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ESTIMATION OF GENETIC DIVERGENCE IN RICE (*ORYZA SATIVA* L.) GERMPLASMS ON THE BASIS OF PADDY YIELD AND RICE STEM BORER'S (PYRALIDAE: LEPIDOPTERA) RESISTANCE

MUHAMMAD SARWAR

Nuclear Institute of Agriculture, Tandojam-70060, Sindh, Pakistan.

Abstract

Field trials were carried out to estimate resistance along with paddy yield in 55 rice germplasm lines (35 aromatic and 20 non-aromatic genotypes) for rice stem borers (Pyralidae: Lepidoptera) to expose their potential in pest management approach. The results expressed significant differences for pest damage build-up and paddy yield among the rice germplasm lines. The findings clearly portrayed that based upon the percentage of pest invasions (dead hearts and white heads damage), no genotype was exclusively resistant to stem borers' damage under field conditions. Two aromatic genotypes, Jajai-15A/97 and Basmati-Cr-34, exhibited least borers' prevalence and amplified paddy yield while Sonehri Sugdasi (P) and Sada Gulab (P) pointed out a peak pest invasion and declined paddy yield. The estimation of pest incidence build-up and paddy productivity within non-aromatic genotypes confirmed that IR8 (P), IR6-15-2 and IR6 (P) were mainly proficient for bearing condensed pest invasion and augmented paddy yield. IR8-2.5-4, IR6-15-10 and IR6-20-9 demonstrated elevated pest susceptibility and gave poor yield. Rest of the germplasms appeared to be least tolerant or vulnerable to pest build-up and reduced paddy production. The tolerant and high yielding genotypes should be popularised in rice borers' endemic areas and can be used in varietals resistance breeding strategy. The outcome of current studies necessitates the integration of existing host plant tolerance along with other management strategies to accomplish a suitable control of rice stem borers and enhance paddy yield.

Keywords: Resistance, Rice, Stem borer, Host plant, Tolerance.

Introduction

Rice (*Oryza sativa* L.) is an ancient food grain and important crop in the world feeding more than 50% of human population (Agrawal et al., 2005). It provides 27% of the dietary energy supply and 20% of dietary protein intake in the developing world. Rice is grown at least in 114 developing countries and is the dominant crop in Asia, where it covers half of the arable land used for agriculture (Cantrell and Hettel, 2004). Intensive selection and cultivation of resistant varieties have increased rice production throughout the world. However, it is attacked by more than 100 insect species, of which stem borers are major pests. Yield losses due to stem borers range from 10-30% (Khush and Toenniessen, 1991). The damage caused by rice borers (*Tryporyza incertulas* [*Scirpophaga incertulas*], *Chilo suppressalis* and *Sesamia inferens*) has become a more serious problem year after year (Jiang et al., 2005).

Plant breeding for resistance to insects is divided into two steps. First one is to create novel genetic variation and second one is to select improved variants (Jackson, 1995). First step depends on screening of rice germplasm to identify novel donors of resistance. The second step involves use of these donors in sexual hybridization with commercial varieties to create novel combinations of genes (Panda and Khush, 1995). According to Sehgal et al. (2001), the use of pest resistant crop varieties is the easiest, most effective, compatible, economical and practical method among all the pest management practices. Such crop varieties are extensively used in pest prone areas as a principal method of integrated pest management or as a supplement to other pest management strategies. It can counter the pest problems and is free from all adverse effects of

***Author for correspondence E-mail: drmsarwar64@yahoo.com**

pesticide uses (Sarwar et al., 2010; Sarwar, 2011; Sarwar, 2012a). In the present trial, 55 rice genotypes (35 aromatic and 20 non-aromatic), which were selected from crosses of different rice varieties, were studied to explore genetic variability for determining agronomic trait and stem borer resistance at natural infestation of insect pests. Pakistan is one of the largest rice exporters in the world; the objective of this research is, therefore, to characterise rice genetic resources for breeding rice cultivars to improve the life condition of farmers in the country for producing high-yielding cultivars tolerant to the pests with little reliance on pesticide applications.

