J.Mycopathol.Res. 63(2) : 267-272 2025, ISSN : 0971-3719 (Print), 2583-6315 (Online)
10.57023/JMycR.63.2.2025.267

Screening and identification of rice genotypes with resistance to False Smut Disease

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Received : 12.03.2025 Accepted : 02.05.2025 Published : 30.06.2025

A total of 44 rice genotypes/varieties were evaluated for resistance to rice false smut disease, using BPT-5204 as the susceptible check and IR-64 as the moderately resistant check. Significant variation in disease incidence and severity was observed among the genotypes. The highest panicle infection was recorded in BL-18 (25.28%), followed by BPT-5204 (11.22%) and Badshah Bhog (8.72%). Disease severity mirrored these trends, with BL-18 showing the highest severity (87.43%), followed by BPT-5204 (34.49%) and Badshah Bhog (28.55%). Of the 44 genotypes, 16 exhibited a highly resistant reaction, including varieties such as Ranjith, MTU-1001, and Chakhaopoireiton. Five genotypes were classified as resistant, while 15 were moderately resistant. Seven genotypes were moderately susceptible, and BL-18 was the only variety showing susceptibility. The long-duration varieties, particularly those with flowering durations over 100 days, displayed higher resistance, likely due to their ability to escape the conditions favorable for disease development. Conversely, some long-duration varieties such as BB-11, Badshah Bhog, and BPT-5204 showed moderate susceptibility. Among short-duration varieties, GB-3 exhibited moderate resistance, while IR-64 and GB-1 were moderately susceptible. Notably, IR-64 showed a shift in reaction from moderately resistant to moderately susceptible under natural epiphytotic conditions. This study highlights the potential of specific genotypes for breeding programs aimed at improving false smut resistance in rice.

Keywords : Epiphytotic, False smut disease, natural and artificial infection, resistant variety

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the most important food crops globally and has been cultivated since ancient times to sustain the growing population (Bhattacharjee *et al*. 2002). As the staple food for over half of the world's population, rice is grown under diverse agro-climatic conditions, ranging from hills to coastal regions. Primarily a *kharif* crop, it is cultivated throughout the year in various parts of the world (Pathak *et al*. 2018).

India is the second-largest producer of rice globally, with West Bengal ranking firstamong Indian states in rice production (Jambhulkar *et al*. 2023).However, changing cultivation practices have led to the emergence of several challenges, particularly biotic and abiotic stresses, which pose significant constraints to rice production. In India, the major pest contributing to crop losses is weeds, accounting for 12.5%, followed by insects at 9.5%, diseases at 6.5%, and other pests at 4.5%. (Mondal *et al*. 2017).Major rice diseases, such as blast, brown spot, sheath blight and bacterial leaf blight have intensified over time. Additionally, minor diseases, including sheath rot, bakanae, false smut, grain discoloration, early seedling blight, and narrow brown spot, have emerged as significant concerns (Raghu *et al*. 2018). Recently, the increasing prevalence of rice false smut (RFS) has been reported in major rice-growing regions worldwide, including China, India, and the United States (Brooks *et al*. 2009). Symptoms of false smut become apparent only after the flowering stage, with individual grains initially replaced by white smut balls. These smut

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balls later rupture, turning yellow to orange, and eventually mature into an olive green to black color . The pathogen survives in the form of chlamydospores, sclerotia, stubbles, or by colonizing weedy plants (Atia, 2004). Yield losses due to RFS range from 0.01% to 8.6%, with higher losses observed in susceptible cultivars compared to resistant ones (Bag *et al*. 2021). Baite *et al*. (2020) mentioned that the yield reduction in rice caused by false smut infection ranged from 0.10% to 5.14% across various genotypes. The disease affects a substantial percentage of rice tillers, with infection rates of 10%–20% in Punjab and 5%–85% in Tamil Nadu (Ladhalakshmi *et al*. 2012). Furthermore, RFS balls produce mycotoxins, such as ustiloxin and ustilaginoidin, which pose serious health hazards to humans and animals by contaminating rice grains and straw. These emerging threats highlight the urgent need for effective management strategies to mitigate the impact of RFS on global rice production. Biswas (2001) assessed the field reactions of 41 rice hybrids to false smut, identifying eight hybrids that demonstrated complete resistance to the disease. Jiang *et al.* (2010) conducted a field assessment to evaluate the resistance of 35 rice (*Oryza sativa*) cultivars to false smut. The results indicated that none of the cultivars were categorized as highly resistant. However, nine cultivars were classified as resistant, ten as moderately resistant, eleven as moderately susceptible, three as susceptible, and one as highly susceptible. Banasode and Hosagoudar (2021) evaluated 102 rice genotypes for resistance to false smut disease under natural epiphytotic conditions. Among the tested genotypes, 11 displayed a highly resistant response, while none exhibited complete resistance. Only one variety, IR-64, was found to exhibit a moderately resistant reaction. The identification of resistant genotypes/ varieties, landraces, traditional or farmer variety's adapted to evolving regional agro-ecological conditions is essential for achieving sustainable rice production and effective disease management.

