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Investigation of Elite Rice Genotypes for Resistant against False Smut Disease of Rice in Bihar

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

False smut of rice caused by *Ustilaginoidea virens* is the most devastating disease of rice in different parts of the world including India. The host resistance approach is most important for the management of this disease. In the present investigation, forty-four elite germplasm were screened epiphytotically in kharif 2019-20 at Bihar Agricultural University research farm, Sabour to know disease reaction against the false smut disease of rice. Out of these, seven germplasms *viz.* RVK-04, RVK-06, RVK-16, BRR-0057, BRR-0060, BRR-0078 and Rajendra Swasini were found immune or highly resistant (HR). Sabour Ardhjal showed resistance (R) reaction with very less percent of disease infection (0.68%). Eight germplasms were found moderately resistance (MR) ranges of disease infection 3.24 - 4.81% and six germplasms were showed maximum percent of disease infection (susceptible) *i.e.,* Arize 6444 Gold, Sahbhagi Dhan, RVK-08, RVK-13, RVK-15, BRR-0071 ranged 25.70-26.26%. The highly resistant genotypes may be further utilized for the development of resistant variety through the rice breeding programme.

Keywords: Rice genotypes; false smut disease; rice breeding; germplasms.

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1. INTRODUCTION

Rice is one of the third most important food crops in the world, forms the staple diet of 2.7 billion people. It is the most valuable staple food crop for more than 60% of the world people. The population will increase by up to 4.6 billion by 2050. The projected demand for rice can only be met by maintaining a steady increase in production over the years [1]. Several breeding strategies are being employed in increasing the yield potential of rice and those among the available strategies, hybrid rice offers an immediate opportunity to break the yield plateau set by the semi-dwarf rice varieties after the first green revolution. Among all rice growing states in India, Bihar is at 6th rank in area and production of rice and at thirteen ranks in productivity occupied 33 lakh ha area and 71.62 lakh tons production, respectively. The area, production and productivity of rice was about 0.032 lakh ha, 9600 tons and 2.96 tons per ha, respectively, in Bhagalpur district of Bihar [2]. Major reasons of low production and productivity of rice are lack of high yielding disease pest resistance varieties, inadequate or excess use of nitrogenous fertilizers, poor water management and non-adaptability of recommended disease and insects' management strategies [3,4]. Many rice diseases in India *viz.,* False smut of rice (*Ustilaginoidea virens*), Blast (*Pyricularia oryzae*), Bacterial leaf blight of rice (*Xanthomonas oryzae pv. oryzae*), Brown leaf spot (*Helminthosporium oryzae*), Sheath blight (*Rhizoctonia solani*), Rice tungro virus (*RTV*), Sheath rot (*Sarocladium oryzae*), Leaf scald (*Rhynchosoprium oryzae*), Bakanae disease (*Fusarium moniliforme*) and grain discoloration were recorded in India [5]. Among major rice diseases, false smut of rice caused by *Ustilaginoidea virens* is one of the most destructive disease in all rice growing regions of the world [6]. False smut of rice caused by *Ustilaginoidea virens* was a minor disease previously due to its sporadic occurrence. But, in recent years, it has emerged as the most devastating grain disease and epidemic in the majority of the rice growing areas of India and caused significant yield losses. Pannu et al. [7] reported losses up to 44% in Punjab. In Northern India, in severe cases, the number of infected grains can reach even more than 50 grain per panicle. Since the disease causes direct economic losses to the farmers. However, in the Southern state of India *viz.,* Tamil Nadu, the disease incidence varied from 5 to 85% [8]. In some rice growing districts of Bihar, 15-50% losses occur due to false smut of rice when comes as medium to severe form [9]. Commercial hybrids/HYV of rice in India has been known to possess only low levels of resistance [10]. Information on the genetic material or source of resistance to the disease is very scarce and gene(s) responsible for resistance are yet to be categorically documented under artificial epiphytotic conditions. Nevertheless, breeding for resistance is being tried in India, so far there has been little success due to the non-availability of donor lines with a high level of resistance. The systemic evaluation and identification of potential resistance genotypes of the rice is the major key to the success of any resistance breeding programme. Therefore, the present studies were carried out to know the elite germplasms resistant to false smut of rice.