Materials and Methods

In the present trials, different rice genotypes were selected from stock produced from different parents in order to assess resistance combined with seed yield against rice stem borers to elucidate their possible involvement in pest management strategy. Out of rice genetic stock, two sets of the germplasms were made. The first set consisted of 35 aromatic whereas the second comprised of 20 non-aromatic genotypes. The basic seeds of these germplasms were provided by Rice Genetics Laboratory of Nuclear Institute of Agriculture, Tandojam. Selected lines were evaluated at experimental farm of the same Institute of Agriculture, during rice growing season (2006). A nursery which was thirty five days old of selected lines was transplanted in well-puddled soil. The nursery of each rice line was transplanted by keeping plant-to-plant and row-to-row distance of 25cm. The crop was grown in a randomised complete block design with three replications. All the plots were kept moist with standing water at the time of transplantation and subsequent growth stages. All the standard agronomic practices were followed at the field site and plants were exposed to local insect herbivores. To control weeds, the first and second weeding was done at an interval of 15 days each. A basal dose of nitrogen and phosphorus at the rate of 30kg as urea and 50kg/ha as triple super-phosphate, respectively, were uniformly incorporated in the soil at the time of sowing and then 30kg nitrogen was added at tillering stage. Stem borers damage was recorded as dead hearts percentage at vegetative growth and white heads percentage at maturity stage by counting number of dead hearts and white heads per m^2 area in each genotype. Total numbers of plants in selected area was observed, total numbers of tillers was recorded and then numbers of dead hearts per hill counted to calculate their percentage. At later stage, data for borer's infestation was taken from one m^2 hills selected randomly and determined on white heads basis. Then, percent infestation as whiteheads was thus calculated. After harvesting, paddy yield data was taken for every 3 m^2 and subjected to proper statistical analysis for testing the significance of results via Statistix 8.1 software. The mean differences among the treatments were compared by multiple comparison tests, using LSD range Test.

Results

The rice genotypes examined differed from one another with respect to stem borer infestation based on dead hearts or white heads and yield agronomically (Tables 1 and 2). On the basis of percent damage, no genotype was totally free from stem borer damage.

1. Rice stem borers incidence and grain yield in aromatic rice genotypes

In field conditions, minimum borers incidence and severity (0.00% dead hearts, 1.47% and 1.79% white heads) and increased seed yield (1773gm and 1753gm per 3 m^2) were expressed by genotypes Jajai-15A/97 and Basmati-Cr-34, respectively, whereas Sonehri Sugdasi (P) and Sada Gulab (P) peaked in holding pest intensity (2.15 and 1.69% dead hearts and 40.45 and 29.99% white heads) and decreased yield (191.7 and 276.7 gm per 3 m^2), respectively. The rest of aromatic rice genotypes were intermediate in tolerance or susceptibility to pest prevalence (Table 1).

2. Rice stem borers incidence and grain yield in non-aromatic rice genotypes

At natural infestation of stem borers, the damage estimation demonstrated that, on an average basis of all tested non-aromatic rice genotypes, IR8 (P), IR6-15-2 and IR6 (P) were most efficient for holding reduced pest infestation (0.02, 0.07 and 0.09% dead hearts and 2.75, 3.00 and 3.77% white heads) and enhanced yield (3297, 3275 and 3122gm per 3 m^2)), respectively whereas IR8-2.5-4, IR6-15-10 and IR6-20-9 exhibited more pest susceptibility responses (1.75, 1.44 and 1.20% dead hearts and 10.67, 9.05

and 8.25% white heads) and inferior yield (986.7, 1422 and 2160gm per 3 m^2), respectively. The remaining non-aromatic rice genotypes were moderately tolerant or susceptible to pest incidence (Table 2).

Table 1. Screening of aromatic rice genotypes against rice stem borers and grain yield