MATERIALS AND METHODS

Forty-four rice genotypes/varieties were screened for resistance to false smut disease caused by *Ustilaginoidea virens* (Cook) Tak. under wetland transplanted field conditions at the experimental fields of Uttar Banga Krishi Vishwavidyalaya, Pundibari, West Bengal (Latitude: 26.398552; Longitude: 89.39072) during the Kharif season of 2022. Twenty-five-day-old seedlings of the forty-four varieties were transplanted into 4 m² plots, with a spacing of 20 × 15 cm. Two seedlings were planted per hill. The experiment was conducted under natural conditions using a Randomized Block Design with three replications. The recommended doses of manures and fertilizers were applied, and no fungicides were used. Areas with a history of the disease and natural disease pressure were selected for planting.

At the mid-booting stage of each genotype, a spore suspension prepared from freshly collected smut balls in distilled water was sprayed in the evening to facilitate disease development under natural epiphytotic conditions. Observations recorded included: days to 50% flowering, percentage of infected panicles, percentage of grains infected per panicle, and disease severity.

The following calculations were made :

1.Percent Infected Tillers (Mandhare *et al*. 2008):

$$\text{Per cent infected tillers} = \frac{\text{Total No. of tillers infected /m}^2}{\text{Total No. of tillers /m}^2} \times 100$$

2.Percent Grains Infected (Singh and Dube, 1978):

$$\text{Per cent infected grains} = \frac{\text{Total No.of grains infected /panicle}}{\text{Total No. of grains /panicle}} \times 100$$

3. Disease Severity (Singh and Dube, 1978):

Disease severity = Per cent infected tillers x Per cent infected grains.

The rice varieties were categorized by following scale given by Hiranya and Das (2023) ; Jakhar *et al*. (2022) as mentioned in (Table.1).

RESULTS AND DISCUSSION

A total of 44 rice genotypes/varieties were evaluated for resistance to false smut disease, using BPT-5204 as the susceptible check and IR-64 as the moderately resistant check. The data

Table 1: Scoring for false smut was done at maturity stage

Visual score	% of Infected Panicles	Host Response
0	0 (No disease)	Highly Resistant
1	<1 %	Resistant
3	1.1-5 %	Moderately Resistant
5	5.1-25 %	Moderately Susceptible
7	25.1-50 %	Susceptible
9	>50%	Highly Susceptible

Score based on the ones given by Hiranya and Das (2023) and Jakhar *et al.* (2022).

summarized in Table 2 revealed significant variation in disease incidence among the genotypes/varieties. The highest panicle infection was observed in genotype BL-18 (25.28%), followed by BPT-5204 (11.22%) and Badshah Bhog (8.72%). Disease severity followed a similar trend, with the highest severity recorded in BL-18 (87.43%), followed by BPT-5204 (34.49%) and Badshah Bhog (28.55%) as shown (Table 2).

Out of the 44 genotypes/varieties, 16 exhibited a highly resistant reaction, including Ranjith, MTU-1001, MTU-1121, MTU-1140, Uttar Samara, Sathiya Bora, Jarowa, Boichi, Upendra, Kalawati, SadabhatKhalo, Adminal Black Rice, ChakhaoPoireiton, Chakhao Amubi, Chakhao Sel-3, and ChakhaoAngangba. Five genotypes/ varieties displayed a resistant reaction, while 15 genotypes/varieties were moderately resistant. Seven genotypes/varieties were classified as moderately susceptible, and only one variety, BL-18, showed a susceptible reaction (25.28%).

The majority of long-duration rice varieties, including Ranjith, MTU-1140, Sathiya Bora, Jarowa, Boichi, Kaliaphulo, Upendra, Kalawati, Sadabhat Khalo, Chakhao Poireiton, Chakhao Amubi, Chakhao Sel-3, and Chakhao Angangba, with a flowering duration of over 100 days, exhibited a highly resistant response to false smut disease. This resistance may be attributed to their ability to escape the prevailing environmental conditions that are conducive to disease development.

