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Screening of rice genotypes against major insect-pests of rice (*Oryza sativa* L.) under field conditions

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Abstract
Forty genotypes were screened against gall midge, yellow stem borer, leaf folder and whorl maggot infestation. The experiment was conducted in research cum instructional farm of Shaheed Gundadhoor College of Agriculture and Research Station, Jagdalpur, Bastar (C.G.) during *Kharif*, 2022. In the screening of rice genotypes against major insect pests, genotype MRST 20221-1 was found to be moderate resistant (score '3') against gall midge and whorl maggot, while resistant (score '1') against stem borer and leaf folder incidence. Genotype MRST 20221-6 was moderate resistant (score '3') against gall midge and whorl maggot, resistant (score '1') against leaf folder while highly resistant (score '0') against stem borer incidence. Genotype MRST 20221-15 was found to be moderate resistant (score '3') against gall midge, resistant (score '1') against whorl maggot, highly resistant (score '0') against stem borer and leaf folder incidence. Genotype MRST 20221-35 had moderate resistance (score '3') against gall midge, resistance (score '1') against whorl maggot and leaf folder, while highly resistance (score '0') against stem borer incidence. Genotype MRST 20221-38 was moderate resistant (score '3') against gall midge, while resistant (score '1') against whorl maggot, leaf folder and stem borer infestations.

Keywords: Screening, gall midge, stem borer, leaf folder, whorl maggot, rice

Introduction
Rice (*Oryza sativa* L.) is monocotyledonous crop, belongs to family Poaceae and genus *Oryza* with 22 wild species and two cultivated species, namely *Oryza sativa* and *Oryza glaberrima*. However, *O. sativa* is grown all over the world, but *O. glaberrima* is primarily grown in west Africa. Rice was believed to have originated from South-East Asia. It is primarily a meal with a lot of calories. (Anonymous, 2004) [1]. More than 95 countries throughout the world grow rice (*Oryza sativa* L.), a staple food for more than half of the world's population. In the developing world, one of the most important cereal crops is rice. (Pandit *et al.*, 2020) [16]. It comprises 80% carbohydrates, 8% protein, 3% fat, and 3% fiber. (Chaudhari *et al*., 2018) [9]. The overall area of rice cultivation worldwide is 165.22 million hectares with the production of 509.29 million metric tonnes and productivity of 4620 kg ha^{-1} during *Kharif* 2020-21. (Anonymous, 2021) [3].

"Global grain" is a term used to describe rice. 90% of the rice consumed and produced worldwide is in Asia. Asia's rice output is so essential for ensuring global food security. India is the second largest producer and consumer of rice in the world, accounting for 20% of world rice production. During the years 2021-22, rice was grown in India over an area of 45.07 million hectares, with a production volume of 127.93 million tonnes and a productivity of approximately 2713 kg ha^{-1}. It was 11.49 million tonnes more than the 116.44 million tonnes average production over the previous five years. (Anonymous, 2022) [4].

Insect pests are among the most damaging biotic factors, causing 21- 40 percent losses in rice yield. (Prakash and Rao, 2003). Finding out the resistance/tolerance of rice varieties suitable for the region with their high production potential is urgently needed to prevent losses caused by insect pests. Rice production technology has changed quickly as a result of the necessity to intensify rice production. Without a doubt, these modifications have raised rice yields, but they have also made the crop more vulnerable to certain pests. (Dhaliwal *et al*., 1985) [10].

This experiment was performed to test the resistance of 40 rice entries against four insect pests of rice *i.e*., gall midge (*Orseolia oryzae* W.), stem borer (*Scirpophaga incertulas* W.), leaf folder (*Cnaphalocrocis medinalis* Guen.) and whorl maggot (*Hydrellia philippina* F.).

Materials and Methods

The experiment was conducted in research cum instructional farm of Shaheed Gundadhoor College of Agriculture and Research Station, Jagdalpur, Bastar (C.G.) during *Kharif*, 2022. For the Multiple Resistance Screening Trial (MRST) against major insect pests, 40 entries of rice were transplanted during *Kharif* 2022. The plant to plat and row to row spacing was 15 x 15 cm. All the agronomic practices were followed during the crop growth period. Incidence of gall midge as silver shoot (SS %), stem borer as dead heart (DH %), leaf folder and whorl maggot as damaged leaf (DL %) were recorded on 30 and 50 days after transplanting and then damage percentages were worked out. In the observation of data, healthy and damaged tillers or leaves per hill were recorded for the percent infestation of major insect pests. Ten randomly selected hills of 40 entries were observed for the confirmation of resistance against major insect pests *viz*., gall midge, stem borer, leaf folder and whorl maggot. Percent infestation of insect-pests were calculated by given formula:

$$\text{Percent silver shoot (SS\%)} = \frac{\text{Number of silver shoots}}{\text{Total numbers of tillers}} \text{ x } 100$$

$$\text{Per cent dead heart (DH\%)} = \frac{\text{Number of dead heart}}{\text{Total numbers of tillers}} \text{ x } 100$$

$$\text{Percent damage (LFI \%)} = \frac{\text{Number of damaged leaves}}{\text{Total numbers of tillers}} \text{ x } 100$$

$$\text{Per cent damage (WMD\%)} = \frac{\text{Number of damaged leaves}}{\text{Total numbers of tillers}} \text{ x } 100$$

