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TOLERANCE OF DIFFERENT RICE GENOTYPES (*ORYZA SATIVA* L.) AGAINST THE INFESTATION OF RICE STEM BORERS UNDER NATURAL FIELD CONDITIONS

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The present studies report the genotypic responses of 61 rice (*Oryza sativa* L.) genotypes (35 aromatic and 26 non aromatic) against the infestation of rice stem borers under natural field conditions. The data obtained on these genotypes on larval infestation in combination with yield were the criteria to assess the resistance depicted by them. The studies showed that among aromatic genotypes, 'Khushboo-95' gave the best yield of grain and harboured the least pest infestation (2.81% deadhearts and 1.85% whiteheads); on the other hand variety 'Sonahri Sugdasi (P)' harboured the highest borers attack (10.37% and 19.30%) and yielded the lowest grain yield. Regarding non-aromatic genotypes, IR8-2.5-11 received least infestation (1.32% and 0.26% deadhearts and whiteheads, respectively) generating highest yield showing its tolerance to borer's attack, in contrast, genotype IR6-252 harboured the highest infestation (5.65%, 4.28%) and yielded minimum grain indicating its susceptibility. These results demonstrate the expression of resistance gene in the genome of tolerant rice genotypes that can provide season-long protection from the natural infestation of insect pests.

Keywords: Varietal resistance, Rice, Borers infestation, Screening, Tolerance.

1. Introduction

Rice (*Oryza sativa* L.) is the most important cereal crop in Asia, providing food to more than half of the world's population [1]. Pakistan produces the best quality rice in the world and has attained the rank of top foreign exchange earner of this crop. Although, rice is not the cardinal food as wheat of Pakistani people, yet it is the second most dominant cereal in the country. The total area, production and yield levels of rice in Pakistan were about 2962.6 thousand hectares, 6952.0 thousand tons and 2347.0 kg per hectare, respectively, during the 2008-09 [2]. As its production remained erratic for the last few years and being a staple food and source of foreign exchange earner, there is a great need for enhancing its yield per acre to fulfill the food requirements of ever increasing population growth in the country. Although the soil and climatic conditions of Pakistan are conducive to high yield of rice, yet its yield is every low. It is imperative to increase the agricultural product both in terms of quality and quantity [3]. There are many factors of low rice yield, but the overall low levels of crop protection practices have deleterious effects on the plant growth. There are over 50 insect species damaging rice plant in Pakistan, but 10 species are of major economic importances that cause economic damage. Among these insect pests, the stem borers are considered serious pests in rice production. From seedling to maturity, this crop is infested by three species of rice stem borers [yellow stem borer, *Scirpophaga incertulas* Wlk.; pink rice borer, *Sesamia inferens* Wlk.; and white stem borer, *Scirpophaga innotata* Wlk.]. The larvae of these borers attack by boring into the central shoot, cause extensive damage and exhibit two kinds of symptoms; "dead heart" early in the life of plant before flowering, and "white head" damage at flowering which are resulting in drying of the entire panicle, ultimately reducing the paddy yield. Among borers, the yellow stem borer, *S. incertulas* is widely distributed through out Pakistan and the most destructive pest of rice in the Sindh province. These borers are reported to be responsible for a steady annual damage of 5-10% of the rice with local catastrophic outbreaks of up to 60% damage [4].

Attempts to prevent insect pests damage have resulted in increased use of pesticides all over the world; in Pakistan too, pesticides use has increased manifold in certain areas without determining their peruses need. This heavy

