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Field Screening of Rice Genotypes for Resistance to Major Rice Pests

Karthikeyan K[1*], Faseela KV, Biji KR[1], Padmavathi Ch[2] and Padmakumari AP [2]

[1]Regional Agricultural Research Station, Pattambi-679306

[2]ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad-500030

*Corresponding author E-mail: karthikeyan.k@kau.in

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Abstract

Preliminary screening studies against rice stem borer and leaf folder were conducted at Regional Agricultural Research Station, Pattambi during *kharif* 2016 and *rabi* 2016-17 involving 14 rice cultures and susceptible check TN 1. The promising rice genotypes were evaluated under All India Coordinated Research Project on Rice (AICRPR) Hyderabad during *kharif* 2017, 2018 and 2019 under Stem borer screening trial, Leaf folder screening trial and multiple pest resistance screening trial. The rice culture KAUPTB 0627-2-11 (Cul 06-1) offered resistance to stem borer (both dead hearts and white ears). Cultures JS1,3,5 and 7 showed tolerance to both Stem borer and Leaf folder while Cul M9 exhibited field tolerance to multiple pests like Stem borer, mixed population of planthoppers and leaf folder.

Key words: Stem borer, Leaf folder, Field screening, multi-location testing, AICRPR

Introduction

Rice is an important staple crop of Asia occupying about 145 m ha or in about 11 per cent of the world's cultivated land (Raheja, 1995). India being the second-largest rice growing country produces about 104.32 million tonnes in about 44.6 million hectares at an average productivity of 2.34 tonnes per hectare (Rajasekaran and Jeyakumar, 2014). Rice plant is subjected to attack by more than 100 species of insects, of which 20 species are of economic importance causing 20-30% yield losses every year (Chatterjee *et al*., 2017). Yellow stem borer, *Scirpophaga incertulas* (Walker) and Leaf folder (*Cnaphalocrocis medinalis* Guenée) of rice are considered as prime devastators responsible for major economic loss (Chatterjee and Mondal, 2014; Chatterjee *et al*., 2017). The host plant resistance depends upon the relationship between the plant-feeding insects and their host plants (Painter, 1951) which enables plants to avoid, tolerate or recover from the effects of insect pest attack and this mechanism has been proved to be a successful tool to protect crops from insects attack (Felkl *et al*., 2005). This investigation reports the performance of cultures from Regional Agricultural Research Station, Pattambi against Leaf folder and Stem borer.

Materials and Methods

Field screening at RARS Pattambi

Field evaluation of 14 rice cultures was carried out at Regional Agricultural Research Station, Pattambi during *kharif* 2016 and *rabi* 2016-17. The entries were planted in a row of 20 hills at a spacing 20x15 cm with TN1 as the susceptible check. The promising entries against yellow stem borer and leaf folder were selected and nominated for testing at multiple locations during *kharif* 2017, 2018 and 2019 under All India Co-ordinated Research Program on rice (AICRPR), Hyderabad. The rice genotypes were tested separately under stem borer screening trial (SBST), leaf folder screening trial (LFST). The most performing entries were further evaluated in Multiple

resistance screening trial (MRST) at ICAR-IIRR, Hyderabad. The standard screening methodology (IIRR Technical programme 2019) was followed with resistant checks: PTB 33 for brown planthopper, W 1263 for leaf folder and gall midge, TKM 6 for stem borer and TN1 as susceptible check. The observations on total tillers, number of dead hearts (vegetative phase); panicle bearing tillers and number of white ears (reproductive phase), total leaves and damaged leaves for leaf folder were recorded and the percent damage was calculated. Damage by mixed population of planthoppers was assessed on visual basis and damage score was given in the scale of 0-9. At all the locations data was considered when the field incidence was very high and at ICAR-IIRR the stem borer damage though natural incidence was supplemented with release of larvae.

Multilocation evaluations under AICRPR: The best entries identified at Pattambi were tested at multiple locations in the pest specific trials *viz*., in stem borer screening trial (SBST) for stem borer and in Leaf folder screening trial (LFST) for leaf folder for two seasons. The entries were also tested in MRST trial to observe the reaction against other pests.

Results and Discussions

Field evaluation at Pattambi

Pooled analysis of the pest damage data of *kharif* 2016 and *rabi* 2016-17 revealed that the dead heart damage did not vary significantly among the cultures tested. However, at reproductive phase, significantly lower white ear damage was noticed in KAUPTB 0627-2-11(1.08%) and KAUPTB 0627-2-14 (1.50%), CulM9 (1.66%), JS1(1.81%), JS3(1.70%), JS5 (1.87%) and JS 7 (1.92%). At 45 days after transplanting nil leaf damage of leaf folder was noticed in Cul M9 while significantly lower damage was recorded in four entries *viz.,* Cul M8 (0.36), JS1 (0.58), Cul M4 (1.03), JS 3 (1.20). At 60 DAT Cul M9 recorded lower leaf damage (5.82) followed by Cul M8 (6.55), JS1 (9.70), JS 3 (10.22), JS4 (10.42), JS (10.89) and Kalluri sel (14.62) as against highest leaf damage in TN1 (82.75) followed by KAUPTB 0627-2-11 (70.24) (**Table 3**).

Reaction to stem borers: During *kharif* 2017 and 2018, KAUPTB 0627-2-11and KAUPTB 0627-2-14 were evaluated along with other cultures in the multilocation testing under stem borer screening trial. The mean per cent dead heart, per cent white ear and per cent leaf folder damaged leaves did not significantly differ among the cultures tested in both the seasons. However, it was interesting to note that KAUPTB 0627-2-11 (Cul 06-1) recorded lower dead heart damage (**Table 3**).

