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Screening of F_3 lines of rice against gall midge resistance in rice

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Abstract
One hundred eighty three F_3 progenies were screened for gall midge [*Orseolia oryzae* (Wood-Mason)] for resistance, at Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Warangal, Telangana during wet season (*Kharif*) of 2021 under delayed planting situation ensuring sufficient pest load. Among these 183 progenies screened, 13 progenies were found highly resistant, 33 progenies had shown resistant reaction and 87 progenies were moderately resistant against gall midge. Single palnt selections were made. The selected plants could be forwarded further towards development of GM resistant rice varities.

Keywords: Gall midge, resistance, rice, screening

1. Introduction
Rice is the most important staple food crop of India, which provides instant energy with high carbohydrate content to millions of Indians. Many biotic and abiotic factors influence the productivity of rice. Among the biotic factors, insect pests play a vital role in reducing the yields of rice. Nearly 300 species of insect pests attack the rice crop at different stages, of which, only 23 species, cause notable damage (Pasalu and Katti, 2006) [9]. Among these, Asian rice gall midge, *Orseolia oryzae* (Wood-Mason) is an important pest which has been prevalent in almost all the rice growing states in India except Western Uttar Pradesh, Uttaranchal, Punjab, Haryana and Hill states of Himachal Pradesh and Jammu and Kashmir (Bentur *et al*., 2003) [2]. This is essentially a monsoon pest and causes damage wherever high humidity and moderate temperature prevail, even in dry seasons (Kalode *et al*., 1976) [6]. This pest attacks rice from the seedling to the end of the tillering stage. In India, it is rated as the third most important pest of rice in terms of spread and severity of damage and yield loss (Bentur *et al*., 2016) [3]. Warangal is an endemic region (biotype 4M) to rice gall midge especially when the transplanting was delayed due to late onset of monsoon or due to late release of water into canals (Vijayalakshmi *et al*., 2006) [13].
The external symptom of damage caused by gall midge is the production of a silvery-white, tubular leaf sheath gall called a silver shoot or onion shoot. This is due to the feeding and salivary secretion by the larvae which turn the growing shoot meristem into a gall. This renders the tiller sterile and do not bear panicle (Bentur *et al.*, 2016) [3]. Use of insecticides may not be effective against rice gall midge due to internal feeding habit of this pest. Though different management strategies, (cultural, chemical, biological *etc.*) are employed to reduce the damage caused by this insect-pest, use of resistant rice varieties appears to offer the most effective component for incorporation into an integrated pest management strategy (Ukwungwu *et al*., 1999; Krishnaiah, 2004) [11, 7]. The present experiment is an effort of development of durable biotic stress resistance resistant rice varieties involved evaluation of rice F_3 progenies against gall midge at Warangal, Telangana, India.

2. Materials and Methods
The present experiment was conducted at Regional Agricultural Research Station, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Warangal, Telangana during wet season (*Kharif*) of 2021. F_3 progines developed at Institute of Biotechnology (IBT), PJTSAU, were evaluated for field resistance against gall midge. Sowing of seedlings in nursery beds was delayed (by one month) for natural build up of gall midge in the experimental block. Nursery of the test entries along with susceptible check TN-1 was grown

on raised beds. Sowing was done on 24 July, 2021 and transplanted on 25 August, 2021 at a spacing of 20 cm between the rows and 15 cm between the plants within the row. Each test entry had 20 plants transplanted in a single row. For every 9 test entries, infestor row of susceptible check TN-1 was grown. TN-1 was also grown as border rows around the block of test entries to facilitate sufficient pest buildup.

All the agronomic practices were followed during the crop growth period except plant protection. Observations on gall midge incidence were recorded twice at 30 and 60 days after transplanting. Number of plants and number of plants with silver shoots were counted and per cent plant damage was arrived at using the formula:

$$\text{Per cent of Damaged Plants (\% DP)} = \frac{\text{Damaged plants}}{\text{Total number of plants}} \times 100$$

Similarly, data were recorded on number of tillers and number of silver shoots in all the 20 plants. Mean was calculated and per cent silver shoot damage (tiller damage) was arrived at using the formula:

$$\text{Per cent of Silver Shoots (\% SS)} = \frac{\text{Number of galls}}{\text{Total number tillers}} \times 100$$

Then, the test entries were assessed for gall midge damage as per Standard Evaluation System (Table 1), International Rice Research Institute (IRRI) for gall midge (IRRI, SES, 2013) [5].

