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Short Communication

Identification of promising resistance sources against sheath blight from the annual wild species of rice *Oryza nivara* (Sharma *et* Shastry)

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Abstract

Sheath blight caused by soil borne necrotrophic fungus *Rhizoctonia solani* [teleomorph-*Thanatephorus cucumeris* (Frank) Donk.] is a major disease of rice. The disease is increasing over the year in India and cause up to 69% yield loss under favourable conditions. A total of 67 accessions of *Oryza nivara* were screened to identify resistance against sheath blight during 2015. Out of these, 16 accessions were found moderately resistant (MR) which were further evaluated during the year 2016 and 2017. After three years of screening, 12 of them were found to have a consistent moderate resistant reaction whereas four of the *O. nivara* accessions namely, IRGC81941, IRGC102463C, CR100097 and CR100110A have shown moderately susceptible to susceptible reaction against sheath blight. A correlation study revealed that different disease variables measured were significantly ($P < 0.05$) correlated. All the genotypes and genotype × environment interaction had a significant ($P < 0.001$) effect on all the disease variables. Cluster analysis showed that all the accessions were clustered into four groups which showed resistant, MR, moderately susceptible and susceptible reactions. Among all the *O. nivara* accessions IRGC81941A showed the maximum potential against sheath blight due to a least relative lesion height of 22.80%. None of the accession had complete resistance to the disease. The identified promising accessions such as IRGC81835, IRGC81941A, CR100008 and CR100111B can be utilized in a sheath blight resistance breeding program.

Keywords: disease variables, *Oryza nivara*, *Rhizoctonia solani*, sheath blight, wild species of rice

Introduction

Rice sheath blight caused by soil borne necrotrophic fungus *Rhizoctonia solani* is one of the major rice (*Oryza sativa* L.) disease (Lee and Rush, 1983; Rush and Lee, 1992). The yield losses due to sheath blight are recorded up to 69% under the intensive crop management and favourable environmental conditions (Sivalingam *et al.*, 2006). The pathogen has a wide host range and necrotrophic nature. Moreover, evaluation of sheath blight resistance in rice fields is very difficult because resistance is

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Table 1. Screening of promising accessions of *Oryza nivara* for sheath blight resistance during the years 2016 and 2017