Then, the test entries were assessed for insect-pest damage as per Standard Evaluation System, International Rice Research Institute (IRRI) for gall midge, yellow stem borer, leaf folder and whorl maggot according to table 1, 2, 3 and 4.

Results and Discussion

On the basis of infestation level, resistance status of a culture was ascertained. The reactions of different rice accessions were observed as promising genotype for infestation at maximum tillering stage were as follows –

1. Gall midge, *Orseolia oryzae* (Wood- Mason)

The percentages of infested tillers were classified into different six groups under 0 - 9 score (Standard evaluation system for rice, IRRI, 2013). According to the Table: 7, total 5 entries *viz*., MRST 20221-1, MRST 20221-6, MRST 20221-15, MRST 20221-35 and MRST 20221-38, were found under '3' score to be moderately resistant to gall midge incidence (Range 3.19 - 4.94 % SS).

Only 1 entry MRST 20221-16 was found under '5' score (having up to 8.73 % SS) to be moderately susceptible to gall midge incidence. Total 6 entries *viz*., MRST 20221-11, MRST 20221-17, MRST 20221-18, MRST 20221-19, MRST 20221-20 and MRST 20221-39 were found '7' score to be susceptible for gall midge incidence (Range 12.20 – 23.08 % SS).

27 entries *viz*., MRST 20221-2, MRST 20221-3, MRST 20221-4, MRST 20221-5, MRST 20221-7, MRST 20221-8, MRST 20221-9, MRST 20221-12, MRST 20221-13, MRST 20221-14, MRST 20221-21, MRST 20221-22, MRST 20221-23, MRST 20221-24, MRST 20221-25, MRST 20221-26, MRST 20221-27, MRST 20221-28, MRST 20221-29, MRST 20221-30, MRST 20221-31, MRST 20221-32, MRST 20221-33, MRST 20221-34, MRST 20221-36, MRST 20221-37 and MRST 20221-40 were recorded under score '9' as highly susceptible (HS) with more than 25 percent silver shoot incidence (Range 25.20 - 49.58 % SS). One of the entries MRST 20221-10 was not germinated. The overall range of gall midge incidence was 3.19 to 49.58 % SS.

Previous researcher, Seni and Naik (2017) [20] screened some rice entries during *Kharif*. In contrast, 12 entries *viz*., W 1263, INRC 3021, Sudu Hondarawala, PTB 26, RP 4686-48-1-937, RMSG-11, WGL 1147, WGL 1127, WGL 1121, WGL 1131, WGL 1141, and JGL 27058 were found to be resistant to gall midge damage. TN-1 had the highest incidence of silver shoot (36.71% SS after 50 DAT). Seni and Naik (2019) [21] further screened some rice entries. Highest incidence of silver shoot was recorded in TN-1 (38.85% SS after 50 DAT) whereas 52 entries *viz.*, WGL 1164, WGL 1127, RP 5925, RP 1, INRC 3021, IBT R4, IBT GM (1, 2, 3, 4, 7, 9, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 46) KNM 6854, IBT GM (5, 6, 10, 14, 15, 24, 44), W 1263, WGL 1147 were found resistant to gall midge.

Similarly, Kumar *et al*. (2020) [12] screened 173 rice entries against gall midge [*Orseolia oryzae* (Wood-Mason)] for resistance. IBT MRR 18, IBT MRR 23, and IBT MRR 24 were found to be extremely resistant among the 173 rice entries that were screened, while IBT MRR 17, IBT MRR 19, IBT MRR 20, IBT MRR 21, IBT MRR 22, and IBT MRR 28 had shown resistant reaction against gall midge.

