47	Selam sanna selection
9	Asaleeya	48	Daasmati
10	Navara	49	Aasana chudi
11	Kaamadhali	50	Burma black selection 2
12	Jasmine black	51	Mugada Sugandha
13	Ambe mohar	52	Hasada
14	Kaagi saale	53	Athi kariya
15	High protein rice	54	Gouri sanna 2
16	Arom rice	55	Kagga selection
17	Kari jodya	56	Masoori
18	Anthara saali	57	Kali gajivili
19	Doddigaselam	58	BPT- 5204
20	Shandar saali	59	Jaldi dhan-1
21	Navalisaali	60	Jaldi dhan-2
22	Jooliga	61	Jaldi dhan-3
23	Karekallu	62	Chitti muthyalu
24	Chitti muthyalu	63	Black rice
25	Gouri sanna 1	64	China ponni
26	Gangavanthi sanna	65	sanakathi
27	Sidda sanna	66	mulamanji
28	Burma black 1	67	Karapu kavalu
29	Andanoor sanna	68	Philippines black rice
30	Mukanna ratna chudi	69	Godhavariis karavalu
31	Kempu battha	70	Khudrath paddy
32	Jeerige sanna	71	Basapathre
33	NMS2	72	Mashuri
34	Madras sanna	73	Nambari
35	Giddagouri	74	Bagiri jhulli
36	New SH sona	75	Kusum kali-1
37	Raichur sanna	76	Kusum kali-2
38	Ganga baali	77	Bhajana
39	Nari kela	78	Odissa -1

List of popular verities used for BPH resistance

Sl. No.	Popular rice varieties	Checks for screening against brown planthopper resistance
1	Gangavathi sona	TN 1 (Susceptible check)
2	GNV-10-89	
3	RNR15048	
4	MTU 1010	
5	GNV-1109	
6	BPT-5204	

Table 2: Details of markers used for detection of R genes/QTLs for brown planthopper in PCR

Sl. No.	Gene/QTL	Marker	Annealing temperature (°C)	Forward (5' – 3')	Reverse (3'- 5')
1	Bph17(t)	RM8213	55	AGCCCAGTGATACAAAGATG	GCGAGGAGATACCAAGAAAG
2	Bph3	RM589	55	GTGGCTTAACCACATGAGAAACTACC	TCACATCATTAGGTGGCAATCG
3	QTL	RM410	55	GCTCAACGTTTCGTTCCTG	GAAGATGCGTAAAGTGAACGG
4	Qbp3	RM154	61	ACCCTCTCCGCCTCGCCTCCTC	CTCCTCCTCCTGCGACCGCTCC
5	QBph6	RM314	55	CTAGCAGGAACTCCTTTCAGG	AACATTCCACACACACACGC
6	Bph21	RM5479	55	AACTCCTGATGCCTCCTAAG	TCCATAGAAACAATTTGTGC

Table 3: Classification of selected rice genotypes according to their reaction to the brown planthopper population during *Kharif* 2021

