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Identification of Resistant Sources against Sheath Blight of Rice Caused by *Rhizoctonia solani* Kuhn

Arpitha H. B.[1], N. Kiran Kumar[1], L. Vijay Kumar[2], K. R. Ashoka[3], N. S. Pankaja[1] and N. Mallikarjuna[1]

[1]Dept. Plant Pathology, [2]Dept. of Agricultural Entomology, [3]Dept. Soil Science and Agricultural Chemistry, CoA, Mandya, Karnataka (571 405), India

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Corresponding arpitha0497@gmail.com

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ABSTRACT

The present study was conducted during *kharif* (July-November) seasons of 2023 and 2024 at V.C. Farm, Mandya, Karnataka, India to identify the resistant genotypes for sheath blight of rice. 240 (Two hundred and forty) popular landraces were screened against sheath blight disease under field condition by artificial inoculation method. The inoculum of *R. solani* was prepared by mass multiplication on sorghum grains and applied at the tillering stage, thirty-days after transplanting. The sorghum grains colonized by the fungus were used for field inoculations on thirty-days old plants. The disease scoring was done by the standard evaluation system (SES) as per IRRI (2013). The mean percent disease index (PDI) of both the seasons ranged from 5.43 to 61.11% and the AUDPC exhibited the values ranging from 176.28–334.41. Based on mean PDI and AUDPC values, rice genotypes were categorized into 5 groups i.e., resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible. None among the 240 landraces screened over two seasons, exhibited an immune response with a score of 0. However, seven genotypes showed a resistant reaction with the score of 1. Seventy-two genotypes which exhibited a score of 5 were categorized as moderately susceptible while, seventy genotypes with the score of 7 were classified as susceptible and thirty-one genotypes were identified as highly susceptible, scoring 9.

KEYWORDS: Disease resistance, landraces, *Rhizoctonia solani*, screening, sheath blight

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal crop of *Graminae* family, cultivated in 113 countries of the world. About 40% of the total food grain production is contributed by rice (Haug et al., 2019). More than 3.5 billion people which translates to at least half of the people worldwide use rice as their staple food (Rajkumar et al., 2022, Reddy, et al., 2023). India has the largest area of 44 mha under rice production with annual rice production of 129 mt and productivity of about 3.86 t ha^{-1} (Anonymous, 2024). Rice production across Karnataka accounts to about 3.5 mt and productivity of 2.5 t ha^{-1} with an area of 1.4 mha (Anonymous, 2022). Rice does not show its full production potential due to stress caused by many pathogens, among which, *Rhizoctonia solani*, the causative agent of sheath blight, is responsible for yield loss up to 4 – 45% depending on the crop stage, time of infection and environmental condition (Singh et al., 2016,). In terms of seasonal production losses of rice, sheath blight disease is considered the second most severe disease after blast (Ou, 1985, Molla, et al., 2020). It is a major production constraint in profusely tillering, fertilizer responsive, high yielding varieties and hybrids under intensive rice production system (Groth, 2008, Koshariya et al., 2018). The pathogen *Rhizoctonia solani* Kuhn AG1- IA (anamorph), *Thanatephorus cucumeris* (Frank) Donk (teleomorph) is a soil-dwelling saprotroph and facultative parasite. The pathogen survives in the soil and water as sclerotia that remain viable for up to 3 years (Kumar et al., 2009, Shamim, et al., 2014), which spreads rapidly through sclerotia when it encounters with plant parts such as tillers and leaves (Tsiboe et al., 2017). The disease emerges around the late tillering stage and achieves an aggressive state at the time of panicle differentiation which affects different plant parts including leaf sheaths, upper leaves and panicles (Timsina et al., 2022). Identification of the disease is generally aided by the appearance of one or more large, oblong or irregularly elongated lesions on the leaf sheath (Uppala and Zhou, 2018). The wide host range of pathogen and persistence of sclerotia on exposure to adverse environmental conditions makes it difficult to manage the disease. The primary method for controlling the disease relies on chemical fungicides. However, these fungicides are often neither environmentally sustainable nor economically viable. Sheath blight (ShB) losses in rice can be mitigated by developing resistant cultivars. The rice landraces are known for their resilience, genetic diversity and invaluable sources of resistance to sheath blight (Willocquet and Savary, 2011). However, progress in developing resistant cultivars through genetic transformation with defense-related genes has been limited (Shiobara et al., 2013). Despite extensive breeding efforts, large-scale germplasm screenings and investigations of wild rice species for resistance genes (Chandra et al., 2016, Goswami et al., 2019; Pavani et al., 2020), no completely resistant rice germplasm has been identified to date (Singh et al., 2015). In spite of extensive global efforts to identify disease-resistant germplasm, no fully resistant rice lines have been discovered against sheath blight (Tejaswini et al., 2017, Bal et al., 2020). Plant Breeders utilize genetic diversity knowledge to choose parents for hybridization programs. Screening for the resistance in popular landraces can uncover novel genes and pathways involved in defence responses against *R. solani*. Insights gained from such studies are valuable for developing high-yielding rice genotypes with improved resistance to sheath blight. Therefore, the study's objective was to screen 240 popular landraces of rice against sheath blight, under field conditions.

2. MATERIALS AND METHODS

The rice genotypes were assessed for resistance to sheath blight caused by *R. solani* through artificial inoculation during *kharif* (July–November) seasons of 2023 and 2024 at 'A' Block, College of Agriculture, V. C. Farm, Mandya, (12° 32' N latitude, 76° 53' E longitude) Karnataka, India. The study used 240 land races that were gathered from the All India Coordinated Research Project (AICRP) on rice, ZARS, V. C. Farm, Mandya.

