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Assessment of rice cultures for resistance against yellow stem borer (*Scirpophaga incertulas*, Walker)

K Vinothini, T Abdul Razak, N Balakrishnan and A Kavitha Pushpam

Abstract
Field evaluation of 82 rice cultures along with the resistant and susceptible check, PTB 33 and TN-1 respectively was done at Rice Research Station, Ambasamudhram. Fourteen rice cultures *viz.,* RMLT-21-102, RMLT-21-103, RMLT-21-105, RMLT-21-109, RMLT-21-207, RMLT-21-212, RMLT-21-213, RMLT-21-302, RMLT-21-303, RMLT-21-401, RMLT-21-402, RMLT-21-405, RMLT-21-602 and RMLT-21-608 were showed resistance at vegetative stage while ten rice cultures *viz.*, RMLT-21-102, RMLT-21-103, RMLT-21-105, RMLT-21-109, RMLT-21-207, RMLT-21-212, RMLT-21-401, RMLT-21-402, RMLT-21-501 and RMLT-21-602 were showed resistance to yellow stem borer damage at reproductive stage. The number of trichomes/ cm^2 was maximum on the upper surface of leaf blade than the lower surface. It ranged from 87.9/cm^2/ leaf to 93.7/cm^2/ leaf on the upper surface and 17.2/cm^2/ leaf to 19.9/cm^2 / leaf on the lower surface in the highly resistant cultures and were categorized as pubescent (scale 3). The highly susceptible entry was found to have minimum number of trichomes i.e., 15.3/cm^2/ leaf on the upper surface and 8.6/ cm^2/ leaf on the lower surface of leaf blade and categorized as glabrous (scale 1). The flag leaf angle of highly resistant cultures/ accessions ranged from 4.13° to 6.83° (decreased leaf attitude) and flag leaf attitude as erect (scale 1). The penultimate leaf angle of highly resistant cultures/ accessions ranged from 6.68° to 8.64° (scale 1 – erect leaf attitude). Resistant and susceptible entries had semi-erect and horizontal leaf attitude, respectively. The highly susceptible entries have the flag leaf angle of 72.17°. Correlation studies were carried out with biophysical parameters and yellow stem borer damage. Results revealed that the trichome density was significantly negatively correlated. While, plant height and leaf length were significantly negatively correlated and leaf breadth is significantly positively correlated.

Keywords: Rice cultures, yellow stem borer, resistance, screening, biophysical resistance

Introduction

Rice (*Oryza sativa* L.) is the most important food crop belongs to the family Poaceae and it is being consumed by more than two-thirds of the population (Lal *et al.*, 2014 and Singh *et al.*, 2014) [10, 19]. India is the second largest producer of rice after China, accounting for about 12.9 million tons of production (USDA, 2022). Several biotic and abiotic variables function as yield restrictions in rice, with insect-pests being one of the most significant biotic contributors causing significant yield loss (Chatterjee and Mondal, 2014) [3]. Landraces and wild rice species have immense potential to endure or resist diverse biotic and abiotic stresses due to the presence of trait-specific genes (Keerthivarman *et al.*, 2019) [9]. In India, more than 100 insect species attack rice, with 20 of them classified as serious pests that cause output losses of up to 30%. (Salim *et al.*, 2001) [16]. Yellow stem borer, *Scirpophaga incertulas* Walker, is the most frequent and destructive insect pest in the country, producing production losses of 10% to 60%. (Chatterjee and Mondal, 2014) [3].

S. incertulas, the yellow stem borer, is an important monophagous pest in rice it produces 'dead heart' at the vegetative stage and 'white ear head' at maturity, resulting in chaffy grains and diminishing yield. Farmers rely on a variety of chemicals to manage the pest, but indiscriminate pesticide usage has resulted in development of insecticide resistance, resurgence, secondary pest outbreaks, and disturbance of the natural enemy complex (Dhaliwal and Arora, 2000) [5].

By producing a variety that is resistant to stem borer, host plant resistance, a crucial component of IPM, has proved to be successful for yellow stem borer control. There are just a few resistance sources available for producing stem borer resistant cultivars. Due to the diversity of genetic features and inherent obstacles in screening, breeding for yellow stem borer resistance has proven tough (Selvi *et al.*, 2002) [18]. This study was conducted to evaluate the resistant source for yellow stem borer from the rice cultures.

Materials and Methods

The present study was carried out under open field condition at Rice Research Station (Ambasamudhram). Totally 82 entries of rice cultures received from Tamil Nadu Rice Research Institute, Aduthurai have been taken for the work along with the susceptible check TN -1 and the resistant check PTB 33.The scoring for stem borer resistance as per the Standard Evaluation System developed by IRRI was done at 35, 55 and 90 days after transplanting (DAT). The damage of dead heart was counted at 35 and 55 DAT and white ear symptom was counted at 90 DAT. The observations were recorded from ten randomly chosen hills/ accessions or culture.

The damage percentage was computed as per cent damage as detailed below.

$$\text{Per cent Dead Heart (DH \%)} = \frac{\text{No. of dead hearts count}}{\text{Total no. of tillers observed}} \times 100$$

Percentage of Dead heart will be converted to D

$$D = \frac{\text{\% Dead heart in test entry}}{\text{\% Dead hearts in susceptible check}} \times 100$$

$$\text{Per cent White Ear (WE \%)} = \frac{\text{No. of damaged productive tillers (White ear)}}{\text{Total no. of productive tillers}} \times 100$$

Percentage of White ear will be converted to D

$$D = \frac{\text{\% White ear in test entry}}{\text{\% White ear in susceptible check}} \times 100$$

The damage rating scale 0-9 was fixed based on the D values suggested by IRRI Standard Evaluation System for screening resistance to stem borer in rice as given below, Standard Evaluation System.