Sl. No.	Genotypes	45 DAT	60 DAT	75 DAT	Mean	Damage score	Reaction
1	Sindhura madhusale	36	91	151	92.66	5	MS
2	Jeerige samba	34	54	102	63.33	1	R
3	Bangara sanna	43	98	169	103.33	3	MR
4	Gandha saale	44	104	183	110.33	9	HS
5	Ratana sagar	28	52	75	51.66	1	R
6	Malgudi sanna	22	94	180	98.66	3	MR
7	Jugal paddy	16	107	*	61.50	9	HS
8	Anandi	33	74	*	53.50	9	HS
9	Asaleeya	35	41	74	50.00	7	S
10	Navara	35	127	143	101.67	5	MS
11	Kaamadhali	27	109	79	71.66	7	S
12	Jasmine black	21	56	68	48.33	3	MR
13	Ambe mohar	20	69	91	60.00	1	R
14	Kaagi saale	19	54	159	77.33	3	MR
15	High protein rice	31	64	*	47.50	9	HS
16	Arom rice	33	93	107	77.67	5	MS
17	Kari jodya	29	83	*	56.00	9	HS
18	Anthara saali	23	77	132	77.33	7	S
19	Doddigaselam	23	81	98	67.33	7	S
20	Shandar saali	37	62	*	49.50	9	HS
21	Navalisaali	22	85	*	53.50	9	HS
22	Jooliga	57	71	144	90.66	5	MS
23	Karekallu	38	63	*	50.52	9	HS
24	Chitti muthyalu	45	98	159	100.66	5	MS
25	Gouri sanna 1	49	74	132	85.00	5	MS
26	Gangavanthi sanna	43	55	*	49.00	9	HS
27	Sidda sanna	42	77	129	82.66	5	MS
28	Burma black 1	37	63	72	57.33	7	S
29	Andanoor sanna	26	49	76	50.33	3	MR
30	Mukanna ratna chudi	26	54	79	53.00	3	MR
31	Kempu battha	30	67	159	85.33	3	MR
32	Jeerige sanna	47	71	175	97.66	3	MR
33	NMS2	23	76	132	77.00	5	MS
34	Madras sanna	45	68	114	75.66	5	MS
35	Giddagouri	40	77	127	81.33	7	S
36	New SH sona	30	80	*	55.00	9	HS
37	Raichur sanna	28	67	116	70.33	5	MS
38	Ganga baali	63	83	132	92.66	5	MS
39	Nari kela	36	57	73	55.33	3	MR
40	Hmt	47	71	*	59.00	9	HS
41	Sanna paddy	40	83	*	61.50	9	HS
42	Ralugali	36	92	71	66.33	7	S
43	Bili chigi	59	87	87	77.66	7	S
44	Alooru sanna	87	90	85	87.33	7	S
45	Rajamudi	66	69	121	85.33	5	MS
46	Phrandarvanki	53	74	143	90.00	5	MS

47	Selam sanna selection	25	57	97	59.66	5	MS
48	Daasmati	53	89	*	71.00	9	HS
49	Aasana chudi	58	61	116	78.33	5	MS
50	Burma black selection 2	41	54	137	77.33	3	MR
51	Mugada Sugandha	100	78	*	89.00	9	HS
52	Hasada	29	49	88	55.33	1	R
53	Athi kariya	80	82	*	81.00	9	HS
54	Gouri sanna 2	44	95	187	108.66	5	MS
55	Kagga selection	49	57	167	91.00	5	MS
56	Masoori	60	64	177	100.33	5	MS
57	Kari gajivili	59	79	181	106.33	7	S
58	BPT- 5204	49	92	*	70.50	9	HS
59	Jaldi dhan-1	21	70	109	66.66	3	MR
60	Jaldi dhan-2	18	72	123	71.00	5	MS
61	Jaldi dhan-3	20	81	98	66.33	7	S
62	Chitti muthyalu	22	63	92	59.00	5	MS
63	Black rice	25	70	137	77.33	5	MS
64	China ponni	55	79	*	67.00	9	HS
65	Sanakathi	21	71	91	61.00	3	MR
66	Mulamanji	27	78	89	64.66	5	MS
67	Karapu kavalu	32	59	97	62.66	1	R
68	Philippines black rice	43	63	122	76.00	5	MS
69	Godhavariis karavalu	59	69	184	104.00	7	S
70	Khudrath paddy	33	51	89	57.66	5	MS
71	Basapathre	27	67	102	65.33	5	MS
72	Mashuri	19	54	89	54.00	3	MR
73	Nambari	21	47	64	44.00	1	R
74	Bagiri jhulli	16	44	81	47.00	3	MR
75	Kusum kali-1	17	42	124	61.00	1	R
76	Kusum kali-2	20	51	67	46.00	5	MS
77	Bhajana	23	45	80	49.33	3	MR
78	Odissa -1	11	57	77	48.33	1	R
79	Gangavathi sona	14	84	197	98.33	7	S
80	GNV-1089	17	52	81	50.00	3	MR
81	RNR15048	31	69	*	50.00	9	HS
82	MTU 1010	34	45	67	48.66	3	MR
83	GNV-1109	36	63	97	65.33	5	MS
84	BPT-5204	32	99	161	97.33	9	HS
85	TN 1 (C)	52	68	81	67.00	9	HS