2.1. Artificial inoculation

The inoculum of *R. solani* was prepared by mass multiplication on sorghum grains and applied at the tillering stage, 30 days after transplanting. For inoculum preparation, sorghum grains were boiled until partially opened and 500 g of these grains were placed into 1000 ml conical flasks. The flasks were sterilized in an autoclave at 1.1 kg cm^{-2} (121°C) for 20 minutes. Under aseptic conditions, two to three 5 mm mycelial discs of *R. solani* were inoculated into the sterilized grains. The flasks were incubated at 27±1°C for 10 days, with regular agitation to ensure uniform fungal growth. The sorghum grains colonized by the fungus were used for field inoculations on 30 days old plants (depending on the maturity group of the rice genotypes) by dropping one gram of grains gently in the middle of the hill. High humidity (>90%) was maintained during the disease development by ensuring waterlogged conditions and closer plant spacing of 15×10 cm^2. Disease incidence was assessed on 10 plants for each entry.

2.2. Disease assessment

The information regarding disease severity was recorded on six different dates, at seven days interval i.e., 35, 42, 49, 56, 63, and 70 days after transplanting (DAT) by applying a field key of 0–9 scale. Where, 0=free from infection; 1=Vertical spread of the lesions up to 20% of plant height; 3=21–30%; 5=31–45%; 7=46–65%; 9=more than 65% (Anonymous, 2013). These scales were transformed to the

percent disease index (PDI) by applying the formula given by Wheeler (1969) and the area under the disease progress curve (AUDPC) was calculated.

Per cent disease index=Sum of the individual rating×100/ Number of plants examined×Maximum disease scale

2.3. Area under disease progress curve (AUDPC)

The "Area under Disease Progress Curve" would be calculated by using the formula suggested by Johnson and Wilcoxson (1982).

$$AUDPC = \sum_{i=1}^{n-1} [\{(X_i + X_{(i+1)}) / 2\} \times (t_{(i+1)} - t_i)]$$

X_i=Disease index expressed as a proportion at the i^{th} observation.

t_i=Time (days after transplanting) at the i^{th} observation

By considering the mean disease severity and AUDPC, all genotypes were categorized into five different reactions, resistant (R) for scale 1, moderately resistant (MR) for scale 3, moderately susceptible (MS) for scale 5, susceptible (S) for scale 7 and highly susceptible (HS) for scale 9 (Pavani et al. 2018).

3. RESULTS AND DISCUSSION

In the current study, 240 landraces were evaluated for resistance to sheath blight under open field conditions using artificial inoculation of *R. solani*. Based on the mean Percent Disease Index (PDI) and the Area Under Disease Progress Curve (AUDPC), the genotypes were categorized into five groups: resistant, moderately resistant, moderately susceptible, susceptible, and highly susceptible (Table 1). In the present study, out of the 240 landraces screened over two seasons, none exhibited an immune response with a score of 0. However, seven genotypes showed a resistant reaction, scoring 1. Seventy-two genotypes were categorized as moderately susceptible with a score of 5, seventy genotypes were classified as susceptible with a score of 7 and thirty-one genotypes were identified as highly susceptible, scoring 9 (Table 3).

3.1. Reaction of popular rice cultivars and landraces during kharif 2023

During the *kharif,* 2023 season, the mean Percent Disease Index (PDI) were ranged from 4.07 to 58.02% and Area under disease progress curve (AUDPC) varied between 132.21 to 2071.27. Genotypes with the PDI ranging from

Table 1: Reaction of popular cultivars and land races of rice against sheath blight

Sl. No.	Genotypes	Scale	Category	*Kharif,* 2023		*Kharif,* 2024		Pooled	
				Mean PDI	AUDPC	Mean PDI	AUDPC	Mean PDI	AUDPC
1.	Ambemohar	5	MR	20.12	689.56	24.69	842.51	22.41	766.03
2.	Anekombu latte	3	MR	10.62	383.67	17.90	635.12	14.26	509.39
3.	Aishwarya	5	MS	24.81	855.47	25.92	920.28	25.37	887.87
4.	AndraBasamati	5	MS	24.44	824.36	29.63	1075.82	27.03	950.09
5.	Antra Sali (233)	3	MR	16.79	596.24	19.13	661.05	17.96	628.64
6.	Adikannebatta 1	5	MS	27.40	964.35	34.56	1257.28	30.98	1110.81
7.	Anandi-1	3	MR	19.13	679.19	14.20	505.51	16.67	592.35
8.	Akkalu	5	MS	28.89	995.46	30.86	1127.67	29.87	1061.56
9.	ArvathPilai	5	MS	30.49	1078.41	32.10	1179.51	31.29	1128.96
10.	Anandi – 2	3	MR	14.44	505.51	19.13	686.97	16.79	596.24
11.	Adri batta	5	MS	30.00	1073.23	34.56	1257.28	32.28	1165.25
12.	Ani maanda	3	MR	15.55	567.72	24.07	868.43	19.81	718.08
13.	Akkalujaddi	5	MS	27.65	982.49	33.33	1205.44	30.49	1093.96
14.	Bili akki	3	MR	17.41	622.16	21.60	764.74	19.50	693.45
15.	Boo Jaddu	5	MS	28.52	1018.79	33.95	1205.44	31.23	1112.11
16.	Bangarasanna 1	5	MR	23.70	824.36	24.69	842.51	24.20	833.44
17.	Bangarasanna 2	3	MR	16.29	575.50	19.13	661.05	17.71	618.27
18.	Bangarasanna 3	5	MS	24.44	847.69	33.95	1231.38	29.19	1039.54
19.	Bangarasanna 4	3	MR	16.67	583.28	21.60	764.74	19.13	674.01

Table 1: Continue...

