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Towards Development of Sheath Blight-Resistant Rice: Screening and Selection of Promising Genotypes

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ABSTRACT

Sheath blight of rice, caused by *Rhizoctonia solani* Kühn (teleomorph: *Thanatephorus cucumeris* (Frank) Donk), is one of the most significant diseases of rice after blast, with reported yield losses ranging from 1.2% to as high as 69.0%. A total of 399 rice germplasms/entries were evaluated under natural field conditions during *Kharif* 2024-25 to assess their resistance against sheath blight caused by *Rhizoctonia solani*. None of the genotypes were found immune or highly resistant. Twenty-three entries exhibited resistant reactions, while 239 were moderately resistant, 133 were susceptible, and 4 genotypes were highly susceptible. The absence of immune and highly resistant types highlights the narrow resistance spectrum within the germplasm pool. The identified resistant and moderately resistant genotypes may serve as potential donors in resistance breeding programs aimed at developing sheath blight-tolerant rice cultivars.

Key words: *Rice, Sheath blight, Screening, Genotypes/entries, Resistant*

Introduction

Rice (*Oryza sativa* L.) is a staple food crop for over half of the global population, playing a critical role in ensuring food and nutritional security, particularly in Asia (Fukagawa and Ziska, 2019). However, rice production faces several biotic constraints, among which sheath blight, caused by the necrotrophic fungus *Rhizoctonia solani* Kühn (teleomorph: *Thanatephorus cucumeris*), is one of the most destructive diseases (Rao *et al.,* 2023). Sheath blight is widespread in irrigated rice ecosystems and can result in yield losses ranging from 5% to as high as 50%, depending on disease severity, variety susceptibility, and prevailing climatic conditions (Senapati *et al.,* 2022).

The disease typically manifests during the tillering to booting stages, characterized by oblong, grayish-green lesions on leaf sheaths that coalesce and ascend towards the flag leaf (Ganesh and Roka, 2024). The pathogen survives as sclerotia and mycelium in the soil and plant debris, making its management a persistent challenge (Akber and Fang, 2024). The increasing adoption of high-yielding, semi-dwarf, and dense-canopied rice varieties, combined with intensive cultivation practices and higher nitrogen inputs, has led to a greater incidence and severity of sheath blight over the years (Cu *et al.,* 1996).

Chemical control using fungicides has been the most common management strategy; however, this approach poses environmental risks, can lead to pathogen resistance, and is not sustainable in the long term (Mclaughlin *et al.,* 2023). Therefore, host plant resistance remains the most eco-friendly, cost-effective, and durable solution to mitigate the impact of sheath blight (Molla *et al.,* 2022). Unfortunately, no complete resistance has been identified in *Oryza sativa* cultivars so far; however, moderate levels of resistance have been observed in some traditional and wild rice accessions, which are valuable resources for breeding programs.

This study was conducted with the objective of evaluating a set of diverse rice genotypes under field conditions to identify entries with promising levels of resistance to sheath blight. The identification and selection of such genotypes will not only aid in the understanding of host-pathogen interaction dynamics but also provide potential genetic sources for incorporation into breeding pipelines aimed at developing sheath blight-resistant rice varieties.

Materials and Methods

Experimental site and location

The field experiment was conducted during *Kharif* 2024-25 at the Crop Research Station (ANDUAT), Masodha, Ayodhya which is situated in the Indo-Gangetic plains of Eastern Uttar Pradesh at a latitude of $26^0$47′ N and longitude $82^0$12′E at an altitude of 113 meters above sea level.

Screening of genotypes

The study was conducted in bunded rice field and under irrigated conditions during *Kharif* 2024-25. Three hundredninety-nine advance rice lines grown in the Crop Research Station (ANDUAT), Masodha, Ayodhya. The 25 days old nursery of these entries transplanted in simple two rows of two meter with a spacing of 20 x 15 cm. The rows of test entries were bordered by two rows of susceptible check var. PB-1 and after each 10 entries susceptible check was transplanted. Fertilizer was applied @ N120: P50: K0 kg ha^{-1}. Fifty percent of N and total P were given as first basal dose and remaining N applied in two split doses. The environment was kept aseptic to ensure that the seedlings were disease and contaminant-free.

Rhizoctonia solani inoculum preparation

Stems of 35-40 days old rice plants were cut in to pieces of about 2 cm size and filled in to 500 ml Erlenmeyer flasks upto one third. Flasks were autoclaved at 15 pound per square inch for 30 minutes. Mycelial discs of 5 mm diameter cut from the margin of 48 hrs old culture of the pathogen were inoculated into the flask and incubated at 27±2 ºC up to fifteen days for full growth of fungus and formation of sclerotia.

