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Durable resistance of rice varieties to blast disease

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Abstract
At the Agricultural Research Station in Lonavala, District of Pune (MS), a thorough screening program was implemented in an effort to identify the basis of the paddy's long-lasting resistance to blast. Over the course of three years, 3,917 advanced entries/varieties of rice from various origins were screened for leaf blast resistance (2016–18). Of the rice entries/varieties that were evaluated, 36 were resistant to neck blast during either of the testing years, while 174 were resistant and the remaining were moderately sensitive to highly susceptible to leaf blast. No rice entry was found to be extremely resistant to neck blast. The entries/varieties VL 31320, KJT 5-1-10-22-38-13, and CR 2675-10-2-1-1 were resistant, KJT-2, out of the 174 resistant entries that were evaluated. RAU 631-9-10, NLR 20104, PAU 3105-45-3-2, and 2K3-337-5-1-1-5. While Swarnadhan, HKR-05-22, and CN 1447-9-4-7 were somewhat vulnerable to leaf blast, CB-06-555 and TeTep were moderately resistant. These entries/varieties are therefore thought to have long-lasting resilience. The remaining entries showed unstable resistance to leaf blasts. It was discovered that the majority of entries/varieties with persistent resistance to leaf blast also had persistent resistance to panicle blast. VL 31320, KJT-2, HKR-05-22, CN 1447-9-4-7, PAU 3105-45-3-2, and 2K3-337-5-1-1-5 were moderately vulnerable to neck blast, whereas NLR 20104 was the only entry that was resistant. KJT 5-1-10-22-38-13 and TeTep were moderately resistant. Less than five disease severity indices to leaf and neck blasts were present in all of these entries. To evolve blast-resistant rice varieties for large-scale production, it is advised to use the types with durable resistance in breeding programs.

Keywords: Rice, *Pyricularia grisea*, blast, durable resistance

Introduction
The most affordable and efficient method of managing blast, a rice disease that frequently causes devastating effects, is to employ resistant cultivars. However, due to resistance breaking down in the face of *Pyricularia* grisea's great pathogenic diversity and adaptability to cultivated variety, many cultivars' usable life spans in disease-prone settings are only a few years. Therefore, the development of more robust cultivars through breeding has taken precedence in the improvement of rice. When a cultivar's resistance holds true despite being widely cultivated in a disease-friendly environment, it is said to be durable. Breeders and pathologists of rice are therefore constantly faced with the task of breeding for disease resistance. The Agricultural Research Station, Lonavala, District - Pune (MS) assessed advanced entries/varieties of rice from various origins for blast resistance from 2016 to 2018.

Materials and Methods
The material included 3976 rice entries /varieties of different origins. EK - 70 and HR-12 were the susceptible and TeTep, Ajaya and Rasi were resistant checks. For screening against leaf blast, the method of uniform blast nurseries was followed (Ahn, 1994) [1] and evaluation of blast resistance was based on 0-9 score (Anonymous, 2002) [4]. Neck blast disease was evaluated for the same rice entries in the separate field nursery during same years where blast disease occurred severely The varieties, EK - 70 and HR-12 were the susceptible while; TeTep, Ajaya and Rasi were resistant checks. The percentage of diseased panicles was computed and converted to score 0-9. Durable resistance was evaluated based on disease severity index (DSI) as defined by Ahn (1994) [1] with slight modifications.

$$DSI = \frac{\text{Sum of compatible reaction scores}}{\text{Total number of years showing compatible reaction}}$$

DSI < 5: indicates durable resistance
DSI >5: indicates susceptibility or unstable resistance

Results and Discussion

Leaf blast: Based on the scores of each variety, the reactions of rice entries / varieties to leaf blast in three years were divided into four groups. Group I: resistance with 174 varieties (4.38%) with score from 1-2; Group II: moderate resistance with 483 varieties (12.16%) with score 3; Group III: moderately susceptible with 2103 varieties (52.90%) with score from 4 to 6; Goup IV: susceptible to highly susceptible with 1183 varieties (29.76%) showing score from 7 to 9 in all the years. Thirty two (0.8%) entries/ varieties did not show. consistent reactions. It was noted that the percentage of highly resistant varieties was nil. Similarly, resistant varieties were very low. A high number of varieties were susceptible or highly susceptible to leaf blast. Typical varieties of rice in each group are given in Table 1.

Durable resistance of the rice varieties to leaf blast: Rice varieties showing consistently resistant to moderately resistant reactions across the years were considered to possess broad spectrum resistance. Varieties showing DSI below 5 after testing over years were considered durably resistant. This type of resistance is generally quantitative and controlled by major gene(s) (Ahn and Ou, 1982) [3]. Ahn (1994) [1] called this type of resistance as durable resistance which had the same meaning of field resistance, partial resistance or quantitative resistance and proposed to use the disease severity index (DSI) as a criterion for evaluating durable resistance to blast disease. Varieties with DSI above 5 were unstable for resistance.