Sl. No.	Genotypes	Scale	Category	*Kharif*, 2023		*Kharif*, 2024		Pooled	
				Mean PDI	AUDPC	Mean PDI	AUDPC	Mean PDI	AUDPC
20.	Bheema sale 1	3	MR	12.84	445.88	22.22	816.61	17.53	631.24
21.	Bheema sale 2	3	MR	15.18	513.28	22.84	816.59	19.01	664.93
22.	Bilikanna hegge	5	MS	26.42	922.87	27.16	972.13	26.79	947.50
23.	Bele jaddi alneram batta	3	MR	13.46	471.80	21.60	764.74	17.53	618.27
24.	Babbayam	3	MR	19.87	694.75	20.37	738.82	20.12	716.78
25.	B. B	1	R	8.02	267.01	11.11	401.81	9.57	334.41
26.	Bangara gundu	5	MS	23.70	832.14	29.63	1075.81	26.66	953.97
27.	Biganmunji	5	MS	25.92	902.13	29.01	1023.97	27.47	963.05
28.	BulBul-1	7	S	40.24	1410.23	49.38	1827.60	44.81	1618.91
29.	Bangara kaddi	5	MS	26.79	922.87	27.78	998.05	27.28	960.46
30.	Bebbanna	5	MS	30.12	1047.30	25.31	894.36	27.71	970.83
31.	Bangara kolee	3	MR	15.92	513.28	17.28	609.20	16.60	561.24
33.	Bili nellu	3	MR	11.73	414.77	12.34	427.74	12.04	421.25
33.	Black basumathi	5	MS	30.12	1078.41	30.24	1075.82	30.18	1077.11
34.	Bidagi kannappa	5	MS	28.52	987.68	32.10	1153.59	30.31	1070.63
35.	Barma Black	1	R	7.04	225.53	9.88	349.97	8.46	287.75
36.	Bili mundaga	3	MR	17.78	606.61	24.07	868.43	20.92	737.52
37.	Basumathi	3	MR	11.73	438.10	12.34	427.74	12.04	432.92
38.	Budda	5	MR	23.33	808.81	25.31	868.43	24.32	838.62
39.	Black sticky	1	R	7.41	241.09	8.02	298.12	7.72	269.60
40.	Chinnur	3	MR	15.92	583.28	21.60	790.66	18.76	686.97
41.	Coimbatore	7	S	32.34	1109.52	44.44	1594.29	38.39	1351.90
42.	Chinneponni 2	5	MS	34.93	1226.17	30.24	1075.84	32.59	1151.01
43.	Chinneponni 3	5	MS	16.29	552.17	25.31	842.54	20.80	697.36
44.	Chinnaponni 4	5	MS	30.00	1049.90	33.33	1179.51	31.66	1114.70
45.	Chinnaponni 5	7	S	42.71	1506.15	46.91	1698.00	44.81	1602.07
46.	Chinagari batta	7	S	32.34	1093.96	40.12	1412.85	36.23	1253.40
47.	Coimbatore sanna	7	S	42.96	1485.41	43.21	1516.52	43.08	1500.96
48.	Coimbatore sanna 1	5	MS	32.34	1140.63	33.33	1179.51	32.84	1160.07
49.	Chippige	5	MS	25.92	902.13	27.16	946.20	26.54	924.17
50.	Doddabyranellu	3	MR	16.67	591.05	24.07	868.42	20.37	729.74
51.	Doddi Batta	5	MS	21.73	741.41	29.01	1023.97	25.37	882.69
52.	Duddoge	7	S	36.79	1280.61	43.21	1542.44	40.00	1411.53
53.	Degundi	7	S	40.74	1446.52	42.59	1490.59	41.66	1468.56
54.	Dappaneya Bilijaddi	7	S	37.65	1309.13	38.27	1360.98	37.96	1335.05
55.	Dodda Batta	5	MS	27.90	969.53	31.48	1101.74	29.69	1035.64
56.	Dodda Baikalu	5	MS	23.95	788.07	25.92	920.28	24.94	854.17
57.	Dappa batta	9	HS	45.67	1560.58	53.08	1879.42	49.38	1720.00
58.	Danggaia	7	S	35.43	1200.25	40.74	1438.75	38.08	1319.50

Table 1: Continue...

Sl. No.	Genotypes	Scale	Category	*Kharif*, 2023		*Kharif*, 2024		Pooled	
				Mean PDI	AUDPC	Mean PDI	AUDPC	Mean PDI	AUDPC
59.	Doddabyra	7	S	41.48	1430.97	48.14	1749.83	44.81	1590.40
60.	Dappa playa	9	HS	55.30	1964.99	66.66	2449.76	60.98	2207.37
61.	Dappa valige	5	MR	27.13	1121.83	33.33	1205.46	30.23	1163.65
62.	Dubainallu	5	MS	26.05	899.54	29.01	1049.90	27.53	974.72
63.	Esadli	5	MS	24.69	811.40	26.54	920.28	25.61	865.84
64.	GK-I	5	MS	29.63	1026.56	30.24	1075.82	29.94	1051.19
65.	G K-5	7	S	36.42	1272.84	48.76	1749.83	42.59	1511.33
66.	G K-7	5	MS	28.39	959.16	32.10	1153.59	30.24	1056.38
67.	G K-9 Light brown	5	MS	28.89	995.46	29.01	998.05	28.95	996.75
68.	G K variety tall	5	MS	30.98	1106.93	32.71	1153.62	31.85	1130.27
69.	Gamnada batta	9	HS	52.96	1843.15	59.25	2138.68	56.11	1990.91
70.	Gandha sale 1	7	S	35.18	1244.32	35.80	1257.28	35.49	1250.80
71.	Gandha sale 2	3	MR	17.04	567.72	21.60	764.74	19.32	666.23
72.	Gangadale	7	S	37.53	1335.05	38.27	1335.05	37.90	1335.05
73.	Giddaraja kamal	7	S	38.89	1384.31	40.12	1438.75	39.50	1411.53
74.	Gowri sanna	7	S	34.56	1226.17	35.18	1231.36	34.87	1228.77
75.	Gud batta-2	5	MS	25.18	847.69	30.86	1101.74	28.02	974.72
76.	Gudda parollul	3	MR	18.27	642.90	23.46	842.52	20.86	742.71
77.	Gujarath basamati	3	MR	15.18	559.94	16.05	557.35	15.62	558.65
78.	Gulwadi sannaki	3	MR	11.97	425.14	12.34	427.74	12.16	426.44
79.	Game	7	S	37.16	1342.83	38.89	1386.90	38.02	1364.86
80.	Honne kattu	7	S	37.28	1324.68	38.27	1335.05	37.77	1329.87
81.	Honasu	3	MR	15.92	552.17	20.37	712.89	18.15	632.53
82.	Hasnudi	3	MR	13.33	474.40	18.52	686.97	15.92	580.68
83.	Hola batta	3	MR	17.04	614.38	21.60	764.74	19.32	689.56
84.	HMT	7	S	38.27	1381.71	40.74	1464.67	39.50	1423.19
85.	Itan gidda	7	S	43.70	1555.40	45.69	1672.81	44.70	1614.11
86.	Itansel	5	MS	25.31	860.65	28.39	998.05	26.85	929.35
87.	Jeerige batta	3	MR	17.65	616.98	22.84	816.59	20.24	716.78
88.	Jenugudu	5	MS	24.81	855.47	25.31	868.41	25.06	861.94
89.	Jeerge sanna	5	MS	28.02	935.83	32.71	1153.60	30.37	1044.72
90.	Jawahar	7	S	40.74	1469.85	43.21	1542.44	41.97	1506.15
91.	Jig madike	5	MS	26.91	904.72	32.10	1127.67	29.50	1016.19
92.	Jadda batta	3	MR	16.29	536.61	21.60	764.75	18.95	650.68
93.	Jeerige sanna	5	MS	25.80	912.50	27.16	946.20	26.48	929.35
94.	Joopvadly	5	MS	23.95	858.06	28.39	998.05	26.17	928.06
95.	Kari batta	3	MR	19.87	725.85	22.22	790.66	21.05	758.26
96.	Krishna leela	7	S	35.31	1257.28	36.42	1283.19	35.86	1270.24
97.	Kempu dadi gidda	7	S	37.90	1327.27	38.89	1386.90	38.39	1357.09