Table 1: Standard Evaluation system for gall midge in rice

Scale	% Silver shoots	Infected tillers in field test	Category
0	No injury	No damage	Highly resistant
1	less than 1%	Less than 1 %	Resistant
3	1-5%	1-5 %	Moderately resistant
5	6-10%	6-10 %	Moderately susceptible
7	11-25%	11-25 %	Susceptible
9	More than25%	More than 25 %	Highly susceptible

Source: SES, IIRR, 2013 [5]

3. Results and Discussion

Total of 183 F3 progenies were evaluated for gall midge resistance at field conditions at RARS, Warangal. The total duration of crop was 120 days. F_3 lines along with parents and TN1 were sown on 24-07-2021 and harvested on 4-12-2021. As per the duration, GM incidence *i.e.* data on silver shoot percentage was recorded on 30 DAT (25-09-2021) and 50 DAT (16-10-2021) using IRRI, SES, 2013 [5] scale. At 30 DAT, the susceptible check TN1 showed only 17.45 % incidence of GM. Among parents, female parent IBTGM14 had 0 % incidence, and the male parent YPB46 showed 15 % incidence. Since the gall score for TN1 (susceptible check) and also susceptible parent YPB46, was very low, the data at 30 DAT was not considered. However at 50 DAT, both TN1 and YPB46 showed % Silver Shoot (SS) score 9 and % plant damage of 95-100% (susceptibility) whereas, the female parent IBTGM14 showed 0 % silver shoots (Highly resistant). Hence, the lines were classified based on GM resistance or susceptibility at 50 DAT.

In the present study based on silver shoot percentage, progenies were classified as per SES of rice for GM resistance (SES, IRRI, 2013) [5] Test entries with nil damage and up to 5% damage based on silver shoot percentage were considered as resistant while others were grouped as susceptible. Damaged plant percentage based on number of plants infested per line was also recorded to assess damaged plants in each line. Though the data on percent damaged plants and percent silver shoots was taken the test entries were scored based on percent silver shoots as they were in F_3 segregating generation. Among 183 F_3 lines, 133 lines were under resistant class with respect to %SS with 13 lines of them being highly resistant, 33 of them being resistant and 87 being moderately resistant. As expected, the susceptible check, TN1 and male parent, YPB46 were highly susceptible (% SS score 9 and >95% DP). Female parent IBTGM14, showed highly resistant reaction (score 0).

Table 2: Reaction of F_3 progenies for gall midge in field conditions during *Kharif* 2021

F_3 progeny code	F_2 plant no	% DP	% SS	Scale	Reaction	F_3 progeny code	F_2 plant no	% DP	% SS	Scale	Reaction
IGBY 1	3	5	0.55	1	R	IGBY 32	227	5	0.55	1	R
IGBY 2	4	10	0.98	1	R	IGBY 33	228	15	1.60	1	R
IGBY3	5	5	0.49	1	R	IGBY 34	233	35	4.40	3	MR
IGBY4	19	15	1.74	3	MR	IGBY 35	241	10	0.54	1	R
IGBY5	20	25	2.50	3	MR	IGBY 36	249	0	0.00	0	HR
IGBY6	21	5	0.54	1	R	IGBY 37	250	0	0.00	0	HR
IGBY7	24	0	0.00	0	HR	IGBY 38	251	0	0.00	0	HR
IGBY8	28	20	2.40	3	MR	IGBY 39	253	0	0.00	0	HR
IGBY 9	31	10	1.12	3	R	IGBY 40	260	15	1.60	1	R
IGBY10	39	0	0.00	0	HR	IGBY 41	265	5	0.62	1	R
IGBY11	41	25	3.06	3	MR	IGBY 42	266	15	0.89	1	R
IGBY12	45	40	4.54	3	MR	IGBY 43	270	20	2.13	3	MR
IGBY13	51	5	0.59	1	R	IGBY 44	281	5	0.55	1	R
IGBY14	52	5	0.60	1	R	IGBY 45	282	15	1.68	1	R
IGBY15	56	5	0.60	1	R	IGBY 46	284	5	0.61	1	R