S. no.	Accession number	Mean PH (cm)		Mean LH (cm)		Mean RLH (%)		DS		Disease reaction	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
1	IRGC81835	97.67 ± 1.15	83.33 ± 2.08	23.33 ± 3.21	23.67 ± 0.58	23.90 ± 3.42	28.4 ± 0.17	3 ± 0	3 ± 0	MR	MR
2	IRGC81847	103.33 ± 4.92	90.67 ± 2.08	25.33 ± 4.93	26 ± 1	24.40 ± 3.51	28.67 ± 0.51	3 ± 0	3 ± 0	MR	MR
3	IRGC81941	102.67 ± 3.21	100.33 ± 2.08	29.33 ± 2.30	35 ± 3.61	28.56 ± 1.79	34.85 ± 2.97	3 ± 1.15	5 ± 0	MR	MS
4	IRGC81941A	124.67 ± 15.50	128.67 ± 1.53	27.33 ± 2.08	29.33 ± 0.58	22.02 ± 1.16	22.8 ± 0.3	3 ± 0	3 ± 0	MR	MR
5	IRGC102463C	117.67 ± 6.65	105.33 ± 2.52	34.00 ± 1.73	50.33 ± 2.08	28.90 ± 0.20	47.83 ± 3.09	3 ± 0	7 ± 1.15	MR	S
6	IRGC103841	118.67 ± 12.85	110.67 ± 1.15	30.33 ± 4.04	28.33 ± 0.58	25.67 ± 3.35	25.6 ± 0.25	3 ± 0	3 ± 0	MR	MR
7	IRGC106397	132.00 ± 3.60	112.67 ± 2.52	28.33 ± 12.42	28.3 ± 2.52	21.31 ± 9	25.09 ± 1.7	3 ± 1.15	3 ± 0	MR	MR
8	CR100008	140.00 ± 10.58	110.67 ± 5.51	30.00 ± 16.09	27.67 ± 0.58	21.58 ± 11.50	25.03 ± 0.81	3 ± 1.15	3 ± 0	MR	MR
9	CR100097	144.33 ± 1.15	141.33 ± 4.04	41.67 ± 3.05	44.33 ± 5.03	28.86 ± 1.94	31.42 ± 4.16	3 ± 1.15	5 ± 1.15	MR	MS
10	CR100103	149.67 ± 5.03	127.33 ± 2.52	33.33 ± 11.71	29.67 ± 1.53	22.24 ± 7.65	23.29 ± 0.78	3 ± 1.15	3 ± 0	MR	MR
11	CR100106A	136.00 ± 19.46	113.67 ± 3.51	30.00 ± 11.35	30.67 ± 2.52	23.05 ± 10.64	26.95 ± 1.39	3 ± 1.15	3 ± 0	MR	MR
12	CR100110A	135.67 ± 1.15	152.67 ± 5.03	40.00 ± 20	48.33 ± 1.53	29.49 ± 1.50	31.66 ± 0.09	3 ± 1.15	5 ± 0	MR	MS
13	CR100110B	141.00 ± 3.60	115.33 ± 4.51	37.33 ± 1.52	25.9 ± 3.0	26.51 ± 1.71	22.41 ± 1.72	3 ± 0	3 ± 0	MR	MR
14	CR100111B	108.33 ± 1.52	98.17 ± 2.02	29.33 ± 2.88	28.93 ± 1.68	27.06 ± 2.40	29.46 ± 1.16	3 ± 0	3 ± 0	MR	MR
15	CR100113	148.67 ± 1.52	143.67 ± 4.04	40.67 ± 1.52	41.33 ± 1.15	27.35 ± 0.74	28.77 ± 0.53	3 ± 0	3 ± 0	MR	MR
16	CR100114	153.00 ± 2	145.67 ± 4.51	43.00 ± 2.64	42.33 ± 2.52	28.10 ± 1.48	29.05 ± 0.85	3 ± 0	3 ± 0	MR	MR
17	PR114	102.67 ± 2.08	103 ± 4	63.67 ± 5.68	63 ± 8.19	61.97 ± 4.44	61.03 ± 5.58	7 ± 1.15	7 ± 1.15	S	S
Mean		126.82	116.65	34.52	35.47	27.70	30.72	3.23	3.78	–	–
Minimum		97	81	12	23	8.33	20.72	1	3	–	–
Maximum		158	158	70	72	66.67	67.28	9	9	–	–
Std deviation		19.46	20.01	10.95	11.02	10.04	9.77	1.36	1.44	–	–
Standard error		2.72	2.80	1.53	1.54	1.40	1.36	0.19	0.20	–	–
LSD (C.D.) 5%		4.16	5.64	3.98	4.91	4.50	3.57	0.70	0.80	–	–