2. Yellow stem borer, *Scirpophaga incertulas* (Walker)

The percentages of infestation (Dead heart) were classified into different six groups under 0-9 score (Standard evaluation system for rice, IRRI, 2013). According to the data presented in Table: 8, total 22 entries *viz*., MRST 20221-2, MRST 20221-3, MRST 20221-4, MRST 20221-5, MRST 20221-6, MRST 20221-7, MRST 20221-8, MRST 20221-9, MRST 20221-11, MRST 20221-12, MRST 20221-15, MRST 20221-24, MRST 20221-25, MRST 20221-26, MRST 20221-27, MRST 20221-29, MRST 20221-33, MRST 20221-34, MRST 20221-35, MRST 20221-37, MRST 20221-39 and MRST 20221-40 were ranked with '0' score (< 1 % DH), which means they were found to be highly resistance to stem borer infestation (Range 0.00 - 0.94 DH %).

The 15 entries *viz*., MRST 20221-1, MRST 20221-13, MRST 20221-16, MRST 20221-18, MRST 20221-19, MRST 20221-20, MRST 20221-21, MRST 20221-22, MRST 20221-23, MRST 20221-28, MRST 20221-30, MRST 20221-31, MRST 20221-32, MRST 20221-36 and MRST 20221-38 were found under '1' score to be resistant to stem borer incidence (Range 1.29 - 10.00 DH %).

Only 2 entries MRST 20221-14 and MRST 20221-17 were found under '3' score to be moderately resistance to stem borer incidence (Range 11.11 - 13.27). One of the entries MRST 20221-10 was not germinated. The stem borer incidence overall ranged from 0.00 to 13.27 DH %.

Former researcher, Preetha (2017) [18] screened different rice cultures/ germplasms for their reaction to stem borer during

the *Kharif* season. The percent infestation of stem borer varied between 0 and 45.71. Among the 46 rice cultures screened, TP 10003, TP 10004, TP 10039 and TP 08095 were found to have no or minimal incidence and were rated as resistant category. TP 10002, TP 10005, TP 10016, TP 10038, TP 10051, TP 10052, TP 09048 and TP 09052 were rated as moderately resistant. Mandloi *et al*. (2018) [14] also evaluated 73 rice varieties/genotypes in the field to see how well they performed against *Scirpophaga incertulas*. White ears were noted when the crop was in the dough stage. Lowest white ear counts (pooled mean) were obtained for genotypes IR 36, R 1700-302-1-156-1, Shymla, and IR 64, respectively, at 0.00, 0.17, 0.17, and 0.17/plant.

Correspondingly, Balaga *et al*. (2020) [6] screened out 41 local Manipuri rice genotypes for stem borer damage included Moirangphou Khokngambi (1.47%), Chingphou (1.70%), Tei (1.71%), Bungpat (1.79%), Phouren Khoknembi (1.83%), and Langphou (1.98%). These genotypes had the lowest incidence of damage from stem borer. The highest incidence of stem borer was recorded in Mieling Manthowean (4.53% damage), Kiebiphou (4.28% damage), Mashi (3.89% damage), Mashi Manui (3.81% damage), Tathai (3.78% stem borer damage), Aso (3.72% damage), and Shangao (3.72% damage). Nalla *et al*. (2020) [15] also conducted a field evaluation of 196 rice accessions to find those that were resistant to *Scirpophaga incertulas*, the yellow stem borer. Five entries were found to be resistant, including entries Nos. 40 (OR 2324-8), 160 (RTN 62-6-7-1), 140 (CR 2698), 60 (HUR-913) and 150 (CN 1561-70-19-35-9- MLD). Four entries were found to be moderately resistant at the reproductive stage (white ear), namely entries Nos. 40 (OR 2324-8), 160 (RTN 62-6-7-1), 70 (R 1138-688-3-533-1) and 140 (CR 2698).

3. Leaf folder, *Cnaphalocrocis medinalis* (Guenee)

The percentages of infestation of leaf folder (Damaged leaves) were classified into different six groups under 0-9 score (Standard evaluation system for rice, IRRI, 2013). By the data presented in Table: 9, total 7 entries *viz*., MRST 20221-3, MRST 20221-14, MRST 20221-15, MRST 20221-17, MRST 20221-18, MRST 20221-19 and MRST 20221-20 are ranked with '0' score (< 1 % DL), which means they were highly resistance to leaf folder infestation (Range 0.00 - 0.77 % DL).

In the present experiment 32 entries *viz*., MRST 20221-1, MRST 20221-2, MRST 20221-4, MRST 20221-5, MRST 20221-6, MRST 20221-7, MRST 20221-8, MRST 20221-9, MRST 20221-11, MRST 20221-12, MRST 20221-13, MRST 20221-16, MRST 20221-21, MRST 20221-22, MRST 20221-23, MRST 20221-24, MRST 20221-25, MRST 20221-26, MRST 20221-27, MRST 20221-28, MRST 20221-29, MRST 20221-30, MRST 20221-31, MRST 20221-32, MRST 20221-33, MRST 20221-34, MRST 20221-35, MRST 20221-36, MRST 20221-37, MRST 20221-38, MRST 20221-39 and MRST 20221-40 were found '1' score to be resistant to leaf folder incidence (Range 1.26 - 7.82 % DL). One of the entries MRST 20221-10 was not germinated. All entries showed resistance reaction because of the low leaf folder incidence. The overall range for leaf folder varied between 0.00 - 7.82 % DL.