The results of screening under station trials showed that among the 14 cultures tested during *kharif* 2016, the cultures KAUPTB 0627-2-11 and KAUPTB 0627-2-14 lowest dead heart and white ear with 0.90, 1.03 per cent and 1.12, 1.50 followed by Cul M9 with 2.35, 1.57 per cent at 30 and 75 DAT against TN 1 with 12.50 and 15.50 per cent dead hearts and white ears at 30 and 75 days after transplanting. The results during *rabi* 2016-17 showed similar results with KAUPTB 0627-2-11 and KAUPTB 0627-2-14 showed lowest dead hearts and white ear with 5.41, 1.12 per cent and 4.52,1.50 followed by Cul M9 with 9.05, 1.74 per cent and JS 3 with 9.72 and 1.80 per cent at 30 and 75 days after transplanting against TN 1 (Check) with 16.50 and 30.15 per cent dead hearts and white ears at 30 and 75 days after transplanting as in **Table 1 and 2**. Results from All India coordinated programme during *kharif* 2017 under SBST showed that the dead heart damage in the trial varied from 0.0-48.1% with an average damage of 17.4% DH across the 6 locations in 8 valid tests. Evaluation of entries for dead heart damage at six locations in two staggered sowings identified KAUPTB 0627-2-11 was found promising with nil damage in one of the 8 tests. The white ear damage across 8 locations in 11 valid tests varied from 0 to 82% with a mean of 9.7% white ears. KAU PTB 0627-2-11 was found promising in 11 valid tests

Table 1: Screening rice genotypes against major rice pests at RARS, Pattambi (*kharif* 2016)

Cultures	Parentage	Stem borer		Leaf folder	
		%DH (30DAT)	%WE (75 DAT)	% DL (45 DAT)	% DL (60 DAT)
KAUPTB 0627-2-11 (Cul 06-1)	Swetha x Kuruka	**0.90**	**1.03**	2.00	85.56
KAUPTB 0627-2-14 (Cul 06-2)	Swetha x Kuruka	**1.12**	**1.50**	3.50	45.50
Cul M4	Mutant of PTB 18	3.50	16.50	4.40	56.01
Cul M6-2	170 Gy Mutant of PTB 18	3.51	14.30	**0.00**	**5.25**
Cul M8	170 Gy Mutant of PTB 21	3.53	7.92	0.00	9.01
Cul M9	Mutant 220 Gy of PTB 18	**2.35**	**1.57**	**0.00**	**8.28**
Cul JS 1	Pure line sln from Jaya	7.70	1.98	0.00	10.60
Cul JS-2	Pure line sln from Jaya	5.88	8.70	1.84	71.43
Cul JS 3	Pure line sln from Jaya	8.33	1.60	0.54	11.13
Cul JS 4	Pure line sln from Jaya	0.00	14.75	0.84	11.20
Cul JS 5	Pure line sln from Jaya	9.43	1.80	1.01	11.62
Cul JS 6	Pure line sln from Jaya	8.51	10.96	1.10	18.88
Cul JS 7	Pure line sln from Jaya	9.32	1.85	0.61	13.01
Kalluruli Sel.	Sln from land race Kalluruli	3.70	18.82	1.12	21.14
TN1		12.50	15.50	5.76	100

with nil white ear damage (**Tables 4 and 5**) (AICRIP progress report 2018 and 2019). During the second year of testing under SBST trial during *kharif* 2018, the dead heart damage varied from 3.0 to 42.1% with an average damage of 19.9% DH across 5 locations in 9 valid tests. Evaluation of entries for dead heart damage at 30 and 50 DAT in two staggered sowings helped in identification of four retested entries - KAUPTB 0627-2-11, as promising in 2 of the 9 tests with ≤10% DH (DS3.0). The white ear damage across 5 locations in 6 valid tests varied from 0.0 to 78.8% with a mean of 21.1%WE. KAUPTB 0627-2-11 showed lowest white ear incidence of 2.2, 6.4 and 8.1% at three locations. In terms of grain yield, KAUPTB 0627-2-11, and TKM 6 were promising in 3 of the 4 tests (**Tables 6 and 7**) with ≥15g/hill in 3 of the 4 valid tests (AICRIP Progress report, 2019 and 2020).

Chatterjee *et al*., (2011) identified rice entries *viz.,*

Table 2: Screening rice genotypes against major rice pests at RARS, Pattambi (*rabi* 2016-17)

Cultures	Parentage	Stem borer		Leaf folder	
		%DH (30 DAT)	%WE (75 DAT)	% DL (45 DAT)	% DL (60 DAT)
KAUPTB 0627-2-11Cul 06-1	Swetha x Kuruka	**5.41**	**1.12**	8.11	54.87
KAUPTB 0627-2-14 (Cul 06-2)	Swetha x Kuruka	**4.52**	**1.50**	3.15	42.50
Cul M4	Mutant of PTB 18	22.80	36.11	**2.06**	**9.42**
Cul M6-2	170 Gy Mutant of PTB 18	31.25	18.91	4.08	75.60
Cul M8	170 Gy Mutant of PTB 21	23.07	11.11	**0.71**	**4.08**
Cul M9	Mutant 220 Gy of PTB 18	**9.05**	**1.74**	**0.00**	**3.35**
Cul JS 1	Pure line sln from Jaya	**9.08**	**1.63**	1.15	8.80
Cul JS 2	Pure line sln from Jaya	12.50	7.05	5.86	12.41
Cul JS 3	Pure line sln from Jaya	**9.72**	**1.80**	1.85	9.31
Cul JS 4	Pure line sln from Jaya	18.36	12.50	3.21	9.63
Cul JS 5	Pure line sln from Jaya	9.80	1.94	**3.40**	**10.16**
Cul JS 6	Pure line sln from Jaya	25.00	19.23	10.54	20.80
Cul JS 7	Pure line sln from Jaya	7.27	1.98	9.84	18.88
Kalluruli Sel.	Sln from land race Kalluruli	9.25	11.95	**1.11**	**8.10**
TN1		16.50	30.15	15.25	65.50