2. MATERIALS AND METHODS

The field experiment was conducted in the N-5/6 block of Research Farm of Bihar Agricultural University, Sabour. The experimental site is irrigated and having loam soil type. In the present studies, 44 elite germplasm 20 comprising hybrids and 24 pure lines (inbreed) of indica rice were used for screening against false smut disease in field conditions in kharif 2019-20. Each genotype was transplanted in five rows of 7 m length with a row to row and plant to plant 20 × 20 cm spacing in Augmented design. Recommended doses of fertilizer *i.e.* 120 kg N, 60 kg P and 40 kg K were applied as per the best agronomic practices.

2.1 Artificial Inoculation

The false smut pathogen *U. virens* was isolated from the locally available false smut infected spikelets in potato dextrose medium. A single isolated colony of the fungus (arising from a single spore) was picked up using a sterilized needle and maintained as a pure culture. The purified culture of *U. virens* was mass multiplied in 100 ml potato broth (PB) liquid media in a 250 ml flask and incubated at 26 ± 1°C for 25 days. The 25 days old mycelial produced in Petri plate was collected and the chlamydospore was harvested. The suspension was prepared with distilled water with the help of haemocytometer, the concentration of chlamydospore suspension maintain (2×10^5 conidial spores/ml). Each germplasm line grown under in field condition was inoculated by spraying spore suspension with the help of knapsack sprayer at the panicle emergence stage. Usually, the inoculation was

done in the evening hours. Disease reaction was recorded by using 0-9 Scale as per SES scale of rice [11] with disease symbol, where 0= (No disease); Highly Resistance (HR), 1=Less than 1% incidence; Resistant (R), 3= 1.1-5% incidence; Moderately Resistant (MR), 5= 5.1-25% incidence; Moderately susceptible (MS), 7= 25.1-50% incidence; Susceptible (S), 9= 50.1-100% incidence; Highly Susceptible (HS).

2.2 Observations Recorded

Observations were recorded by randomly selected five tagged plants. Numbers of smutted balls per panicle and the number of infected panicles per hill were recorded and the average was calculated. The percent of smutted balls was calculated by the following formula (Bhargava et al. [12]):

> Percent of smutted balls = No. of smutted balls per panicle / Total number of grains per panicle.

For the disease incidence, five plants were randomly tagged from each germplasm and observations were taken on the total number of tillers and the total number of infected tillers in the tagged plants and were calculated by the given formula (Bhargava et al. [12]):

> Disease incidence = No. of smutted tillers× 100 / Total No. of tillers.

For the disease severity (%) randomly five plants were selected and tagged. The percent of disease severity was calculated by multiplying the percent infected tillers with percent smutted balls per panicle [13]. Data analysis was done by used software INDOSTAT 8.3 at the level of significance 0.05%.

3. RESULTS AND DISCUSSION

The symptoms were seen after 15-18 days after the inoculation of spore suspension. Different disease variables such as number of smut balls/panicle, percent of smutted balls/panicle, days to 50% flowering, number of infected grain per panicle, percent disease incidence and percent disease severity were calculated. Among 44 germplasm lines screened against *U. Virens,* RVK-04, RVK-06, RVK-16, BRR-0057, BRR-0060, BRR-0078, Rajendra Suwasini were found to be completely free from the disease (Tables 1 & 2) whereas, the maximum number of smut balls per panicle, number of infected grains/panicle and days of 50% flowering were recorded in case of germplasm Arize 6444 Gold with (5.22, 34.40 and 105 days) followed by Sahbhagi Dhan (4.95, 32.20 and 85 days), RVK-15 (4.65, 27.10 and 93 days), RVK-08 (4.21,24.20 and 86 days), RVK-13 (4.18, 26.10 and 91 days), BRR-0071 (4.05, 23.60 and 102 days) respectively.