Preceding researcher, Appala Raju *et al*. (2018) [5] screened 21 rice varieties against rice leaf folder (*Cnaphalocrocis medinalis* Guenee). The results showed that BPT-2231 had the least (7.10%) and BPT-5204 had the most (18.20%) leaf folder infestation, followed by BPT-2570 (16.90%).

Likewise, Kumari and Prasad (2021) [13] screened sixteen rice cultivars in a field trial against rice leaf folder. Out of the sixteen varieties screened, Suraksha, C.R. Dhan 304, C.R. Dhan 201, and PAC-801 emerged as resistant and promising against the leaf folder, moderately resistant genotypes included IR-64 (Drt-1), BVD-203, Akshay Dhan, C.R. Dhan 303, Naveen, Vita-12, US- 362 and US-380.

4. Whorl maggot, *Hydrellia philippina* (Ferino)

The percentages of infestation of whorl maggot (Damaged leaves) were classified into different six groups under 0-9 score (Standard evaluation system for rice, IRRI, 2013). According to the data presented (Table: 10), in the present experiment 19 entries *viz*., MRST 20221-5, MRST 20221-9, MRST 20221-12, MRST 20221-15, MRST 20221-16, MRST 20221-17, MRST 20221-21, MRST 20221-24, MRST 20221-27, MRST 20221-29, MRST 20221-30, MRST 20221-31, MRST 20221-33, MRST 20221-35, MRST 20221-36, MRST 20221-37, MRST 20221-38, MRST 20221-39 and MRST 20221-40 were found under '1' score to be resistant to whorl maggot infestation (Range 6.02 - 9.93 % DL).

Total 20 entries *viz*., MRST 20221-1, MRST 20221-2, MRST 20221-3, MRST 20221-4, MRST 20221-6, MRST 20221-7, MRST 20221-8, MRST 20221-10, MRST 20221-11, 20221-13, MRST 20221-14, MRST 20221-18, MRST 20221-19, MRST 20221-20, MRST 20221-22, MRST 20221-23, MRST 20221-25, MRST 20221-26, MRST 20221-32 and MRST 20221-34 were recorded under score '3' as moderately resistance (MR) to whorl maggot damage (Range 10.36 – 14.83 % DL). One of the entries MRST 20221-10 was not germinated. The overall incidence range of whorl maggot damage was 6.02 - 14.83 % DL.

Previously, Viajante and Heinrichs (1986) [22] compared grain yields of rice cultivars IR36 and IR40 artificially infested with whorl maggot flies with those of non-infested plants in two screenhouse and four field tests. Although 82% of the leaves were destroyed by infestation rates as high as 800 flies per 49 plants, neither the IR36 nor the IR40 grain yields were affected. The number of panicle-bearing tillers on IR36 rose after larval feeding whereas plant height dropped. Plants that were injured took 7-10 days longer to mature.

Similarly, Sain and Hakim (1988) [9] screened 52 rice lines for resistance to whorl maggot and found that 11 were found to be promising, with 10% or fewer damaged leaves. The least susceptible varieties had 3-5% damaged leaves, including RP2418-5, RP2418-10, and RP2419-3.

5. Multiple resistance

The percentages of infestation of major insect pests were classified into different six groups under 0-9 score (Standard evaluation system for rice, IRRI, 2013). According to the Table 11, in the present experiment, entry MRST 20221-1 showed moderate resistance (score '3') against gall midge and whorl maggot, while resistance (score '1') against stem borer and leaf folder incidence. MRST 20221-6 showed moderate resistance (score '3') against gall midge and whorl maggot, while resistance (score '1') against leaf folder and highly resistance (score '0') against stem borer incidence. MRST 20221-15 showed moderate resistance (score '3') against gall midge, resistance (score '1') against whorl maggot, highly resistance (score '0') against stem borer and leaf folder incidence. MRST 20221-35 showed moderate resistance

(score '3') against gall midge, resistance (score '1') against whorl maggot and leaf folder, while highly resistance (score '0') against stem borer incidence. MRST 20221-38 had moderate resistance (score '3') against gall midge, while resistance (score '1') against whorl maggot, leaf folder and stem borer infestations.