*Plants died due to hopper burn ; DAT- Days after transplanting

Table 4: Classification of selected rice genotypes according to their reaction to brown planthopper

Reaction	Number of genotypes	Genotypes
Highly Resistant	**0**	-
Resistant	8	Jeerige samba, Ratana sagar, Ambe mohar, Hasada, Karapu kavalu, Nambari, Kusum kali-1, Odissa -1.
Moderately Resistant	17	Bangara sanna, Malgudi sanna, Jasmine black, Kaagi saale, Andanoor sanna, Mukanna ratna chudi, Kempu battha, Jeerige sanna, Nari kela, Burma black selection 2, Jaldi dhan-1, sanakathi, Mashuri, Bagiri jhulli, Bhajana, GNV-1089, MTU 1010.
Moderately susceptible	27	Sindhura madhusale, Navara, Arom rice, Jooliga, Chitti muthyalu, Gouri sanna 1, Sidda sanna, NMS2, Madras sanna, Raichur sanna, Ganga baali, Rajamudi, Phrandarvanki, Selam sanna selection, Aasana chudi, Gouri sanna 2, Kagga selection, masoori, Jaldi dhan-2, Chitti muthyalu, Black rice, mulamanji, Philippines black rice, Khudrath paddy, Basapathre, Kusum kali-2, GNV-1109.
susceptible	13	Asaleeya, Kaamadhali, Anthara saali, Doddigaselam, Burma black 1, Giddagouri, Ralugali, Bili chigi, Alooru sanna, Kari gajivili, Jaldi dhan-3, Godhavariiskaravalu, Gangavathi sona.
Highly Susceptible	20	BPT-5204, Gandha saale, Jugal paddy, Anandi, High protein rice, kari jodya, Shandar saali, Navalisaali, karekallu, Gangavanthi sanna, New SH sona, Hmt, Sanna paddy, Daasmati, Mugada Sugandha, Athi kariya, China ponni, RNR15048, TN-1.

Table 5: Scores of promising genotypes for the presence of brown planthopper resistance genes following genotypic evaluation with markers

Sl. No.	Genotypes	Phenotypic score	Markers						Number of R genes/QTLs present
			RM8213	RM589	RM410	RM154	RM314	RM5479	
			Bph17	Bph3	QTL	Qbp3	Qbph6	Bph21	
			150-230 bp	160-220 bp	180-295 bp	170-230 bp	120-140 bp	180-260 bp	
1	TN-1	9	1	0	0	0	0	0	1
2	Jeerige samba	1	1	0	1	0	0	0	2
3	Bangara sanna	3	0	0	1	1	1	0	3
4	Ratana sagar	1	1	0	0	0	1	0	2
5	Malgudi sanna	3	0	0	1	1	1	0	3
6	Ambe mohar	1	1	1	0	1	1	1	5
7	Kaagi saale	3	1	0	1	0	1	1	4
8	Kempu battha	3	1	1	1	1	1	1	6
9	Jeerige sanna	3	1	1	0	0	1	1	4
10	Nari kela	3	1	1	1	1	1	1	6
11	Burma black selection 2	3	1	1	1	1	1	1	6
12	Hasada	1	1	1	1	1	1	0	5
13	Jaldi dhan-1	3	1	0	1	1	1	1	5
14	Karapu kavalu	1	1	1	1	1	1	0	5
15	Mashuri	3	1	0	0	1	1	1	4
16	Nambari	1	1	1	1	1	0	1	5
17	Bagiri jhulli	3	1	1	1	1	1	0	5
18	Kusum kali-1	1	1	1	0	1	1	1	5
19	Bhajana	3	1	1	1	1	1	0	5
20	Odissa -1	1	1	1	0	1	1	1	5
21	GNV-1089	3	1	0	0	1	1	1	4
22	Sanakathi	3	1	1	1	1	1	0	5
23	MTU-1010	3	0	1	0	1	1	0	3
24	Mukanna ratna chudi	3	1	1	1	1	1	1	6
25	Jasmine black	3	1	1	0	1	0	0	3
26	Andanoor sanna	3	1	0	0	0	1	0	2

