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Genetic evaluation for resistance to rice white backed planthopper *Sogatella furcifera* (Horvath) in brown planthopper resistant rice varieties

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Abstract : Of 15 planthopper resistant varieties evaluated for resistance to *Sogatella furcifera,* nine had high levels of resistance. Among the IR varieties, IR 36 and IR 56 had field resistance to *S.furcifera* as indicated by their susceptibility in the standard seedbox test and resistance as older plants in the modified seedbox test. Insect growth and development, food intake, longevity and egg hatchability differed significantly among varieties of the same age and at different plant ages within the same variety. Population increase on resistant varieties was low at the two plant ages tested. ***(Key words :** Whitebacked planthopper, Sogatella furcifera; Mechanisms of resistance, Plant resistance to insects)*

The whitebacked planthopper, *Sogatella furcifera* (Horvath) has emerged as a serious pest of rice in many Asian countries. Serious outbreaks of the pest have been reported in Bangladesh, China, Nepal, Pakistan, Taiwan, Vietnam and India (Alam and Alam, 1988; Mochida *et. al.,* 1982; Gyawali, 1983; Khush, 1984). In India, serious outbreaks of *S.furcifera* and subsequent yield reduction have been reported from Madhya Pradesh, Haryana, Punjab, Uttar Pradesh, Orissa, West Bengal, Andhra Pradesh and Tamil Nadu (Kuswaha and Kapoor, 1986). The increased incidence of *S.furcifera* is attributed to genetic vulnerability of brown planthopper, *Nilaparvata lugens (Stal)* resistant varieties which are grown extensively in many Asian countries (Heinrichs and Rapusas, 1983).

Using the seedbox screening test, nearly 400 accessions of *Oryza sativa* with resistance to *S.furcifera* have been identified at the International Rice Research Institute, Philippines, through the evaluation of more than 53,000 accessions (Heinrichs *et. al., 1985).* Genetic analysis of resistant cultivars indicated four dominant genes designated as Wbph 1, Wbph 2, Wbph 3 and Wbph 5 and one recessive gene Wbph 4. Four genes have been incorporated into improved breeding lines (Khush, 1984; Wu and Khush, 1985).

Although Heinrichs and Rapusas (1983) observed high populations of *S.fucifera* on rice varieties with genetic resistance to brown planthopper, preliminary studies indicated high levels of resistance to *S. furcifera* among rice varieties with diverse genes for brown planthopper resistance. In the present study conducted at the Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore during 1994, 15 brown planthopper resistant varieties were evaluated for resistance to the local population of *S.furcifera* at two different plant ages with a view to identify those which might serve as donor sources in the breeding programmes.

Materials and Methods

S. furcifera adults collected from the rice fields at the Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore were reared on 30 to 40 day old potted plants of the susceptible rice variety TN 1 for one generation prior to the tests and used as a source of test insects. All the tests were conducted at $27\pm2^{\circ}C$, $70\pm$ 10% R.H. and a 12 h photoperiod. The experiments were conducted during 1995-1996. The varieties tested for possible whitebacked planthopper resistance were: BPH resistant IR 747-B2-6, IR 26, Mudgo, and IR 64 (BPh1 gene), Ptb 18 and IR 36 (bph2 gene), Rathu Heenati, IR 56 and IR 62 (Bph3 gene), Babawee and Gambada Samba (bph 4 gene), ARC 10550 (bph5 gene), Swarnalata (bph6 gene), Ptb 21 and Ptb33 (bph2 + Bph3 genes) and the susceptible check TN 1 (no gene).

Seedling Bulk Test

Eighteen BPH resistant rice varieties were evaluated for their resistance to *S.furcifera* using the Standard Seedbox Screening Test (SSST) and Modified Seedbox Screening Test (MSST). The tests were conducted in a split plot design with screening methods as the main plot treatments and varieties as the sub-plot treatments. Treatments were replicated five times.

Standard Seedbox Screening Test (SSST)

Seeds of 15 BPH resistant varieties together with TN 1 as susceptible check were sown in rows in seedboxes measuring 60 x 40 x 10 cm. Seven days after sowing (DAS), seedlings were thinned to 15 per row and infested with eight second instar *S.furcifera* nymphs per plant. When all TN 1 seedlings were dead, plants were rated for damage based on 0 to 9 scale where 0-3 is classified as resistant and 7-9 as susceptible.