Table 1: Dead Heart (DH) define Percentage White Ear (WE)

Dead Heart (DH)			White Ear (WE)		
Damage %	**Scale**	**Resistant rating**	**Damage %**	**Scale**	**Resistant rating**
No damage	0	Highly resistant	0	0	Highly resistant
1-20%	1	Resistant	1-10%	1	Resistant
21-40%	3	Moderately resistant	11-25%	3	Moderately resistant
41-60%	5	Moderately susceptible	26-40%	5	Moderately susceptible
61-80%	7	Susceptible	41-60%	7	Susceptible
81-100%	9	Highly susceptible	61-100%	9	Highly susceptible

(Heinrichs *et al.*, 1985) [7]

Biophysical basis of resistance

Leaf blade pubescence

The leaf blade pubescence for resistance to yellow stem borer was carried out. The trichome density of rice leaf in different accessions were estimated as described by Maiti *et al.*, (1980) [11]. Leaf samples from 82 different rice cultures were collected and cut into 5 cm bits and boiled in water then boiled using ethanol and then lactic acid was added and boiled. Once the chlorophyll content gets cleared the leaves were transferred to the slide and viewed under microscope. Five replications were maintained for each rice culture. Leaf pubescence is categorised as glabrous (scale 1), intermediate (scale 2) and pubescent (scale 3), (Bioversity international, IRRI and WARDO, 2007).

Leaf angle

The angle of openness of the leaf blade tip was measured against the culm of the leaf. The leaf angle was measured using protractor with its 900 set vertically to theculm for the flag leaf and penultimate leaf after a growth period of 39 days. The flag leaf attitude was scored as erect (score 1), semi erect / intermediate (score 3), horizontal (score 5) and deflexed/ descending/ drooping (scale 7). The position of the tip of the blade relative to its base, scored on the leaf below the flag leaf (penultimate leaf) is called leaf blade attitude, which was measured at the late vegetative stage (prior to heading). It was categorised as erect, horizontal and drooping (Bioversity international, IRRI and WARDO, 2007).

Leaf length, breadth and plant height

The leaf length, breadth and plant height were measured in the 82 different rice cultures at seven days after a thesis at two stages (45 and 75 DAT).

Results and Discussion

Among the 82 rice entries screened against rice yellow stem borer, 10 cultures *viz.*, RMLT-21-102, RMLT-21-103, RMLT-21-105, RMLT-21-109, RMLT-21-207, RMLT-21-212, RMLT-21-401, RMLT-21-402, RMLT-21-501 and RMLT-21-602 recorded nil incidence of dead heart and white ear head damage and they were found to be highly resistant. One entry (RMLT-21-301) was found to be moderately resistant. The highly susceptible damage was found to be in the check variety TN-1 (Table 1&2). Bandong and Litsinger (2005) [2] recorded in early maturing rice variety IR-72, resistance occurred from panicle initiation to pre booting, while resistance was extended from late vegetative to booting in the medium maturing rice variety IR-70. Elanchezhyan *et al.* (2015) [6] reported that the infestation by stem borer varied from 2.48 to 23.58 per cent dead heart during the vegetative stage and 1.94 to 12.25 per cent white ear during the reproductive stage in rice. Reuolin *et al.*, (2019) [15] revealed that from field screening that the wild rice introgressed nine lines among 38 entries tested were moderately resistant to yellow stem borer. Sarao *et al.*, (2013) [17] examined 62 wild rice germplasm accessions and found that CR100316 (*O. nivara*) had the least stem borer damage. Chen *et al.*, (2006) reported that the larval survival rate was 25 per cent higher in cultivated accessions than wild rice accessions of *Oryza nivara* and *O. rufipogon*.

The flag leaf angle of highly resistant cultures ranged from 4.13° to 6.83° (decreased leaf attitude) and flag leaf attitude as erect (scale 1). The penultimate leaf angle of highly resistant cultures ranged from 6.68° to 8.64° (scale 1 – erect leaf attitude). Resistant and susceptible entries had semi-erect and horizontal leaf attitude, respectively. The highly susceptible entries have the flag leaf angle of 72.17° (Table 3). The leaf angle for highly resistant cultures was categorized under vertical/ erect leaf attitude and scored with Scale 1, resistant and moderately resistant cultures showed semi- erect leaf attitude scored with scale 3, susceptible and highly susceptible cultures showed horizontal leaf attitude and scored with scale 5. The leaf insertion angle was one of the most essential features of the plant to output capacity, according to Sharmitha *et al.*, (2019) who reported that the highly resistant cultures possessed the flag leaf angle in the range of 1.33° to 4.33° (decreased leaf angle). The leaf attitude is erect. The penultimate leaf angle ranged as 6.33° to 8.33° for the highly resistant cultures and considered as erect. The susceptible cultures leaf angle ranged from 76.00° to 84.67° and considered as horizontal leaf attitude.