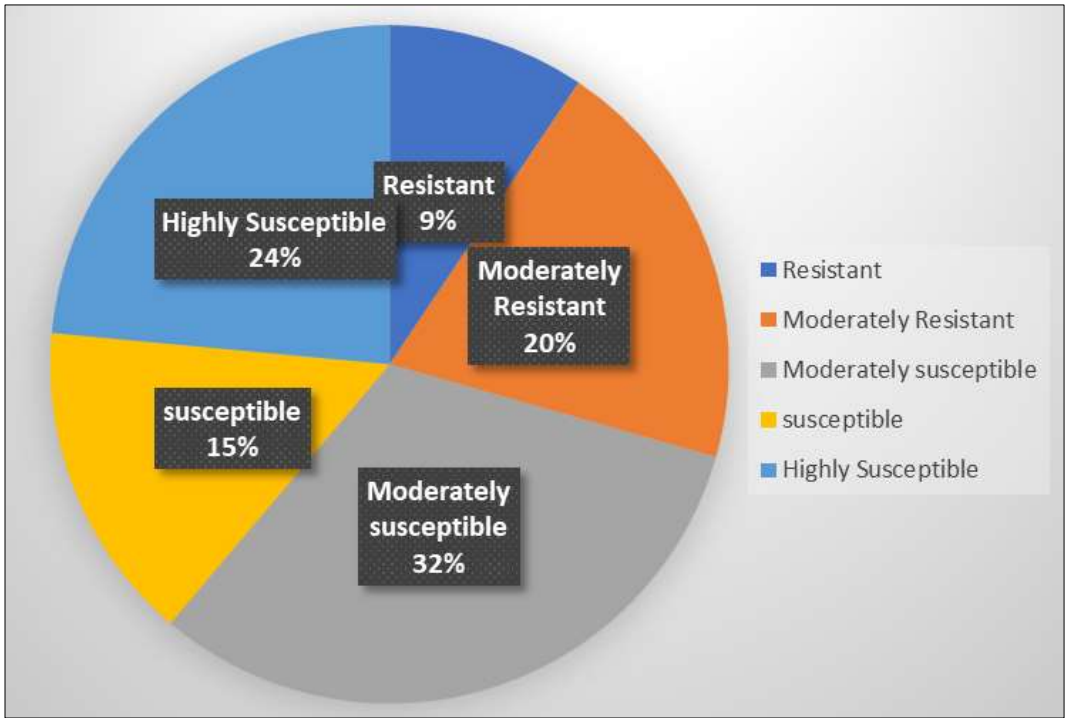

Fig 1: Per cent of rice genotypes with different reaction towards brown planthopper **infestation**