Former researchers, Bhatt and Tiwari (2015) [7] demonstrated plant hopper screening (PHS) and multiple resistance screening trials (MRST) in 120 rice genotypes. In the PHS, the entries RP 2068-18-3 and CR 3006-8-2 were found to be resistant, while 10 additional entries were found to be moderately resistant. However, RP 4918-228(S) and PTB 33 demonstrated a modest level of resistance against BPH on the MRST test, whereas none of the entries displayed a resistant reaction.

Correspondingly, Chatterjee *et al*. (2016) [8] also screened out different rice entries against stem borer, leaf folder and whorl maggot of rice during *Kharif*. The experiment was carried out to identify multiple resistant varieties. This experiment resulted that CN 2008-3-2, CN 2017-3-2 and W 1263 are the multiple resistant entries against all the test insect-pests, CR 2274-2-3-3-1, RP 5587-B-B-B-305-13, CN 2015-5-4, IET 23148 and CN 1233-33-9 against stem borer and leaf folder and RP 2068-18-3-5, RP 5588-B-B-B-B-76 and RNT 14-1-1-2-2 against stem borer and whorl maggot.

Table 1: Standard evaluation system scale for scoring the reaction against gall midge

Percent damage	Score	Reaction
No damage	0	HR
< 1%	1	R
1-5%	3	MR
6-10%	5	MS
11-25%	7	S
>25%	9	HS

(**Source:** Standard evaluation system for rice, IRRI, 2013)

Table 2: Standard evaluation system scale for scoring the reaction against stem borer (Dead heart)

Percent damage	Score	Reaction
< 1 %	0	HR
1-10%	1	R
11-20%	3	MR
21-30%	5	MS
31-60%	7	S
> 60%	9	HS

(**Source:** Standard evaluation system for rice, IRRI, 2013)

Table 3: Standard evaluation system scale for scoring the reaction against leaf folder

Percent damage	Score	Reaction
< 1 %	0	HR
1-10%	1	R
11-20%	3	MR
21-35%	5	MS
36-50%	7	S
50-100%	9	HS

(**Source:** Standard evaluation system for rice, IRRI, 2013)

Table 4: Standard evaluation system scale for scoring the reaction against whorl maggot

Percent damage	Score	Reaction
No damage (< 1 %)	0	HR
< 2 leaves/hill damaged (1-10%)	1	R
2 or more leaves/hill but < 1/3 of leaves damaged (11-20%)	3	MR
1/3 to ½ of leaves damaged (21-35%)	5	MS
> ½ of the leaves damaged with no broken leaves (36-50%)	7	S
> ½ of the leaves damaged with some broken leaves (50-100%)	9	HS

(**Source:** Standard evaluation system for rice, IRRI, 2013)

(HR- highly resistant, R- resistant, MR- moderately resistant, MS- moderately susceptible, S - susceptible, HS- highly susceptible)

Table 5: Screening of rice genotypes for resistance against rice gall midge and stem borer

No.	Entry	Observation I (30 DAT)	Observation II (50 DAT)	Damage Score	Reaction	Observation I (30 DAT)	Observation II (50 DAT)	Damage Score	Reaction
		%SS	%SS			% DH/WEH	% DH/WEH		
1	MRST 20221-1	1.69	4.85	3	MR	0.00	1.94	1	R
2	MRST 20221-2	0.00	25.20	9	HS	0.00	0.00	0	HR
3	MRST 20221-3	0.00	28.89	9	HS	0.00	0.00	0	HR
4	MRST 20221-4	1.49	48.57	9	HS	0.00	0.00	0	HR
5	MRST 20221-5	0.00	30.19	9	HS	0.00	0.00	0	HR
6	MRST 20221-6	0.00	4.35	3	MR	0.00	0.00	0	HR
7	MRST 20221-7	0.00	26.42	9	HS	0.00	0.94	0	HR
8	MRST 20221-8	0.00	25.45	9	HS	0.00	0.00	0	HR
9	MRST 20221-9	0.00	27.56	9	HS	0.00	0.00	0	HR
10	MRST 20221-10	NG	NG	-	-	-	-	-	-
11	MRST 20221-11	0.00	20.83	7	S	0.00	0.00	0	HR
12	MRST 20221-12	5.71	36.97	9	HS	0.00	0.00	0	HR
13	MRST 20221-13	0.00	27.68	9	HS	0.00	1.79	1	R
14	MRST 20221-14	0.00	38.1	9	HS	0.00	13.27	3	MR
15	MRST 20221-15	0.00	3.19	3	MR	0.00	0.00	0	HR
16	MRST 20221-16	0.00	8.73	5	MS	2.56	5.56	1	R
17	MRST 20221-17	0.00	15.38	7	S	0.00	11.11	3	MR
18	MRST 20221-18	4.55	20.86	7	S	1.52	3.60	1	R
19	MRST 20221-19	0.00	23.08	7	S	0.00	6.59	1	R
20	MRST 20221-20	0.00	12.66	7	S	0.00	6.33	1	R
21	MRST 20221-21	0.00	32.00	9	HS	0.00	10.00	1	R
22	MRST 20221-22	0.00	43.24	9	HS	0.00	9.01	1	R
23	MRST 20221-23	1.35	40.80	9	HS	0.00	2.40	1	R
24	MRST 20221-24	1.30	49.58	9	HS	0.00	0.00	0	HR
25	MRST 20221-25	0.00	25.71	9	HS	0.00	0.00	0	HR
26	MRST 20221-26	0.00	45.33	9	HS	0.00	0.00	0	HR
27	MRST 20221-27	2.56	35.71	9	HS	0.00	0.00	0	HR
28	MRST 20221-28	0.00	34.59	9	HS	1.61	0.00	1	R
29	MRST 20221-29	0.00	39.84	9	HS	0.00	0.00	0	HR
30	MRST 20221-30	1.64	40.65	9	HS	1.64	1.29	1	R
31	MRST 20221-31	1.79	38.81	9	HS	3.57	0.75	1	R
32	MRST 20221-32	0.00	41.86	9	HS	1.82	0.00	1	R
33	MRST 20221-33	0.00	36.00	9	HS	0.00	0.00	0	HR
34	MRST 20221-34	0.00	39.45	9	HS	0.00	0.00	0	HR
35	MRST 20221-35	0.00	3.72	3	MR	0.00	0.47	0	HR
36	MRST 20221-36	1.49	34.86	9	HS	1.49	0.00	1	R
37	MRST 20221-37	0.00	28.45	9	HS	0.00	0.00	0	HR
38	MRST 20221-38	0.00	4.94	3	MR	7.27	0.00	1	R
39	MRST 20221-39	0.00	12.20	7	S	0.00	0.00	0	HR
40	MRST 20221-40	2.70	34.87	9	HS	0.00	0.00	0	HR

