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GENETICS OF BROWN PLANTHOPPER (*NILAPARVATA LUGENS* STAL.) RESISTANCE IN ELITE DONORS OF RICE (*ORYZA SATIVA* L.)

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ABSTRACT
The inheritance of resistance to the brown planthopper (BPH) in four BPH resistant donors of rice *i.* e., Sinna Sivappu, Sudu Hondarawala, PTB 33 and BM 71 was studied both in field and greenhouse conditions. The F_2 population of crosses involving donors Sinna Sivappu, Sudu Hondarawala and PTB 33 fit into the ratio of 13:3 indicating the resistance to BPH was controlled by two genes *i.* e., one dominant and one recessive gene segregating independent to each other. The F_2 population of donor BM 71 involving crosses fit into the ratio of 3:1 revealing single dominant gene control of BPH resistance. So that BM 71 can be used for easy incorporation of BPH resistance into susceptible high yielding rice varieties.

INTRODUCTION

Rice (*Oryza sativa* L.) is an important food crop that serves as a major carbohydrate source for nearly half of the world's population (Sundaram *et al*., 2008). In India also rice is the most important cereal food crop after wheat. It is being grown over 42.86 m ha area with a total production of 104.32 m t annually (Ministry of Agriculture, 2011-12). Although, rice is cultivating in large area but the final yield gain per unit area is very less due to biotic and abiotic stresses. So that in rice, breeding for resistance to biotic and abiotic stresses is one of the important breeding objectives as they affect the yield levels. Among the biotic stresses, breeding for insect resistance is very important as various insect pests attack rice plant during different stages of its growth and development and reduce yields.

Among the various insect pests which effect rice brown planthopper (BPH) is one of the most devastating pest and causes yield loss up to 60 per cent (Panda and Khush, 1995). Out breaks of BPH in 1972, 1973 and 1974 in Asian countries and several parts of India had created unprecedented yield losses in rice (Kulshreshtha *et al*., 1974). Similarly in Andhra Pradesh high yielding varieties like Sambamashuri and Swarna were developed and being cultivated but these varieties lack resistance to BPH resulting in severe yield losses (Mathur *et al*., 1999 and Krishnaiah *et al*., 1999). Attempts to control brown planthopper with chemical pesticides have given rise to many problems, including elimination of natural predators and environmental pollution. Therefore, development of resistant varieties to BPH is the best and cheap method. In breeding of BPH resistant varieties the crucial step is identification of appropriate donors by studying the number, nature and diversity of genes controlling resistance. Sources of resistance to BPH were first identified in 1967 (Pathak *et al*., 1969). Since then, many donors like Mudgo, ASD 7, Rathu Heenathi, Babawee, ARC 10550 and Swarnalata *etc*., were identified and used in breeding BPH resistant varieties (Heong and Hardy, 2009). 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 elite donors *viz*., Sinna Sivappu, Sudu Hondarawala, PTB 33 and BM 71 of rice.

MATERIALS AND METHODS

In the present investigation during *rabi* 2011 crosses were made involving four BPH resistant donors *viz*., Sinna Sivappu, Sudu Hondarawala, PTB 33 and BM 71 and five high yielding BPH susceptible rice varieties *viz*., IR 64, PLA 1100, BPT 5204, MTU 7029 and MTU 1075 in line × tester fashion and obtained 20 crosses. The crosses were evaluated for their reaction against BPH resistance both in field and greenhouse conditions.

During *kharif* 2011 seedlings of parents, F_1 crosses and susceptible check (TN1) were transplanted in main field and in standard seed box in greenhouse. In *rabi* 2012 the test seedlings (F_2s and parents) were transplanted in paired rows in main field. After every two paired rows and between the two different crosses test seedlings (F_2 seedlings) paired rows, four rows of susceptible check *i.e*., TN1 seedlings were

transplanted. In addition to that six rows of susceptible check *i.e.*, TN1 seedlings were transplanted as border rows of the field to serve as bombardment rows for infestation of test seedlings with BPH insects (Radhakrishna Murthy, 1983) and also seeds of F_2s were sown in trays *i.e.*, standard seed box screening technique (Heinrichs *et al.*, 1985) to know the reaction of test seedlings to BPH under green house conditions.

In standard seed box screening method seeds were sown in rows of about 5 cm apart in 60 × 45 × 10 cm galvanized iron trays filled with soil. PTB 33 was used as the resistant check and TN1 as the susceptible check. Seven to eight days old seedlings were infested with 2nd and 3rd instar nymphs of brown planthopper. The seedlings were infested uniformly by distribution of 8 to 10 nymphs per seedling throughout the seed box. Observations on the plant reaction were recorded on single plant basis when about 95 per cent of the susceptible check *i.e.*, TN1 in seed box was damaged.