Table 1: Continue...

Sl. No.	Genotypes	Scale	Category	*Kharif*, 2023		*Kharif*, 2024		Pooled	
				Mean PDI	AUDPC	Mean PDI	AUDPC	Mean PDI	AUDPC
98.	Kappu batta	5	MS	21.36	702.52	24.69	868.50	23.02	785.51
99.	Kempunellu	3	MR	18.27	658.45	23.46	842.53	20.86	750.49
100.	Kulaj	3	MR	12.47	407.00	16.67	583.28	14.57	495.14
101.	Kagisale-1	3	MR	17.28	585.87	23.45	842.51	20.37	714.19
102.	Kalikatesi	7	S	36.05	1226.17	45.06	1620.21	40.55	1423.19
103.	Kaggali kecrona	5	MS	20.99	772.52	25.31	894.36	23.15	833.44
104.	Kari kandake	3	MR	20.62	756.96	23.45	842.51	22.03	799.73
105.	Kadulile	3	MR	13.83	502.91	19.75	687.05	16.79	594.98
106.	Kanakunja	3	MR	16.29	591.05	20.37	712.89	18.33	651.97
107.	Karikagga	1	MR	7.65	290.34	8.02	272.21	7.84	281.27
108.	Kamadari	3	MR	11.48	381.07	11.73	401.81	11.60	391.44
109.	Kalanamak-1	3	MR	4.32	150.36	6.79	220.36	5.56	185.36
110.	Kalanamak-2	7	S	40.98	1433.56	46.91	1697.96	43.95	1565.76
111.	Kavadari	3	MR	21.85	785.48	22.22	790.66	22.03	788.07
112.	Kagesale	5	MS	27.90	946.20	32.71	1179.49	30.31	1062.85
113.	Kaduvelpe	3	MR	15.18	544.39	22.22	790.66	18.70	667.53
114.	Kave kantak	3	MR	13.09	471.80	14.81	505.51	13.95	488.65
115.	Kalajeera	3	MR	14.81	489.95	22.22	790.66	18.52	640.31
116.	KN- local	5	MS	25.43	896.95	26.54	920.28	25.99	908.61
117.	Kyasakki	1	R	5.06	197.02	9.26	324.09	7.16	260.55
118.	Kempurajmudi	7	S	37.53	1319.50	43.82	1594.29	40.67	1456.89
119.	Kariga javele	7	S	35.68	1249.50	43.82	1542.44	39.75	1395.97
120.	KS Local	9	HS	53.57	1876.85	55.55	2009.06	54.56	1942.95
121.	Kari doddi	7	S	32.34	1117.30	38.89	1360.98	35.61	1239.14
122.	Karpoora keli	9	HS	52.34	1856.11	58.02	2086.83	55.18	1971.47
123.	Kannur	3	MR	13.58	430.33	20.37	712.89	16.97	571.61
124.	Kundi pullan	5	MS	27.03	979.90	29.01	1049.90	28.02	1014.90
125.	Khushi adikshan	5	MS	29.63	1065.45	30.25	1075.87	29.94	1070.66
126.	Kyasare-1	7	S	36.29	1244.32	46.91	1697.98	41.60	1471.15
127.	Kyasare-2	7	S	39.01	1397.27	39.50	1412.81	39.26	1405.04
128.	Koohadi samba	5	MS	25.18	871.02	28.39	998.05	26.79	934.54
129.	Kari jaddu	5	MS	25.68	899.54	29.63	1075.82	27.65	987.68
130.	Kari swarna	7	S	36.17	1278.02	42.59	1516.52	39.38	1397.27
131.	Kanada thumba	7	S	35.06	1278.02	43.82	1594.29	39.44	1436.15
132.	Kotayam-1	9	HS	56.78	2034.98	64.19	2346.06	60.49	2190.52
133.	Kari dodi budda	7	S	35.43	1239.14	41.35	1490.59	38.39	1364.86
134.	Laalya	7	S	36.79	1311.72	45.06	1620.21	40.92	1465.96
135.	Mugad suganda	9	HS	54.32	1993.50	51.85	1827.60	53.08	1910.55
136.	Muththina sanna	9	HS	52.34	1832.78	54.32	1957.21	53.33	1895.00

Table 1: Continue...