*HR- highly resistant, R- resistant, MR- moderately resistant, MS- moderately susceptible, S - susceptible, HS- highly susceptible,
% SS - Silver shoot percentage, % DH - Dead heart, NG – Not germinated

Table 6: Screening of rice genotypes for resistance against leaf folder and whorl maggot

No.	Entry	Leaf folder		Damage Score	Reaction	Whorl maggot		Damage Score	Reaction
		Observation I (30 DAT)	Observation II (50 DAT)			Observation I (30 DAT)	Observation II (50 DAT)		
		%DL	%DL			%DL	%DL		
1	MRST 20221-1	0.41	1.50	1	R	13.06	12.72	3	MR
2	MRST 20221-2	0.37	1.34	1	R	8.09	11.71	3	MR
3	MRST 20221-3	0.00	0.77	0	HR	6.23	13.81	3	MR
4	MRST 20221-4	0.00	1.41	1	R	12.64	9.15	3	MR
5	MRST 20221-5	0.00	1.74	1	R	5.59	9.18	1	R
6	MRST 20221-6	0.75	4.20	1	R	11.70	8.41	3	MR
7	MRST 20221-7	0.35	2.36	1	R	6.74	10.73	3	MR
8	MRST 20221-8	0.00	2.17	1	R	11.81	7.71	3	MR
9	MRST 20221-9	0.72	2.07	1	R	8.96	6.71	1	R
10	MRST 20221-10	NG	NG	-	-	-	-	-	-
11	MRST 20221-11	0.40	7.82	1	R	10.53	10.54	3	MR
12	MRST 20221-12	0.68	4.53	1	R	9.93	5.87	1	R
13	MRST 20221-13	0.00	3.02	1	R	10.41	9.53	3	MR
14	MRST 20221-14	0.00	0.24	0	HR	11.34	8.19	3	MR