IGBY16	63	30	4.14	3	MR	IGBY 47	289	5	0.56	1	R
IGBY17	77	35	4.49	3	MR	IGBY 48	8	35	4.94	3	MR
IGBY18	112	35	4.50	3	MR	IGBY 49	10	40	4.60	3	MR
IGBY19	114	30	4.57	3	MR	IGBY 50	17	40	4.94	3	MR
IGBY20	121	5	0.63	1	R	IGBY 51	23	30	4.09	3	MR
IGBY21	133	20	4.28	3	MR	IGBY 52	27	30	3.40	3	MR
IGBY22	147	5	0.53	1	R	IGBY 53	33	35	4.94	3	MR
IGBY23	189	5	0.51	1	R	IGBY 54	37	35	4.62	3	MR
IGBY24	195	10	0.50	1	R	IGBY 55	43	35	4.96	3	MR
IGBY25	202	10	1.30	1	R	IGBY 56	49	5	0.56	1	R
IGBY26	205	5	0.63	1	R	IGBY 57	54	35	4.93	3	MR
IGBY27	208	0	0.00	0	HR	IGBY 58	57	0	0.00	0	HR
IGBY28	209	0	0.00	0	HR	IGBY 59	62	5	0.57	1	R
IGBY29	219	25	3.03	1	R	IGBY 60	76	35	4.41	3	MR
IGBY30	220	5	0.54	1	R	IGBY 61	101	40	4.50	3	MR
IGBY31	226	25	3.40	3	MR	IGBY 62	103	40	4.60	3	MR
IGBY63	105	35	4.87	3	MR	IGBY94	34	50	11.25	3	MR
IGBY64	115	30	3.38	3	MR	IGBY95	35	40	5.00	3	MR
IGBY65	117	35	4.65	3	MR	IGBY96	38	40	4.79	3	MR
IGBY66	118	35	4.00	3	MR	IGBY97	44	35	4.45	3	MR
IGBY67	128	35	4.32	3	MR	IGBY98	66	55	7.20	5	MS
IGBY68	129	40	4.70	3	MR	IGBY99	69	35	4.11	3	MR
IGBY69	140	30	4.04	3	MR	IGBY100	70	65	13	5	MS
IGBY70	182	35	4.54	3	MR	IGBY101	81	45	4.68	3	MR
IGBY71	184	40	4.49	3	MR	IGBY102	82	40	4.49	3	MR
IGBY72	200	40	4.59	3	MR	IGBY103	88	60	5.67	5	MS
IGBY73	201	35	4.59	3	MR	IGBY104	90	45	4.94	3	MR
IGBY74	224	0	0.00	0	HR	IGBY105	95	40	4.60	3	MR
IGBY75	237	30	4.39	3	MR	IGBY106	102	40	5.00	3	MR
IGBY76	240	36	4.65	3	MR	IGBY107	104	45	4.70	3	MR
IGBY77	243	40	4.76	3	MR	IGBY108	108	50	9.34	5	MS
IGBY78	247	40	4.50	3	MR	IGBY109	110	60	11.04	5	MS
IGBY79	248	40	4.90	3	MR	IGBY110	111	40	4.59	3	MR
IGBY80	254	55	10.79	7	MS	IGBY111	119	60	4.16	5	MS
IGBY81	259	5	0.60	3	MR	IGBY112	125	45	4.70	3	MR
IGBY82	262	40	4.54	3	MR	IGBY113	137	40	4.94	3	MR
IGBY83	263	40	4.80	3	MR	IGBY114	139	40	4.76	3	MR
IGBY84	267	40	4.90	3	MR	IGBY115	142	40	4.45	3	MR
IGBY85	269	65	11.56	5	MS	IGBY116	168	60	7.40	5	MS
IGBY86	273	40	4.60	3	MR	IGBY117	192	5	0.50	1	R
IGBY87	275	35	5.00	3	MR	IGBY118	194	5	0.50	1	R
IGBY88	11	35	4.50	3	MR	IGBY119	196	5	0.90	1	R
IGBY89	15	30	4.16	3	MR	IGBY120	197	0	0.00	0	HR
IGBY90	16	35	4.40	3	MR	IGBY121	204	40	4.61	3	MR
IGBY93	32	0	0.00	0	HR	IGBY124	212	50	6.20	5	MS
IGBY125	216	45	4.59	5	MS	IGBY156	84	10	1.00	1	R
IGBY126	217	40	4.95	3	MR	IGBY157	89	100	14.34	7	MS
IGBY127	221	50	9.27	5	MS	IGBY158	91	100	15.34	7	MS
IGBY128	222	50	4.97	3	MR	IGBY159	93	45	4.72	3	MR
IGBY129	223	55	8.62	5	MS	IGBY 160	94	50	7.40	5	MS
IGBY130	231	40	4.76	3	MR	IGBY161	97	50	7.11	5	MS
IGBY131	234	50	8.33	5	MS	IGBY162	98	55	5.46	5	MS
IGBY132	236	45	4.90	3	MR	IGBY163	106	40	5.56	5	MS
IGBY133	239	25	4.80		MS	IGBY164	113	75	9.09	5	MS
IGBY134	244	45	6.79	5	MS	IGBY165	124	90	9.40	5	MS
IGBY135	245	50	8.80	5	MS	IGBY166	134	50	4.65	3	MR
IGBY136	252	60	10.10	7	MS	IGBY167	138	55	4.66	3	MR
IGBY137	255	65	9.47	5	MS	IGBY168	159	90	9.44	5	MS
IGBY138	256	50	5.70	5	MS	IGBY169	162	75	10.70	5	MS
IGBY139	257	65	7.50	5	MS	IGBY170	171	50	8.03	5	MS