The scoring was done as per 0-9 scale (0 = no damage, 1 = slight yellowing of the plant, 3 = Leaves partially yellow but with no hopper burn, 5 = Leaves with pronounced yellowing and some stunting or wilting and hopper burn, 7 = Wilting of the plant, 9 = Death of whole plant) of Standard Evaluation System (SES) for rice (IRRI, 1980). In F_1 generation, all the individual plants were scored for BPH damage. Whereas, in F_2 population of different crosses, score for BPH damage was recorded on 600 plants in field screening and on 200 plants in standard seed box screening, when 95 % of the susceptible check TN1 was damaged.

Table 1: Reaction of parents to BPH

Parent	Type of reaction
Sinna Sivappu	R(2.4)
PTB 33	R (2.2)
Sudu Hondarawala	R (2.2)
BM 71	R (2.1)
IR 64	S (7.0)
BPT 5204	S (8.0)
PLA 1100	S (7.4)
MTU 7029	S (8.6)
MTU 1075	S (7.0)

R- Resistant S- Susceptible; Figures in the parenthesis indicate the average plant damage score recorded as per 0-9 scale of Standard Evaluation System (SES) for rice (IRRI, 1980)

RESULTS

The inheritance pattern of resistance to BPH was studied in twenty F_1s along with their nine parents during *kharif* 2011and *rabi* 2012. Out of nine parents, Sinna Sivappu, PTB 33, Sudu Hondarawala and BM 71 were BPH resistant donors while, IR 64, BPT 5204, PLA 1100, MTU 7029 and MTU 1075 were high yielding BPH susceptible varieties (Table 1). The F_1 plants of all the crosses showed resistant reaction to BPH in both field and greenhouse conditions (Tables 2 and 3). During *rabi,* 2012 F_2 population of all the crosses studied in both field and greenhouse conditions under standard seed box technique.

The F_2s of the crosses *viz*., Sinna Sivappu × IR 64, Sinna Sivappu × BPT 5204, Sinna Sivappu × PLA 1100, Sinna Sivappu × MTU 7029, Sinna Sivappu × MTU 1075, PTB 33 × IR 64, PTB 33 × BPT 5204, PTB 33 × PLA 1100, PTB 33 × MTU 7029, PTB 33 × MTU 1075, Sudu Hondarawala × IR 64, Sudu Hondarawala × BPT 5204, Sudu Hondarawala × PLA 1100, Sudu Hondarawala × MTU 7029 and Sudu Hondarawala × MTU 1075 segregated into 13:3 (R:S) ratio (Tables 2 and 3) in both field and green house conditions. The F_2 population of crosses *viz*., BM 71 × IR 64, BM 71 × BPT 5204, BM 71 × PLA 1100, BM 71 × MTU 7029 and BM 71× MTU 1075 segregated into 3:1 (R:S) ratio (Tables 2 and 3) in both field and green house conditions.

DISCUSSION

In the present study all the F_1s showed resistant reaction to

Table 2: Chi- square test for goodness of fit in F_2 populations of crosses involving four BPH resistant donors and five BPH susceptible testers (Field screening)

Cross	Reaction of F_1 population	F_2 population (no. of seedlings) Resistant	Susceptible	Genetic ratio	χ^2 value
Sinna Sivappu × IR 64	R (3.0)	482	118	13:3	0.3309
Sinna Sivappu × BPT 5204	R (2.4)	479	121	13:3	0.7904
Sinna Sivappu × PLA 1100	R (2.6)	488	112	13:3	0.0027
Sinna Sivappu × MTU 7029	R (2.8)	486	114	13:3	0.0246
Sinna Sivappu × MTU 1075	R (2.8)	489	111	13:3	0.0246
PTB 33 × IR 64	R (3.0)	489	111	13:3	0.0246
PTB 33 × BPT 5204	R (2.6)	483	117	13:3	0.2215
PTB 33 × PLA 1100	R (2.6)	481	119	13:3	0.4622
PTB 33 × MTU 7029	R (3.0)	485	115	13:3	0.0684
PTB 33 × MTU 1075	R (2.8)	480	120	13:3	0.6154
Sudu Hondarawala × IR 64	R (2.8)	484	116	13:3	0.1340
Sudu Hondarawala × BPT 5204	R (2.8)	478	122	13:3	0.9873
Sudu Hondarawala × PLA 1100	R (3.0)	491	109	13:3	0.1340
Sudu Hondarawala × MTU 7029	R (2.8)	488	112	13:3	0.0027
Sudu Hondarawala × MTU 1075	R (2.6)	481	119	13:3	0.4622
BM 71 × IR 64	R (2.1)	448	152	3:1	0.0356
BM 71 × BPT 5204	R (2.5)	445	155	3:1	0.2222
BM 71 × PLA 1100	R (2.4)	453	147	3:1	0.080
BM 71 × MTU 7029	R (2.3)	445	155	3:1	0.2223
BM 71 × MTU 1075	R (2.4)	443	157	3:1	0.4356