Modified Seedbox Screening Test (MSST)

Seed was sown and seedling thinned as described for SSST. Twenty days after sowing, the plants were infested with four second instar nymphs per plant and damage ratings were recorded at 25 days after infestation (DT) when the susceptible check was killed. In the SSST, the initial infestation killed the susceptible plants while in MSST, the progeny of initially infested insects killed the susceptible plants.

Quality of food ingested and metabolic utilisation

Varieties evaluated in the seedbox screening test were further used to determine nature of resistance at two plant ages: 15 and 45 days after sowing (DAS). Seeds of BPH residant varieties and TN1 were sown in seedboxes at fortnightly interval in order to have test plants of two ages at the same time. One week after sowing, five seedlings of each variety were transplanted into each of five clay pots (12 cm diameter), each pot serving as a replicate. When the plants reached the desired ages (15 and 45 DAS), they were arranged in a split plot design with varieties as main plots and plant ages as sub-plots. To determine the quantity of food ingested and assimilated, newly emerged 2-h-starved but water satiated brachypterous females were used. Females were weighed individually on a microbalance (Metler ME 30; 1µg sensitivity) before infestation to determine their initial weight (WI) and again a 24h after infestation for their respective final weights (W2). Each test insect was placed within a parafilm sachet on the stem of a 30-day-old test plant as described by Pathak *et. al.* (1982). Likewise control insects were individually weighed before infestation to determine their initial weights (C1) and 24h after starvation inside a parafilm sachet containing water soaked cotton for their final weights (C2). The amount of food assimilated was calculated as follows (Saxena and Pathak, 1977) :

$$\text{Food assimilated} = W_1 x (C1-C2)/C1) + (W2-W1)$$

The sum of the assimilated food and the fresh weight of the excreta or honey dew gave the total weight of the food ingested by the insect. The amount of honeydew excreted was determined by first weighing the parafilm sachet containing the honeydew, then removing the honeydew with blotting paper and reweighing the parafilm sachet (Saxena and Pathak, 1977).

Nymphal growth and development

Growth and development of the nymphs were determined at two plant ages : 15 and 45 DAS. Seeds of test varieties were sown as above. Three 7-day-old seedlings were transplanted into a clay pot (12 cm dia.) with five pots for each variety, each pot serving as a replication. When the plant reached the desired ages (15 and 45 DAS), they were covered with mylar film cages (10 cm diameter and 90 cm high) arranged in a split plot design. Plants in each cage were infested with 10 first instar nymphs. Insect growth was measured in terms of the number of nymphs that become adults and the time taken to reach the adult stage. A growth index was calculated as the rate of percentage of nymphs becoming adults to the mean growth period in days (Khan and Saxena, 1985).

Adult longevity

Plants were grown in the same manner and test varieties and experimental design were the same as in the nymphal growth and developmental test. When the plants reached the desired ages (15 and 45 DAS), they were covered with mylar film cages (10 cm dia and 90 cm height) and infested with 10 pairs of newly emerged males and brachypterous females per plot. Survival of males and females was recorded daily upto 25 days after infestation.

Fecundity and egg hatchability

Fecundity and egg hatchability of *S. furcifera* were determined on 15 and 45 day old plants of test varieties. Plants were grown in the same manner and test varieties and experimental design were the same in the nymphal growth and developmental tests. When the plants reached the desired age (15 and 45 DAS), each potted plant was covered with a mylar film cage (10 cm diameter and 90 cm height) and infested with three pairs of newly emerged males and females. Newly emerged nymphs were recorded daily and removed from the cage up to 12 DAI, a period longer than the incubation period of *S.furcifera*. Unhatched eggs were counted by dissecting the leaf sheaths under a 20X binocular microscope.

Population growth

Conditions were same as in nymphal growth and development test. When the plants reached the desired ages (15 and 45 DAS), each potted plant was enclosed in a mylar film cage (10 x 90 cm) and infested with three pairs of newly emerged males and females. First generation progeny were counted 30 DAI.

Results and Discussion

Because of high yield losses from rice pests, incorporation of insect resistance into modern high yielding varieties has been recongnised as a major tactic in the integrated control of rice pests. Many high yielding brown planthopper resistant rice varieties have been extensively cultivated and have contributed to increased rice production in Asia. Although the susceptibility of brown planthopper resistant varieties has been cited as one of the factors for increased severity of this pest, the present study provides evidence that high levels of resistance to *S. furcifera* exist among most of the rice varieties with diverse genes for brown planthopper resistance.