IGBY140	258	50	5.50	5	MS	IGBY171	176	75	9.60	5	MS
IGBY141	261	50	5.58	5	MS	IGBY172	181	65	7.17	5	MS
IGBY142	264	60	7.17	5	MS	IGBY173	213	50	4.58	3	MR
IGBY143	276	50	4.80	3	MR	IGBY174	215	60	11.48	5	MS
IGBY144	277	75	8.59	5	MS	IGBY175	218	45	8.00	5	MS
IGBY145	279	40	3.77	3	MR	IGBY176	230	70	7.50	5	MS
IGBY146	283	40	4.76	3	MR	IGBY177	246	70	7.60	5	MS
IGBY147	286	0	0.00	0	HR	IGBY178	271	50	6.80	5	MS
IGBY148	1	45	4.10	5	MS	IGBY179	285	45	4.50	3	MR
IGBY149	14	60	7.80	5	MS	IGBY 180	288	50	4.74	3	MR
IGBY150	26	35	4.72	3	MR	IGBY 181	293	60	8.96	5	MS
IBY 151	42	50	4.20	3	MR	IGBY182	294	55	7.70	5	MS
IGBY152	46	45	4.90	3	MR	IGBY 183	178	50	9.28	5	MS
IGBY153	48	70	10.52	7	MS	TN-1	Check	100	26.37	9	S
IGBY154	50	30	2.57	3	MR	IBT GM14	Female	0	0.00	0	HR
IGBY155	75	45	4.36	3	MR	YPB 46	Male	90	25.5	9	S

% DP: Percentage of plant damage; % SS: Percentage of silver shoots, HR: Highly resistant, R: Resistant, MR: Moderately resistant, MS: Moderately susceptible, S: Susceptible

In the present study F_3 generation was screened under field conditions for GM resistance. The data on % silver shoot damage for each plant in a progeny was recorded and average data of progeny was used to classify the plants highly resistant (no damage : 0 score), resistant (less than 1% SS: score1), and moderately resistant (1-5 % SS,: score 3) whereas remaining all the progenies with higher damage fell into susceptible classes (Table 2). Many workers also screened the rice cultivars of different segregating/ homozygous generations, pre breeding lines for gall midge at field conditions and scores were recorded based on percent silver shoots. Venkanna *et al*., 2018 [12] screened improved lines for gall midge at field conditions and classified lines based on silver shoot damage, 5% of silver shoots damage were considered resistant and remaining are susceptible and found the improved lines displayed higher level of resistance. Sama *et al*., 2013 screened F_2 mapping population for gall midge at biotype 4M and scored as susceptible or resistant based on the presence or absence of gall (Silver shoots).

Kumar *et al.* (2020) screened 173 rice entries for gall midge resistance at Warangal for biotype 4M in field conditions. The test entries were assessed for gall midge damage as per standard evaluation system (IRRI, 2013) [5] and data was recorded at 30 and 50DAT. The test entries with 0-10 % plant damage was considered resistant while and more than 10% was considered as susceptible.

In a study conducted at Chiplima, Odisha, for screening of 137 entries revealed that the germplasm lines *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 promising against gall midge with scores 0 and 1. (Seni *et al*., 2019) [10].

In a study Anusha *et al.* (2017) [1] evaluated rice pre-breeding lines with known source of gall midge resistance through *Gm1* gene in the elite backgrounds in a replicated trial in field at Jagtial and Warangal against biotype 3 and 4M, respectively and classified based on silver shoots and found 12 lines that showed nil damage (0% silver sjoots) of score 0.

4. Conclusion

On the basis of present investigation, it can be concluded that among 183 rice F_3 progenies screened against gall midge, 13 and 33 progenies were highly resistant and resistant respectively against rice gall midge are to be evaluated for yield and best promising progenies will be forwarded further.

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