Out of 44 germplasms, seven germplasms namely, RVK-04, RVK-06, RVK-16, BRR-0057, BRR-0060, BRR-0078 and Rajendra Suwasini were completely free of disease incidence, disease severity and smut balls/panicle whereas Arize 6444 Gold had highest level of disease and smut balls/panicle with (26.26, 1.85 and 48.62%) followed by Sahbhagi Dhan (26.22, 1.75 and 46.69%), RVK-15 (26.19, 1.69 and 44.28%), RVK-08 (26.15,43.80 and 1.67%), RVK-13 (26.11, 1.66 and 43.24%), BRR-0071 (25.70,1.64 and 42.17%) respectively (Table 1).

The disease reaction was calculated based on disease variable such as No. of smut balls/panicle, percent of infection and disease score (0-9 scale) (Table 2). The germplasms were grouped into six disease scoring scale. Arize 6444 Gold, Sahbhagi Dhan, RVK-08, RVK-13, RVK-15 and BRR-0071 with the highest average of No. of smut balls/panicle (4.05-5.22), percent of infection (25.70-26.26%) and disease scoring (25.1-50%). 22 hybrids and inbreed i.e, RVK-01, RVK-02, RVK-03, RVK-05, RVK-7, RVK-10, RVK-11, RVK-12, RVK-14, Sabour Deep, 27 P 31, Rajendra Sweta, NP-950, BRR-0044, BRR-0053, BRR-0055, BRR-0086, BRR-0089, BRR-0092, MTU-1010, Rajendra Mahsuri-1, Sabour Shree with average of No. of smut balls/panicle (0.97-3.72), percent of infection (10.69-24.68%) and disease scoring (5.1-25.%). 08 hybrids /inbreed *i.e,* RVK-09, Arize 6129 Gold, Sabour Harshit, Sabour Surbhit, Sabour Sampann, Rajendra Kasturi, Swarna, Swarna Sub-1 average of No. of smut balls/panicle (0.72-0.86), percent of infection (3.24-4.81%) and disease scoring (1.1-5%). Sabour Ardhjal showed lowest average values of percent of smut balls/panicle (0.08 %), No. of smut balls/panicle (0.02), No. of infected grains/panicle (4.20) with disease score (< 1%). 07 hybrids/ inbreed i.e. RVK-04, RVK-06, RVK-16, BRR-0057, BRR-0060, BRR-0078, Rajendra Suwasini were free from any infection and showed immune or highly resistance (HR) reaction (Tables 1 & 2). Based on different disease parameters, cluster analysis was done. Out of forty-four germplasms, forty-two elite germplasms differentiated into seven groups. In cluster -1 (11), Cluster-2 (6), Cluster-3 (5), Cluster- 4 (5), Cluster -5 (2), Cluster -6 (10) and Cluster-7 (3) germplasms were found respectively (Fig. 1).

Table 1. Different disease parameters of rice germplasms/varieties against false smut disease of rice

