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Evaluation of Rice Genotypes for Resistance to Yellow Stem borer, *Scirpophaga incertulas* (Walker) through Artificial Screening Methods

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Abstract
Rice yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) is one of the important internal insect pest causing serious damage to rice growing areas recently. Limited resistant sources are available for this borer insect to develop resistant varieties. The present investigation focused on the evaluation of a diverse collection of germplasm materials for resistance to YSB damage. Artificial screening methodology was adopted for a set of 44 genotypes by two methods, no choice method to assess the damage and choice method to assess the non preference for oviposition and dead heart (DH) damage. In the choice method, the DH per cent ranged from 28.00 to 92.00 recorded in TKM 6 and TN 1 respectively. In no choice method, the number of egg mass ranged from 1.0 to 4.75/plant. Minimum number of egg mass per plant was recorded on four genotypes *viz.,* TKM 6, RG 146, RG 74 and RG 50. Maximum number of egg mass was recorded on two genotypes *viz.,* IR 36 and Sahbhagi Dhan. The dead heart damage ranged from 50.00 to 95.83 per cent in RG 74 and TN 1 respectively under no choice method. Four genotypes *viz.,* RG 53, RG 74, RG 148 and TPS 5 were moderately resistant in both methods of screening. Among them RG 53 and RG 74 also recorded with least preference for oviposition.

Keywords: Rice, yellow stem borer, germplasm, artificial screening

1. Introduction

Increasing the productivity and reducing the yield loss due to pest and disease attack are the vital choices for crop breeders to meet the global rice demand. The yield potential of modern rice varieties cannot be fully realized when they succumb to biotic stresses. It is estimated that the biotic factors alone can cause yield loss of up to 25 per cent annually. Insect pests are one of the major limiting factors of which, yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) leads to yield loss of 3 to 95 per cent in different areas of India. YSB is a chronic, monophagous pest of rice and the incidence varies between fields, locations, seasons and period [1]. YSB attack rice crop from seedling to grain filling stage. Damage caused by stem borer differs depending on the growth stages of the plant [2]. Caterpillars tend to destroy the stems through boring the leaf sheaths at the nodal region, leading to a destructive effect on the terminal shoots are manifested through the damage symptom known as "dead heart" [3]. Dead heart symptom is characterized by whitish or discolored area at feeding site of the leaf blade and finally the stem turns brown, wilts and dry. A high dead heart density during the post transplanting is more detrimental because a single larva can damage up to three tillers [4].

Several cultural practices combined with the application of systemic insecticides at the susceptible stage are adopted by the farmers when ETL (10% dead heart) is crossed. Growing resistance variety is an excellent alternative to other management tactics. Identification of resistant or moderately resistant varieties for stem borer damage is prime step to forward in the direction. A rigorous advancement to identify the resistant source is to develop a robust screening system that ensures uniform pest load on the test material. Screen house screening and field screening are the methods widely adopted for screening of YSB. The main drawback of field screening is the occurrence, abundance of the insect pest and pest complexity. Screen house screening ensures that pest load is disseminated evenly and the genotype is devoid of other pest and diseases. Field collected moths have to be used in artificial screening techniques since mass culturing of YSB is difficult. Investigations that pertain to field resistance of genotypes has been reported by several authors [5, 6, 7]. Several studies have been carried out earlier for morphological, physiological and biochemical factors associated with resistance, each controlled by different sets of genes [8]. Identification of varietal resistance has been in progress for the past three decades. Many cultivars are susceptible to YSB, very high levels of resistance have not been found yet and there is the continuous variation for this trait among rice varieties, from highly susceptible to moderately resistant. Even moderate resistance is desirable for breeding resistance varieties. Hence, the present study was taken up to screen rice genotypes under two different methods of artificial screening against yellow stem borer resistance

2. Materials and methods

2.1. Plant materials

A set of 44 diverse genotypes that comprises of released varieties, hybrids and selected genotypes from germplasm collection were screened for yellow stem borer resistance under artificial screening methods. The experimental set up was carried at the Entomology glass house, Department of Rice, Tamil Nadu Agricultural University, Coimbatore, India.

2.2. Artificial screening methods

2.2.1. No Choice method

Freshly collected moths were reared in oviposition cages planted with susceptible variety Taichung Native-1 (TN 1). The adult moths lay the egg mass at 1/3 away from the leaf tip or at the base of stem. The egg masses were collected on 4th day and placed in Petriplates lined with moist filter paper. The freshly emerged larvae were released carefully using camel hair brush on 25-30 day old plants which were trimmed to five tillers per plant for infestation. The larva at the rate of 2 per tiller (10 per plant) was released at the base of leaf near the auricle region [9]. The seedling was covered with mylar cage to avoid infestation by other pest and disease and escape of released larvae. The symptom for dead heart was observed after 11-14 days after release of larva. The stem with dead heart was observed for feeding symptom of larva. The damage scale was calculated by comparing with the susceptible check TN 1. Five replications were maintained for each genotype.