Table 2: Field screening of rice cultures against yellow stem borer for dead heart damage

Rice cultures	Dead heart (%)							
	35 DAT				55 DAT			
	Damage (%)	D Value	Damage Scale	Resistant Rating	Damage (%)	D Value	Damage Scale	Resistant Rating
RMLT – 21 – 101	3.17	12.14	1	R	3.73	11.52	1	R
RMLT – 21 – 102	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 103	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 104	1.58	6.05	1	R	4.54	14.02	1	R
RMLT – 21 – 105	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 106	4.76	18.22	1	R	6.06	18.71	1	R
RMLT – 21 – 107	4.76	18.22	1	R	4.57	14.10	1	R
RMLT – 21 – 108	0.00	0.00	0	HR	3.03	9.35	1	R
RMLT – 21 – 109	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 110	3.17	12.14	1	R	4.54	14.02	1	R
RMLT – 21 – 111	4.76	18.22	1	R	6.06	18.71	1	R
RMLT – 21 – 112	4.76	18.22	1	R	6.06	18.71	1	R
RMLT – 21 – 113	6.34	24.27	3	MR	9.09	28.06	3	MR
RMLT – 21 – 114	0.00	0.00	0	HR	3.03	9.35	1	R
RMLT – 21 – 115	0.00	0.00	0	HR	1.51	4.66	1	R
RMLT – 21 – 201	0.00	0.00	0	HR	2.22	6.85	1	R
RMLT – 21 – 202	2.77	10.60	1	R	3.33	10.28	1	R
RMLT – 21 – 203	1.38	5.28	1	R	2.22	6.85	1	R
RMLT – 21 – 204	5.55	21.25	3	MR	6.67	20.59	3	MR
RMLT – 21 – 205	0.00	0.00	0	HR	4.44	13.71	1	R
RMLT – 21 – 206	0.00	0.00	0	HR	1.11	3.43	1	R
RMLT – 21 – 207	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 208	2.77	10.60	1	R	5.55	17.13	1	R
RMLT – 21 – 209	5.55	21.25	3	MR	7.77	23.99	3	MR
RMLT – 21 – 210	0.00	0.00	0	HR	2.22	6.85	1	R
RMLT – 21 – 211	1.38	5.28	1	R	3.33	10.28	1	R
RMLT – 21 – 212	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 213	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 214	1.38	5.28	1	R	1.11	3.43	1	R
RMLT – 21 – 215	1.38	5.28	1	R	2.22	6.85	1	R
RMLT – 21 – 301	0.00	0.00	0	HR	2.56	7.90	1	R
RMLT – 21 – 302	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 303	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 304	0.95	3.64	1	R	1.28	3.95	1	R
RMLT – 21 – 305	2.85	10.91	1	R	5.12	15.81	1	R
RMLT – 21 – 306	1.90	7.27	1	R	3.84	11.86	1	R
RMLT – 21 – 307	2.85	10.91	1	R	5.12	15.81	1	R
RMLT – 21 – 308	3.81	14.59	1	R	6.41	19.79	1	R
RMLT – 21 – 309	0.00	0.00	0	HR	1.28	3.95	1	R
RMLT – 21 – 310	0.00	0.00	0	HR	2.56	7.90	1	R
RMLT – 21 – 311	0.95	3.64	1	R	1.28	3.95	1	R
RMLT – 21 – 312	3.81	14.59	1	R	7.69	23.74	3	MR
RMLT – 21 – 313	3.81	14.59	1	R	6.41	19.79	1	R
RMLT – 21 – 314	2.85	10.91	1	R	5.12	15.81	1	R
RMLT – 21 – 315	0.00	0.00	0	HR	1.28	3.95	1	R
RMLT – 21 – 316	0.95	3.64	1	R	2.56	7.90	1	R
RMLT – 21 – 317	0.95	3.64	1	R	2.56	7.90	1	R
RMLT – 21 – 401	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 402	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 403	2.22	8.50	1	R	3.70	11.42	1	R
RMLT – 21 – 404	0.00	0.00	0	HR	1.85	5.71	1	R