S.N.	Germplasm/Variety	No. of smut balls / panicle	No. of infected grains / panicle	Days of 50% flowering	Per cent of smut balls / panicle	Disease incidence (%)	Disease severity (%)
1	RVK-01	2.75	15.2	93	1.05 (5.88) *	17.77 (24.93) *	18.62 (25.57)*
2	RVK-02	3.33	17.1	92	1.49 (7.01)	20.88 (27.19)	31.12 (33.91)
3	RVK-03	3.23	16.3	82	1.35 (6.68)	19.29 (26.05)	26.14 (30.75)
4	RVK-04	0.00	0.00	96	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
5	RVK-05	3.37	18.3	94	1.50 (7.04)	22.13 (28.06)	33.20 (35.18)
6	RVK-06	0.00	0.00	87	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
7	RVK-07	0.97	13.7	95	0.43 (3.76)	10.85 (19.24)	4.67 (12.48)
8	RVK-08	4.21	24.2	86	1.67 (7.44)	26.15 (30.76)	43.80 (41.44)
9	RVK-09	0.76	8.6	83	0.32 (3.24)	4.30 (11.97)	1.37 (6.72)
10	RVK-10	2.77	15.6	88	1.14 (6.13)	17.99 (25.09)	20.50 (26.72)
11	RVK-11	2.56	12.5	93	1.03 (5.84)	15.73 (23.37)	16.27 (23.79)
12	RVK-12	3.34	17.1	94	1.46 (6.93)	21.03 (27.30)	30.62 (33.60)
13	RVK-13	4.18	26.1	91	1.66 (7.39)	26.11 (30.73)	43.24 (41.12)
14	RVK-14	3.22	16.2	93	1.25 (6.43)	19.14 (25.94)	24.00 (29.83)
15	RVK-15	4.65	27.1	93	1.69 (7.47)	26.19 (30.78)	44.28 (41.72)

S.N.	Germplasm/Variety	No. of smut balls / panicle	No. of infected grains / panicle	Days of 50% flowering	Per cent of smut balls / panicle	Disease incidence (%)	Disease severity (%)
16	RVK-16	0.00	0.00	87	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
17	Arize 6129 Gold	0.85	13.1	87	0.36 (3.45)	4.81 (12.68)	1.74 (7.58)
18	Sabour Deep	2.54	12.4	87	1.04 (5.85)	15.89 (23.49)	16.50 (23.96)
19	27 P 31	2.76	14.2	95	1.06 (5.90)	17.91 (25.03)	18.89 (25.76)
20	Rajendra Sweta	0.98	13.8	86	0.45 (3.84)	10.69 (19.08)	4.79 (12.65)
21	NP-950	3.38	18.4	95	1.50 (7.05)	21.97 (27.95)	33.07 (35.10)
22	BRR-0044	3.35	17.2	102	1.47 (6.96)	20.87 (27.18)	30.61 (33.59)
23	BRR-0053	3.76	22.8	88	1.57 (7.21)	24.68 (29.79)	38.83 (38.54)
24	BRR-0055	1.00	14.4	86	0.41 (3.68)	11.50 (19.83)	4.74 (12.58)
25	BRR-0057	0.00	0.00	86	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
26	BRR-0060	0.00	0.00	117	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
27	BRR-0071	4.05	23.6	102	1.64 (7.36)	25.70 (30.46)	42.17 (40.50)
28	BRR-0078	0.00	0.00	117	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
29	BRR-0086	3.24	16.8	91	1.38 (6.75)	19.32 (26.07)	26.70 (31.11)
30	BRR-0089	2.78	15.7	88	1.14 (6.14)	18.05 (25.14)	20.65 (27.03)
31	BRR-0092	3.42	19.2	102	1.55 (7.15)	24.11 (29.41)	37.31 (37.65)

S.N.	Germplasm/Variety	No. of smut balls / panicle	No. of infected grains / panicle	Days of 50% flowering	Per cent of smut balls / panicle	Disease incidence (%)	Disease severity (%)
32	MTU-1010	3.22	16.8	86	1.37 (6.73)	19.38 (26.12)	26.62 (31.06)
33	Rajendra Mahsuri-1	2.55	12.4	115	1.03 (5.84)	15.77 (23.40)	16.33 (23.83)
34	Sabour Harshit	0.86	13.2	90	0.37 (3.47)	4.80 (12.66)	1.76 (7.63)
35	Sabour Shree	1.02	14.4	96	0.42 (3.72)	11.43 (19.76)	4.81 (12.66)
36	Sabour Ardhjal	0.20	4.20	110	0.08 (1.66)	0.68 (4.73)	0.06 (1.73)
37	Sabour Surbhit	0.82	12.6	102	0.36 (3.43)	4.72 (12.55)	1.69 (7.48)
38	Sabour Sampann	0.72	5.8	117	0.33 (3.29)	3.24 (10.38)	1.07 (5.94)
39	Rajendra Suwasini	0.00	0.00	96	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
40	Rajendra Kasturi	0.78	6.4	95	0.35 (3.39)	3.84 (11.29)	1.34 (6.65)
41	Swarna	0.75	8.2	110	0.32 (3.22)	4.10 (11.69)	1.30 (6.53)
42	Swarna Sub-1	0.77	9.4	110	0.32 (3.26)	4.59 (12.37)	1.49 (7.01)
43	Sahbhagi Dhan (check)	4.95	32.2	85	1.78 (7.67)	26.22 (30.80)	46.69 (43.10)
44	Arize 6444 Gold (check)	5.22	34.4	105	1.85 (7.82)	26.26 (30.83)	48.62 (44.21)
	CD at (P=0.05)	0.11	0.43	-	0.03	0.024	1.02