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dependence on pesticides has created numerous problems such as resistance in insects to insecticides, frequent crop contamination and environmental pollution [5]. It is well known fact that certain varieties or strains of rice are attacked less by insect pests than others because of the natural resistance of this plant. During the recent years, the growing of resistant rice varieties have received much attention due to awareness of environmental and health risks. To lower down the cost of rice production, the development of insect resistance varieties is an urgent need of the day. Aside from undesirable effects of pesticides, many farmers in South and South East Asia, where mostly rice is grown, have limited access to capital, pesticides and application equipments. Various studies have demonstrated the existence of natural resistance to insect pests in several rice varieties and wild rice, such resistance can be transferred to the high yielding rice varieties by conventional methods or innovative breeding technique [6]. Using resistance traits (morphological and biochemical) in plants, such as, naturally occurring or inserted in new varieties by biotechnological procedures could markedly reduce the need for chemical treatments. Host plant resistance in rice is a useful strategy that can be applied in the control of insect pests. It does not require any special action from growers and constitutes a cheap and practical input in the sustainable integrated pest control system. Accordingly, the expansion of insect resistant and high yielding varieties of rice containing moderate to high levels of resistance is a proficient approach for exploration of integrated pest management tactic. The present studies discuss the status of host plant resistance in rice genotypes against stem borers' species by determining the borers' infestation on the growth of rice and the ability of the plant to produce paddy yield.

2. Materials and Methods

Field experiments were carried out at the farm of Nuclear Institute of Agriculture (NIA), Tandojam, during the year 2001 to evaluate the genotypic responses of 61 rice genotypes (35 aromatic and 26 non aromatic) tested against the infestation of rice stem borers. All the rice genotypes were obtained from Plant Genetic Division of NIA, and raised the seedlings according to standard procedures. The nursery was sown on May 15 and transplanted on July 1 in the fields selected for screening purpose against rice stem borers' infestation. Nursery sowing and transplanting of seedlings was completed during the optimum time of May and July, respectively, to observe the peak period of rice stem borers population multiplication.

For nursery raising dry bed method was adopted, seedlings of all the genotypes were transplanted at the optimum age. To obtain the optimum plant population nursery was sown directly on puddle field having plot each measuring 3.5 m^2, and the spacing between rows and between plants in row was 25 cm. Experiments were designed in randomized complete bock fashion having three repeats and genotypes assigned randomly within the replicates. Fertilizers were used as N_2: P_2 O_5 in combination @ 150: 80 kg/ h with all of the P and 1/3 N incorporated into the soil at the last ploughing; the remaining 2/3 N applied in two equal splits at tillering and flowering stages of plant growth. During the investigations, no plant protection measures were adopted from sowing to harvest of the crop. Weeds were controlled through adequate land preparation, judicious use of water, pulling the weeds mechanically, but no weedicide or herbicide was used. After transplanting and up to one week later, the water depth in the field was about 4 cm. One week after transplanting, the water depth was kept about 7 cm. Timely harvesting and threshing was conducted because both early and late operations may be able to affect the crop yield.

The data obtained from these test genotypes on larval infestation in comparison to yield were used to assess the resistance or susceptibility depicted by them. To note the percent borers infestation (dead hearts, white heads), data were recorded 3 times after 40 and 55 days of transplantation (from 16 plants within an area of 1 meter square in each replicate of genotype at random), and finally at pre harvest stage. Number of infested tillers (borers' infestation) of each genotype were recorded by counting the damaged tillers on randomly selected plants in each replicate and continued till before harvest. Following formula was used to calculate the percent damage: -

$$\text{Percent damage} = \frac{\text{Number of damaged tillers} \times 100}{\text{Total number of tillers}}$$

In each plot the, grain yield was recorded by taking the sample within the radius of 3.5 square meter after harvesting and threshing operations. The data thus was subjected to statistical analysis by using Steel and Torrie [7] MSTATC software and mean values for percentage larval infestation and grain yield were compared by DMRT at P= 0.05.

3. Results and Discussion

The results on rice plant infestation by yellow, white and pink stem borers (*Scirpophaga incertulas*, *Scirpophaga innotata* and *Sesamia inferens*), varied significantly on different aromatic and non-aromatic genotypes (Tables 1 and 2). At vegetative growth stage stem borers' infestation (dead heart) was fairly lower by an average of 1.32-10.37%, as compared to the infestation (white heads) at reproductive stage, which was observed from 0.26 to19.30%. Yield potential of all the

Table 1. Mean borers' infestation and yield of aromatic rice genotypes.