RMLT – 21 – 405	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 406	2.22	8.50	1	R	3.70	11.42	1	R
RMLT – 21 – 407	4.44	17.00	1	R	3.40	10.49	1	R
RMLT – 21 – 408	0.00	0.00	0	HR	1.85	5.71	1	R
RMLT – 21 – 501	1.75	6.70	1	R	2.46	7.59	1	R
RMLT – 21 – 502	1.75	6.70	1	R	3.70	11.42	1	R
RMLT – 21 – 503	1.75	6.70	1	R	4.93	15.22	1	R
RMLT – 21 – 504	0.00	0.00	0	HR	1.23	3.80	1	R
RMLT – 21 – 505	2.85	10.91	1	R	3.70	11.42	1	R
RMLT – 21 – 506	3.51	13.44	1	R	6.17	19.05	1	R
RMLT – 21 – 601	0.00	0.00	0	HR	2.08	6.42	1	R
RMLT – 21 – 602	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 603	1.44	5.51	1	R	2.08	6.42	1	R
RMLT – 21 – 604	1.45	5.55	1	R	3.12	9.63	1	R
RMLT – 21 – 605	3.58	13.71	1	R	4.17	12.87	1	R
RMLT – 21 – 606	7.02	26.88	3	MR	10.35	31.95	3	MR
RMLT – 21 – 607	1.44	5.51	1	R	2.08	6.42	1	R
RMLT – 21 – 608	0.00	0.00	0	HR	0.00	0.00	0	HR
RMLT – 21 – 609	2.22	8.50	1	R	3.57	11.02	1	R
RMLT – 21 – 610	2.22	8.50	1	R	4.76	14.70	1	R
RMLT – 21 – 611	3.33	12.75	1	R	5.95	18.37	1	R
RMLT – 21 – 612	2.22	8.50	1	R	3.57	11.02	1	R
RMLT – 21 – 613	3.58	13.71	1	R	4.76	14.70	1	R
ART – 4 - 21 - 1	0.00	0.00	0	HR	1.85	5.71	1	R
ART – 4 – 21 – 2	0.00	0.00	0	HR	1.85	5.71	1	R
ART – 4 – 21 – 3	2.56	9.80	1	R	3.70	11.42	1	R
ART – 15 – 21 – 1	0.00	0.00	0	HR	1.38	4.26	1	R
ART – 15 – 21 – 2	1.85	7.08	1	R	1.38	4.26	1	R
ART – 15 – 21 – 3	3.70	14.17	1	R	2.94	9.07	1	R
ART - 15 - K - 21 - 1	1.33	5.09	1	R	1.51	4.66	1	R
ART – 15 – K – 21 – 2	2.67	10.22	1	R	4.54	14.02	1	R
TN – 1	26.12	100.00	9	HS	32.39	100.00	9	HS

Table 3: Field screening of rice cultures against yellow stem borer for white ear damage

Rice cultures	White Ear Damage (%)			
	90 DAT			
	% Damage	D value	Damage scale	Resistant rating
RMLT – 21 – 101	0.67	2.65	1	R
RMLT – 21 – 102	0.00	0.00	0	HR
RMLT – 21 – 103	0.00	0.00	0	HR
RMLT – 21 – 104	1.56	6.18	1	R
RMLT – 21 – 105	0.00	0.00	0	HR
RMLT – 21 – 106	1.79	7.09	1	R
RMLT – 21 – 107	2.05	8.12	1	R
RMLT – 21 – 108	1.43	5.66	1	R
RMLT – 21 – 109	0.00	0.00	0	HR
RMLT – 21 – 110	1.11	4.39	1	R
RMLT – 21 – 111	1.56	6.18	1	R
RMLT – 21 – 112	2.05	8.12	1	R
RMLT – 21 – 113	1.11	4.39	1	R
RMLT – 21 – 114	0.76	3.01	1	R
RMLT – 21 – 115	1.81	7.17	1	R
RMLT – 21 – 201	1.27	5.03	1	R
RMLT – 21 – 202	0.75	2.97	1	R
RMLT – 21 – 203	1.23	4.87	1	R
RMLT – 21 – 204	1.40	5.54	1	R
RMLT – 21 – 205	1.96	7.76	1	R
RMLT – 21 – 206	2.50	9.90	1	R
RMLT – 21 – 207	0.18	0.71	1	R
RMLT – 21 – 208	0.48	1.90	1	R
RMLT – 21 – 209	0.50	1.98	1	R
RMLT – 21 – 210	0.67	2.65	1	R
RMLT – 21 – 211	0.95	3.76	1	R
RMLT – 21 – 212	0.00	0.00	0	HR
RMLT – 21 – 213	0.52	2.06	1	R
RMLT – 21 – 214	1.11	4.39	1	R

RMLT – 21 – 215	2.15	8.52	1	R
RMLT – 21 – 301	6.44	25.52	3	MR
RMLT – 21 – 302	3.57	14.14	1	R
RMLT – 21 – 303	2.30	9.11	1	R
RMLT – 21 – 304	1.28	5.07	1	R
RMLT – 21 – 305	3.13	12.40	1	R
RMLT – 21 – 306	1.75	6.93	1	R
RMLT – 21 – 307	3.33	13.19	1	R
RMLT – 21 – 308	1.33	5.27	1	R
RMLT – 21 – 309	2.22	8.79	1	R
RMLT – 21 – 310	1.67	6.61	1	R
RMLT – 21 – 311	1.17	4.63	1	R
RMLT – 21 – 312	1.96	7.76	1	R
RMLT – 21 – 313	0.58	2.29	1	R
RMLT – 21 – 314	0.95	3.76	1	R
RMLT – 21 – 315	1.78	7.05	1	R
RMLT – 21 – 316	1.78	7.05	1	R
RMLT – 21 – 317	2.56	10.14	1	R
RMLT – 21 – 401	0.00	0.00	0	HR
RMLT – 21 – 402	0.00	0.00	0	HR
RMLT – 21 – 403	1.39	5.50	1	R
RMLT – 21 – 404	1.21	4.77	1	R
RMLT – 21 – 405	0.71	2.81	1	R
RMLT – 21 – 406	0.51	2.02	1	R
RMLT – 21 – 407	1.28	5.07	1	R
RMLT – 21 – 408	1.21	4.79	1	R
RMLT – 21 – 501	0.00	0.00	0	HR
RMLT – 21 – 502	1.42	5.62	1	R
RMLT – 21 – 503	1.90	7.53	1	R
RMLT – 21 – 504	1.17	4.63	1	R
RMLT – 21 – 505	0.44	1.74	1	R
RMLT – 21 – 506	0.76	3.01	1	R
RMLT – 21 – 601	0.27	1.07	1	R
RMLT – 21 – 602	0.00	0.00	0	HR
RMLT – 21 – 603	1.17	4.63	1	R
RMLT – 21 – 604	1.42	5.62	1	R
RMLT – 21 – 605	1.26	4.99	1	R
RMLT – 21 – 606	1.57	6.22	1	R
RMLT – 21 – 607	1.67	6.61	1	R
RMLT – 21 – 608	0.35	1.38	1	R
RMLT – 21 – 609	0.78	3.09	1	R
RMLT – 21 – 610	0.92	3.64	1	R
RMLT – 21 – 611	1.67	6.61	1	R
RMLT – 21 – 612	1.67	6.61	1	R
RMLT – 21 – 613	1.79	7.09	1	R
ART – 4 – 21 – 1	1.51	5.98	1	R
ART – 4 – 21 – 2	2.12	8.40	1	R
ART – 4 – 21 – 3	2.05	8.12	1	R
ART – 15 – 21 – 1	1.17	4.63	1	R
ART – 15 – 21 – 2	0.83	3.28	1	R
ART – 15 – 21 – 3	1.05	4.16	1	R
ART – 15 – K – 21 – 1	0.67	2.65	1	R
ART – 15 – K – 21 – 2	1.11	4.39	1	R
TN – 1	25.23	100.00	9	HS