R- Resistant; Figures in the parenthesis indicate the average plant damage score recorded as per 0-9 scale of Standard Evaluation System (SES) for rice (IRRI, 1980)

Table 3: Chi- square test for goodness of fit in F_2 populations of crosses involving four BPH resistant donors and five BPH susceptible testers (Standard seedbox screening)

Cross	Reaction of F_1 population	F_2 population (no. of seedlings) Resistant	Susceptible	Genetic ratio	χ^2 value
Sinna Sivappu × IR 64	R (2.8)	166	34	13:3	0.2954
Sinna Sivappu × BPT 5204	R (3.0)	165	35	13:3	0.1313
Sinna Sivappu × PLA 1100	R (2.6)	161	39	13:3	0.0328
Sinna Sivappu × MTU 7029	R (3.0)	160	40	13:3	0.1313
Sinna Sivappu × MTU 1075	R (2.8)	165	35	13:3	0.1313
PTB 33 × IR 64	R (2.4)	159	41	13:3	0.2954
PTB 33 × BPT 5204	R (2.6)	167	33	13:3	0.5251
PTB 33 × PLA 1100	R (2.6)	165	35	13:3	0.1313
PTB 33 × MTU 7029	R (3.0)	166	34	13:3	0.2954
PTB 33 × MTU 1075	R (3.0)	161	39	13:3	0.0328
Sudu Hondarawala × IR 64	R (2.8)	161	39	13:3	0.0328
Sudu Hondarawala × BPT 5204	R (2.8)	164	36	13:3	0.0328
Sudu Hondarawala × PLA 1100	R (2.8)	158	42	13:3	0.5251
Sudu Hondarawala × MTU 7029	R (2.8)	158	42	13:3	0.5251
Sudu Hondarawala × MTU 1075	R (2.6)	164	36	13:3	0.0328
BM 71 × IR 64	R (2.3)	152	48	3:1	0.060
BM 71 × BPT 5204	R (2.5)	154	46	3:1	0.3267
BM 71 × PLA 1100	R (2.4)	155	45	3:1	0.540
BM 71 × MTU 7029	R (2.1)	150	50	3:1	0.1667
BM 71 × MTU 1075	R (3.0)	155	45	3:1	0.540

R- Resistant; Figures in the parenthesis indicate the average plant damage score recorded as per 0-9 scale of Standard Evaluation System (SES) for rice (IRRI, 1980)

Table 4: Number and nature of genes controlling BPH resistance in donors

Name of the donor	No. of genes	Nature of gene (s)
Sinna Sivappu	Two	One dominant gene and one recessive gene
PTB 33	Two	One dominant gene and one recessive gene
Sudu Hondarawala	Two	One dominant gene and one recessive gene
BM 71	One	One dominant gene

BPH damage, this revealed that the resistance to BPH was governed by dominant genes. These findings were in close agreement with the findings of Sidhu and Khush (1978), Ryoichi and Chukichi (1981), Radhakrishna Murthy (1983), Angeles *et al*. (1986), Lakshminarayana and Khush (1977) and Haiyuanyang *et al*. (2002). The segregation pattern in F_2 population of different crosses indicated that the resistance to BPH in Sinna Sivappu, PTB 33 and Sudu Hondarawala was conditioned by two genes *i.e*., one dominant gene and one recessive gene segregating independent of each other *i. e*., inhibitory gene action. This study thus substantiates the findings of Sidhu and Khush (1978), Ryoichi and Chukichi(1981), Radhakrishna Murthy (1983) and Angeles *et al*. (1986). The segregation pattern in F_2 population of BM 71 involving crosses indicated the resistance to BPH was found to be monogenic dominant. Similar results were also reported by Lakshminarayana and Khush (1977), Haiyuanyang *et al*. (2002) (Table 4).