S. No.	Rice genotypes	Days for flowering	Borers' infestation (%)		Yield/ plot (g) ($3.5\ m^2$)
			Deadhearts	Whiteheads	
1.	Basmati-370 (P)	95	4.72 bcdef	7.15 hijkl	641.7 hij
2.	Basmati-370-5	95	6.61 abcdef	4.84 klmno	781.7 de
3.	Basmati-1.5-3/97	95	7.86 abcdef	5.83 jklm	686.7 g
4.	Basmati-2.0-1/95	95	5.54 abcdef	5.13 klmn	748.3 efs
5.	Basmati-2.0-11	101	4.36 bcdef	7.98 ghij	635.0 ij
6.	Basmati-15-1	101	3.20 ef	2.56 op	1008 a
7.	Basmati-15-2/93	101	6.16 abcdef	10.97 cde	908.3 b
8.	Basmati-15-3	101	5.32 abcdef	3.39 nop	948.3 b
9.	Basmati-15-5/97	101	3.78 def	5.74 jklmn	806.7 cd
10.	Basmati-15-9	101	4.41 bcdef	7.81 ghij	728.3 f
11.	Basmati-15-13/96	95	3.37 ef	8.97 efgh	653.3 ghij
12.	Basmati-15-14/93	101	4.53 bcdef	4.04 mnop	786.7 de
13.	Basmati-15-22	95	8.26 abcdef	4.94 klmn	460.0 qr
14.	Basmati-15-56	106	4.09 cdef	8.52 fghi	683.3 gh
15.	Basmati-15-213	95	4.73 bcdef	10.55 def	515.0 nop
16.	Basmati-20-1/93	106	5.66 abcdef	9.86 defg	921.7 b
17.	Basmati-30-2/93	95	8.39 abcde	4.71 lmno	568.3 lm
18.	Basmati-30-4/94	95	5.91 abcdef	6.51 ijkl	480.0 pqr
19.	Basmati-385	95	8.18 abcde	8.01 ghij	496.7 pqr
20.	Super Basmati	95	5.55 abcdef	7.17 hijk	501.7 nopq
21.	Jajai-77 (P)	95	8.92 abcd	11.44 cd	458.3 qr
22.	Khushboo-95	95	2.81 f	1.85 p	1027 a
23.	Jajai-LG-2	99	5.81 abcdef	3.57 mnop	831.7 c
24.	Jajai-15-A/97	95	4.36 bcdef	5.73 jklmn	846.7 c
25.	Jajai-15-1/94	95	5.58 abcdef	9.68 defgh	543.3 mn
26.	Jajai-15-2/94	95	7.13 abcdef	9.04 efgh	506.7 nop
27.	Jajai-15-4/97	95	9.60 ab	14.91 b	446.7 r
28.	Jajai-20	95	9.29 abc	8.42 fghi	563.3 lm
29.	Jajai-25-1	95	6.97 abcdef	7.15 hijkl	611.7 jk
30.	Jajai-30-2	95	3.74 def	6.83 hijkl	540.0 mno
31.	Sada Gulab (P)	95	5.05 bcdef	5.06 klmn	673.3 ghi
32.	S.G-15-3/96	95	6.22 abcdef	8.36 fghi	566.7 lm
33.	S.G-15-7/95	95	8.31 abcde	8.42 fghi	590.0 kl
34.	Sonehri Sugdasi (P)	95	10.37 a	19.30 a	403.3 s
35.	S.S-20-1	101	5.51 abcdef	13.09 bc	506.7 nop

Means sharing by the same letters in a column are not significantly different at *P*= 0.05.