Method of inoculation

In the field inoculation, fungal culture of *R. solani* was introduced to rice straw, allowing the pathogen to colonize and grow on the straw. After sufficient fungal growth, the rice straw was chopped into small pieces and placed between the rice tillers, just above the water level. This method simulated natural infection conditions, as the flooded environment helped facilitate the spread of the pathogen to the rice plants

Data analysis

The relative lesion height (cm) in each tiller was calculated by using formula given by Sharma *et al.* (1990).

$$\text{RLH} = \frac{\text{Maximum height at which lesion appear}}{\text{Plant height}} \text{ x } 100$$

Table 1. Standard evaluation system (SES) (0-9 rating scale), IRRI (2014)

Scale	Reaction	Description
0	Immune	No Infection
1	Resistant	Vertical spread of the lesions up to 20% of plant height
3	Moderately Resistant	Vertical spread of the lesions up to 21-30% of plant height
5	Moderately susceptible	Vertical spread of the lesions up to 31-45% of plant height
7	Susceptible	Vertical spread of the lesions up to 46-65% of plant height
9	Highly Susceptible	Lesion limited to lower more 65% of plant height

Result and Discussion

Screening of rice germplasm/entries against sheath blight disease of rice

Total 399 germplasms/varieties were evaluated under natural field conditions against sheath blight of rice during *Kharif*, 2024-25. Result is given in the Table 2. None of the germplasm were found immune to sheath blight, none were highly resistant to sheath blight.23 genotypes/entries were found resistant, i.e. 30505, 31515, 31540, 31552, 31553, 32038, 31618, 31629, 31492(H), 31641, 31476(H), WGL 314, 32847, 31927, 31938, 31120, 31115, DRR DHAN 60, 31982, 31103, 32061, 32051, 32983. Two hundred thirty nine (239) genotypes were found moderately resistant i.e. 30555(H), 30561(H), 30641, 30656, 30657, 30669, 30690, 29694, 31433(H), 31434(H), 31436(H), CO-51(NC), 31437(H), 31440(H), Narendra 97(ZC), 31444(H), 31501, 31509, 31510, 31512, 31519, 31533, 31550, 31557, 30568, 30681, 30653, 30660, 30668, 30679, 30688, 30661, 30637, 30640, 30683, 30659(R), 30647(R), 31889, 31063, 31871, 31065, Buthnath, 32037NIL, 31075, PUSA 44, 31884, MTU 1010(RP), FL 478, 31875, 31876, 31878, 31067, 30576(H), 30578(H), 30593(H), 30704, 31608, 30556(H), 30649, 30692, 30713, Gontra Bidhan 3(NC), 31447(H), 31449(H), 31456(H), 31462(H), 31611, 31572, 31587, 31589, 31594, Tetep, HR 12, Vikramarya, Ajaya, Rasi, IR 64, 31044, CSR 36, 31051, 31055(R), 31853, 31857, 31859, 31861, ADT 45(RP), 32036 NIL, 30603(H), 30613(H), 30608(H), 30617(H), 30605(H), 30772, 30819, 31483(H), 29877(R), 31472(H), 31478(H), 31473(H), 31639, NDR 359(NC), 31643, 31479(H), 31619, 31654, 31471(H), 31673, 31481(H), 31678, Swarna(NC), 31686(H), 31689, NDR 8002, 31693, 31709(H), 31714(H), 31726, 30882(H), ISM, 29019, 30622, 30961, 31001, 31494(H), 31806, 31808, Telangana Sona(NC), 31827, 30989, 32828, 32829, Shobini(NC), 32831, 32832, 32833, 32834, 31901(R), 32835, Dubraj Sel 1(QC), 32836, 32837, 32838, 32839, 32841, 32842, RNR 15435(C), 31912(R), 32844, 32845, 32846, 32849, 32850, 31961, 31947, 31939, 31951, 31937, DRR DHAN 45, 31950, 32005, 32003, 32009, 32010, 31118, 29851, 31117, 31131, 30273, 29578, 31134, 31989, 29579, 31980, 29558, 31098, 31975, 31976, 31985, 28070, 31096, 31986, 31968, 31097, 31973, 29546, 31969, 31979, 30919(H), PA 6129, 31779, 30932(R), 30928(R), 31784, 30934(R), CR DHAN 201(NC), 30911(R), 30910(R), 30045(R), 31740, 31759, CR DHAN 202(ZC), 31765, DRR DHAN 54(NC), 31777, 32963, 32964, 32965, 32072, 32966, 32967, 32968, 32969, 32970, 32971, 32056, 32062, 32054, 32058, Jaya (RP), 32973, MTU 1121(RP), 32974, 32976, 32064, 32065, 32978, 32980, DRR DHAN 50, 32982, 32984, 32987, 32989, 32990, 32991, 32045, 32047, 31110, White Ponni(C), Swarna Dhan.