Sl. No.	Genotypes	Scale	Category	*Kharif*, 2023		*Kharif*, 2024		Pooled	
				Mean PDI	AUDPC	Mean PDI	AUDPC	Mean PDI	AUDPC
137.	Malgudi sanna 2	5	MS	28.02	990.27	33.33	1179.51	30.68	1084.89
138.	Mysore mallige	7	S	37.28	1278.02	47.53	1697.98	42.40	1488.00
139.	Musali	9	HS	53.08	1856.11	54.32	1957.21	53.70	1906.66
140.	Mara batta-1	7	S	35.31	1218.40	41.35	1490.58	38.33	1354.49
141.	Malkod	7	S	33.58	1176.92	35.80	1257.28	34.69	1217.10
142.	Mullu batta	5	MS	29.63	1049.90	32.71	1179.49	31.17	1114.69
143.	Masuri	5	MS	26.05	891.76	27.16	972.13	26.60	931.94
144.	Mavaokar	3	MR	13.95	515.87	15.43	531.43	14.69	523.65
145.	Mise batta	5	MS	25.18	855.47	33.33	1179.51	29.26	1017.49
146.	Muttina sanna	3	MR	17.04	622.16	20.37	712.89	18.70	667.53
147.	Manjupani	5	MS	26.91	966.94	28.39	1023.97	27.65	995.46
148.	Mallige-1	9	HS	54.07	1920.92	61.72	2242.37	57.90	2081.64
149.	Mallige-2	9	HS	53.08	1871.66	56.78	2034.98	54.93	1953.32
150.	Mobikar	9	HS	54.07	1928.70	56.78	2060.91	55.43	1994.80
151.	Moradda	9	HS	54.32	1915.73	58.02	2086.83	56.17	2001.28
152.	Manjula sona	9	HS	55.30	2019.43	58.02	2086.83	56.66	2053.13
153.	Mukkana rathna choodi	5	MS	25.18	878.80	30.24	1075.82	27.71	977.31
154.	Malgudi sanna 1	3	MR	11.36	375.89	11.73	401.84	11.54	388.86
155.	Mapilai samba 1	7	S	33.58	1192.47	36.42	1283.21	35.00	1237.84
156.	Mapilai samba 2	7	S	36.29	1267.65	48.14	1749.83	42.22	1508.74
157.	Mahasuri	5	MS	23.33	839.92	27.16	972.13	25.24	906.02
158.	Murkanna sanna	3	MR	14.94	534.02	20.37	712.89	17.65	623.46
159.	Narikel	7	S	36.79	1319.50	37.65	1335.05	37.22	1327.27
160.	Nawali	9	HS	52.09	1814.63	53.08	1905.37	52.59	1860.00
161.	Nati batta	3	MR	13.70	489.95	19.13	686.97	16.42	588.46
162.	Neermullare	7	S	36.79	1296.17	41.35	1464.67	39.07	1380.42
163.	Naland paddy	7	S	33.82	1132.85	36.42	1231.37	35.12	1182.11
164.	Nagabatta	7	S	40.49	1428.38	43.82	1542.44	42.16	1485.41
165.	Nirga samba	9	HS	51.35	1783.53	58.02	2086.83	54.69	1935.18
166.	NLR 3449	5	MS	29.38	1016.19	30.24	1049.91	29.81	1033.05
167.	Nazar bat	5	MS	20.49	681.78	25.92	920.28	23.21	801.03
168.	Navara black	7	S	36.29	1267.65	43.82	1594.29	40.06	1430.97
169.	Navalisale	7	S	39.13	1371.34	41.35	1464.67	40.24	1418.01
170.	Nellur sanna	3	MR	15.92	591.05	16.67	583.28	16.29	587.16
171.	Navara	7	S	34.56	1163.96	37.65	1335.05	36.11	1249.50
172.	Neergula batta	7	S	44.19	1560.58	46.91	1697.96	45.55	1629.27
173.	Narali	3	MR	16.67	575.50	22.84	816.59	19.75	696.04
174.	Nail batta	9	HS	58.02	2079.05	62.96	2294.22	60.49	2186.63

Table 1: Continue...