Anjali, Pusa RH 10, ADT 44, JKRH 10, Pant Dhan 19, Gorsa, CSR 27, IC 115737, LF 270 resistant to stem borer at vegetative stage (dead hearts) and CHOORAPUNDY, INRC 3021, PTB 12, CR-MR-1523, LF 256 and AGANNI at flowering stage (white ear). Singh *et al*., (2006) screened fifty-three cultivars of rice against *S. incertulas* under natural infestation and found that only eighteen rice varieties were totally free from stem borer damage in terms of DH and WE. Balasubramanian *et al.*, (2000) screened 178 advanced yield trial genotypes of rice for their reaction to insect pests under natural conditions and found that genotypes, IET 15742 and IET 15072 were moderately resistant against yellow stem borer. Visalakshmi *et al*., (2014) reported that cultures *viz.,* CR 2711-76, CR 3005-230-5 were resistant and CR 3005-77-2 was moderately resistant to stem borer. Paramasiva *et al*., (2021) screened 28 rice cultures, and found that nil dead heart incidence was observed in NLR 3548, 3582, 3585, 3589, 3601, 3635, 3637, 3643 and NLR 3647 at 30 DAT and were rated as highly resistant.

Reaction to leaf folder: The results of screening under station trials showed that among the 14 cultures tested during *kharif* 2016 the culture Cul M9 showed lower leaf damage of 0.00, 8.28 per cent Cul M6-2 with 0.00, 5.25 per cent and Cul M8 with 0.00 and 9.01 at 45 and 60 DAT against TN 1 with 5.76 and 100 per cent leaf damage at 45 and 60 days after transplanting respectively. During *rabi* 2016-17 similar observation made with Cul M9 exhibiting lowest damaged leaves with 0.00, 3.35 per cent followed by Cul M8 and Cul M4 with 0.71, 4.08 per cent and 2.06 and 9.42 damaged leaves at 45 and 60 days after transplanting against TN 1 (Check) with 15.25 and 65.50 per cent damaged leaves at 45 and 60 days after transplanting as in **Tables 1 and 2**. Pooled analysis of both the crop seasons showed that Cul M9 was promising with low leaf damage of 0.00 and 5.82 damaged leaves followed by Cul M8 with 0.36 and 6.55 per cent damaged leaves at 45 and 60 days after transplanting (**Table 3**).

Table 3: Pooled Analysis of the reaction of Pattambi cultures to stem borer and leaf folder in two crop seasons at Pattambi (*kharif* 2017 and *rabi* 2017-2018)

Cultures	Parentage	Stem borer (% DH)	Stem borer (% WE)	Leaf folder% DL (45 DAT)	Leaf folder% DL (60 DAT)
KAUPTB 0627-2-11 (Cul 06-1)	Swetha x Kuruka	3.16 (0.17)	**1.08 (0.11)**	5.06 (0.22)	70.24 (1.01)
KAUPTB 0627-2-14 (Cul 06-2)	Swetha x Kuruka	2.82 (0.16)	**1.50 (0.12)**	3.33 (0.19)	44.00 (0.73)
Cul M4	Mutant of PTB 18	13.15 (0.35)	26.31 (0.53)	1.03 (0.07)	32.72 (0.58)
Cul M6-2	170 Gy Mutant of PTB 18	17.38 (0. 40)	16.61 (0.42)	4.24 (0.21)	40.43 (0.64)
Cul M8	170 Gy Mutant of PTB 21	13.30 (0.35)	9.52 (0.31)	**0.36 (0.04)**	**6.55 (0.25)**
Cul M9	Mutant 220 Gy of PTB 18	5.70 (0.23)	**1.66 (0.13)**	**0.00 (0.00)**	**5.82 (0.24)**
Cul JS 1	Pure line sln from Jaya	8.39 (0.30)	**1.81 (0.14)**	0.58 (0.06)	9.70 (0.32)
Cul JS-2	Pure line sln from Jaya	9.19 (0.30)	7.88 (0.29)	3.85 (0.19)	41.92 (0.69)
Cul JS 3	Pure line sln from Jaya	9.03 (0.31)	**1.70 (0.13)**	1.20 (0.11)	10.22 (0.33)
Cul JS 4	Pure line sln from Jaya	9.18 (0.22)	13.63 (0.38)	2.03 (0.14)	10.42 (0.33)
Cul JS 5	Pure line sln from Jaya	9.62 (0.32)	**1.87 (0.14)**	2.21 (0.14)	10.89 (0.34)
Cul JS 6	Pure line sln from Jaya	16.76 (0.41)	15.10 (0.40)	5.82 (0.22)	19.84 (0.46)
Cul JS 7	Pure line sln from Jaya	8.30 (0.30)	**1.92 (0.14)**	5.23 (0.20)	15.95 (0.41)
Kalluruli Sel.	Sln from land race Kalluruli	6.48 (0.25)	15.39 (0.40)	1.12 (0.11)	14.62 (0.39)
TN1	Susceptible check	14.50 (0.39)	22.83 (0.49)	10.51 (0.32)	82.75 (1.26)
CD (0.05)		NS	0.12	0.12	0.54

*Values in parentheses are arc sine transformed values.