2.2.2. Free choice method

A set of potted plants of different genotypes along with TN 1 plants were placed in a cage of size 2’ x 2’ x 2.5’ to accommodate 12 potted plants. Fresh adult moths emerged from pupa were released on 35-40 days old seedlings @ one pair per plant and allowed for oviposition. The moths have free choice to select the genotypes for oviposition. Two replications were maintained for each genotype. The number of egg masses on the seedlings was counted. The first instar larvae were allowed to feed on the tillers till the appearance of dead heart symptom. The damage symptom was counted on 14 -18 days after oviposition and per cent dead heart damage was worked out.

The percentage of dead heart was computed for each genotype using the formula

$$\text{Percent of dead hearts} = \frac{\text{No. of dead hearts}}{\text{Total no. of tillers}} \times 100$$

D values were calculated using the formula

$$D = \frac{\text{Percent dead hearts in test genotype}}{\text{Percent dead hearts in susceptible check}} \times 100$$

The rating scale 0 -9 was fixed based on the D values as suggested [9].

Damage (%)	Scale	Category of resistance
0	0	Highly Resistant (HR)
1-10	1	Resistant (R)
11-20	3	Moderately Resistant (MR)
21-30	5	Moderately Susceptible (MS)
31-60	7	Susceptible (S)
61 & above	9	Highly Susceptible (HS)

2.3. Statistical analysis

The data collected were subjected to statistical scrutiny through Completely Randomized Design (CRD) using analysis of variance (ANOVA) through IRRISTAT statistical software.

3. Results and Discussion

There was a significant difference in the stem borer damage through artificial screening methods among the rice genotypes. In the no choice method, the percentage of dead heart damage varied from 28.00 to 92.00 in TKM 6 and TN 1 respectively (Table 1). Two genotypes *viz.*, TKM 6 and W 1263 recorded minimum damage of 28.00 per cent and 32.00 per cent respectively and the data were statistically on par with other. Both are categorized as resistant based on SES scoring system. A set of 13 genotypes were grouped under moderately resistant category with the damage ranging from 44.33 to 58.55. Among them, two genotypes *viz.*, RG 148 and RG 53 were recorded with less damage of 44.3 and 45.00 per cent dead heart respectively. The genotype RG 148 is a land race of Tamil Nadu. PTB 33 which is usually included as a resistant check for hopper screening programmes confers the moderate level of resistance to yellow stem borer in the present study. Among the two hybrids screened in this method, rice hybrid CO 4 (CORH 4) recorded with a damage of48.95 per cent and grouped in the moderately resistant category. Similar result was observed for hybrid TNRH 206 with moderate resistance [6].

Table 1: Artificial screening of rice genotypes against yellow stem borer (No Choice Method)

S. No.	Genotypes	Dead heart* (%)	Score	Category of resistance
1	TKM 6	28.00 (31.63)	3	R
2	W 1263	32.00 (34.16)	3	R
3	PTB 33	46.00 (42.41)	5	MR
4	CO 43	72.00 (58.37)	7	MS
5	TN 1	92.00 (79.26)	9	HS
6	IR36	76.00 (63.64)	9	HS
7	ADT 43	68.00 (56.03)	7	MS
8	ASD 16	70.86 (57.70)	7	MS
9	Sahbhagi Dhan	78.00 (62.40)	9	HS
10	ADT 37	60.00 (51.22)	7	MS

11	IR 50	62.60 (52.45)	7	MS
12	MDU 5	71.70 (58.07)	7	MS
13	ADT 45	55.33 (48.10)	7	MS
14	RG 148	44.30 (41.61)	5	MR
15	RG 107	52.29 (46.35)	5	MR
16	RG 137	71.75 (56.39)	7	MS
17	RG 85	55.08 (48.08)	5	MR
18	RG 77	49.66 (44.83)	5	MR
19	CO(R) 51	73.57 (59.68)	7	MS
20	RG 146	58.55 (49.96)	7	MS
21	RG 74	54.58 (47.64)	5	MR
22	Anna(R) 4	56.09 (48.71)	5	MR
23	IR 64	68.00 (56.03)	7	MS
24	Hinohikari	60.00 (50.99)	7	MS
25	ADT 36	63.43 (52.97)	7	MS
26	CO 47	62.36 (52.24)	7	MS
27	RG166	75.00 (62.95)	9	HS
28	RG 188	75.33 (63.28)	9	HS
29	RG 53	45.00 (42.00)	5	MR
30	Jaya	68.00 (55.83)	7	MS
31	GEB 24	69.65 (56.78)	7	MS
32	Sampada	75.33 (63.28)	9	HS
33	TRY 3	53.33 (46.94)	5	MR
34	TPS 5	54.67 (47.74)	5	MR
35	Swarna *Sub1*	65.33 (54.09)	7	MS
36	CO(R) 52	66.66 (54.89)	7	MS
37	CO 49	76.68 (61.39)	9	HS
38	ADT 46	73.33 (59.16)	7	MS
39	CORH 4	48.95 (44.36)	7	MS
40	RG 7	68.13 (55.66)	7	MS
41	Pusa Basmati 1	86.83 (70.87)	9	HS
42	CORH 3	71.43 (57.99)	7	MS
43	RG 50	79.67 (63.74)	9	HS
44	RG 178	76.00 (60.77)	9	HS
	SEd	5.50	-	-
	CD (0.05)	10.86	-	-