15	MRST 20221-15	0.00	0.00	0	HR	7.20	6.58	1	R
16	MRST 20221-16	0.00	1.51	1	R	8.02	7.74	1	R
17	MRST 20221-17	0.32	0.70	0	HR	8.86	8.90	1	R
18	MRST 20221-18	0.37	0.00	0	HR	11.90	0.00	3	MR
19	MRST 20221-19	0.00	0.31	0	HR	8.07	12.58	3	MR
20	MRST 20221-20	0.00	0.63	0	HR	8.41	14.83	3	MR
21	MRST 20221-21	1.30	0.00	1	R	9.52	9.68	1	R
22	MRST 20221-22	0.00	3.89	1	R	12.45	6.57	3	MR
23	MRST 20221-23	0.33	4.29	1	R	11.07	6.44	3	MR
24	MRST 20221-24	1.89	4.83	1	R	7.55	3.22	1	R
25	MRST 20221-25	0.36	2.65	1	R	10.36	7.41	3	MR
26	MRST 20221-26	1.29	5.69	1	R	8.62	11.37	3	MR
27	MRST 20221-27	0.31	4.34	1	R	7.55	6.07	1	R
28	MRST 20221-28	1.20	3.42	1	R	11.20	6.84	3	MR
29	MRST 20221-29	0.00	5.89	1	R	8.62	6.95	1	R
30	MRST 20221-30	0.40	5.55	1	R	8.43	5.36	1	R
31	MRST 20221-31	0.42	3.23	1	R	9.75	4.84	1	R
32	MRST 20221-32	0.00	1.26	1	R	9.96	11.30	3	MR
33	MRST 20221-33	0.90	4.83	1	R	6.02	5.04	1	R
34	MRST 20221-34	0.00	2.67	1	R	12.16	7.77	3	MR
35	MRST 20221-35	0.00	3.70	1	R	6.99	6.30	1	R
36	MRST 20221-36	1.48	3.74	1	R	7.38	5.93	1	R
37	MRST 20221-37	2.06	3.82	1	R	7.41	6.97	1	R
38	MRST 20221-38	0.87	2.43	1	R	8.73	8.81	1	R
39	MRST 20221-39	1.27	4.57	1	R	8.86	7.62	1	R
40	MRST 20221-40	0.32	3.42	1	R	9.74	5.70	1	R

*****HR- highly resistant, R- resistant, MR- moderately resistant, MS- moderately susceptible, S - susceptible, HS- highly susceptible, % DL - Damaged leaf percentage, NG – Not germinated

Table 7: Screening of various rice entries/germplasm against rice gall midge

Percent damage (SS%)	Score	Reaction	No. of entries	Name of entries	Range
0 %	0	HR	0		
< 1 %	1	R	0		
1-5 %	3	MR	5	MRST 20221-1, MRST 20221-6, MRST 20221-15, MRST 20221-35 and MRST 20221-38	3.19 - 4.94 %
6-10 %	5	MS	1	MRST 20221-16	8.73 %
11-25 %	7	S	6	MRST 20221-11, MRST 20221-17, MRST 20221-18, MRST 20221-19, MRST 20221-20 and MRST 20221-39	12.20 - 23.08 %
> 25 %	9	HS	27	MRST 20221-2, MRST 20221-3, MRST 20221-4, MRST 20221-5, MRST 20221-7, MRST 20221-8, MRST 20221-9, MRST 20221-12, MRST 20221-13, MRST 20221-14, MRST 20221-21, MRST 20221-22, MRST 20221-23, MRST 20221-24, MRST 20221-25, MRST 20221-26, MRST 20221-27, MRST 20221-28, MRST 20221-29, MRST 20221-30, MRST 20221-31, MRST 20221-32, MRST 20221-33, MRST 20221-34, MRST 20221-36, MRST 20221-37, MRST 20221-40	25.20 - 49.58 %
		NG	1	MRST 20221-10	
		Total	40	Overall range	3.19 - 49.58 %

*HR- highly resistant, R- resistant, MR- moderately resistant, MS- moderately susceptible, S - susceptible, HS- highly susceptible, NG – Not germinated

Table 8: Screening of various rice entries/germplasm against rice stem borer

Percent damage	Score	Reaction	No. of entries	Name of entries	Range
< 1 %	0	HR	22	MRST 20221-2, MRST 20221-3, MRST 20221-4, MRST 20221-5, MRST 20221-6, MRST 20221-7, MRST 20221-8, MRST 20221-9, MRST 20221-11, MRST 20221-12, MRST 20221-15, MRST 20221-24, MRST 20221-25, MRST 20221-26, MRST 20221-27, MRST 20221-29, MRST 20221-33, MRST 20221-34, MRST 20221-35, MRST 20221-37, MRST 20221-39 and MRST 20221-40	0.00 - 0.94 %
1-10 %	1	R	15	MRST 20221-1, MRST 20221-13, MRST 20221-16, MRST 20221-18, MRST 20221-19, MRST 20221-20, MRST 20221-21, MRST 20221-22, MRST 20221-23, MRST 20221-28, MRST 20221-30, MRST 20221-31, MRST 20221-32, MRST 20221-36 and MRST 20221-38	1.29 - 10.00 %
11-20 %	3	MR	2	20221-14 and MRST 20221-1	11.11 - 13.27 %
21-30 %	5	MS	0		
31-60 %	7	S	0		
> 60 %	9	HS	0		
		NG	1	MRST 20221-10	

		Total	40	Overall range	0.00 - 13.27 %

*HR- highly resistant, R- resistant, MR- moderately resistant, MS- moderately susceptible, S - susceptible, HS- highly susceptible, NG – Not germinated