Table 4: Reaction of promising genotypes against stem borer in SBST trail (*kharif* 2017) across locations (AICRIP progress report 2018)

Designation	Reaction to stem borer (% DH)							
	CHN	IIRR1	IIRR2	MSD	NVS1	PNT1	PNT1	PTB
	33-60 DT	68DT	70DT	78-82 DT	50DT	60DT	68DT	50DT
JGL 32467	10.4	20.7	23.1	4.6	0.0	31.0	19.3	25.7
JGL 32485	11.1	15.9	27.8	2.0	0.0	28.7	18.8	19.9
BK 39-179*	6.0	19.8	28.7	2.9	0.0	27.7	21.4	21.4
JGL 33080	5.9	10.7	30.6	4.2	7.5	30.5	11.7	16.3
JGL 33124	9.6	16.1	34.5	3.0	10.6	34.8	15.5	15.6
JGL 34508	9.5	10.8	28.9	6.6	9.2	31.3	19.5	25.3
RP 5587-B-B-B-209	11.0	NT	NT	3.5	NG	NG	NT	NT
RP 5587-B-B-B-253-2	7.9	10.7	13.3	0.0	0.0	38.4	22.2	28.0
BK 35-155	11.0	13.6	23.8	3.4	0.0	32.4	18.6	13.9
JGL 34505	8.0	7.0	17.4	4.8	9.9	30.9	30.6	23.2
KAUPTB 0627-2-11 (Cul 06-1)	8.6	26.0	22.1	4.5	0.0	32.9	21.7	26.3
KAUPTB 0627-2-14 (Cul 06-2)	7.1	21.8	26.0	1.6	7.1	37.6	14.6	25.4
RP 5587-B-B-B-258-1	8.1	23.1	20.0	3.1	14.5	31.0	21.8	36.8
RP 5587-B-B-B-262	6.7	20.7	27.3	0.0	11.1	35.6	21.1	35.8
RP 5588-B-B-B-B-232	8.8	28.8	22.4	3.5	0.0	33.1	21.2	14.3
JGL 28547	9.5	2.2	13.4	4.3	0.0	31.6	10.3	13.3
TKM6	12.6	16.8	15.8	4.4	9.4	25.2	12.5	19.4
Pusa Basmathi 1	15.7	36.8	27.9	2.9	9.0	41.2	16.8	27.3

*CHN:Chinsurah; IIRR: Indian Institute of Rice Research; MSD:Masoda; NVS: Navsari; PNT: Pantnagar; PTB: Pattambi

Table 5: Reaction of promising genotypes against stem borer in SBST trail (*kharif* 2018) across locations (AICRIP progress report 2019)

Designation	Reaction to stem borer (%WE)							
	CHN	ADT	CBT	PTB	RNR	PNT1	PNT2	NVS
	80-110DT	90DT	Pre.h	85DT	101DT	Pre Harvest		
JGL 32467	4.1	8.4	10.5	3.3	0.0	22.6	3.8	0.0
JGL 32485	4.8	8.8	15.8	5.0	3.2	29.2	9.0	0.0
BK 39-179*	0.0	5.9	14.4	4.6	6.7	17.2	4.5	0.0
JGL 33080	0.0	7.0	10.0	3.3	2.5	9.8	0.0	5.6
JGL 33124	9.3	7.7	15.2	18.5	2.3	23.5	4.8	7.2
JGL 34508	4.5	7.8	6.2	0.0	1.4	32.5	2.7	4.3
RP 5587-B-B-B-209	NG	NG	NG	NG	16.2	NT	NT	NG
RP 5587-B-B-B-253-2	4.8	9.5	12.2	17.7	7.4	1.4	1.0	0.0
BK 35-155	6.4	4.4	13.5	15.6	2.1	29.8	9.6	0.0
JGL 34505	11.6	6.3	6.0	0.9	3.1	30.2	6.0	3.9
KAUPTB 0627-2-11 (Cul 06-1)	1.7	5.2	9.5	1.3	1.7	22.4	1.0	0.0
KAUPTB 0627-2-14 (Cul 06-2)	7.4	12.5	6.3	2.9	3.7	11.8	0.0	4.3
RP 5587-B-B-B-258-1	7.1	6.2	17.5	0.0	7.8	4.5	4.5	5.8
RP 5587-B-B-B-262	13.0	4.8	9.8	0.0	4.0	21.3	7.9	8.6
RP 5588-B-B-B-B-232	10.5	4.8	8.1	0.0	12.7	15.0	10.3	0.0
JGL 28547	7.1	7.0	10.3	0.0	7.7	15.1	1.0	0.0
TKM 6	31.7	11.7	6.0	1.0	8.5	19.8	18.1	5.9
Pua Basmathi 1	19.1	8.3	5.7	3.8	9.6	43.0	11.8	6.0

*CHN: Chinsurah; ADT: Aduthurai; CBT: Coimbatore; RNR: Rajendranagar; PNT: Pantnagar; NVS: Navsari; MSD: Masoda; RPR: Raipur

Table 6: Reaction of promising genotypes entries against stem borer in SBST trail (*kharif* 2018) across locations (AICRIP progress report 2019)