genotypes was varied from 310 to 1523 g / 3.5 m^2 plot. Regarding aromatic rice genotypes, the data on dead heart and white head symptoms induced due to borers attack have been depicted in Table 1. It is clear from the data that varieties responded differentially towards borers' infestation during different growth stages. The study showed that among aromatic genotypes, 'Khushboo-95' gave the highest yield of paddy (1027.0 g / plot) and harboured 2.81% (dead hearts) and 1.85% (white heads) infestation, followed by Basmati-15-1 having 1008.0 g yield and 3.20% and 2.56% damage. On the other hand cultivar 'Sonahri Sugdasi (P)' harboured the highest borers attack (10.37% dead hearts, 19.30% white heads) and yielded the lowest grain (403.3 g) per plot, which was the most susceptible for infestation followed by genotype Jajai-15-4/97 (9.60%, 14.91%), and yielded 446.7 g of paddy, indicating that they exhibited susceptibility toward pest population. The time for 100% flowering in all genotypes ranged from 95 to 106 days.

Non-aromatic genotypes (Table 2), IR8-2.5-11 received least infestation (1.32%, 0.26% dead hearts and white heads, respectively) generating highest paddy yield (1523.0 g) per plot (3.5 m^2),

Table 2. Mean borers' infestation and yield of non-aromatic rice genotypes.

S. No.	Rice genotypes	Days for flowering	Borers' infestation (%)		Yield/ plot (3.5 m^2) (g)
			Deadhearts	Whiteheads	
1.	IR8 (P)	102	1.65 cd	1.56 efghi	1175.00 fgh
2.	Shua-92	100	2.64 bcd	1.14 ijkl	1267.00 cd
3.	Sarshar	96	2.36 bcd	0.31 mn	1510.00 a
4.	IR8-2.5-11	100	1.32 d	0.26 n	1523.00 a
5.	IR8-15-3	100	3.24 abcd	1.80 efgh	1310.00 c
6.	IR8-25-1/96	100	1.91 bcd	1.84 efgh	1423.00 b
7.	IR8-178	100	4.74 ab	2.70 bc	1173.00 fgh
8.	IR8-202	100	2.66 bcd	0.90 jklm	1280.00 cd
9.	IR6 (P)	102	2.38 bcd	1.50 fghij	1090.00 I
10.	Shadab	102	2.49 bcd	2.19 cde	1040.00 j
11.	IR6-1.0-2	100	1.91 bcd	2.51 bcd	1410.00 b
12.	IR6-1.5-2	100	1.84 cd	1.30 ghijk	1192.00 fg
13.	IR6-2.5-2	100	2.21 bcd	2.06 def	1273.00 cd
14.	IR6-15 A/94	100	3.36 abcd	1.37 ghijk	1213.00 f
15.	IR6-15 B/94	100	2.27 bcd	1.00 ijkl	1218.00 ef
16.	IR6-15-1	100	2.29 bcd	1.62 efghi	1418.00 b
17.	IR6-15-11	100	1.74 cd	1.22 hijkl	1420.00 b
18.	IR6-15-18	100	2.83 bcd	0.67 lmn	1260.00 de
19.	IR6-20-1/A	100	2.19 bcd	1.19 efg	1413.00 b
20.	IR6-20 B/94	102	2.20 bcd	1.34 ghijk	1387.00 b
21.	IR6-20-9	100	3.99 abcd	1.92 efg	1210.00 f
22.	IR6-25-1	100	3.10 abcd	0.65 lmn	1157.00 gh
23.	IR6-25 B/94	102	4.33 abc	0.87 klm	1135.00 h
24.	IR6-30-1	102	3.01 abcd	2.93 b	701.70 k
25.	IR6-30-2	102	3.58 abcd	3.83 a	616.70 l
26.	IR6-252	102	5.65 a	4.28 a	310.00 m

Means sharing by the same letters in a column are not significantly different at *P*= 0.05.

showing tolerance to borer attack, in contrast, genotype IR6-252 harboured the greatest infestation (5.65%, 4.28%), and yielded minimum grain (310.0 g) indicating its susceptibility. Results clearly demonstrated that these genotypes responded differently towards borers' infestation and paddy production. Days for 100% flowering varied from 96 to 102 among all genotypes.

The present efforts to locate resistance in rice genotypes by using the combination of rice stem borers population and yield are similar to work of earlier researchers [8- 48]; who used similar criteria for the evaluation of resistance within different genotypes. The earlier researchers have reported similar results on the rice host plant resistance, which are in agreement to our current findings.