Table 4: Biophysical parameters of rice cultures at vegetative stage in Rice Research Station, Ambasamudhram

Rice Cultures	Leaf Length (cm)*	Leaf Breadth (cm)*	Leaf Area (cm^2)*	Flag Leaf Angle	Penultimate Leaf Angle	Plant Height (cm)*	Leaf Blade Pubescence	
							Upper surface	Lower surface
RMLT-21-101	33.70	1.28	32.35	8.07	14.28	64.6	85.5	12.3
RMLT-21-102	34.53	0.55	40.14	5.33	6.68	74.1	87.9	19.8
RMLT-21-103	35.33	0.59	42.13	5.59	7.10	72.7	92.3	18.9
RMLT-21-104	35.00	1.56	34.95	8.45	13.36	66.4	84.0	13.5
RMLT-21-105	34.60	1.05	42.82	6.83	7.13	76.0	90.7	17.2
RMLT-21-106	34.40	1.56	36.25	8.04	13.94	68.5	86.1	14.6
RMLT-21-107	34.17	1.51	38.70	8.82	14.13	74.0	85.2	13.7
RMLT-21-108	34.30	1.47	37.82	8.50	14.18	72.0	87.0	14.9

RMLT-21-109	34.80	1.00	43.54	5.67	7.63	77.1	91.9	18.2
RMLT-21-110	34.37	1.54	39.70	8.79	14.58	74.6	86.4	15.6
RMLT-21-111	35.87	1.69	35.47	8.85	14.79	70.9	83.7	12.0
RMLT-21-112	34.30	1.49	38.33	8.12	14.52	70.1	84.6	11.8
RMLT-21-113	34.67	1.32	34.32	8.69	23.61	75.4	88.0	14.6
RMLT-21-114	33.97	1.58	35.25	9.11	14.35	72.4	86.3	15.8
RMLT-21-115	32.80	1.60	33.36	8.42	14.85	69.1	88.4	14.6
RMLT-21-201	33.47	1.47	36.90	9.01	16.84	73.8	85.3	12.3
RMLT-21-202	34.50	1.53	39.59	7.91	17.60	76.9	82.5	10.3
RMLT-21-203	34.23	1.56	32.05	8.16	17.75	76.8	86.9	14.6
RMLT-21-204	32.57	1.45	35.42	8.44	21.93	74.7	87.4	17.5
RMLT-21-205	29.87	1.33	29.80	8.51	18.21	72.2	86.4	16.5
RMLT-21-206	33.00	1.46	36.14	8.74	17.89	73.7	87.2	17.2
RMLT-21-207	33.70	0.75	44.88	5.27	8.07	77.7	90.5	19.4
RMLT-21-208	35.10	1.29	33.96	4.78	17.47	70.1	87.5	15.3
RMLT-21-209	32.80	1.33	32.72	6.87	17.76	72.3	85.6	14.2
RMLT-21-210	32.43	1.32	32.11	8.34	16.90	69.5	89.6	17.9
RMLT-21-211	32.20	1.31	31.64	9.04	15.34	71.1	84.6	13.4
RMLT-21-212	33.37	0.99	39.79	4.13	8.64	78.0	93.7	19.5
RMLT-21-213	36.17	1.33	36.08	8.37	17.22	69.4	83.3	12.4
RMLT-21-214	34.10	1.29	32.99	8.69	17.92	71.4	87.5	16.8
RMLT-21-215	33.33	1.26	31.50	8.95	17.77	69.1	84.6	14.6
RMLT-21-301	35.97	1.45	39.12	7.54	24.76	70.2	76.7	10.8
RMLT-21-302	35.07	1.47	38.66	5.88	7.50	71.0	82.9	12.2
RMLT-21-303	36.77	1.49	37.09	5.59	7.75	66.7	83.5	13.5
RMLT-21-304	34.37	1.61	34.50	7.30	17.95	68.2	85.2	14.9
RMLT-21-305	35.40	1.31	34.78	7.58	18.20	70.1	82.9	10.9
RMLT-21-306	34.00	1.32	33.66	8.66	18.59	70.5	83.9	11.8
RMLT-21-307	36.00	1.23	33.21	8.44	18.36	65.3	82.5	13.2
RMLT-21-308	33.30	1.32	32.97	8.43	18.89	71.7	86.8	16.9
RMLT-21-309	32.83	1.57	38.66	8.40	18.38	72.9	72.3	10.2
RMLT-21-310	35.43	1.19	31.62	8.32	18.86	68.5	84.6	18.5