** Figures under parenthesis are angular transformed values*

Table 2. Disease reaction and disease variables of different elite germplasms/varieties against false smut disease of rice

Disease scoring scale	Scoring (Infection per cent)	Resistance level	No. of germplasms	Per cent of infection (%)	No. Smut Balls/ panicle	Disease Severity (%)	Germplasms
0	0 (No disease)	Highly resistance (HR)	07	0.00 – 0.00	0.00-0.00	0.00-0.0	RVK-04, RVK-06, RVK-16, BRR00-57, BRR-0060, BRR-0078, Rajendra Suwasini
1	< 1%	Resistance (R)	1	0.00-0.68	0.00-0.20	0.00-0.60	Sabour Ardhjal
3	1.1-5%	Moderately resistance (MR)	08	3.24-4.81	0.72-0.86	1.07-1.76	RVK-09, Arize 6129 Gold, Sabour Harshit, Sabour Surbhit, Sabour Sampann, Rajendra Kasturi, Swarna, Swarna Sub-1
5	5.1-25%	Moderately susceptible (MS)	22	10.69-24.68	0.97- 3.72	4.67-38.83	RVK-01, RVK-02, RVK-03, RVK-05, RVK-7, RVK-10, RVK-11, RVK-12, RVK-14, Sabour Deep, 27 P 31, Rajendra Sweta, NP-950, BRR-0044, BRR-0053, BRR-0055, BRR-0086, BRR-0089, BRR-0092, MTU-1010, Rajendra Mahsuri-1, Sabour Shree
7	25.1-50%	Susceptible (S)	06	25.70-26.26	4.05-5.22	42.17-48.62	Arize 6444 Gold, Sahbhagi Dhan, RVK-08, RVK-13, RVK-15, BRR-0071
9	> 50%	Highly Susceptible (HS)	-	-	-	-	-