Table 9: Screening of various rice entries/germplasm against rice leaf folder

Percent damage	Score	Reaction	No. of entries	Name of entries	Range
< 1 %	0	HR	7	MRST 20221-3, MRST 20221-14, MRST 20221-15, MRST 20221-17, MRST 20221-18, MRST 20221-19 and MRST 20221-20	0.00 - 0.77 %
1-10 %	1	R	32	MRST 20221-1, MRST 20221-2, MRST 20221-4, MRST 20221-5, MRST 20221-6, MRST 20221-7, MRST 20221-8, MRST 20221-9, MRST 20221-11, MRST 20221-12, MRST 20221-13, MRST 20221-16, MRST 20221-21, MRST 20221-22, MRST 20221-23, MRST 20221-24, MRST 20221-25, MRST 20221-26, MRST 20221-27, MRST 20221-28, MRST 20221-29, MRST 20221-30, MRST 20221-31, MRST 20221-32, MRST 20221-33, MRST 20221-34, MRST 20221-35, MRST 20221-36, MRST 20221-37, MRST 20221-38, MRST 20221-39 and MRST 20221-40	1.26 - 7.82 %
11-20 %	3	MR	0		
21-35 %	5	MS	0		
36-50 %	7	S	0		
50-100 %	9	HS	0		
		NG	1	MRST 20221-10	
		Total	40	Overall range	0.00 - 7.82 %

*HR- highly resistant, R- resistant, MR- moderately resistant, MS- moderately susceptible, S - susceptible, HS- highly susceptible, NG – Not germinated

Table 10: Screening of various rice entries/germplasm against rice whorl maggot

Percent damage	Score	Reaction	No. of entries	Name of entries	Range
< 1 %	0	HR	0		
1-10 %	1	R	19	MRST 20221-5, MRST 20221-9, MRST 20221-12, MRST 20221-15, MRST 20221-16, MRST 20221-17, MRST 20221-21, MRST 20221-24, MRST 20221-27, MRST 20221-29, MRST 20221-30, MRST 20221-31, MRST 20221-33, MRST 20221-35, MRST 20221-36, MRST 20221-37, MRST 20221-38, MRST 20221-39 and MRST 20221-40	6.02 - 9.93 %
11-20 %	3	MR	20	MRST 20221-1, MRST 20221-2, MRST 20221-3, MRST 20221-4, MRST 20221-6, MRST 20221-7, MRST 20221-8, MRST 20221-11, MRST 20221-11, 20221-13, MRST 20221-14, MRST 20221-18, MRST 20221-19, MRST 20221-20, MRST 20221-22, MRST 20221-23, MRST 20221-25, MRST 20221-26, MRST 20221-28, MRST 20221-32 and MRST 20221-34	10.36 - 14.83 %
21-35 %	5	MS	0		
36-50 %	7	S	0		
50-100 %	9	HS	0		
		NG	1	MRST 20221-10	
		Total	40	Overall range	6.02 - 14.83 %
*HR- highly resistant, R- resistant, MR- moderately resistant, MS- moderately susceptible, S - susceptible, HS- highly susceptible, NG – Not germinated					

Table 11: Entries having resistance against multiple insect pests

Name of entry	Damage Score	Reaction	Reaction against the pest
MRST 20221-1	1	R	SB and LF
	3	MR	GM and WM
MRST 20221-6	0	HR	SB
	1	R	LF
	3	MR	GM and WM
MRST 20221-15	0	HR	SB and LF
	1	R	WM
	3	MR	GM
MRST 20221-35	0	HR	SB
	1	R	LF and WM
	3	MR	GM
MRST 20221-38	1	R	SB, LF and WM
	3	MR	GM

*HR - highly resistant, R - resistant, MR - moderately resistant, MS - moderately susceptible, S - susceptible, HS- highly Susceptible, GM - Gall midge, SB - Stem borer, LF - Leaf folder, WM - Whorl maggot

Conclusion

In the screening experiment, against gall midge a total of 5 entries were found '3' score to be moderately resistant, only 1 entry was found '5' score to be moderately susceptible, 6 entries were of '7' score to be susceptible and 27 entries were recorded under score '9' as highly susceptible. In case of stem borer, total 22 entries were ranked with '0' score as highly resistance, 15 entries were found '1' score to be resistant and only 2 entries were found '3' score to be moderately resistance to stem borer incidence.

Against the leaf folder, 7 entries were ranked with '0' score as highly resistance, 32 entries were found '1' score to be resistant and in case of whorl maggot, total 19 entries were found '1' score to be resistant and 20 entries were recorded under score '3' as moderately resistance (MR) to whorl maggot damage. One of the entries MRST 20221-10 was not germinated.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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