Sl. No.	Genotypes	Scale	Category	*Kharif*, 2023		*Kharif*, 2024		Pooled	
				Mean PDI	AUDPC	Mean PDI	AUDPC	Mean PDI	AUDPC
175.	Neermuka	5	MS	30.74	1096.56	33.33	1205.44	32.03	1151.00
176.	Onamardininellu	7	S	37.90	1311.72	43.21	1542.44	40.55	1427.08
177.	Padme rekha 1	7	S	42.09	1488.00	48.14	1749.85	45.12	1618.92
178.	Padma rekha 2	9	HS	58.02	2071.27	64.19	2346.06	61.11	2208.67
179.	Padma rekha 3	7	S	42.96	1508.74	46.29	1672.03	44.62	1590.38
180.	PB Local	7	S	36.79	1288.39	41.35	1490.59	39.07	1389.49
181.	Punkutt kodi 1	9	HS	52.83	1853.52	54.32	1957.21	53.57	1905.37
182.	Punkutt kodi 2	7	S	37.16	1358.38	36.42	1257.28	36.79	1307.83
183.	PSB- 87	9	HS	52.83	1876.85	53.08	1905.37	52.96	1891.11
184.	Pushpa	7	S	39.75	1358.38	43.82	1542.44	41.79	1450.41
185.	Possugand	5	MS	25.18	871.02	30.24	1075.82	27.71	973.42
186.	Putta batta	5	MS	31.11	1112.11	31.48	1127.67	31.29	1119.89
187.	Putta batta-2	9	HS	54.07	1920.92	56.78	2034.98	55.43	1977.95
188.	Raichur sanna	7	S	40.49	1389.49	48.14	1749.83	44.32	1569.66
189.	Roy bag	5	MS	24.81	847.69	25.92	894.36	25.37	871.02
190.	Raskadar	7	S	35.43	1223.58	37.65	1335.05	36.54	1279.32
191.	Rajbhoga	7	S	34.93	1187.29	38.89	1386.90	36.91	1287.09
192.	Rasakadam	9	HS	52.09	1837.96	54.32	1957.21	53.20	1897.59
193.	Rathanachoodi 1	3	MR	11.48	381.07	11.73	375.87	11.60	378.47
194.	Rathanachoodi 2	9	HS	51.35	1783.53	56.78	2060.91	54.07	1922.22
195.	Rajamani	5	MS	24.07	816.59	28.39	998.05	26.23	907.32
196.	Red sticky	9	HS	51.35	1783.53	51.85	1853.52	51.60	1818.52
197.	Rajamudi kempu	7	S	42.22	1462.08	44.44	1568.36	43.33	1515.22
198.	Rat bat	7	S	40.49	1389.49	45.06	1620.21	42.77	1504.85
199.	Rahodaya	3	MR	17.41	583.28	22.22	790.66	19.81	686.97
200.	Rajaboga	7	S	35.43	1200.25	38.89	1386.90	37.16	1293.57
201.	Rajakime	7	S	38.27	1296.17	43.82	1542.45	41.05	1419.31
202.	Rajamudi	9	HS	52.83	1845.74	56.78	2060.91	54.81	1953.32
203.	RB	7	S	41.72	1425.78	46.91	1698.00	44.32	1561.89
204.	Sanna mallige	3	MR	13.46	448.47	16.05	557.35	14.75	502.91
205.	Sanna mallige 2	9	HS	45.80	1573.55	49.99	1775.69	47.90	1674.62
206.	Sanna mullu	7	S	41.72	1441.34	44.44	1594.29	43.08	1517.81
207.	Sada halga	7	S	43.21	1488.00	47.53	1723.93	45.37	1605.96
208.	Sarjana	5	MS	30.86	1062.86	29.01	1023.97	29.94	1043.41
209.	Sannakki	9	HS	55.55	1944.25	59.25	2164.60	57.40	2054.42
210.	Selam sanna	3	MR	15.92	552.17	23.45	842.51	19.69	697.34
211.	Sanna batta-1	9	HS	52.96	1843.15	53.08	1905.37	53.02	1874.26
212.	Sanna batta-2	5	MS	20.49	681.78	29.01	1049.90	24.75	865.84
213.	Sanna rajakime	5	MS	25.18	839.92	30.86	1101.74	28.02	970.83

Table 1: Continue...

Sl. No.	Genotypes	Scale	Category	*Kharif*, 2023		*Kharif*, 2024		Pooled	
				Mean PDI	AUDPC	Mean PDI	AUDPC	Mean PDI	AUDPC
214.	Siri sanna	7	S	39.75	1358.38	47.52	1723.83	43.64	1541.11
215.	Sanbag	5	MS	29.26	1034.34	31.48	1127.67	30.37	1081.00
216.	Sidda sanna	5	R	4.07	132.21	6.79	220.36	5.43	176.28
217.	Selam sanna 1	7	S	38.27	1327.27	40.74	1464.67	39.50	1395.97
218.	Sona masuri	7	S	38.27	1327.27	42.59	1542.44	40.43	1434.86
219.	Sirsi	3	MR	12.34	394.03	14.81	505.51	13.58	449.77
220.	Santetala	5	MS	24.07	832.14	29.63	1049.90	26.85	941.02
221.	Theerthahalli local 1	3	MR	14.32	492.54	18.52	661.05	16.42	576.79
222.	Tai jasmine	5	MS	24.07	816.59	29.01	1023.97	26.54	920.28
223.	Tornado batta 2	7	S	37.16	1288.39	38.27	1360.98	37.71	1324.68
224.	TRV s Dangi red	7	S	35.06	1176.92	48.14	1723.90	41.60	1450.41
225.	TRV s Biladadi martiga	9	HS	52.83	1814.63	61.72	2242.37	57.28	2028.50
226.	TRV s pokkali	5	MS	25.18	839.92	32.71	1179.51	28.95	1009.71
227.	Tulasiya	7	S	34.19	1132.85	46.91	1697.98	40.55	1415.41
228.	TRV s Dodda alur	3	MR	15.43	523.65	22.84	816.56	19.13	670.11
229.	TRV s that jasmine	9	HS	54.81	1913.14	66.66	2449.76	60.73	2181.45
230.	Togarsi	9	HS	53.82	1856.11	59.25	2164.60	56.54	2010.35
231.	TRV s mysore sanna	7	S	36.91	1246.91	48.14	1749.83	42.53	1498.37
232.	TRV s murkanna sanna	3	MR	13.46	448.47	22.22	790.66	17.84	619.57
233.	Tonnaru	5	MS	30.74	1065.45	32.67	1177.62	31.70	1121.54
234.	TRV s valtgya gidda	5	MS	28.89	1026.56	30.24	1075.82	29.56	1051.19
235.	Tagarhi	5	MS	25.18	855.47	27.78	998.05	26.48	926.76
236.	Ugi batta	3	MR	15.92	552.17	19.13	661.05	17.53	606.61
237.	Ubarnuunda	7	S	40.12	1350.61	46.91	1697.93	43.51	1524.27
238.	Vol bag sugandha	3	MR	16.67	575.50	19.13	661.05	17.90	618.27
239.	Vanasu	5	MS	26.66	886.58	32.71	1179.51	29.69	1033.04
240.	White sticky	5	MS	23.70	808.81	25.31	868.41	24.50	838.61

4.07 to 8.02% and AUDPC values ranging from 132.21 to 267.01 were classified as resistant with scale 1, indicating significant resistance among all genotypes. Genotypes in the moderately resistant category (scale 3) exhibited a PDI range of 10.62–19.87% and AUDPC of 383.67–725.85. Whereas, the PDI and AUDPC of moderately susceptible genotypes with scale 5 varied from 20.12 to 31.11% and 689.56 to 1,112.11 respectively. Genotypes with a PDI ranging from 32.34 to 44.19% and AUDPC from 1,112.11 to 1,560.58 were considered as susceptible (scale 7), while genotypes with a PDI from 45.67 to 58.02% with AUDPC values between 1,560.58 to 2,071.27 were classified as highly susceptible category exhibiting the scale 9 (Table 2).