Seedling Bulk Test

There were distinct differences among the brown planthopper resistant varieties both in the SSST and MSST (Table 1). Among the BPH resistant varieties tested, Mudgo and IR 64 (Bph 1 gene), Rathu Heenati and IR 62 (Bph 3 gene), Babawee and Gambada Samba (bph 4 gene), ARC 10550 (bph 5 gene), Swarnalata (bph 6 gene), Ptb 21 and Ptb 33 (bph 2 + Bph 3 genes) were rated as resistant in both screening methods (Table 1). Varieties Ptb 18 and IR 36 (bph 2 gene), IR 56 (Bph 3 gene) which had a susceptible reaction in the SSST as seedlings, were highly resistant as older plants in the MSST (Table 1). The level of resistance in Ptb, 18 IR 56 and IR 62 increased with plant age. Because *S.furcifera* population generally build up in a rice field at about 30-40 days after transplanting, high levels of resistance are not needed in the seedling stage and resistance at 25-30 days after transplanting as identified in the MSST is considered adequate for *S. furcifera* control (Velusamy and Heinrichs, 1986).

Quantity of food ingested and metabolic utilisation

Insect responses such as food intake, growth and development of nymphs, longevity and fecundity of adults, egg hatchability and population increase were adversely affected on highly resistant Mudgo, Rathu Heenati, Gambada Samba, Babawee, ARC 10550, Swarnalata, Ptb 21 and IR 64. Food ingestion and assimilation was minimum in Gambada Samba and Ptb 21, which were statistically on par (Table 2). Similarly, the percentage of nymphs becoming adults was also severely affected in both these varieties as well as in Rathu Heenati and Ptb 33 (Table 3).

Adult longevity

Longevity of males and females differed significantly among the varieties and among plant growth stages within varieties (Table 4). Both males and females survived significantly longer periods on 15 day old plants of IR 747B2-6, IR 26, Ptb18, IR 36, IR 56 and IR 62 similar to the susceptible check TN 1. Adult longevity was significantly shortest on resistant Ptb 21, Gambada Samba, Rathu Heenati and Swanrnalata. Adults survived for longer periods on 45 day old plants of IR 747B2-6, IR 26, Pth18, IR 36, IR 56 and IR 62 but significantly longer than that of susceptible TN 1 plants

Fecundity and egg hatchability

Fecundity and egg hatchability of *S. furcifera* differed significantly on varieties with diverse genes for brown planthopper resistance (Table 5). Fecundity and egg hatchability were significantly higher on susceptible 15 day old plants of IR 747B2-6, IR 26, Ptb18, IR 36, IR 56 and TN 1 and the lowest on resistant Gambada Samba and Ptb 21. These two parameters declined on 45 day old plants of all resistant varieties.

Population Growth

Several brown planthopper resistant varieties adversely affected the population growth of *S.furcifera* at both plant growth stages. On 15 day old IR 747B2-6, Ptb 18, IR 56, plants, significantly more progeny were produced similar to susceptible TN 1 (Table 6). However, population growth was significantly lower on 45 days old plants of Ptb 18, IR 36 and IR 56 than on susceptible IR 747B2-6, IR 26 and TN 1. Brown planthopper resistant varieties Mudgo, Rathu Heenati, Gambada Samba, Swarnalata, Ptb 21 and Ptb 33 had significantly much smaller populations than TN 1 at both plant growth stages.

Other workers have also made similar observations with *S. furcifera* on resistant varieties (Khan and Saxena, 1985). Among the high yielding brown planthopper resistant varieties tested, IR 36, IR 56 and IR 62 had moderate levels of resistance to *S. furcrifera* ; Ptb18 and Ptb33 have been used as broun planbhopper resistant donors in developing IR36 and IR62 and it is likely that they may also have interited genes for resistance to *S.furcrifera* from their parents. IR 36, IR 56, IR 62 and IR 64 are currently grown in many Asian countries and were also identified as having field resistance to *S.furcifera* (Velusamy and Heinrichs, 1986).