RMLT-21-311	34.10	1.37	35.04	8.85	18.81	68.2	83.2	12.6
RMLT-21-312	35.30	1.29	34.15	17.15	20.60	67.3	84.4	13.5
RMLT-21-313	36.10	1.34	36.28	8.70	18.27	66.5	83.7	14.6
RMLT-21-314	33.63	1.47	37.08	8.14	18.17	68.4	82.6	11.3
RMLT-21-315	36.23	1.40	38.04	8.97	18.48	68.6	82.8	10.9
RMLT-21-316	34.73	1.36	35.42	8.34	18.83	70.3	83.4	12.5
RMLT-21-317	37.10	1.33	37.01	8.39	18.30	69.5	83.6	14.9
RMLT-21-401	35.13	0.57	40.68	5.90	7.15	78.0	89.7	18.5
RMLT-21-402	34.70	0.85	40.60	5.66	7.58	80.3	92.1	19.4
RMLT-21-403	33.33	1.30	32.50	7.58	10.70	74.7	83.2	11.6
RMLT-21-404	32.93	1.46	36.06	7.85	10.49	80.6	82.8	10.6
RMLT-21-405	35.07	1.32	34.72	5.83	7.57	79.3	85.8	14.6
RMLT-21-406	33.10	1.39	34.51	8.32	10.33	74.0	83.8	12.3
RMLT-21-407	34.10	1.56	39.90	8.00	10.82	78.7	81.5	10.2
RMLT-21-408	35.57	1.48	39.48	8.19	11.03	79.8	81.9	10.6
RMLT-21-501	31.13	0.95	39.35	5.85	8.42	82.5	90.9	17.6
RMLT-21-502	36.07	0.69	38.41	8.88	7.55	83.2	88.5	17.5
RMLT-21-503	34.30	1.42	36.53	8.75	8.03	80.0	84.3	12.6
RMLT-21-504	33.73	1.48	37.44	8.75	8.59	82.9	85.4	14.6
RMLT-21-505	35.40	1.28	33.98	8.74	8.24	82.0	89.2	17.8
RMLT-21-506	34.23	1.38	35.43	8.83	8.26	81.3	82.4	12.3
RMLT-21-601	34.47	1.31	33.87	7.11	8.35	83.4	83.3	14.6
RMLT-21-602	34.73	0.75	39.12	5.71	7.66	87.1	93.7	19.9
RMLT-21-603	33.47	1.40	35.14	7.53	8.48	84.6	86.3	14.5
RMLT-21-604	36.30	1.33	36.21	8.17	8.18	86.4	85.0	16.5
RMLT-21-605	32.80	1.45	35.67	8.12	8.37	88.4	86.9	15.7
RMLT-21-606	36.53	1.40	38.36	15.47	23.25	87.1	85.9	14.2
RMLT-21-607	33.50	1.56	33.20	7.96	8.56	85.5	84.3	13.6
RMLT-21-608	35.33	1.37	36.30	5.94	7.24	85.0	84.9	12.5
RMLT-21-609	33.27	1.28	31.94	8.32	10.78	84.8	86.8	16.7
RMLT-21-610	33.77	1.51	38.24	8.06	10.16	84.8	72.3	14.2
RMLT-21-611	36.77	1.57	33.30	8.02	10.32	84.7	81.9	12.4
RMLT-21-612	35.17	1.25	32.97	8.05	10.29	84.0	79.4	10.7
RMLT-21-613	33.57	1.27	31.98	8.49	10.36	84.0	80.5	11.3
ART-4-21-1	35.57	1.42	37.88	14.33	16.43	88.5	80.7	12.0

ART-4-21-2	33.97	1.40	35.67	15.07	16.52	90.9	81.6	13.6
ART-4-21-3	35.80	1.43	38.40	15.41	17.16	91.2	81.3	12.5
ART-15-21-1	35.20	1.33	35.11	17.58	16.88	90.6	85.3	14.9
ART-15-21-2	33.97	1.43	36.43	15.45	18.62	92.9	85.1	14.6
ART-15-21-3	34.00	1.52	38.76	16.47	16.66	90.4	81.9	11.5
ART-15-K-21-1	36.17	1.80	48.83	15.55	16.55	105.7	89.5	18.6
ART-15-K-21-2	35.47	1.76	46.82	16.38	16.37	115.3	84.4	12.5
TN-1	23.97	1.09	19.60	72.17	35.91	63.0	15.3	8.6
PTB 33	35.17	1.44	37.98	5.21	7.56	96.0	88.2	18.6

Table 5: Biophysical parameters of rice cultures at reproductive stage in Rice Research Station, Ambasamudhram