3.2. Reaction of popular rice cultivars and landraces during kharif 2024

During *kharif* 2024, the mean PDI was more compared to earlier season which ranged from 6.79 to 66.66% and the AUDPC ranged from 220.36 to 2449.76. The PDI ranging from 6.79–11.11% with AUDPC values between 220.36–401.81 were categorized as resistant genotypes with scale 1, which were significantly resistant among all the genotypes. Whereas, in moderately resistant categories (scale 3), the PDI and AUDPC ranged between 11.73–24.07% and 375.87–868.43 respectively. Likewise, in moderately susceptible categories (scale 5) the PDI varied from 24.69 to 34.56% and AUDPC ranged from 842.51 to 1257.28.

Table 2: Mean PDI and AUDPC range of popular land races of rice against sheath blight

Scale	Mean PDI			AUDPC		
	Kharif -2023	*Kharif* -2024	Pooled	*Kharif* -2023	*Kharif* -2024	Pooled
0	Nil	Nil	Nil	Nil	Nil	Nil
1	4.07 –8.02	6.79–11.11	5.43–9.57	132.21 –267.01	220.36– 401.81	176.28–334.41
3	10.62 –19.87	11.73– 24.07	11.54–22.03	383.67 –725.85	375.87–868.43	388.86 –799.73
5	20.12 –31.11	24.69–34.56	22.41–32.84	689.56 –1112.11	842.51–1257.28	766.03 –1160.07
7	32.34 –44.19	35.80–48.76	34.69–45.37	1112.11–1560.58	1257.28–1748.83	1217.10–1605.96
9	45.67 –58.02	49.99–66.66	47.90–61.11	1560.58–2071.27	1775.69–2449.76	1674.62–2208.67

Table 3: List of rice genotypes under different resistance categories against sheath blight

Reaction	No. of genotypes	Genotypes
Immune	0	0
R	7	B. B, Barma Black, Black sticky, Kalanamak-1, Karikagga, Kyasakki, Siddasanna
MR	60	Ambe mohar, Anekombu latte, Antra Sali (233), Anandi-1, Anandi-2, Ani maanda, Bili akki, Bangara sanna-1, Bangara sanna-2, Bangara sanna-4, Bheema sale-1, Bheema sale-2, Bele jaddi alneram batta, Babbayam, Bangara kolee, Bili nellu, Bili mundaga, Basumathi, Budda, Chinnur, Dodda Byranellu, Gandha sale-2, Gudda parollul, Gujarath basamati, Gulwadi sannaki, Honasu, Hasnudi, Hola batta, Jeerige batta, Jadda batta, Kari batta, Kempunellu, Kulaj, Kagisale-1, Kari kandake, Kadulile, Kanakunja, Kamadari, Kavadari, Kaduvelpe, Kave kantak, Kalajeera, Kannur, Mavaokar, Muttina sanna, Malgudi sanna-1, Murkanna sanna, Nati batta, Nellur sanna, Narali, Rathanachoodi-1, Rahodaya, Sanna mallige, Selam sanna, Sirsi, Theerthahalli local-1, TRV s Dodda alur, TRV s murkanna sanna, Ugi batta, Vol bag sugandha
MS	72	Aishwarya, Andra Basamati, Adi kanne batta-1, Akkalu, Arvath Pilai, Adri batta, Akkalu jaddi, Boo Jaddu, Bangara sanna-3, Bilikanna hegge, Bangara gundu, Bigan munji, Bangara kaddi, Bebbanna, Black basumathi, Bidagi kannappa, Chinne ponni-2, Chinne ponni-3, Chinna ponni-4, Coimbatore sanna-1, Chippige, Doddi Batta, Dodda Batta, Dodda Baikalu, Dappa valige, Dubainallu, Esadli, GK-I, G K-7, G K-9 Light brown, G K variety tall, Gud batta-2, Itansel, Jenugudu, Jeerge sanna, Jig madike, Jeerige sanna, Joopvadly, Kappu batta, Kaggali kecrona, Kagesale, KN- local, Kundi pullan, Khushi adikshan, Koohadi samba, Kari jaddu, Malgudi sanna-2, Musali, Mullu batta, Masuri, Mise batta, Manjupani, Mukkana rathna choodi, Mahasuri, Nazar bat, Neermuka, Possugand, Putta batta, Roy bag, Rajamani, Sarjana, Sanna batta-2, Sanna rajakime, Sanbag, Santetala, Tai jasmine, TRV s pokkali, Tonnaru, TRV s valtgya gidda, Tagarhi, Vanasu, White sticky
S	70	Bul Bul -1, Coimbatore, Chinna ponni-5, Chinagari batta, Coimbatore sanna, Duddoge, Degundi, Dappaneya Bilijaddi, Danggaia, Doddabyra, G K-5, Gandha sale-1, Gangadale, Giddaraja kamal, Gowri sanna, Game, Honne kattu, HMT, Itan gidda, Jawahar, Krishna leela, Kempu dadi gidda, Kalikatesi, Kalanamak-2, Kempurajmudi, Kariga javele, Kari doddi, Kyasare-1, Kyasare-2, Kari Swarna, Kanada thumba, Kari dodi budda, Laalya, Mysore mallige-1, Mara batta-1, Malkod, Maplilai samba-1, Mapilai samba-2, Narikel, Neermullare, Naland paddy, Nagabatta, Navara black, Navalisale, Navara, Neergula batta, Onamardini nellu, Padme rekha-1, Padma rekha-3, PB Local, Punkutt kodi-2, Pushpa, Raichur sanna, Raskadar, Rajbhoga, Rajamudi kempu, Rat bat, Rajaboga, Rajakime, RB, Sanna mullu, Sada halga, Siri sanna, Selam sanna-1, Sona masuri, Tornado batta-2, TRVs Dangi red, Tulasiya, TRVs mysore sanna, Ubarnuunda
HS	31	Dappa batta, Dappa playa, Gamnada batta, KS Local, Karpoora keli, Kotayam-1, Mugad suganda, Muththina sanna, Musali, Mallige-1, Mallige-2, Mobikar, Moradda, Manjula sona, Nawali, Nirga samba, Nail batta, Padma rekha-2, Punkutt kodi-1, PSB- 87, Putta batta-2, Rasakadam, Rathanachoodi-2, Red sticky, Rajamudi, Sanna mallige-2, Sannakki, Sanna batta-1, TRV s Biladadi martiga, TRV s thai jasmine, Togarsi