Designation	Reaction to Stem borer (%WE)					
	IIRR1	IIRR2	MNC	PSA	PSA	ADT
KAUPTB 0627-2-11	31.0	8.2	2.2	15.5	8.1	6.4
JGL 34452	26.7	26.7	8.4	2.5	11.2	14.6
JGL 33440	42.3	35.4	4.7	11.8	9.2	4.5
NND 2	48.7	32.1	8.8	11.7	0.0	3.8
JGL 32994	23.4	36.8	4.4	2.5	27.0	10.4
JGL 33080	33.1	29.6	5.6	3.6	11.5	10.2
BK 49-76	32.1	20.2	10.7	11.4	7.7	10.0
RP bio 4919-385	40.2	36.6	14.5	10.5	4.9	14.3
KMR3	61.9	54.5	4.5	15.1	5.2	5.0
IET 27049	48.3	64.7	14.8	13.4	21.2	3.7
CRCPT 7	58.4	54.9	1.8	15.9	4.9	5.1
TKM 6	25.0	8.4	4.4	13.2	14.1	7.7
TN1	34.5	49.8	8.4	12.7	30.4	2.6

*IIRR: Indian Institute of Rice Research; MNC: Moncompu ; PSA: Pusa; ADT: Aduthurai; PNT: Pantnagar

Table 7: Reaction of promising genotypes against stem borer in SBST trail (*kharif* 2019) across locations (AICRIP progress report 2020)

Designation	Reaction of entries to stem borer (Dead hearts%)								
	ADT (50DT)	MNC	IIRR1 (47DT)	IIRR2 (68DT)	PSA (39DT)	PNT1 (53DT)	PNT2 (53DT)	PNT1 (71DT)	PNT2 (73DT)
KAUPTB 0627-2-11	8.2	11.1	31.6	8.6	18.2	12.9	13.1	29.4	28.4
JGL 34452	14.1	8.7	20.8	16.8	3.0	22.9	13.0	30.2	21.9
JGL 33440	5.0	8.6	28.5	11.6	15.4	24.2	10.9	29.5	24.2
NND 2	6.5	9.7	39.6	25.0	16.8	16.6	24.9	32.5	26.7
JGL 32994	10.7	11.2	24.6	26.5	4.2	17.5	19.7	25.4	30.2
JGL 33080	19.4	13.7	33.6	20.0	5.2	23.2	12.8	28.0	26.7
BK 49-76	22.1	9.8	28.4	15.9	12.9	8.5	13.9	25.3	22.8
RP bio 4919-385	18.6	13.0	26.9	15.5	13.8	9.8	21.9	28.5	21.1
KMR3	4.5	10.4	26.5	20.4	18.6	10.4	17.8	27.5	23.3
IET 27049	3.6	21.9	28.3	19.3	18.1	17.4	19.6	36.8	30.0
CRCPT 7	5.0	11.2	34.6	24.2	19.8	24.3	18.0	40.8	24.9
TKM 6	20.6	11.9	23.3	21.9	17.6	20.8	10.4	26.3	27.7
TN1	23.7	12.4	26.0	18.4	15.1	15.6	19.6	33.8	29.5

*ADT: Aduthurai; MNC: Moncompu; IIRR: Indian Institute of Rice Research; PSA: Pusa; PNT: Pantnagar

Nine cultures were evaluated against leaf folder during *kharif* 2018 and *kharif* 2019 with TN1 as susceptible check and W 1263 as resistant check in LFST trial under AICRPR. During *kharif* 19, four entries as promising in 3-4 tests of nine valid field tests**.** Average damage in the trial varied from 7.7 to 78.2% while the maximum damage ranged between 14.7 and 92.8% across locations. The average damage by leaf folder in susceptible check varied from 13.8 to 82.1%. Two mutant cultures, Cul M8 and Cul M9 were

found promising in four out of nine valid field tests. Another mutant culture, Cul M6-2 and a selection from landrace Kalluruli were found promising in three of the nine valid field tests (**Table 8**) and were found at par with resistant check, W 1263. (AICRIP progress report 2019).

Table 8: Reaction of promising genotypes entries against leaf folder in LFST trail (*kharif* 2018) across locations (AICRIP progress report 2019)