One hundred thirty three (133) genotypes were found susceptible, i.e. 30565(H), 30636, 30642, 30651, 29700, 31435(H), 30635, 30671, 30674, 30572, 30687, 30638, 30677, CSR-10, 31074, 31863, 31877, 30573(H), 30574(H), 30575(H), 30577, 30579(H), 30587(H), 30589(H), 30558(H), 31448(H), Arize 6444(HC), 31603, 31452(H), 31461(H), 31466(H), 31469(H), 31582, TN 1, IR 50, CO 39, 30f 165, 30178, 31045, 31048, 31050, 31053, 30180, 31852, 31855, CSR 23, 31858, 32055 NIL, 30604(H), 31623, 31644, 31480(H), 31633, 29860(R), 31637, 31490(H), 31630, 31659, 31638, 31672, 31680, 31715, 31731, 29891(R), 30957, 27P63(HC), 31795, 31804, BPT 5204(NC), 31820, 31822, 31835, 31839, 31850, 31802, 31002(R), 31816, 31826, 32826, 32827, 31909(R), 32830, 32843, DRR DHAN48, 31929, 31946, 31925, Chittimutyalu, 31948, 31004(R), 31998, 31990, 31993, 31994, 31135, 31128, 31119, 30269, 28084, Vardhan, 31102, 31107, Vandana, 31106, 29560, 31966, 29549, 30893(R), 30907, 30904, 31741, 31760, 31787, 31770, 31778, Phule Radha(RP), Improved Sambha Mahsuri, 32074, 32975, 32043, 32977, 32979, DRR DHAN 53, 32981, CARI DHAN 5, 32986, 32988, 28P67, 32053, WGL 14, 31105, 31640, CH 45 and the rest 4 varieties i.e. 31496(H), 31108, 32985, 32052 were found highly susceptible.

The present findings are in agreement with the study by Ravali *et al*. (2020), who screened 146 rice germplasm lines for resistance to sheath blight using the susceptible check MTU 7029. Out of these, 2 germplasm lines were found to be immune, 81 showed resistance, 43 were moderately resistant, 18 were susceptible, and 2 genotypes were highly susceptible. Similarly, Mosaddeque *et al*. (2008) evaluated 44 parental lines and found that 10 lines were resistant, 31 were moderately resistant, and 3 were susceptible at the maximum tillering stage. Prasad *et al.* (2020) evaluated 31 rice cultivars for resistance to sheath blight and reported that no cultivars were highly resistant, 21 cultivars, including 22250 and 21665, showed resistant reactions, nine cultivars, such as R1896-81-2-59-1, were moderately resistant. The remaining cultivars, including IR10F36, were moderately susceptible. Kapoor *et al.* (2022) identi-

Table 2. Disease reaction in advance rice lines/entries against sheath blight disease under artificial inoculated conditions.