The cultivars found resistant to brown planthopper cannot themselves be developed as improved variety due to poor genetic background, but the genes for resistance which they possess can be incorporated into agronomically sound rice genotypes (Verma *et al*., 2001). For instance Bph1, the dominant gene for resistance to brown planthopper was incorporated in released varieties *viz*., IR 26, IR 28, IR 29 and IR 30. The resistance was subsequently broken down by a new biotype of BPH at IRRI, Philippines. Later on, other genes were incorporated into IR 32, IR 36 and IR 38. Thus, for sequential release of resistant varieties, new genes for resistance for combating changed biotypes of insect are required after a span of time.

The cultivars which possess single dominant or recessive gene for resistance to BPH are of immense value for crop improvement. Hence, with the single gene inheritance of BM 71 for BPH resistance is considered to be more advantageous than the other traditional donors for easy incorporation of the resistance trait into the susceptible high yielding varieties of rice by breeding methods like back cross breeding and hybridization. Further investigations will focus on to confirm the genetic ratios obtained in F_2 generation and whether the genes present in these donors are novel or similar.

REFERENCES

Angeles, E. R., Khush, G. S. and Heinrichs, E. A. 1986. Inheritance of resistance to brown planthopper and leafhoppers in rice. *Proceedings of the International Rice Genetics Symposium*, 27-31 may 1985, Manila, Philippines. **IRRI:** 537-549.

Haiyuanyang, Xiang Ren., Qingmei, W., Lili, Z. and Guangcun, H. 2002. Molecular mapping and genetic analysis of a rice brown planthopper (*Nilaparvata lugens* Stal.) resistance gene. *Hereditas*. **136**: 39-43.

Heinrichs, E. A., Medrano, F. G. and Rapusas, H. R. 1985. Genetic evaluation for insect resistance in rice. *Los Banos (Philippines): International Rice Research Institute*. 1-356.

Heong, K. L. and Hardy, B. 2009. Plant hoppers: new threats to the sustainability of intensive rice production systems in Asia. *Los Banos (Philippines): International Rice Research Institute*. pp. 401-428.

IRRI 1980. Standard Evaluation System for rice. The International Rice Research Institute, Los Banos, Philippines. p. 44.

Krishnaiah, K., Reddy, A. P. K., Krishnaiah, N. and Pasalu, I. C. 1999. Current problems and future needs in plant protection in rice. *Indian J. f Plant Prot*. **27(1&2):** 47-64.

Kulshreshtha, J.P., Anjaneyulu, A. and Padmanabhan, S. Y. 1974. A disastrous brown plant hopper attack in Kerala. *Indian Farming*. **24(9)**: 5-9.

Lakshminarayana, A. and Khush, G. S. 1977. New genes for resistance to the brown planthopper in rice. *Crop Science*. **17:** 96-100.

Mathur, I. C. C., Reddy, P. R., Rajamani, S. and Moorthy, B. T. S. 1999. Integrated pest management in rice to improve productivity and sustainability. *Oryza*. **36(3):** 195-205.

Ministry of Agriculture 2011-12. Government of India. www.indiastat.com.

Panda, N. and Khush, G. S. 1995. *Host Plant Resistance to Insects*. CAB International, Walling Ford, Oxon, U.K. 431.

Pathak, M.D., Cheng, C.H. and Furtono, M.E. 1969. Resistance to *Nephotettix cincticeps* and *Nilaparvata lugens* in varieties of rice. Nature. **223:**502-504.

Radhakrishna Murthy, K. 1983. Genetics of inheritance of resistance to brown planthopper (*Nilaparvatalugens* Stal.) in rice (*Oryza sativa* L.) using diverse sources of resistance. *M.sc. (Ag) Thesis*.Andhra Pradesh Agricultural University, Hyderabad, India.

Ryoichi, I. and Chukichi, K. 1981. Genetic analysis of resistance to brown planthopper (*Nilaparvatalugens*Stal.) in rice. *Japan J. Breeding*. **3(3):** 279-285.

Sidhu, G. S. and Khush, G. S. 1978. Genetic analysis of brown planthopper resistance in twenty varieties of rice (*Oryza sativa* L.). *Theoretical and Applied Genetics*. **53:** 199-203.

Sundaram, R. R., Vishnupriya, M. R., Birdar, S. K., Laha, G. S., Ashok Reddy, G., Shoba Rani, N., Sarma, N. P and Sonti, R. V. 2008. Marker assisted introgression of bacterial blight resistance in Samba Mahsuri, an elite indica rice variety. *Euphytica*. **160**: 411-422.

Verma, V. K., Rastogi, N. K., Pophaly, D. J. and Mishra, R. K. 2001. Genetics of resistance to brown planthopper (*Nilaparvata lugens* Stal.) in rice (*Oryza sativa* L.). *Oryza*. **38(1&2):** 6-8.