Designation	Parentage	CHT	KRK	LDN	MLN	NVS	NWG	PTB	ADT	RNR	NPT
		60DT	60DT	80DT	114DT	80DT	60DT	50DT	80DT	83DT	(9)
Cul M8	Mutant 170 GY of PTB 21	23.7	4.4	14.1	35.4	3.2	32.3	49.3	22.8	3.9	4
Cul M9	Mutant 220 GY of PTB 18	22.9	11.3	19.8	29.4	9.4	34.1	81.9	31.6	10.4	4
Cul M6-2	Mutant 170 GY of PTB 18	19.7	24.4	27.3	28.5	13.4	71.5	85.2	28.4	6.0	3
Kalluruli	Selection from landrace Kalluruli	25.0	14.6	16.5	31.7	7.9	29 .0	74.0	31.8	11	3
JS 3	Pureline selection from Jaya	27.1	27.7	30.3	32.1	8.0	26.0	86.0	32.2	1.4	2
JS 4	Pureline selection from Jaya	22.4	22.5	31.5	42.9	9.5	26.6	85.8	31.1	7.4	2
JS 5	Pureline selection from Jaya	22.8	34.0	31.1	32.8	6.6	32.6	81.8	30.8	2.2	2
Cul 3	Swetha x Kuruka	25.4	33.5	27.5	36.9	13.6	24.4	84.5	27.8	7.7	2
Cul M4	Mutant of PTB 18	22.1	17.1	34.3	32.9	9.9	38.2	61.4	22.0	2.8	2
Matali	Local red rice from Kullu valley in HP	24.2	16.7	20.9	26.6	13.8	43.2	66.5	19.6	12.4	2
NWGR 16041	NWGR 2006/ Mahisugandha/47-1-1-1-1-1-1	23.4	42.3	28.8	29.6	8.5	31.4	87.1	31.4	12.0	2
JS 1	Pureline selection from Jaya	24.0	23.6	33.3	37.8	15.6	34.0	88.0	28.1	8.0	1
JS 6	Pureline selection from Jaya	22.8	28.8	26.3	30.8	13.3	25.3	86.1	29.3	7.7	1
Cul 7	Pureline selection from Jaya	22.2	32.5	31.7	34.9	11	41.7	89.4	22.6	3.9	1
Chohartu	Local red rice from Rohru in Shimla region	27.1	27.8	28.8	41.5	10.6	32.8	85.5	22.3	4.8	1
NWGR 9078	GR 7/NWGR 99038/1-1-1-1	24.9	36.9	23.1	30.4	19.6	50.4	82	20.8	6.6	1
JS 7	Pureline selection from Jaya	23.5	30.3	31.9	34	18.2	29.7	92.8	31.4	11.4	0
W 1263	Resistant check	22.8	27.6	18.7	34.2	0.2	43.5	36.3	9.2	11.9	3
TN 1	Susceptible check	24 4	30.1	0.9	37.6	32.6	47.0	82.1	32.5	13.8	0
Minimum damage		19.7	4.4	14.1	26.6	0.2	24.4	36.3	9.2	1.4	
Maximum damage		27.1	42.3	34.3	42.9	36.7	71.5	92.8	32.2	14.7	
Average damage in trial		23.8	25.7	26.7	33.3	12.4	35.9	78.2	25.9	7.7	
Promising level		20	15	20	30	10	25	30	20	10	
No. Promising		1	3	4	4	9	1	0	3	12	
Total entries tested		20	20	20	20	20	20	20	20	20	

*CHT: Chatha; KRK: Karaikal; LDN: Ludhiana; MLN: Malan; NVS: Navsari; NWG: Nawagam; PTB: Pattambi; ADT: Aduthurai; RNR: Rajendranagar

During *kharif 2018*, the trial was conducted at 16 locations with 36 entries replicated twice in a randomised block design under All India Coordinated Trials. The average damage in the trial ranged between 8.4 and 47.2% while the maximum damage varied from 13.0 to 63.1%. Data analysis revealed 14 entries as Promising in 4-6 tests of 13 valid field tests. In the second year of testing *kharif* 2019, Cul M9 the mutant culture of PTB 18 was found promising in 6 out of 13 valid tests. Two pureline selections from Jaya (JS 1 & JS 3) were found promising in 5 out of 13 valid tests. JS 5, JS 6, Cul M8, Cul M6-2, were found promising in 4 out of 13 valid tests conducted at different locations (**Table 9**) (AICRIP progress report 2020).

Table 9: Reaction of promising genotypes entries against leaf folder in LFST trail (*kharif* 2019) across locations (AICRIP progress report 2020)

Designation	Parentage	ADT	BPT	CHT	CHN	JDP	KRK	LDN	MLN	NVS	NWG	PTB	RNR	KUL	NPT (13)
		80 DT	88 DT	57 DT	80 DT	82 DT	80 DT	80 DT	78 DT	80 DT	80 DT	50 DT	79 DT	60 DT	
Cul M8	Mutant 170 GY of PTB 21	17.5	11.2	13.8	10.9	4.0	38.8	25.5	20.8	7.8	31.2	36.9	4.4	24.2	4
Cul M9	Mutant 220 GY of PTB 18	6.5	10.5	13.5	8.2	7.0	44.5	19.2	22.1	3.2	29.2	21.9	4.8	22.3	6
Cul M6-2	Mutant 170 GY of PTB 18	27.3	10.5	12.5	8.9	12.9	43.3	27.5	26.4	2.8	24.6	31.2	8.0	22.1	4
JS 3	Pureline selection from Jaya	14.6	11.6	15.0	9.0	8.9	56.0	25.8	19.9	8.2	21.7	22.9	6.4	29.1	5
JS 5	Pureline selection from Jaya	11.8	12.8	17.5	12.2	7.6	46.4	23.0	20.2	8.8	18.2	26.1	6.4	31.9	4
JS 6	Pureline selection from Jaya	9.6	14.6	15.4	7.1	7.3	56.0	22.1	23.9	11.1	19.1	20.8	7.6	34.7	4
Matali	Local red rice from Kullu valley in HP	4.3	NG	NG	11.8	NG	NG	23.7	22.8	7.4	18.8	30.5	8.3	34.7	4
Ghocha	Landrace from tribal belt of Kangra	3.8	16.1	24.0	7.4	4.2	52.8	33.4	19.4	NG	31.0	30.1	11.9	31.7	4
BPT 2932	BPT 5204/ MTU 1075	31.7	16.0	12.1	9.0	9.8	46.3	25.5	25.3	5.4	22.9	26.4	4.8	21.6	4
BPT 2677	MTU 2077/ Ajay/ MTU 2077	30.1	14.8	12.5	9.1	7.5	43.0	33.5	24.0	7.6	24.4	19.8	6.4	28.0	4
BPT 2954	NLR 34449/ Annada/NLR 34449	29.7	13.5	13.2	5.4	6.2	42.2	32.2	25.6	7.9	18.9	26.9	6.1	32.8	4
BPT 3049	MTU 1010/IR 50	29.3	11.2	17.1	5.4	9.0	50.6	24.7	23.1	1.0	23.6	27.4	8.5	23.2	4
NPS 54	Swarna/*Oryza nivara* BIL	28.4	27.0	16.0	4.7	3.6	46.8	32.1	24.8	17.0	25.4	17.8	7.0	33.4	4
W 1263	Resistant check	4.9	7.7	9.6	5.6	2.5	4.4	19.4	19.5	0.7	18.3	19.9	7.7	27.3	12
TN 1	Susceptible check	33.4	19.4	14.5	10.3	14.5	40.9	25.5	38.2	29.1	48.3	30.4	18.5	39.9	0
Minimum damage		3.8	7.7	9.6	4.7	2.4	4.4	19.2	18.9	0.7	18.2	17.8	2.9	21.6	
Maximum damage		62.9	29.3	24.0	14.4	13.0	63.1	36.3	28.8	36.6	47.3	45.0	14.6	34.7	
Average damage in trial		21.7	15.6	15.0	9.1	8.6	47.2	26.0	23.0	9.0	24.8	26.7	8.4	28.9	
Promising level		15	10	10	10	5	15	20	20	10	20	20	10	25	
No. Promising		11	1	1	24	4	1	2	5	24	5	6	26	10	