The entries/varieties (Table 2) *viz*., KJT 5-1-10-22-38-13, CR 2675-10-2-1-1, VL 31320, KJT-2, NLR 20104, RAU 631-9-10. PAU 3105-45-3-2, 2K3-337-5-1-1-5, CB-06-555. Swarnadhan, and CN 1447-9-4-7 had score normally varying from 0-4, which showed durable resistance to leaf blast. The susceptible checks EK - 70 and HR - 12 had scores of 9 and 8-9 with DSI of 9 and 8.67, respectively. The resistant checks TeTep, Rasi and Ajaya showed DSI of 2.67, 3.33 and 4.0, respectively. Data from the international testing program for blast resistance of IRRI showed DSI of TeTep = 5.3 (Ahn, 1998) [2].

Neck/Panicle blast: The occurrence of neck blast at the flowering to maturity stage causes empty spikelets resulting in yield loss directly. The correlation between leaf blast resistance at the early stage and panicle blast resistance at the flowering stage of the same variety is not always positive. Therefore, it is essential to evaluate the resistance of rice varieties to panicle blast also.

The results (Table 3) indicated that Groups I (resistance), II (moderate resistance), III (moderate susceptible), and IV (susceptible to highly susceptible) had 36, 129, 885 and 2743 rice entries/varieties with 0.90, 3.24, 22.25 and 68.98 percentage of total varieties in the related groups, respectively. One hundred eighty-four (4.63%) entries/ varieties did not show consistent reactions. Father, the percentage of highly resistant varieties to neck blast was nil. Similarly, resistant varieties were very low. A high number of varieties were susceptible or highly susceptible to leaf blast.

The data in Table 4 reveal that NLR 20104, VL 31320, KJT 5-1-10-22-38-13, KJT-2, CN 1447-9-4-7, PAU 3105-45-3-2 and 2K3-337-5-1-1-5 had low percentage of panicles infected (1.0-5.0 %). These varieties were also resistant to leaf blast. The results in respect of both, leaf and neck, blasts are in agreement with Luu and Bong (1999) [5].

Table 1: Reaction of rice varieties to leaf blast Total varieties

Variety group	Range of Score (0-9)	Number of varieties	Total varieties in Group (%)	Typical varieties
HR	0	0	0	
R	1-2	174	4.38	VL 31320, KJT 5-1-10-22-38-13, CR 2675-10-2-1-1
MR	3	483	12.16	KJT-2, NLR 20104, RAU 631-9-10, PAU 3105-45-3-2, 2K3-337-5-1-1-5, CB-06-555. TeTep
MS	4-6	2103	52.90	Swarnadhan, CN 1447-9-4-7, Rasi, Ajaya
S to HS	7-9	1183	29.76	EK70, HR - 12
Unstable	0-9	32	0.8	HKR-05-22

Table 2: Disease severity index (DSI) of leaf blast in promising entries/ varieties of rice

Varieties showing different frequency of leaf blast DSI 1.01-2						
0	**0-1**	**1.01 -2.00**	**2.01-3.00**	**3.01 -4.00**	**4.01-5.00**	**>5.01**
--	--	KJT 5-1-10-22-38-13, CR 2675-10-2-1-1	VL 31320, KJT-2, NLR 20104, RAU 631-9-10, PAU 3105-45-3-2, 2K3-337-5-1-1-5, CB-06-555, TeTep.	Swarnadhan, CN 1447-9-4-7, Rasi, Ajaya	HKR-05-22	EK-70, HR - 12

Table 3: Reaction of rice varieties to neck blast

Variety group	Range of Score (0-9)	Number of varieties	Total varieties in Group (%)	Typical varieties
HR	0	0	0	
R	1-2	36	4.38	NLR 20104
MR	3	129	12.16	KJT 5-1-10-22-38-13, TeTep
MS	4-6	885	52.90	VL 31320, KJT-2, HKR-05-22, Swarnadhan, CN 1447-9-4-7, PAU 3105-45-3-2, 2K3-337-5-1-1-5, Rasi, Ajaya
S to HS	7-9	2743	29.76	EK-70, HR - 12
Unstable	0-9	184	0.8	RAU 631-9-10, CR 2675-10-2-1-1, CB-06-555

HR = Highly resistant, R = Resistant, MR = Moderately resistant, MS = Moderately susceptible, S = Susceptible and HS = Susceptible to highly susceptible.

Table 4: Disease severity index (DSI) of neck blast in promising entries/varieties rice

Varieties showing different frequency of leaf blast DSI 1.01-2						
0	**0-1**	**1.01 -2.00**	**2.01-3.00**	**3.01 -4.00**	**4.01-5.00**	**>5.01**
--	--	NLR-20104	--	KJT 5-1-10-22-38-13, PAU 3105-4-3-2, TeTep	VL 31320, KJT-2, HKR-05-22, CN 1447-9-4-7, 2K3-337-5-1-1-5 and RAU 631-9-10	Swarnadhan, CR 2675-10-2-1-1, CB-06-555, Rasi, Ajaya, EK70, HR - 12

Conclusions

The blast resistant varieties *viz*., VL 31320, KJT 5-1-10-22-38-13, CR 267/11-2-1-1, KJT-2, CN 1447-9-4-7, NLR 20104, RAU 631-9-10, PAU 3105-45-3-2 and 2K3-337-5-1-1-5 identified in this study could be utilized in the breeding program to evaluate varieties with durable resistance to leaf and panicle blast. These varieties should be used only with high caution in pest management. Due to the high variability of the fungus races, the evaluation of rice varieties for blast resistance should be done continuously over time and place in the State of Maharashtra.

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