Score	Disease reaction	Total	Genotypes/varieties
0	Immune	Nil	Nil
1	Highly Resistant	Nil	Nil
3	Resistant	23	30505, 31515, 31540, 31552, 31553, 32038, 31618, 31629, 31492(H), 31641, 31476(H), WGL 314, 32847, 31927, 31938, 31120, 31115, DRR DHAN 60, 31982, 31103, 32061, 32051, 32983,
5	Moderately Resistant	239	30555(H), 30561(H), 30641, 30656, 30657, 30669, 30690, 29694, 31433(H), 31434(H), 31436(H), CO-51(NC), 31437(H), 31440(H), Narendra 97(ZC), 31444(H), 31501, 31509, 31510, 31512, 31519, 31533, 31550, 31557, 30568, 30681, 30653, 30660, 30668, 30679, 30688, 30661, 30637, 30640, 30683, 30659(R), 30647(R), 31889, 31063, 31871, 31065, Buthnath, 32037NIL, 31075, PUSA 44, 31884, MTU 1010(RP), FL 478, 31875, 31876, 31878, 31067, 30576(H), 30578(H), 30593(H), 30704, 31608, 30556(H), 30649, 30692, 30713, Gontra Bidhan 3(NC), 31447(H), 31449(H), 31456(H), 31462(H), 31611, 31572, 31587, 31589, 31594, tete, HR 12, Vikramarya, Ajaya, Rasi, IR 64, 31044, CSR 36, 31051, 31055(R), 31853, 31857, 31859, 31861, ADT 45(RP), 32036 NIL, 30603(H), 30613(H), 30608(H), 30617(H), 30605(H), 30772, 30819, 31483(H), 29877(R), 31472(H), 31478(H), 31473(H), 31639, NDR 359(NC), 31643, 31479(H), 31619, 31654, 31471(H), 31673, 31481(H), 31678, Swarna(NC), 31686(H), 31689, NDR 8002, 31693, 31709(H), 31714(H), 31726, 30882(H), ISM, 29019, 30622, 30961, 31001, 31494(H), 31806, 31808, Telangana Sona(NC), 31827, 30989, 32828, 32829, Shobini(NC), 32831, 32832, 32833, 32834, 31901(R), 32835, Dubraj Sel 1(QC), 32836, 32837, 32838, 32839, 32841, 32842, RNR 15435(C), 31912(R), 32844, 32845, 32846, 32849, 32850, 31961, 31947, 31939, 31951, 31937, DRR DHAN 45, 31950, 32005, 32003, 32009, 32010, 31118, 29851, 31117, 31131, 30273, 29578, 31134, 31989, 29579, 31980, 29558, 31098, 31975, 31976, 31985, 28070, 31096, 31986, 31968, 31097, 31973, 29546, 31969, 31979, 30919(H), PA 6129, 31779, 30932(R), 30928(R), 31784, 30934(R), CR DHAN 201(NC), 30911(R), 30910(R), 30045(R), 31740, 31759, CR DHAN 202(ZC), 31765, DRR DHAN 54(NC), 31777, 32963, 32964, 32965, 32072, 32966, 32967, 32968, 32969, 32970, 32971, 32056, 32062, 32054, 32058, Jaya (RP), 32973, MTU 1121(RP), 32974, 32976, 32064, 32065, 32978, 32980, DRR DHAN 50, 32982, 32984, 32987, 32989, 32990, 32991, 32045, 32047, 31110, White Ponni(C), Swarna Dhan
7	Susceptible	133	30565(H), 30636, 30642, 30651, 29700, 31435(H), 30635, 30671, 30674, 30572, 30687, 30638, 30677, CSR-10, 31074, 31863, 31877, 30573(H), 30574(H), 30575(H), 30577, 30579(H), 30587(H), 30589(H), 30558(H), 31448(H), Arize 6444(HC), 31603, 31452(H), 31461(H), 31466(H), 31469(H), 31582, TN 1, IR 50, CO 39, 30f 165, 30178, 31045, 31048, 31050, 31053, 30180, 31852, 31855, CSR 23, 31858, 32055 NIL, 30604(H), 31623, 31644, 31480(H), 31633, 29860(R), 31637, 31490(H), 31630, 31659, 31638, 31672, 31680, 31715, 31731, 29891(R), 30957, 27P63(HC), 31795, 31804, BPT 5204(NC), 31820, 31822, 31835, 31839, 31850, 31802, 31002(R), 31816, 31826, 32826, 32827, 31909(R), 32830, 32843, DRR DHAN48, 31929, 31946, 31925, Chittimutyalu, 31948, 31004(R), 31998, 31990, 31993, 31994, 31135, 31128, 31119, 30269, 28084, Vardhan, 31102, 31107, Vandana, 31106, 29560, 31966, 29549, 30893(R), 30907, 30904, 31741, 31760, 31787, 31770, 31778, Phule Radha(RP), Improved Sambha Mahsuri, 32074, 32975, 32043, 32977, 32979, DRR DHAN 53, 32981, CARI DHAN 5, 32986, 32988, 28P67, 32053, WGL 14, 31105, 31640, CH 45
9	Highly susceptible	4	31496(H), 31108, 32985, 32052

fied 14 resistant and 16 moderately resistant lines, while 20 lines were categorized as moderately susceptible or susceptible against sheath blight disease. Naveenkumar *et al.* (2022) observed that 23 genotypes were found moderately resistant, 38 were moderately susceptible, and 2 exhibited a susceptible reaction to sheath blight disease.

These studies further support the variation observed in our results and emphasize the importance of identifying and utilizing resistant lines in breeding programs to manage sheath blight effectively.

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Conflict of Interest- None

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