*CHT: ADT: Aduthurai; BPT: Bapatla; CHT: Chatha; CHN: Chinsurah; JDP: Jagdalpur; KRK: Karaikal; LDN: Ludhiana; MLN: Malan; NVS: Navsari; NWG: Nawagam; PTB: Pattambi; RNR: Rajendranagar; KUL: Kaul

Chatterjee *et al.,* (2011) screened 51 rice genotypes and reported that five cultures CSR 23, TNAU 831311, ARC 6626, IC 115737, AGANNI, IC 155876 and ARC 5982 were resistant to rice leaf folder. Balasubramanian *et al*., (2000) screened 178 advanced yield trial genotypes of rice for their reaction to insect pests under natural conditions and found that genotype, IET 16120 was moderately resistant against rice leaf folder. Sudhakar *et al*., (1991) evaluated 24 rice varieties in India for resistance against *C. medinalis* and reporded that IET 7564, ES 29-3-3-1; Pusa 2-21 and Type-3 were the least susceptible entries. Paramasiva *et al*., (2021) found 15 cultures *viz.,* NLR 3542, NLR 3548, NLR 3582, NLR 3595, NLR 3598, NLR 3601, NLR 3634, NLR 3635, NLR 3636, NLR 3637, NLR 3641, NLR 3643, NLR 3644, NLR 3645 and NLR 3647 recorded resistant reaction by recording less than 10 per cent leaf damage (8.06 to 10.18%).

Performance of entries to multiple injuries

Reaction to Mixed population of planthoppers: The rice genotypes of various states were evaluated for multiple resistance to two or more pests under Multiple resistance trial during *kharif* 2018 and *kharif* 2019 under All India coordinated programme wherein Cul M9 (Mutant 220 Gy of PTB 18) and PTB33 exhibited field tolerance with a DS ≤3.0 in two valid tests at against mixed population of planthoppers, where BPH was predominant at Maruteru and WBPH at Gangavathi (**Tables 10 and 11**) (AICRIP progress report 2019 and 2020). Dhawande *et al*., (2018) assessed 1003 germplasm for resistance to brown plant hopper and found that 37 entries exhibited a damage

score (DS) ranging from 0-5 and were designated as highly resistant and moderately resistant to BPH, and the remaining 966 entries were susceptible with a damage score of 5.1-9.0. Out of 37 accessions, two accessions *viz.,* IC 75975 (DS-0.77), IC 216750 (DS-0.80) were highly resistant, 21 accessions were resistant (DS-1.0-3.0) and 14 accessions were moderately resistant (DS-3.1-5.0).

Table 10: Reaction of promising genotypes entries under MRST trail (*kharif* 2018) across locations (AICRIP progress report 2019)

Designation	Stem borer (% White ears)					PH		Stem borer (% Dead hearts)				
	PSA (69DT)	MSD (85DT)	CHN (69DT)	RPR (110DT)	RNR (113DT)	GNV	MTU	IIRR (68DT)	PNT (55DT)	MSD (70DT)	NVS (50DT)	PSA (39DT)
Sinna sivappu	10.3	38.1	6.7	23.1	11.09	3.0	9.0	15.44	14.2	38.5	19.0	13.3
JS 5	11.6	0.0	10.5	7.4	7.77	5.0	1.0	23.80	26.9	0.0	22.2	15.5
SKL -07-11-177-50-65-60-267	14.5	0.0	13.4	30.9	19.45	3.0	9.0	19.90	15.3	0.0	11.1	17.1
Cul M9	7.6	1.7	1.6	0.0	0.0	3.0	GF	12.30	13.8	0.0	5.3	16.7
Checks												
PTB 33	12.3	36.5	3.5	0.0	0.00	1.0	1.0	27.30	14.7	21.7	0.0	13.6
W1263	13.4	12.5	6.9	15.3	9.24	3.0	9.0	17.54	18.9	61.2	10.5	15.3
TN1	11.0	23.8	3.4	13.5	4.97	5.0	9.0	15.72	28.5	38.0	35.3	12.9