*values in parenthesis are arc sine transformation

Ovipositional preference is one among the antixenosis mechanism in host plant resistance. This may be due to the presence of volatile compounds that emanate from the leaf or other parts of the plant. In the choice method of artificial screening, oviposition on different genotypes showed significant variation. The number of egg mass on different germplasm ranged from 1.0 to 4.75 per plant (Table 2). All the genotypes used in the study exhibited preference for oviposition by the YSB adults. Ten genotypes *viz.*, TKM 6, RG 146, RG 74, RG 50, RG 137, CO 47, RG 53, Sampada, TNAU rice hybrid CO 4, CORH 3 recorded with minimum number of egg masses ranged from 1.0 - 1.5/plant and the data were statistically on par with each other. Four genotypes *viz.*, TKM 6, RG 146, RG 74 and RG 50 recorded only one egg mass per plant. Similar results on non-preference to oviposition were observed in a coarse grain variety Shua-92 [10]. Moreover, at a high population density (200 moths/20 plants) TKM 6 was the least preferred and Jaya the most preferred [11]. TKM 6 was also reported to have a biochemical resistance factor, oryzanone against *Chilo suppressalis* that inhibits oviposition and disturbs the insect's growth and development [12]. In the present study, eggs laid by adult moths were allowed to hatch on the same genotype in the free choice method. The dead heart count was recorded 14-18 days after release of moths and per cent dead heart ranged from 50 to 95.83. None of the genotypes were resistant, only four genotypes were moderately resistant *viz.*, RG 74 (50.00%), RG 148 (50.85%), RG 53 (53.57%) and TPS 5 (59.29%).

It is well-known fact that the degree of susceptibility and nutritional suitability of the host plant play a dominant role in varietal resistance [13]. Based on two *in vitro* screening methods in the present study, it is apparent that varying level of resistance exists between the genotypes and within two screening methods (Table 3). The reported resistant varieties *viz.*, TKM 6 and W 1263 recorded 28.0 and 32.0 per cent dead heart respectively in no choice method, whereas 64.33 and 74.18 per cent respectively in the free choice method. In no choice method of screening, only minimum larva were released whereas in free choice method all emerged larvae from the egg mass were allowed to bore the rice stems. The pest load is more in the second method and hence the two designated stem borer resistant varieties exhibits more dead heart in the free choice screening method. TKM 6 is well known old stem borer resistant donor and was released during 1952. The mechanisms of resistance were attributed to a comparatively broad and thick sclerenchymatous hypodermis in the stem to the narrow central lumen in the culm, narrow and hairy leaves [14, 15]. TKM 6 is less susceptible at both vegetative and heading stages against yellow stem borer [16]. The variety is known for their field resistance [17] however, in the present artificial screening it is recorded with considerable dead heart damage. The reduction in the level of resistance may also due to detoriation of varietal character over the years.

Two genotypes RG 53 and RG 74 were moderately resistant in the no choice method with very less preference for oviposition with the dead heart damage of 53.57 and 50.00 per cent in the choice method. Among the two hybrids taken in the study, CORH 4, a bold grain type was moderately resistant with less ovipositional preference. The hybrid CORH

3, a fine grain type exhibited less ovipositional preference but was categorized as moderately susceptible in both methods. Likewise, the genotypes RG 148 and TPS 5 were moderately resistant under both the methods, the genotype RG 146 exhibited moderate resistance in the no choice method with less ovipositional preference. The two aromatic genotypes *viz.*, Pusa Basmati 1 and GEB 24 were grouped in the highly susceptible and moderately susceptible respectively. Similar findings were reported wherein the aromatic types were highly susceptible to the yellow stem borer compared to the coarse varieties [18, 19].