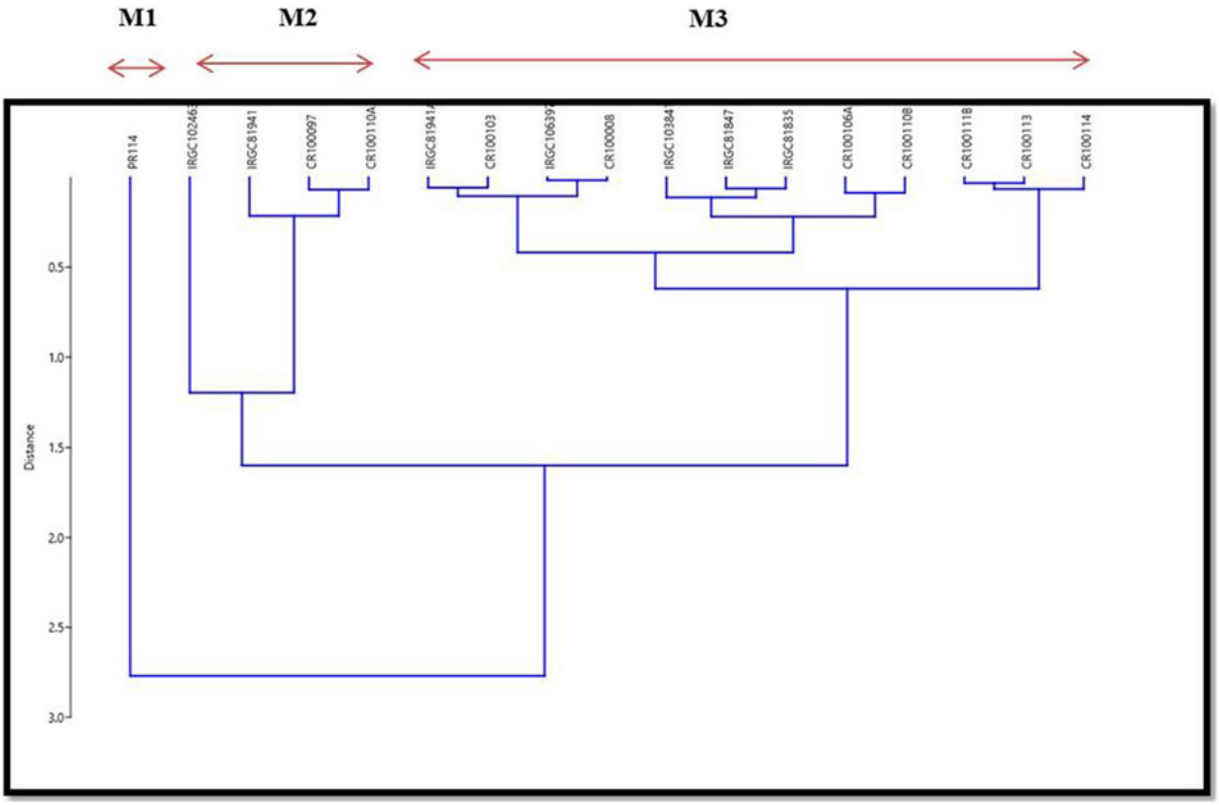

Fig. 1. Cluster representation among *O. nivara* accessions during 2016 and 2017.

largely affected by morphological characteristics such as plant height (PH), plant type, tillering, heading date and ecological aspects such as water and N fertilization (Hashiba *et al.*, 1981; Groth and Nowick 1992). As a consequence, no source of complete genetic resistance or immunity to sheath blight is known in *O. sativa* (Chen *et al.*, 2000; Eizenga *et al.*, 2002; Liu *et al.*, 2006; Zhang *et al.*, 2006). Thus, exploring different germplasm became an international effort for getting resistance to sheath blight (Xie *et al.*, 1992; Jia *et al.*, 2007; Zuo *et al.*, 2009). Wild species germplasm of rice constitute a valuable resource for the improvement of modern rice cultivars in terms of providing resistance/tolerance against biotic and abiotic stresses (Khush *et al.*, 1990; Rangel *et al.*, 2008; Zhang and Xie, 2014; Arbelaez *et al.*, 2015; Eizenga *et al.*, 2016; Ma *et al.*, 2016; Haritha *et al.*, 2018; Kishor *et al.*, 2018; Quan *et al.*, 2018). An investigation was carried out to identify potential sources for resistance against sheath blight in *Oryza nivara* accessions at Punjab Agricultural University (PAU), Ludhiana during 2015, 2016 and 2017.