However, three long-duration varieties—BB-11 (6.11%), Badshah Bhog (17.95%), and BPT-5204 (11.22%)—were moderately susceptible, while one medium-duration variety was classified as susceptible. Among the three short-duration varieties, with a flowering period of less than 90 days, IR-64 (5.39%) and GB-1 (5.36%) were moderately susceptible, whereas GB-3 (3.03%) displayed a moderately resistant reaction. Notably, IR-64, which was previously classified as moderately resistant, has now shown a shift to moderately susceptible under natural epiphytotic conditions.

The observed variation in resistance among rice cultivars to false smut disease can be attributed to several factors, including genetic differences and environmental influences. Genetic resistance is a key determinant in managing the disease, as specific genotypes possess inherent mechanisms that either prevent or limit pathogen infection. However, environmental factors, such as temperature, humidity, and field conditions, play a significant role in influencing the expression of disease resistance. Host-pathogen interactions are dynamic, and the ability of a cultivar to resist disease is often a result of both its genetic predisposition and the prevailing environmental conditions during the cropping season.

The screening of rice genotypes in this study revealed a diverse range of disease reactions, highlighting the genetic variability in resistance to false smut. Long-duration rice varieties, particularly those with a flowering duration of over 100 days, showed a tendency to be more resistant to the disease, potentially due to their ability to escape the period of peak disease development. In contrast, certain short-duration varieties and some long-duration varieties exhibited moderate susceptibility, indicating that susceptibility is not

Table 2: Categorization of rice varieties on the basis of percentage of infected panicles (% IP).

Serial No.	Variety No.	Variety name	% IP	% IG	Disease severity	Disease reaction
1	UB 1	Ranjith	0.00	0.00	0.00	HR
2	UB 2	Satiya	0.54	0.68	0.36	R
3	UB 3	Shyamshree	2.94	2.97	8.74	MR
4	UB 4	MTU-1001	0.00	0.00	0.00	HR
5	UB 5	MTU-1121	0.00	0.00	0.00	HR
6	UB 6	MTU-1153	5.17	1.43	7.42	MS
7	UB 7	MTU-1140	0.00	0.00	0.00	HR
8	UB 8	MTU-7029	1.17	0.57	0.66	MR
9	UB 9	IET-4786	7.51	2.78	20.85	MS
10	UB 10	Uttar Samir	0.00	0.00	0.00	HR
11	UB 11	Uttar Lakshmi	2.68	1.21	3.24	MR
12	UB 12	Uttar Sugandhi	2.53	1.01	2.55	MR
13	UB 13	Uttar Sona	1.94	1.04	2.02	MR
14	UB 14	GB-1	5.36	2.08	11.16	MS
15	UB 15	GB-3	3.03	1.44	4.35	MR
16	UB 16	DubariKomal	1.75	1.59	2.79	MR
17	UB 17	Kalonunia	0.45	1.56	0.70	R
18	UB 18	BB-11	6.11	2.05	12.51	MS
19	UB 19	UBL-18	2.74	0.99	2.72	MR
20	UB 20	Banga Lakshmi (BL)-18	25.18	3.47	87.43	S
21	UB 21	BPT-5204	11.22	3.07	34.49	MS
22	UB 22	IR-64	5.39	2.09	11.28	MS
23	UB 23	Jhora	2.14	1.38	2.95	MR
24	UB 24	Badshah Bhog	8.72	3.27	28.55	MS
25	UB 25	Guti Swarna	0.81	0.85	0.69	R
26	UB 26	Sathiya Bora	0.00	0.00	0.00	HR
27	UB 27	Jarowa	0.00	0.00	0.00	HR
28	UB 28	Wairi	1.96	0.77	1.51	MR
29	UB 29	Boichi	0.00	0.00	0.00	HR
30	UB 30	Kaliaphulo	1.15	2.16	2.49	MR
31	UB 31	Upendra	0.00	0.00	0.00	HR
32	UB 32	Lagedhan	2.67	0.91	2.44	MR
33	UB 33	Kalawati	0.00	0.00	0.00	HR
34	UB 34	SadabhatKhalo	0.00	0.00	0.00	HR
35	UB 35	Jugal	1.78	1.90	3.37	MR
36	UB 36	Balam	1.10	2.32	2.55	MR
37	UB 37	AdminalBlack rice	0.00	0.00	0.00	HR
38	UB 38	ChakhaoPoireiton	0.00	0.00	0.00	HR
39	UB 39	ChakhaoBoiton	0.48	1.15	0.55	R
40	UB 40	ChakhaoAmubi	0.00	0.00	0.00	HR
41	UB 41	ChakhaoSel-2	0.47	0.62	0.29	R
42	UB 42	ChakhaoSel-3	0.00	0.00	0.00	HR
43	UB 43	ChakhaoAngangba	0.00	0.00	0.00	HR
44	UB 44	ChakhaoAngangbi	1.06	1.68	1.79	MR

%IP - Percentage of infected panicles;%IG - Percentage of infected grains;HR - Highly Resistant; R - Resistant; MR- Moderately Resistant; MS - Moderately Susceptible; S – Susceptible. The Chakhao varieties are the local ones from Manipur.