The need for developing multiple insect resistant rice varieties is increasingly recognised and there is potential for utilising Rathu Heenati, Gambada Samba and Ptb 21 as donors in developing multiple insect resistant varieties as they also confer resistance to thrips, *Stenchaetothrips biformis* Bagnall, green leafhopper, *Nephotettix virescens* Distant, and brown planthopper *N. lugens*.

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Table 1. Resistance of brown planthopper resistant rice varieties to *S. furcifera* in Standard Seedbox Screening Test (SSST) and Modified Seedbox Screening Test (MSST).

Variety	Genes for resistance to brown planthopper	Plant damage	
		SSST	MSSR
IR 747-B2-6	Bph1	9.0a	9.0a
Mudgo	Bph1	1.8bc	1.0b
Ptb 18	bph 2	9.0a	1.0b
Rathu Heenati	Bph 3	1.0c	1.0b
Gambada Samba	bph 4	1.0c	1.0b
Babawee	bph 4	1.4bc	1.0b
ARC 10550	bph 5	1.8bc	1.0b
Swarnalata	bph 6	1.4bc	1.0b
Ptb 21	bph2+Bph3	1.0c	1.0b
Ptb 33	bph2+Bph3	1.4bc	1.0b
IR 26	Bph1	9.0a	9.0a
IR 36	bph 2	9.0a	1.0b
IR 56	Bph 3	9.0b	1.0b
IR 62	Bph 3	2.2b	1.0b
IR 64	Bph 1	1.4bc	1.0b
TN 1		9.0a	9.0a

In a column, means followed by the same letter are not significantly different at P=0.05; Duncan's multiple range test; mean of five replications.

Table 2. Quality of food ingested and assimilated by *S.furcifera* on brown planthopper resistant rice varieties

Variety	Food ingested per female per 24h (mg)		Food assimilated per female per 24h (mg)	
	15 DAS	45 DAS	15 DAS	45 DAS
IR 747-B2-6	10.13c	8.89a	0.53b	0.51b
Mudgo	3.05e	2.32d	0.23gh	0.16de
Ptb 18	9.76d	5.79b	0.52bc	0.39c
Rathu Heenati	2.42g	1.40f	0.25ef	0.16de
Gambada Samba	1.64h	1.09g	0.15i	0.09i
Babawee	3.02e	2.22de	0.26e	0.18d
ARC 10550	2.27g	2.12de	0.25ef	0.12g
Swarnalata	2.33g	2.18de	0.24efg	0.13ef
Ptb 21	1.81h	1.04g	0.14i	0.08i
Ptb 33	2.35g	2.31d	0.24efg	0.14ef
IR 26	10.46ab	8.85a	0.49cd	0.48b
IR 36	9.77d	5.75bc	0.52bcd	0.38c
IR 56	10.21bc	5.51c	0.49cd	0.38c
IR 62	2.69f	2.00e	0.21h	0.12g
IR 64	2.48fg	2.08de	0.22gh	0.10gh
TN 1	10.50a	8.66a	0.58a	0.54a

In a column, means followed by the same letter are not significantly different at P=0.05; Duncan's multiple range test; mean of five replications.

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Table 3. Growth and development of *S.furcifera* nymphs on brown planthopper resistant rice varieties

Variety	Nymphs becoming adult		Developmental period		Growth Index	
	15 DAS	45 DAS	15 DAS	45 DAS	15 DAS	45 DAS
IR 747-B2-6	92.00ab	96.00a	12.74e	12.62h	7.20ab	7.60a
Mudgo	50.00cde	46.00d	14.46cd	15.06cde	3.46cde	3.00cd
Ptb 18	94.00ab	54.00bc	12.68a	13.96g	7.38ab	3.80b
Rathu Heenati	42.00f	36.00fg	15.30a	16.20b	2.72fg	2.20f
Gambada Samba	30.00g	26.00h	16.36a	16.88a	1.82h	1.50g
Babawee	52.00cd	48.00cd	14.24de	14.92e	3.64cd	3.22c
ARC 10550	44.00ef	42.00def	14.50c	15.28cd	3.16def	2.72cde
Swarnalata	46.00def	38.00efg	14.82b	15.03c	3.10efg	2.44ef
Ptb 21	28.00g	24.00h	16.38a	17.00a	1.70h	1.38g
Ptb 33	40.00f	34.00g	15.26a	16.24b	2.62g	2.06f
IR 26	94.00ab	92.00a	12.66e	12.60h	7.40ab	7.30a
IR 36	96.00a	60.00a	12.54e	14.00fg	7.06ab	4.26b
IR 56	88.00b	60.00b	12.62e	14.22f	6.90b	4.20b
IR 62	54.00c	44.00de	14.04e	14.84e	3.80c	2.96cd
IR 64	44.00ef	38.00efg	14.30cd	15.04de	3.06efg	2.52def
TN 1	96.00a	94.00a	12.70e	12.74h	7.52a	7.34a

In a column, means followed by the same letter are not significantly different at P=0.05: Duncan's multiple range test; mean of five replications.