S. No.	Rice genotypes	Stem borers infestation (%)		Yield/plot (3 m^2) (gm)
		Dead hearts	White heads	
1.	Basmati-370 (P)	0.58 cdefgh	15.07 efg	681.7 hijklm
2.	Basmati-15-1	0.26 fgh	4.37 jklmn	1170 bcde
3.	Basmati-15-2/93	0.54 defgh	10.72 ghij	886.7 defghij
4.	Basmati-15-5/97	0.48 efgh	6.62 ijklmn	1030 cdefgh
5.	Basmati-15-13/96	0.46 efgh	11.36 ghij	820 defghijkl
6.	Basmati-15-14/93	0.59 cdefgh	7.58 hijklmn	858.7 defghijk
7.	Basmati-20-1/93	0.99 bcdefgh	12.92 ghi	796.7 efghijkl
8.	Basmati-30-2/93	0.96 bcdefgh	13.09 fghi	776.7 fghijkl
9.	Basmati-385	1.06 abcdefgh	15.10 efg	630 ijklmn
10.	Super Basmati	1.21 abcdefg	20.60 de	618.7 ijklmn
11.	Jajai-77 (P)	1.14 abcdefgh	19.99 def	628.3 ijklmn
12.	Khushboo-95	0.75 bcdefgh	11.49 ghij	883.3 defghij
13.	Jajai-LG-2	0.93 bcdefgh	6.64 ijklmn	1063 cdefgh
14.	Jajai-15A/97	0.00 h	1.47 n	1773 a
15.	Jajai-15-2/94	0.78 bcdefgh	9.01 ghijklm	970.0 defghi
16.	Jajai-20	0.18 gh	14.68 efgh	726.7 hijkl
17.	Sada Gulab (P)	1.69 abc	29.99 b	276.7 no
18.	S.G-15-3/96	1.41 abcde	22.13 d	510.0 jklmno
19.	S.G-15-7/95	1.83 ab	28.96 bc	291.7 no
20.	Sonehri Sugdasi (P)	2.15 a	40.45 a	191.7 o
21.	S.S-20-1	1.49 abcde	22.46 cd	485.0 klmn
22.	M.S. Line-14	1.68 abcd	25.88 bcd	329.7 mno
23.	M.S. Line-17	1.36 abcdef	21.90 d	525.0 jklmno
24.	M.S. Line-18	1.56 abcde	25.76 bcd	435.0 lmno
25.	M.S. Line-19	0.92 bcdefgh	13.41 fghi	740.0 hijkl
26.	M.S. Line-22 A	0.74 bcdefgh	1.84 mn	1377 bc
27.	M.S. Line-22 B	0.26 fgh	7.75 hijklmn	746.7 ghijkl
28.	Basmati-20-1	0.04 h	8.63 ghijklmn	1129 bcdefg
29.	Basmati-1.5-2	0.26 fgh	10.53 ghijk	643.3 ijklmn
30.	Jajai-15-1	0.21 gh	11.13 ghij	998.3 defghi
31.	Basmati-Cr-3	0.23 fgh	5.29 jklmn	1185 bcd
32.	Basmati-Cr-6	0.21 gh	3.18 lmn	1430 b
33.	Basmati-Cr-34	0.00 h	1.79 n	1753 a
34.	Basmati-Cr-37	0.22 gh	3. 38 klmn	1148 bcdef
35.	Basmati-Cr-40	0.62 cdefgh	9.46 ghijkl	1064 bcdefgh
LSD value		0.928	6.104	319.7

The values followed by same letters are not significantly different (P<0.05) by LSD range test.

Table 2. Screening of non-aromatic rice genotypes against rice stem borers and grain yield

S. No.	Rice genotypes	Stem Borers infestation (%)		Yield/plot ($3m^2$) (gm)
		Dead hearts	White heads	
1.	IR8 (P)	0.02 e	2.75 c	3297 a
2.	Shua-92	0.25 cde	5.59 abc	2522 fgh
3.	Sarshar	0.40 cde	6.71 abc	2555 efgh
4.	IR8-2.5-11	0.68 bcde	4.87 abc	2770 cdef