Table 3 : Categorization of rice genotypes on the basis of disease reaction

Genotypes	Disease reaction	No. of genotypes
Ranjith, MTU-1001, MTU-1121, MTU-1140, Uttar Samara, Sathiya bora, Jarowa, Boichi, Upendra, Kalawati, SadabhatKhalo, AdminalBlack Rice, Chakhaopoireiton, ChakhaoAmubi,ChakhaoSel-3, ChakhaoAngangba.	Highly Resistant	16
Satiya, Kalonunia, Guti Swarna, ChakhaoBoiton, ChakhaoSel-2.	Resistant	5
Shyamshree, MTU-7029, Uttar Sugandhi, Uttar Lakshmi, Uttar Sona, GB-3, DubariKomal, Kaliaphulo, Jhora, UBL-18, Wairi, Lagedhan, Jugal, Balam, ChakhaoAngangbi.	Moderately Resistant	15
MTU-1153, IET-4786, GB-1. BB-11, IR-64, Badshah Bhog, BPT-5204.	Moderately susceptible	7
Banga Lakshmi-18.	Susceptible	1
-	Highly susceptible	-

Table 4: Categorization of rice genotypes on the basis of number of days to 50% flowering

Rice genotypes	Days to 50% flowering	Duration
IET-4786, GB-1, GB-3	< 90	Short
Satiya, Shyamshree, MTU-1001, MTU-1121, MTU-1153, Uttar samara, Uttar Lakshmi, Uttar Sugandi, Uttar Sona, BL-18, IR-64, Adminal Black Rice, Chakhao sel-2, ChakhaoAngangbi.	90-100	Medium
Ranjith, MTU-1140, MTU-7029, DubariKomal, Kalonunia, BB-11, UBL-18, BPT-5204, Jhora, BhadshahBhog, Guti Swarna, Sathiya Bora, Jarowa, Wairi, Boichi, Kaliaphulo, Upendra, Lagedhan, Klawati, SadabhatKhalo, Jugal, Balam, Chakhaopoireiton, ChakhaoBoiton, Chakhao Amubi, Chakhao sel-3, ChakhaoAngangba.	> 100	Long

solely dependent on flowering duration, but may also involve other factors such as maturity stage, plant architecture, and resistance mechanisms at the molecular level.

Hiranya and Das (2023) assessed 22 rice varieties by applying a conidial suspension. Among them, Manohar Sali, Pareshash Biroin, and Keteki Joha exhibited complete resistance to false smut while Mahsuri recorded the highest disease incidence at 25.64%, followed by Bhogali Bora with 25.14%, and Bokul Joha with 16.37%. Similarly, Banasode and Hosagoudar (2021) screened 102 rice genotypes for resistance to false smut disease under natural field conditions and identified 11, including IET 24956, IET 25530, IET 26273, and several others, demonstrated a high level of resistance. Chaudhari *et al*. (2019) assessed eighteen rice cultivars under natural field conditions and cultivars such as GNR-2, GNR-3, GNR-5, GNRH-1, Mahisagar, NAUR-1, and Dandi showed high resistance with visual score of zero. In contrast, GNR-4, Tapeswari, Masuri, Jaya, Gurjari, Sambha-Masuri, GR-4, and GR-7 were classified as moderately resistant with a visual score of three while TN-1, GR-11, and US-312 were moderately susceptible averaging a visual score of five over two years.

For more accurate and reliable assessment of resistance, it is essential to perform further screening using standardized inoculation methods under controlled, uniform environmental conditions. This approach would minimize environmental variability and provide clearer insights into the true genetic potential of each cultivar to resist false smut. Such standardized assessments will help to differentiate between true genetic resistance and the environmental influences that might obscure accurate evaluations of disease susceptibility.

In conclusion, while genetic resistance is a crucial component of managing false smut, the interaction between host and pathogen under specific environmental conditions cannot be overlooked. Future research should aim to identify the molecular mechanisms underlying resistance and to explore how environmental factors can be optimized to support the cultivation of resistant rice varieties. Additionally, the identification and deployment of resistant cultivars in disease-prone regions will be critical for sustainable rice production and for mitigating the impact of false smut on global rice yields.

ACKNOWLEDGEMENTS

The authors are grateful to the Departments of Plant Pathology and Seed Science & Technology for providing all facilities to conduct the present study.

DECLARATION

Conflict of interest. Authors declare no conflict of interest.

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