Experimental

The plant materials consisted of 67 accessions of *O. nivara* were originally procured from International Rice Research Institute (IRRI), Manila, Philippines and National Rice Research Institute (NRRI), Cuttack, India. Isolation of *Rhizoctonia solani* was performed from the susceptible cultivar PR121 showing the sheath blight symptoms. The standard protocol for isolation was used. The maize meal-sand (1:3) medium method was used for inoculation (Lore *et al.*, 2012). Disease assessment was made 21 days after inoculation under field conditions. Three plants from each accession in two replications were screened every year. Relative lesion height (RLH) was calculated using the formula given by Sharma *et al.* (1990). Data were analysed using the general linear model procedure in the SAS system Cary, NC). The cluster is reported as unweighted pair group method using arithmetic means based on the Mahalanobis distance algorithm (PAST 3.0).

Results

A total of 67 accessions with susceptible check PR114 were screened during 2015. Out of these, 16 (23.88%) were moderately resistant (MR), 21 (31.34%) were moderately susceptible (MS) and 30 (44.77%) were susceptible (S) (online Supplementary Figure S1). The PH ranged from 44 to 171 cm, lesion height (LH) ranged from 21 to 99 cm, RLH ranged from 18.84 to 97.67% and DS (DS) ranged

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from 1 to 9 (online Supplementary Table S1). All the accessions were clustered into four groups (M1, M2, M3 and M4) by the Mahalanobis distance on the basis of RLH and DS. The group M2 with 16 accessions showed the MR reaction with the minimum values of LH, RLH and DS, i.e. 34.56 cm, 22.67% and 3 respectively. The group M4 had the maximum values of LH, RLH and DS, i.e. 70.48 cm, 74.84% and 8.2 respectively (online Supplementary Table S2). All the genotypes and genotype × environment interaction had a significant ($P < 0.001$) effect on all the disease variables. The environment interaction had a significant ($P < 0.001$) effect on all the disease variables except LH ($P > 0.30$) (online Supplementary Table S3).

Based on screening during the year 2015, 16 MR accessions were selected and further evaluated during the years 2016 and 2017 (Table 1). The PH ranged from 81 to 158 cm, the LH ranged from 12 to 72 cm, the RLH ranged from 8.33 to 67.28% and the DS ranged from 1 to 9 for both the years. The different disease variables measured were significantly ($P < 0.05$) correlated. RLH had a positive correlation with LH (0.86) and DS (0.93). The LH showed positive correlation with DS, with a correlation coefficient of 0.81. There was a negative correlation between PH and DS, with a correlation coefficient of −0.24 (online Supplementary Table S4). Sixteen accessions *O. nivara* were selected and clustered into three groups (M1, M2 and M3) on the basis of different disease variables (Fig. 1). The first group M1 with susceptible check PR114 showed the highest values of LH (63.33 cm), RLH (61.50%) and DS (7.0) (online Supplementary Figure S2).

Discussion

Several attempts were made to identify sources for sheath blight resistance in rice genotypes but only partial resistance was identified to date (Amante *et al.*, 1990; Pan *et al.*, 1999; Prasad and Eizenga, 2008; Ram *et al.*, 2008). We also observed partial resistance in the studied *O. nivara* accessions. The most probable explanation is the pathogen behaviour like necrotrophic nature, wide host range, soil borne and anastomosis. These characters make the pathogen to invade positively and lesion progression is higher than the resistant level. The other attributes includes significant effects of GXE interaction on disease variables which ultimately resulted in moderate resistance behaviour of studied germplasm. Zeng *et al.* (2017) studied the environmental effect on disease progression among 169 genotypes and observed a highly significant ($P < 0.0001$) effect. A positive correlation between RLH and DS was observed. This is due to the fact that the LH is determining factor for the progression of disease and the RLH is directly proportional to LH. Similarly, a negative correlation was explicable between PH and RLH as the RLH is the ratio of LH and PH. Similar relationship among disease variables is also reported by other scientist (Hossain *et al.*, 2014; Wen *et al.*, 2015). We identified *O. nivara* accessions with possible sheath blight resistance and were crossed with the elite cultivars to generate backcrossed derivatives for transferring the sheath blight resistance.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S1479262119000315.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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