Plate 1: Field view of paddy genotypes screening against brown planthopper

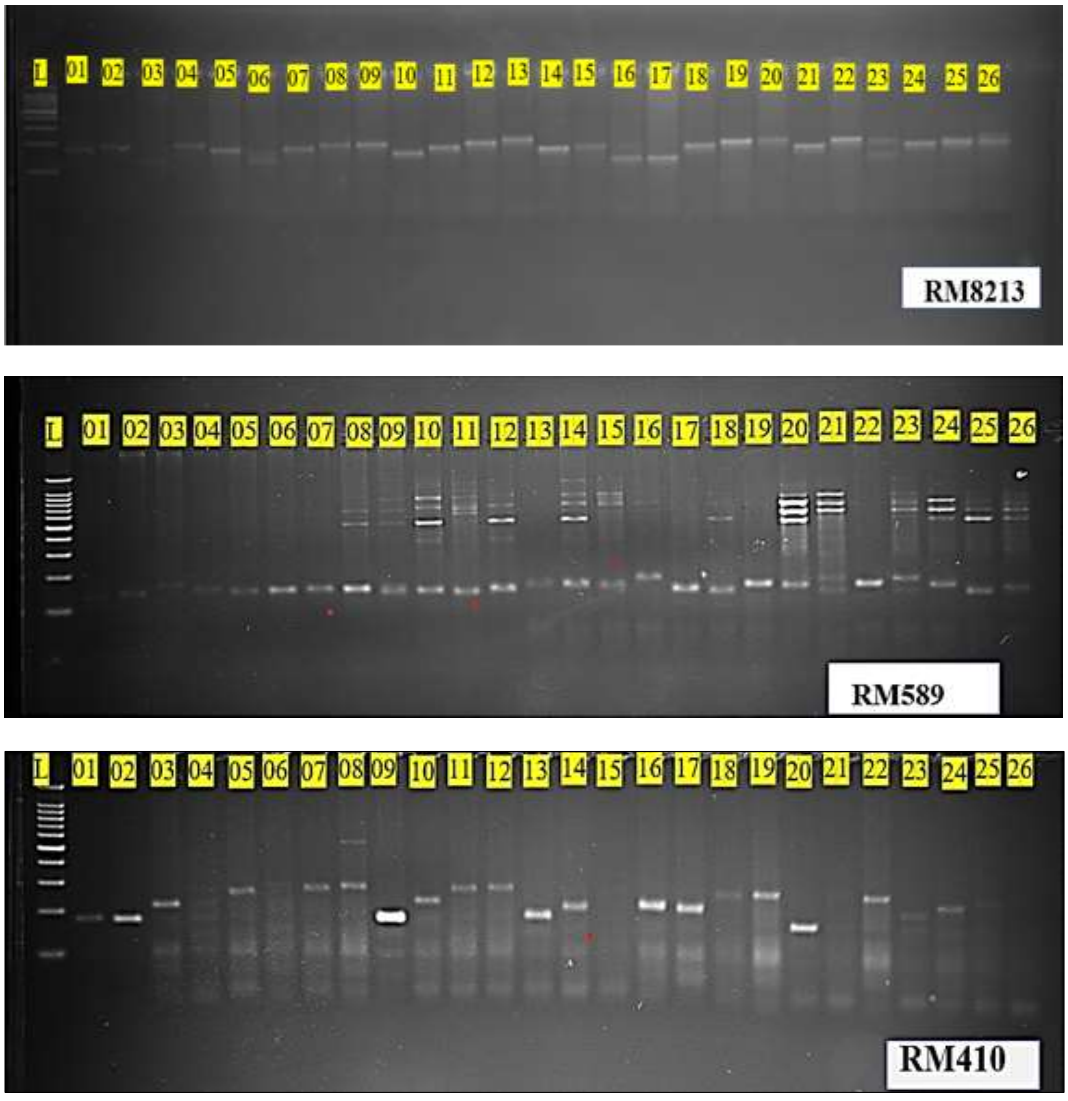

Plate 2: Molecular profiling of promising genotypes resistant to brown planthopper