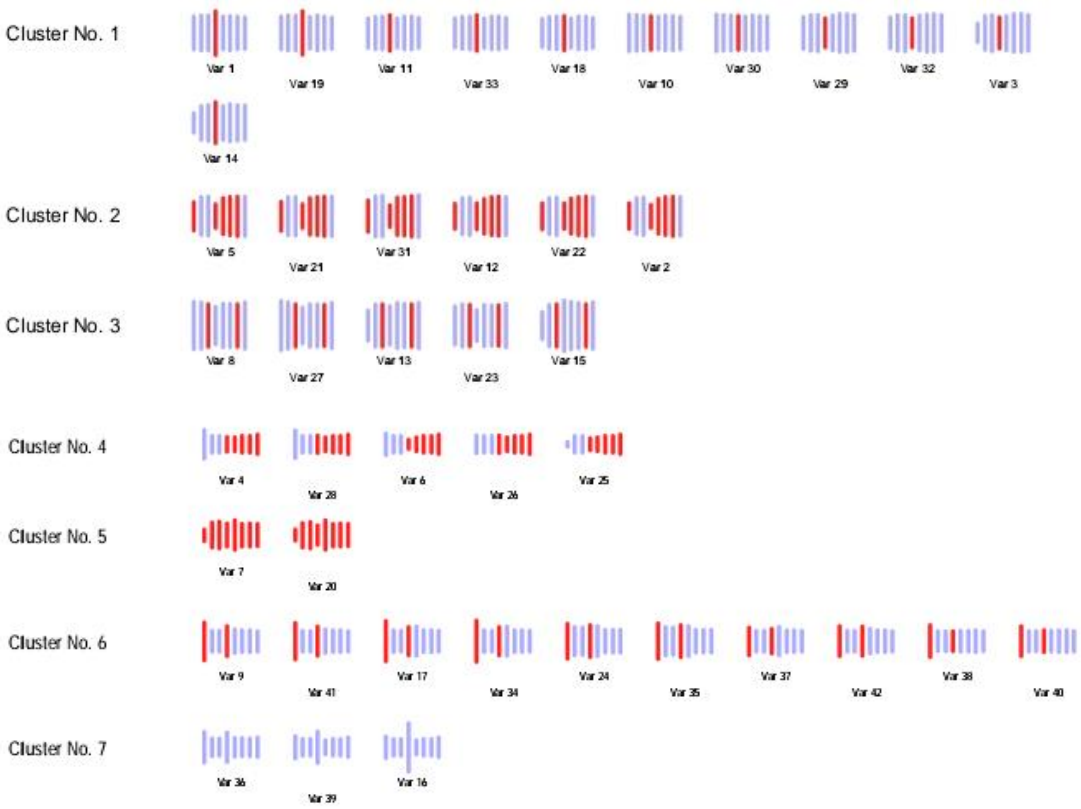

Fig. 1. The cluster analysis based on different disease parameters

The differences between rice cultivars to rice false smut can be attributed to the genetic differences of the tested cultivars in addition to the environmental factors that might affect the host-pathogen interactions [14]. Kumar et al. [15] evaluated 21 rice genotypes for resistance to false smut and found that four rice genotypes resistance *i.e.,* Swarna Shreya, IR96321-1447-521-B-2-1-2, IR96321-1447-651-B-1-1-2, and IR 83294-66-2-2-3-2 were immune or highly resistant against false smut. Sahbhagi Dhan is a highly susceptible variety against false smut of rice in the Middle Indo-Gangetic Zone of Bihar. Lore et al. [16] reported two cultivars *viz.,* PR113 and PR114 were having the lowest level of disease intensity and two hybrids *viz.* NPH 369 and NPH 909, consistently had the highest level of disease intensity. Based on the reaction of 41 rice hybrids to false smut, Biswas [17] reported that eight hybrids were free from the disease. Singh and Singh [18] also screened 98 genotypes against false smut and reported that 27 were highly resistant and 45 were resistant while the remaining 26 had an infection from 5 to 70%. Rao [19] noted that in medium to late duration group of rice, the disease severity index was found high in some cultivars because of the high percentage of incidence and smutted balls. The late duration cultivars were also reported to be more severely infected with false smut [20,21]. The varietal character may also be one important reason for the difference in disease severity. Thus, it may be due to that hybrids had the highest percent infected tillers, smutted ball per panicle and disease severity index as compared to improved varieties in late duration. This might be due to the long duration flowering phase in hybrids favoured the disease severity. The resistance to false smut may be attributable to plant perception of pathogen-associated molecular patterns, activation of resistance signaling pathways in different genotyped and suppression of pathogenicity genes in *U. virens* [22].

4. CONCLUSION

Based on the above findings, it was observed that the seven rice genotypes *viz.* RVK-04, RVK-06, RVK-16, BRR00-57, BRR-0060, BRR-0078, Rajendra Suwasini were found immune or highly resistant against false smut disease of rice. The

highest percent of disease infection was recorded in Arize 6444 Gold, Sahbhagi Dhan, RVK-15, RVK-13, RVK-08, BRR-0071. In the present study, the promising genotypes may be further utilized as the donor genetic sources for the disease resistance rice breeding programme against false smut disease.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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