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5.	**IR8-15-3**	**0.14 de**	**4.57 bc**	**3033 abc**
6.	**IR8-25-1/96**	**0.15 de**	**4.65 abc**	**3007 abcd**
7.	**IR6 (P)**	**0.09 e**	**3.77 bc**	**3122 ab**
8.	**Shadab**	**0.16 de**	**4.74 abc**	**2873 bcde**
9.	**IR6-15-2**	**0.07 e**	**3.00 c**	**3275 a**
10.	**IR6-15-1**	**0.18 de**	**4.82 abc**	**2828 bcdef**
11.	**IR6-15-11**	**0.50 bcde**	**7.01 abc**	**2743 cdef**
12.	**IR6-20-1/A**	**1.12 abcd**	**7.73 abc**	**2295 hi**
13.	**IR6-20-9**	**1.20 abc**	**8.25 abc**	**2160 i**
14.	**IR6-20 B/94**	**0.79 bcde**	**7.61 abc**	**2387 ghi**
15.	**IR6-30-1**	**0.58 bcde**	**5.95 abc**	**2557 efgh**
16.	**IR6-30-2**	**0.52 bcde**	**7.38 abc**	**2640 efg**
17.	**IR6-252**	**0.28 cde**	**5.49 abc**	**2700 defg**
18.	**IR8-2.5-4**	**1.75 a**	**10.67 a**	**986.7 k**
19.	**IR8-20-28**	**0.21 de**	**6.82 abc**	**2622 efg**
20.	**IR6-15-10**	**1.44 ab**	**9.05 ab**	**1422 j**
LSD value		**0.831**	**5.006**	**288.1**

The values followed by same letters are not significantly different (P<0.05) by LSD range test.

Discussion

Some promising rice germplasms were screened to locate sources of resistance that could be used to develop varieties resistant to rice stem borers attack and efficient for agronomic traits. The results revealed that selected lines expressed considerable range of variations for tested criteria due to their phenotypic and genotypic differences. The grain yield was correlated with the degree of stem borer infestation and yield increased with decrease in infestation level. Our results agreed with the findings of several earlier researchers. For instance, higher yield at lower percentage infestation level may be attributed to the fact that rice plant has the ability to compensate the rice stem borer damage by increasing the production of new tillers (Islam and Karim, 1997; Heong and Escalada, 1999). These additional tillers contributed to increase the paddy yield. Hence, enhancing plant compensation mechanism to stem borer injury may be a better strategy for stem borer management than insecticide application (Rubia et al., 1996). According to El-Malky et al. (2008), highly significant positive correlation was found between white head percentage and heading date and plant height and flag leaf area, indicating the importance of these characters for selecting stem borer resistant lines for breeding white head resistant varieties.

The present study implies that genotypes were highly significant for all studied parameters and expressed considerable series of divergence. These results are aligned with those of previous researchers. For instance, Shafiq et al. (2000), Khan et al. (2005), Suharto and Usyati (2005) and Sarwar (2012 b; 2012 c) reported that rice genotypes vary in degree of resistance for stem borers infestation and yield. Observations confirmed that various germplasms, which were greatly tolerant at one phase, became vulnerable at a different phase while some others retained their resistance or susceptibility over the whole growth period. This points out that the factors responsible for dead hearts and white heads were independent. The mechanism of rice varietals resistance to the yellow stem borer, *S. incertulas*, was investigated and analysed by earlier workers. The resistant cultivars had the lower interval between vascular bundles and larger sheath bridge in the outer leaf sheath than the susceptible ones (Fang et al., 2002). Mann and Shukla (2005) characterised rice genotypes for mechanisms of resistance against stem borer. Four genotypes including Pakistan Basmati were scored resistant/ moderately resistant both at dead hearts and white heads stages in early and normal transplanting dates. These four genotypes possessed better antixenosis for egg laying and antibiosis for larval survival and larval and pupal weights against borers compared to the susceptible variety Basmati-370. Padhi (2006) studied that the susceptible cultivar showed high amounts of amino acids and nucleic acids (RNA and DNA), causing profuse tillering than resistant to borer attacks. Xu et al. (2006) monitored the relationship among resistance to stem borer and morphological and anatomical characteristics of rice plants: the highest number of tillers, higher plant height, leaf width, leaf angle of rice plant, the narrowest space between vascular bundles in leaf sheath of the tillers than the broadest, higher number of silica cells in leaf sheath and the diameter of vascular bundles may influence the resistance of rice cultivars. These results supported by other researchers can elicit the interest of scientists to intensify the morphological and anatomical characteristics of rice plants contributing to resistance through breeding to elucidate their possible involvement in pest management strategy.

Conclusion

The information attained from these studies would enhance the selection of stem borer resistant lines with better accuracy to avoid environmental influence of stem borer attack. To control rice pests effectively and reduce yield losses, an organised system of plant protection should be implemented, the technical knowledge of plant protection personnel should be heightened and the working condition and investment required to monitor the pests should be guaranteed.

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