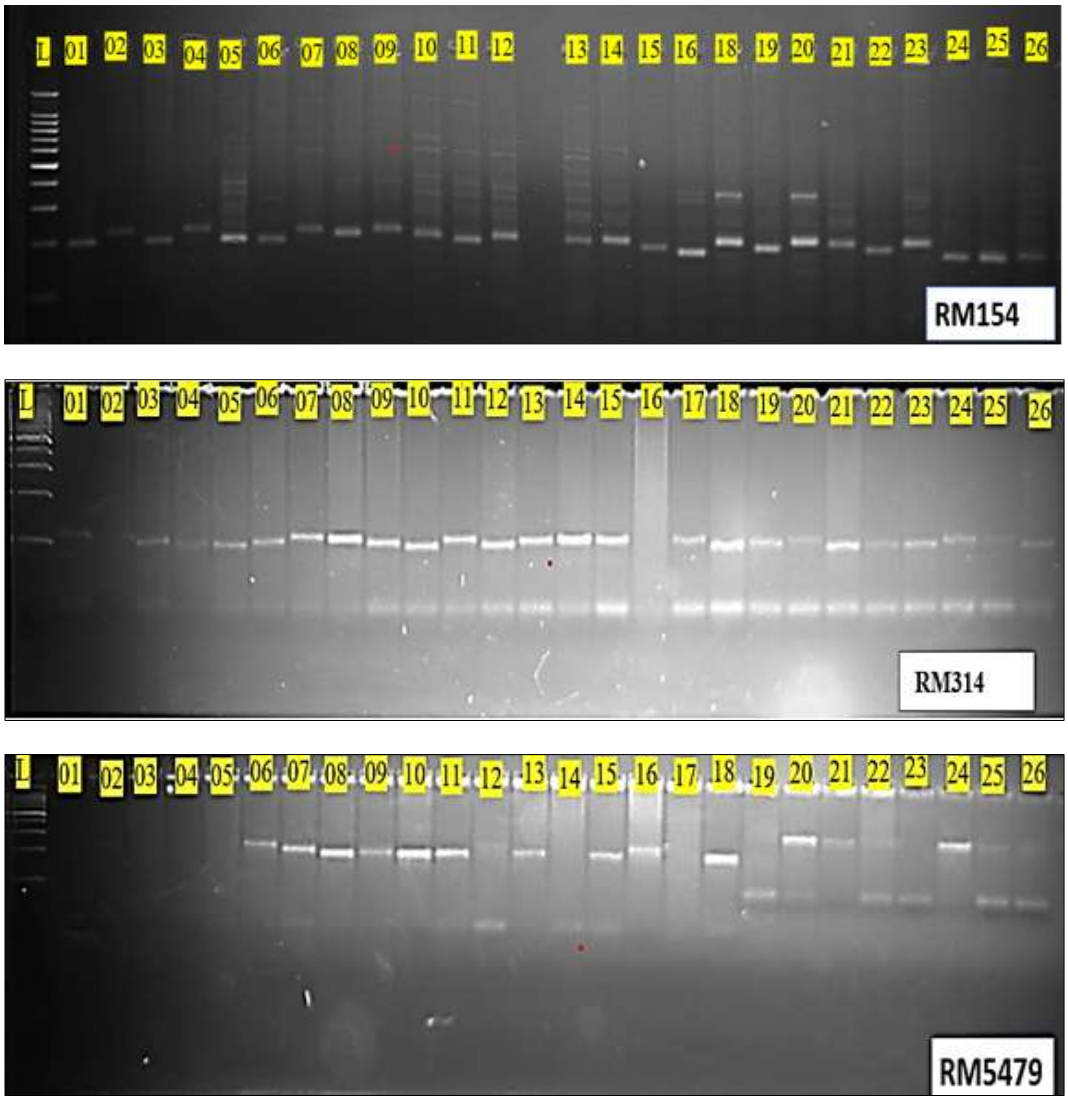

Plate 3: Molecular profiling of promising genotypes resistant to brown planthopper

Conclusion

This study detailed the BPH resistance phenotyping and genotyping of the 84 rice genotypes for brown plant hopper resistance. Specifically in Kempu battha, Nari kela, Burma black selection 2, and Mukanna ratna chudi, the accurate evaluation of rice phenotyping and the molecular characterisation found in this work are highly informative and effective in selecting parent lines and establishing new breeding populations. The neutral and co-dominant nature of SSR markers makes them effective instruments for evaluating the genetic variability of the genotypes being studied. The data gathered from the genotypes' phenotypic response and genetic variability will be highly helpful for choosing the right parents for rice breeding projects as well as in the process of using marker-assisted selection (MAS) and mapping genes.

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