*PSA: Pusa; MSD: Masoda; CHN: Chinsurah RPR: Raipur; RNR: Rajendranagar; GNV:Gangavathi; MTU: Maruteru; IIRR: Indian Institute of Rice Research; PNT: Pantnagar; NVS: Navsari; PSA: Pusa

Table 11: Reaction of promising Pattambi genotypes entries under MRST trail (*kharif* 2019) across locations (AICRIP progress report 2020)

Designation	Stem borer (% Dead hearts)				Stem borer (% White ears)				Leaf folder (% damaged leaves)				PH
	IIRR 52DT	TTB 45DT	PSA 45DT	PNT 54DT	IIRR 83DT	PSA 68DT	NWG 95DT	TTB 100DT	PSA 45DT	TTB 50DT	PTB 50DT	ADT 50DT	GNV No./ 10 hill
Cul M9	22.1	31.4	9.0	36.8	NF	5.9	4.4	8.7	5.4	12.4	3.8	1.4	193
SKL -07-11-177-50-65-60-267	23.0	21.7	13.6	43.2	21.7	13.7	18.2	7.9	11.2	7.9	NG	NT	255
BK 35-155	26.0	14.3	15.9	30.7	26.6	12.5	14.3	19.4	9.9	4.1	10.8	10.0	224
JS 5	17.0	7.3	14.6	37.3	31.8	15.7	8.3	6.8	14.0	9.0	6.8	7.3	216
RP 5587-B-B-B-262	24.4	51.5	14.3	30.7	26.0	13.6	22.7	10.3	10.8	17.0	11.0	5.0	200
JGL 33440	21.9	24.1	19.0	36.1	41.7	13.0	24.3	15.5	17.1	13.8	8.5	1.0	202
Checks													
PTB 33	30.2	30.4	8.4	33.5	NF	7.6	4.3	10.4	6.6	16.7	8.2	6.6	190
W1263	22.0	16.7	15.3	23.4	18.4	13.4	12.1	14.5	14.2	7.1	6.3	8.1	184
TN 1	11.8	9.1	20.4	44.4	32.2	23.4	50.9	10.6	14.1	11.4	10.3	23.5	226

*IIRR: Indian Institute of Rice Research; TTB: Titabar; PSA: Pusa; PNT:Pantnagar; NWG: Nawagam; PTB: Pattambi; ADT: Aduthurai GNV: Gangavathi

Stem borer

During *kharif* 2018 and 2019, evaluation of entries against stem borer at vegetative phase for dead heart damage in seven valid tests identified JS1 (a pure line selection from Jaya) with nil damage. Cul 7, Cul M9, JS 3, PTB33 and Suraksha were identified as promising in 2 of the14 valid tests at reproductive phase for white ear damage. In *kharif* 2019, under Multiple screening trial, culture Cul M9 was promising in 3 tests *viz.,* JS 3, JS 5 and PTB33 were identified as promising in two of the four valid tests at reproductive phase for

white ear damage. Of these, CulM9, JS 3 and PTB 33 were promising in second year of testing as in **Table 10 and 11** (AICRIP progress report 2019 and 2020).

Leaf folder: During *kharif* 2019, under Multiple screening trial cultures, Cul M9, RP 5587-B-B-B-262 and Suraksha were promising for leaf folder damage in two of the seven valid tests with ≤5% DL under All India coordinated testing programme as in **Table 10** (AICRIP progress report 2020) **Table 11** (AICRIP progress report 2020). Chatterjee *et al*., (2016) screened rice entries for multiple tolerance to various rice pests and found that entries CN 2008-3-2, CN 2017-3-2 and W 1263 showed multiple tolerance against stem borer, leaf folder and whorl maggot of rice. Entries CR 2274-2-3-3-1, RP 5587-B-B-B-305-13, CN 2015-5-4, IET 23148 and CN 1233-33-9 showed multiple against stem borer and leaf folder while entries RP 2068-18-3-5, RP 5588-B-B-B-B-76 and RNT 14-1-1-2-2 showed multiple tolerance against stem borer and whorl maggot. Chatterjee *et al.*, (2021) found that the early duration varieties Narendra 97, IR 50 and mid-early duration varieties IR 64 and IET 17904 were resistant against both yellow stem borer (dead heart) and leaf folder. The medium duration variety, Ranjit was highly resistant against both yellow stem borer (dead heart) and leaf folder, and the variety, Pratiksha showed a fair degree of resistance against both yellow stem borer and leaf folder. Padmavathi *et al.,* (2017) screened forty eight genotypes by two methods of screening methods against rice leaf folder and found that six genotypes were resistant with a damage score of 3.0 including resistant check W 1263 and ten genotypes were moderately resistant with score of 5.0 in first method of screening and in another special method of screening entries IET 22449 and W 1263 showed minimum leaf area damage of 68.41 to 428.81 mm^2.

Conclusion

The evaluation of rice cultures from Pattambi against major rice pests and in multi-locations in AICRPR showed that KAUPTB 0627-2-11 (Cul 06-1) was resistant to stem borer and cultures JS 1,3,4,5 and 7 resistant to both stem borer and leaf folder while Cul M9 showing multiple resistance to stem borer, mixed population of plant hoppers and leaffolders.

Authors contribution: KK, screened the cultures at Pattambi against stem borer and leaf folder. FKV and BKR were involved in development of the material. CHPV designed the LFST trial for multilocation testing in AICRPR and analysed the data. APPK designed the SBST and MRST trials in AICRPR and analysed the data. KK, APPK and CHPV wrote the manuscript. All authors read and approved the manuscript.

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