Among the two methods of screening, the choice method of screening requires more attention, since the maintenance of egg mass in the controlled condition and immediate release of hatched larvae without starvation is a prime concern in spite of uniform distribution of pest load. While, the choice method allows for intense pest load where a single egg mass can hatch approximately 15 to 35 larvae. Hence none of the genotypes were resistant in the choice method of screening due to the intense larval population. Hence, the choice method proves to be more vigorous and less laborious. The genotypes proved in this method as moderate resistance will have a definite and considerable level of resistance. Several mechanisms of resistance like intact leaf sheath, interval vascular bundles and larger width of the leaf sheath ridge have been investigated [20, 21]. The tolerance mechanisms investigated include increased tillering, increased percentage of productive tillers, increased grain weight and translocation of assimilates from stem borer-injured tillers to healthy tillers [22]. Hence several complex mechanisms of resistance and tolerance or both phenomenon has to be explored in detail for selection of desirable donors for yellow stem borer resistance in rice.

Table 2: Artificial screening of rice genotypes against yellow stem borer (Free choice Method)

S. No.	Genotypes	Mean no. of egg mass/plant	Dead heart* (%)
1	TKM 6	1.00	68.33 (55.76)
2	W 1263	2.00	74.18 (59.49)
3	PTB 33	3.25	74.24 (59.75)
4	CO 43	2.00	87.31 (69.24)
5	TN 1	2.75	95.83 (81.46)
6	IR36	4.75	75.00 (60.32)
7	ADT 43	3.00	81.36 (65.04)
8	ASD 16	2.50	70.83 (57.37)
9	Sahbhagi Dhan	4.75	78.75 (63.04)
10	ADT 37	2.00	84.52 (66.84)
11	IR 50	2.00	90.83 (72.39)
12	MDU 5	4.25	77.08 (62.01)
13	ADT 45	3.50	60.61 (51.17)
14	RG 148	4.00	50.85 (45.49)
15	RG 107	2.50	67.50 (55.38)
16	RG 137	1.50	71.25 (57.83)
17	RG 85	2.00	74.11 (60.01)
18	RG 77	2.25	62.50 (52.26)
19	CO(R) 51	2.50	68.75 (56.12)
20	RG 146	1.00	66.48 (54.68)
21	RG 74	1.00	50.00 (45.00)
22	Anna(R) 4	2.00	70.00 (57.10)
23	IR 64	4.00	80.11 (58.52)
24	Hinohikari	3.50	62.50 (52.50)
25	ADT 36	2.63	70.83 (57.37)
26	CO 47	1.50	60.32 (51.38)
27	RG166	2.50	75.28 (60.38)
28	RG 188	2.25	72.12 (58.15)
29	RG 53	1.50	53.57 (47.04)
30	Jaya	2.88	87.50 (74.85)
31	GEB 24	2.00	85.42 (67.60)
32	Sampada	1.50	69.66 (56.77)
33	TRY 3	2.50	76.39 (60.94)
34	TPS 5	2.50	59.29 (50.82)
35	Swarna *Sub1*	3.13	77.78 (61.87)
36	CO(R) 52	2.00	76.36 60.97)
37	CO 49	2.00	78.89 (62.65)
38	ADT 46	2.00	62.50 (52.24)
39	CORH 4	1.50	77.78 (62.63)
40	RG 7	2.00	90.00 (71.57)
41	Pusa Basmati 1	2.00	90.00 (71.57)
42	CORH 3	1.50	70.00 (56.79)
43	RG 50	1.00	64.62 (53.54)
44	RG 178	2.00	75.00 (60.11)
	S.Ed	0.48	7.43
	CD (0.05)	0.97	14.99

*values in parenthesis are arc sine transformation

Table 3: List of promising genotypes identified through artificial screening

Screening method	Reaction to YSB	Damage	Genotypes
No choice method	Resistant	28.00- 32.00 (dead heart %)	TKM 6, W 1263
	Moderately Resistant	44.33-58.55 (dead heart %)	RG 148, RG 53, PTB 33, CORH 4, RG 77, RG 107, TRY 3, RG 74, TPS 5, RG 85, ADT 45, Anna 4, RG 146
Free choice method	Non preference for oviposition	1.0-1.5 (egg mass/plant)	TKM 6, RG 146, RG 74, RG 50, RG 137, CO 47, RG 53, Sampada, CORH 4, CORH 3
	Moderately Resistant	50.00-59.29 (dead heart %)	RG 74, RG 148, RG 53, TPS 5

4. Conclusion

Identification and evaluation of stem borer resistance is a primary task for the development of resistant varieties. Though controlled screening methods for stem borer resistance is time consuming and laborious, artificial screening provides solid and valid information on varietal resistance. Under free choice method more larval population were allowed to feed on the rice varieties and even the designated resistant varieties TKM 6 and W 1263 had more than 60 per cent dead heart damage in the present study. The genotypes RG 53, RG 74, RG 148 and TPS 5 were moderately resistant in both method of screening, of which RG 53 and RG 74 also recorded the least preference for oviposition by adult moths. Multiple crosses among these genotypes could provide resistant segregants, further selection can be made for resistant varieties or donors for yellow stem borer resistance.

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