Present investigations have clearly demonstrated that different rice genotypes had responded differently towards stem borers infestation and grain production because of the natural resistance occurring in them. According to Pathak [11], Manwan [49], and Das [50] the basis of resistance may be different; in some genotypes, it may be the result of simple physical factors, such as porosity, heavily sclerotized stem tissues, ridged stem surface, closed spaced vascular bundle sheaths; in other, it may be contributed by multiple factors, such as chemical or physiological features like high silica content. This resistance is made up of one or more than one component, viz., non-preference and preference, antibiosis and tolerance. So, these characters can be heritable through hybridization. With pure line selection, these desired factors can be intensified in rice plant. Physiological resistance through somatic means can also be transmitted by good stock. Thus, through interdisciplinary approach by entomologist and plant breeder, it would be possible to evolve rice varieties resistant to various pests especially stem borers infestation. Success achieved in the past would indicate that dividends paid by such research workers justify the efforts.

According to the findings of previous researchers, some other factors responsible for conferring resistance in rice plant against rice stem borers are for example; Dutt et al. [51] investigated the inheritance of resistance to *Scriphophaga incertulas* as a cross of the resistant and susceptible rice varieties. Results showed that resistance was independent of the recessive gene that governs semi dwarf plant height. Catling and Islam [4] recorded more than 40% damage and 20-40% yield losses by larvae of borer. It was suggested that high populations of borers was mainly because of long growing period of the plant, elongating stem is easily penetrated by the larvae and afford good nutrition for them, and the general ability of the pest to adapt to an aquatic environment. The succulence, nutritional value and anatomy of the elongating stems appeared to favour the penetration and development of larvae. Yang et al. [21] discussed the leaf blade characters, such as relatively high number of leaf hairs and relatively low chlorophyll content, and anatomical characteristics such as thick-walled stems, was the major factors conferring resistance. Marwat and Baloch [28] proved that *Scripophaga* species showed a significant positive correlation with moisture content and negative correlation with silica content but ash content was not related to the infestation. Padhi and Chattergi [52] studied nitrogen content of susceptible and resistant varieties and its influence on borers' infestation. The susceptible varieties had higher nitrogen content than either of resistant varieties. Islam [53] proved that taller and dense plant canopies were preferred for oviposition; leaf blade and foliage colour had no apparent effect. Liu et al. [54] reported resistance to rice stem borers positively correlated with rice stem thickness and width. According to Solangi [55] trichome density was negatively correlated with borers' infestation. In accordance with Shahjahan [56] broader and thicker sclerenchymatous hypodermis, compact parenchyma cells of ground tissue, small air spaces in the ground tissue, more vascular bundles with narrower spaces between vascular bundles, ridged stem surface containing vascular bundles and narrower pith were considered to be the characters for resistance. Hence, all theses plant characteristics should be kept in mind while evolving rice varieties and the tolerant genotypes located in these studies may be used as source of resistance.

4. Conclusions

It is concluded from the present research findings that among the tested aromatic rice genotypes, 'Khushboo-95' gave the best yield of grain and harboured the least pest incidence; on the other hand variety 'Sonahri Sugdasi (P)' harboured the highest borers attack and yielded the lowest grain yield. Regarding non-aromatic genotypes, IR8-2.5-11 received least pest infestation generating highest yield showing its tolerance to borer attack, in contrast, genotype IR6-252 harboured the highest infestation and yielded minimum grain indicating its susceptibility. As a consequence, the use of insect resistant rice varieties located in these studies would be an ideal method of controlling the insect pests. Identification of factors that confer resistance or susceptibility and study of their inheritance in rice plants would greatly improve breeding strategy. Increased understanding of resistance factors will pave the way for manipulation of insect's behaviour for use in pest management programme. Through this interdisciplinary research approach by entomologist and plant breeder, it will be possible to evolve rice varieties resistant to pests especially against stem borers' infestation for a long term crop protection.

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