Rice cultures	Leaf Length (cm)*	Leaf Breadth (cm)*	Leaf Area (cm^2)*	Plant Height (cm)*	Leaf Blade Pubescence	
					Upper Surface	Lower Surface
RMLT-21-101	36.83	1.44	39.78	87.0	94.7	16.3
RMLT-21-102	37.67	1.67	47.18	100.6	119.0	18.9
RMLT-21-103	38.27	1.70	48.79	99.8	118.7	22.0
RMLT-21-104	37.97	1.72	48.98	92.8	102.3	17.6
RMLT-21-105	38.17	1.79	51.24	100.9	119.1	21.3
RMLT-21-106	37.53	1.67	47.01	94.9	98.7	18.7
RMLT-21-107	37.20	1.61	44.92	100.3	101.7	17.4
RMLT-21-108	37.27	1.62	45.28	98.0	102.7	17.8
RMLT-21-109	38.10	1.56	44.58	103.1	116.8	22.3
RMLT-21-110	37.37	1.68	47.09	103.0	95.8	19.7
RMLT-21-111	38.73	1.86	54.03	99.9	97.0	16.1
RMLT-21-112	37.20	1.67	46.59	97.0	97.9	15.9
RMLT-21-113	38.00	1.48	42.18	96.4	96.8	18.6
RMLT-21-114	37.20	1.74	48.55	97.9	92.1	19.9
RMLT-21-115	35.70	1.75	46.86	97.3	110.0	18.7
RMLT-21-201	36.53	1.61	44.11	99.8	101.9	14.6
RMLT-21-202	37.90	1.63	46.33	100.8	97.5	14.4
RMLT-21-203	37.63	1.68	47.41	100.7	98.7	18.7
RMLT-21-204	36.00	1.60	43.20	98.4	98.5	21.8
RMLT-21-205	33.33	1.45	36.25	98.9	99.4	20.4
RMLT-21-206	36.33	1.62	44.14	104.2	101.1	21.4
RMLT-21-207	36.83	1.50	41.43	105.9	120.0	20.5
RMLT-21-208	38.53	1.44	41.61	99.1	93.3	19.6
RMLT-21-209	36.17	1.48	40.15	103.5	96.0	18.3
RMLT-21-210	36.03	1.51	40.80	100.6	97.7	21.0
RMLT-21-211	35.07	1.47	38.66	97.5	98.8	17.8
RMLT-21-212	36.60	1.57	43.10	103.8	133.4	23.5
RMLT-21-213	39.27	1.51	44.47	96.5	95.9	16.5
RMLT-21-214	37.27	1.44	40.25	96.7	110.4	19.9
RMLT-21-215	36.33	1.42	38.69	98.5	98.3	18.7
RMLT-21-301	38.70	1.58	45.86	98.9	90.0	15.9
RMLT-21-302	38.03	1.59	45.35	100.6	96.0	16.5
RMLT-21-303	40.17	1.60	48.20	97.8	97.5	17.6
RMLT-21-304	37.40	1.73	48.53	99.3	93.2	18.0
RMLT-21-305	38.60	1.46	42.27	101.4	98.9	15.6
RMLT-21-306	36.30	1.47	40.02	99.2	102.1	15.9
RMLT-21-307	38.60	1.40	40.53	93.1	101.0	17.3
RMLT-21-308	36.43	1.49	40.71	100.1	100.2	21.0
RMLT-21-309	36.17	1.67	45.30	103.7	93.4	15.3
RMLT-21-310	38.67	1.39	40.31	97.5	90.3	22.6
RMLT-21-311	37.40	1.50	42.08	99.7	96.7	16.7
RMLT-21-312	38.30	1.44	41.36	97.9	94.4	17.6
RMLT-21-313	38.57	1.48	42.81	97.2	96.3	18.7
RMLT-21-314	37.03	1.63	45.27	98.9	97.8	15.4
RMLT-21-315	39.23	1.58	46.49	98.2	91.8	11.0
RMLT-21-316	38.03	1.50	42.78	100.8	94.8	16.6
RMLT-21-317	40.53	1.43	43.47	99.5	95.6	18.0
RMLT-21-401	37.87	1.66	47.15	103.8	96.9	22.6
RMLT-21-402	37.23	1.70	47.47	102.5	115.0	23.5
RMLT-21-403	37.83	1.57	44.54	100.2	95.6	15.6
RMLT-21-404	35.83	1.53	41.11	98.2	102.3	14.7
RMLT-21-405	38.50	1.50	43.31	102.5	104.2	18.7
RMLT-21-406	35.73	1.58	42.34	100.7	98.7	16.4