Table 4. Longevity of *S.furcifera* on brown planthopper resistant rice varieties

Variety	Longevity (Days)			
	Male		Female	
	15 DAS	45 DAS	15 DAS	45 DAS
IR 747-B2-6	15.60ab	13.40a	19.80a	24.60a
Mudgo	6.60de	5.6cd	7.0efg	6.60e
Ptb 18	14.40ab	8.80b	17.4cd	9.60cd
Rathu Heenati	6.40def	6.20cd	6.40fgh	5.40fg
Gambada Samba	6.00ef	5.60cd	5.80hi	5.00g
Babawee	7.00de	6.40c	7.20ef	6.60e
ARC 10550	6.20ef	6.60c	7.80e	6.80e
Swarnalata	6.40def	6.00cd	7.00efg	6.20ef
Ptb 21	5.00f	4.80d	5.40i	5.20fg
Ptb 33	6.00ef	6.00cd	6.00hi	6.40e
IR 26	15.00ab	14.40a	21.20a	22.00b
IR 36	14.00bc	9.00b	19.00b	10.60c
IR 56	12.40c	9.60b	17.00d	9.00d
IR 62	7.50de	7.00c	7.80e	8.80d
IR 64	8.00d	6.60c	6.80fgh	7.20e
TN 1	16.00a	14.00a	19.00b	23.60a

In a column, means followed by the same letter are not significantly different at P=0.05; Duncan's multiple range test; mean of five replications.

Table 5. Fecundity of *S.furcifera* adults and egg hatchability on brown planthopper resistant rice varieties

Variety	Fecundity (Number of eggs laid by 3 females		Hatchability (%)	
	15 DAS	45 DAS	15 DAS	45 DAS
IR 747-B2-6	274.00a	408.00b	94.00	92.20
Mudgo	84.00e	65.00l	38.70	34.60
Ptb 18	279.00a	237.00c	94.40	56.10
Rathu Heenati	71.00f	62.00l	45.00	39.30
Gambada Samba	55.00g	40.00j	36.70	31.70
Babawee	187.00b	166.00e	51.30	39.40
ARC 10550	146.00c	119.00f	42.60	36.70
Swarnalata	91.00e	73.00h	44.80	35.90
Ptb 21	50.00g	42.00j	34.90	30.80
Ptb 33	71.00f	59.00l	39.20	36.00
IR 26	281.00a	400.00b	94.20	93.60
IR 36	285.00a	246.00c	92.40	62.10
IR 56	283.00a	207.00d	94.80	57.50
IR 62	136.00c	116.00f	66.20	45.30
IR 64	100.00d	87.00g	39.80	33.20
TN 1	277.00a	412.00a	92.60	95.30

In a column, means followed by the same letter are not significantly different at P=0.05; Duncan'smultiple range test; mean of five replications.

Table 6. Population increase of *S.furcifera* on brown planthopper resistant rice varieties

Variety	Population increase	
	15 DAS	45 DAS
IR 747-B2-6	262.00a	371.00b
Mudgo	65.00g	41.00l
Ptb 18	260.00a	219.00d
Rathu Heenati	57.00h	48.00k
Gambada Samba	38.00i	32.00m
Babawee	167.00d	148.00f
ARC 10550	122.00e	102.00g
Swarnalata	66.00g	55.00j
Ptb 21	35.00i	30.00m
Ptb 33	55.00h	47.00k
IR 26	257.00bc	374.00b
IR 36	260.00a	226.00c
IR 56	254.00c	168.00e
IR 62	123.00e	87.00h
IR 64	84.00f	68.00i
TN 1	264.00a	380.00a

In a column, means followed by the same letter are not significantly different at P=0.05; Duncan'smultiple range test; mean of five replications.