However, genotypes with PDI from 35.80 to 48.76% and AUDPC values from 1257.28–1748.83 were categorized as susceptible (scale 7), while genotypes with PDI and AUDPC ranged from 49.99 to 66.66% and 1775.69–2449.76 respectively were regarded as highly susceptible with scale 9 (Table 2). The slightly increase in level of disease development was attributed by the varied environmental factors like high rainfall, humidity and low temperature contributed for creating favourable conditions for the pathogen which, further influenced disease development.

3.3. Pooled data of reaction of popular cultivars and land races of rice against sheath blight during kharif 2023 and 2024

The average disease reaction of both seasons represented here wherein, the mean PDI ranged from 5.43 to 61.11%. The genotypes with least PDI (5.43–9.57%) and AUDPC (176.28–334.41) range was categorized as resistant genotypes with scale 1. Whereas, in moderately resistant categories (scale 3), the PDI and AUDPC ranged between 11.54 to 22.03% and 388.86 to 799.73 respectively. Likewise, genotypes in moderately susceptible categories (scale 5) exhibited a varied level of PDI (22.41–32.84%) and AUDPC (766.03–1160.07) However, genotypes with PDI varied from 34.69–45.37% and AUDPC from 1217.10–1605.96 were categorized as susceptible (scale 7) and with highest range of PDI (47.90–61.11%) and AUDPC (1674.62–2208.67) were regarded as highly susceptible which were exhibiting the scale 9 (Table 2).

Landraces served as invaluable genetic resources for exploring novel genetic variations to address challenges in crop production. Their high adaptability made them excellent sources for pathogen resistance, disease tolerance and resilience to various abiotic stresses, providing potential donor traits for breeding programs (Newton et al., 2011). The varied results in sheath blight resistance among the genotypes could be attributed to genetic diversity, differential expression of resistance genes and environmental influences. Additionally, host-pathogen interactions could have contributed to the observed differences in disease resistance across the genotypes.

A similar result was observed by Pavani et al. (2018) who screened 196 germplasm under natural conditions after inoculation with virulent isolate of *R. solani* (RS 49). None of the entries were found immune or resistant. Fifty-seven entries were found moderately resistant, moderately susceptible and rest of the entries showed highly susceptible reaction. Goswami et al. (2019) conducted a field trial with 261 rice germplasm during the 2013–2014 and 2014–2015 *kharif* seasons to screen the *R. solani* AG1IA resistant germplasm. Mean percent disease index (PDI) varied between 22.95 and 27.40%. On the basis of AUDPC (area under disease progress curve) values, rice germplasm lines belonged to 5 groups i.e., resistant, 57 (262.93–957.92), moderately resistant, 169 (957.93–1220.87), moderately susceptible, 14 (1220.88–1490.81), susceptible, 18 (1490.82–1753.75) and highly susceptible, 3 (1753.76–2016.69)

The current findings align with Gupt et al. (2021) who evaluated forty-two diverse rice genotypes against sheath blight by considering four disease variables viz., PDLI (Percent diseased leaf incidence), PDTI (Percent diseased tiller incidence), PRCHI (Percent relative collar height infection), and AUDPC (Area under disease progress curve). Out of forty-two genotypes Sabitri, GSR 310 and Hardinath-3 were found moderately resistant with mean AUDPC values 217.99, 252.78 and 214.67 per day respectively. Furthermore, IR 15D 110, Pant-1, NR 2152-23-1-2-1-1-1-1 and IR 82635-B-B-114-3 were found moderately susceptible with mean AUDPC values 438.48, 445.55, 421.81 and 437.59 respectively. Disease variables were positively and significantly correlated with AUDPC.

Similar finding was observed by Arshad et al. (2022) who screened 85 rice germplasm originated from IRRI and Pakistan were inoculated with *R. solani* through toothpick inoculation method under field conditions during 2020 and 2021. The results revealed that none of the genotype reflected immune response against sheath blight disease while two rice varieties, Noor Basmati and IRRI-29 with disease severity (15.21–15.77% and 18.39–19.97% respectively) were found resistant in both years. 8 varieties were categorised as moderately resistant with the disease severity ranging from 21 to 30% in both years. 26 varieties were found moderately susceptible with the disease infectivity of 31.33 to 44.94% while 49 were susceptible with 45.72 to 65.26% in 2020–2021. The findings also align with Timsina et al. (2022), who assessed 122 F3 rice populations for sheath blight resistance under field conditions. The populations were categorized into four groups based on AUDPC values: moderately resistant (24), moderately susceptible (38), susceptible (40) and highly susceptible (20). Moderate resistance was observed in 24 lines with mean PDI ranging from 12.22% to 36.6%. Additionally, 38 lines exhibited moderate susceptibility with AUDPC values between 1012 and 1446. The highest recorded PDI and AUDPC values were 76.11 and 2325.56, while the lowest were 22.78 and 622.22, respectively.

The current findings also agreed with those of Ashwini et al. (2024), who screened ninety landraces and ten popular varieties of rice against sheath blight disease by artificial inoculation method. The results revealed that the, mean percent disease index (PDI) ranged from 11.11 to 79.56%. Based on AUDPC values, rice genotypes were categorized into 5 groups i.e., resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible.

4. CONCLUSION

No rice germplasm had shown complete resistance to sheath blight (*R. solani*). This study screened 240 rice landraces to identify resistance sources for breeding programs. Results revealed no immune, 7 resistant, 60 moderately resistant, 72 moderately susceptible, 70 susceptible and 31 highly susceptible genotypes.

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6. REFERENCES

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