RMLT-21-407	37.63	1.70	47.98	105.2	99.1	15.8
RMLT-21-408	38.63	1.65	47.80	106.1	97.8	15.7
RMLT-21-501	34.10	1.44	36.83	107.6	116.3	21.6
RMLT-21-502	39.07	1.52	44.54	102.4	109.5	22.5
RMLT-21-503	36.93	1.59	44.04	99.9	93.8	16.7
RMLT-21-504	37.23	1.68	46.91	100.5	99.1	18.6
RMLT-21-505	38.50	1.48	42.74	99.8	118.2	21.3
RMLT-21-506	37.87	1.51	42.89	99.2	98.4	16.9
RMLT-21-601	37.53	1.50	42.22	106.3	99.3	18.9
RMLT-21-602	37.63	1.47	41.49	106.3	119.8	23.4
RMLT-21-603	36.33	1.53	41.69	103.4	102.9	18.9
RMLT-21-604	36.20	1.47	39.91	104.7	102.7	21.1
RMLT-21-605	35.80	1.51	40.54	104.5	109.6	19.8
RMLT-21-606	39.73	1.48	44.10	102.2	116.3	18.3
RMLT-21-607	36.77	1.70	46.88	103.0	99.6	17.7
RMLT-21-608	38.53	1.48	42.77	104.6	101.2	16.3
RMLT-21-609	36.17	1.43	38.79	104.0	97.1	21.4
RMLT-21-610	37.03	1.68	46.66	105.0	92.1	18.3
RMLT-21-611	39.97	1.73	51.86	106.1	97.8	16.5
RMLT-21-612	37.97	1.35	38.44	105.7	93.4	14.8
RMLT-21-613	36.63	1.39	38.19	105.5	96.6	16.8
ART-4-21-1	38.50	1.54	44.47	114.0	97.7	16.4
ART-4-21-2	37.33	1.55	43.40	120.7	98.8	17.8
ART-4-21-3	38.77	1.55	45.07	122.8	98.8	16.4
ART-15-21-1	38.70	1.44	41.80	122.7	100.2	18.0
ART-15-21-2	36.87	1.59	43.97	123.8	102.3	18.7
ART-15-21-3	37.17	1.70	47.39	120.0	103.1	15.9
ART-15-K-21-1	39.33	1.92	56.64	135.9	105.2	22.7
ART-15-K-21-2	39.03	1.98	57.96	139.3	98.6	16.6
TN-1	26.80	1.24	24.92	83.4	29.1	12.5
PTB 33	38.73	1.64	47.64	117.4	97.2	22.7

The number of trichomes/cm^2 was maximum on the upper surface of leaf blade than the lower surface. It ranged from 87.9 to 93.7 on the upper surface and 17.2 to 19.9 leaf on the lower surface in the highly resistant cultures and were categorized as pubescent (scale 3). The highly susceptible entry was found to have minimum number of trichomes i.e., 15.3/ cm^2/ leaf on the upper surface and 8.6/ cm^2/ leaf on the lower surface of leaf blade and categorized as glabrous (scale 1). Trichomes operate as a physical barrier to stem borer, leaf folder, and plant hoppers, according to Ananthakrishnan *et al.*, (2001) [1].

Correlations of morphological parameters *viz.*, trichome density, plant height, leaf length and leaf breadth with stem borer resistance were examined at 45 and 75 DAT and the results are given in Table 5 & 6. The results revealed that trichome density in the abaxial and adaxial surface showed negative but significant correlation with yellow stem borer damage at vegetative stage (r = - 0.788, r = - 0.355) and at reproductive stage (r = - 0.761, r = - 0.374). Rakesh *et al.*, (2021) [14] have correlated the trichome density with stem borer infestation and reported that the trichome density was significant and negatively correlated i.e., r = -0.725 and r = -0.816 at vegetative and reproductive stage, respectively. In the present study, the entry RMLT-21-602` has recorded the highest trichome density of 93.7/ cm^2/ leaf and 19.9/ cm^2/ leaf respectively on the upper and lower surface of leaves.

Plant height showed significantly negative correlation with stem borer damage *viz.*, at vegetative stage (r = - 0.199) and at reproductive stage (r = -0.278) which was in accordance with Ntanos and Koutroubas (2000) [12] who reported that *S. incertulas* infestation was significantly negatively correlated (r = -0.093) with plant height and stem diameter (r = -0.299). Leaf length was significantly negatively correlated with yellow stem borer damage *viz.*, vegetative stage (r = - 0.541) and at reproductive stage (r = - 0.309). Islam and Karim (1997) [8] suggested plant characters like plant height, productive tiller numbers, leaf length (r = 0.970) and leaf area and leaf thickness have significant effects on the food searching capability of rice leaf folder. Punithavalli *et al.*, (2013) [13] have reported that the leaf length was negative and significantly correlated (r = - 0.53) with the leaf folder incidence. Leaf breadth was significant and positively correlated with yellow stem borer damage *viz.*, at vegetative stage (r = 0.794) and at reproductive stage (r = 0.697). Punithavalli *et al.*, (2013) [13] revealed leaf width and total productive tillers were shown to have a positive association (r = 0.30) with leaf folder (*Cnaphalocrocis medinalis*) and it shall be inferred from the present findings that, if the breadth of the leaf is more there may be every possibility of more egg laying by the adult female and it is preferable to have less leaf breadth to develop resistant varieties against stem borer.

Table 6: Correlation of biophysical parameters and stem borer damage percentage at vegetative stage

Morphological parameters	Correlation Co-efficient (r)
Trichome density (Upper surface)	-0.788**
Trichome density (Lower surface)	-0.355**
Plant height	-0.199**
Leaf length	-0.541**
Leaf breadth	0.794**

** Significant at 1%

Table 7: Correlation of biophysical parameters and stem borer damage percentage at reproductive stage

Morphological parameters	Correlation Co-efficient (r)
Trichome Density (Upper surface)	-0.761**
Trichome Density (Lower surface)	-0.374**
Plant height	-0.278**

Leaf length	-0.598**
Leaf breadth	0.697**

** Significant at 1 %

Conclusion

The rice cultures with high amount of trichomes density on the upper and lower surface along with low leaf angle with reduced leaf breadth conferred resistance to the yellow stem borer with low incidence of dead heart and white ear.

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