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INTERACTIVE EFFECT OF GENOTYPE AND ENVIRONMENT ON THE PADDY YIELD IN SINDH PROVINCE

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Abstract

The implication of genotype-by-environment (G x E) interaction is an important consideration in plant breeding programmes. A significant G x E interaction for a quantitative trait such as yield can seriously limit efforts in selecting superior genotypes for both new crop introduction and improved cultivar development. To determine the possible effects of environments and genotypic differences for yield, 7 advanced mutants of non-aromatic rice alongwith parent variety IR6 and 2 commercial checks were tested at 8 different sites in Sindh during 2004 and 2005 rice crop-growing season. Genotypes, locations, genotype x environment interactions were highly significant ($P< 0.01$) indicating genetic variability between genotypes by changing environments. Stability analysis showed that mutants IR6-15/A and IR6-15/E had the mean paddy yield with regression coefficient (b) less than or close to unity (1.10 and 0.85) and the lowest deviation from regression (S^2d) (0.03 and 0.17) suggesting above average stability and adaptability over environments. IR6-15-18 produced low mean yields with the highest regression coefficient (b) and highest deviation from regression coefficient (S^2d) had below average stability and is specifically adapted to favourable environments.

Introduction

Rice is the second most important staple food crop in Pakistan not only in respect of local consumption but also in view of large exports. Rice was grown on approximately 2.52 million hectares with a total production of 5.02 million tones out of which 3.69 million tones was exported and earned a foreign exchange of worth 69325.1 million rupees (Anon., 2006-07). Rice production in Pakistan is concentrated in four, more or less distinct agro-ecological zones. Each zone represents diverse edaphic, hydrological and climatic conditions. In Sindh, rice is cultivated in two different ecological zones almost 400 Km apart from each other with wide environmental variation. The situation demands genotypes with wide adaptability, which can perform consistently well over a range of environments. Crop stability, is the ability of a crop to exhibit minimum interaction with both predictable and unpredictable environments (Qayyum *et al*., 2000).

Study of G x E interaction is important to plant breeders because it can limit the progress in the selection process, hence is a basic cause of differences between genotypes for yield stability. Linnemann *et al*., (1995) stated that it is important to understand crop development in relation to biophysical conditions and changes in season when selecting well-adapted genotypes and correct planting date. Varieties that show low G x E interaction and have high stable yields are desirable for crop breeders and farmers, because that indicates that the environments have less effect on the performance of genotypes and their yields are largely due to their genetic composition. Therefore, evolution of rice varieties that have high yield and stability in performance over a wide range of environments will remain an important criterion in rice breeding (Tai, 1971).

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Blum (1980) defined yield stability as a measure of variation between potential and actual yield of genotypes across different environments. Fehr (1987) stated that yield stability of a cultivar is influenced by the genotype of individual plants and the genetic relationship between plants. It can be measured through analysis of variance procedures and regression analysis. Domitruck *et al*., (2001) indicated that the analysis of variance procedure is a useful tool for estimating the existence and magnitude of G x E interactions. However, the components of variances do not provide explanation of interaction. Yates & Cochran (1938) proposed a purely statistical analysis, which was later used by Finlay & Wilkinson (1963) and Eberhart & Russell (1966). They used the analysis to detect and measure the magnitude of G x E interactions. The objective of the present study was to present results of the analysis of genotype x environment interactions and stability of performance of rice mutants grown in different environments in Sindh.

Materials and Methods

The performance of one parent IR6 and its 7 advanced mutants viz., IR6-15/A, IR6-15/B, IR6-15/E, IR6-15-18, IR6-20-2, IR6-25/B and IR6-1.0-2 along with two commercial check varieties Shadab and Sarshar of non-aromatic rice (*Oryza sativa* L.) were evaluated in zonal varietals trials for 2 years (2004 and 2005) at 8 different locations viz., Tando Jam, Badin, Thatta, Sanghar, Dadu, Larkana, Shikarpur and Jacobabad in Sindh. The experiments were sown in randomized complete block design in a triplicate fashion at each site. Plot size for each genotype was 15 m^2 with 25 rows, 3 meter long and 20 cm apart from each other. Standard agronomic practices were followed during crop growth stages. At maturity, paddy yield was recorded and subjected to analysis of variance (ANOVA) as suggested by Steel & Torrie (1980) to determine the significance of genotypes, environments and genotype environment interactions. The Duncans Multiple range test was also performed to rank the genotypes (Duncan, 1955). The stability analysis was carried out by Eberhart & Russell (1966) Model to calculate the regression coefficient (b) standard error (S.E) and variance due to deviation from regression (S^2d) as parameters of stability and adaptability.

Results and Discussion

The combined analysis of variance for paddy yield showed highly significant differences between locations (L) genotypes (G) and genotypes x location interaction (G x L). The year and location (Y x L) and year x location x genotype (Y x L x G) interactions were also highly significant for paddy yield (Table 1). Significant Y x L interaction indicated that location means were inconsistent in both the years. Significance of genotype x location interaction indicated that it may be due to either by crossover (qualitative) interaction, in which a significant change in ranking occurs from one environment to another (Singh *et al*., 1998; Akram *et al*., 1999) or a non-crossover interaction (Quantitative), G x L interaction, in which case the ranking of genotypes remains constant across environments and the interaction is significant because of change in the magnitude of response (Cooper, 1999; Honarnejad, 2003). In the presence of crossovers, the breeders have to select one genotype for one set of environments and a different genotype for the other environment. In the absence of crossovers, the performance of a genotype remains consistent in all the environments. Non-crossover interactions is desirable which reflect the heterogeneity of genotypic differences across environments, Y x G and Y x L x G interactions are significant which reflected the inconsistency of genotypes in different years (Reddy *et al*., 1998; Singh & Payasi, 1999).

Table 1. Pooled analysis of variance for paddy yield (kg/plot) of 10 non-aromatic rice mutants/ varieties grown over 8 locations of Sindh, Pakistan during 2004 and 2005.

Source	Degree of freedom	Mean square	F-value
Replication	2	0.11**	1.05
Location (L)	7	33.4**	327.5
Year (Y)	1	107.9**	1058.6
Y x L	7	9.0**	88.7
Error	30	0.1	
Genotype (G)	9	28.2**	284.9
L x G	63	0.5**	6.0
Y x G	9	3.8**	39.2
L x Y x G	63	0.6**	6.9
Error	288	0.10	

Table 2. Pooled mean performance for paddy yield (kg/plot) of 10 non-aromatic rice mutants/ varieties grown over 8 locations of Sindh, Pakistan during 2004 and 2005.

Varieties / locations	IR6 parent	IR6 15/A	IR6-15/B	IR6-15/E	IR6-15-18	IR6-20-2	IR6-25/B	IR6-1.0-2	Shadab	Sarshar	Location means
Tando Jam	7.5 f	9.3 a	8.1 de	8.5 bc	7.9 e	8.8 b	7.9 e	8.4 cd	7.4 f	8.4 cd	8.2
Badin	9.1 d	11.3 a	8.5 e	9.2 d	9.4 d	10.3 b	8.2 e	9.1 d	8.2 e	9.9 c	9.3
Thatta	8.6 cde	10.6 a	8.4 de	8.9 c	8.7 cd	9.5 b	8.3 e	8.8 c	7.7 f	9.7 b	8.9
Sanghar	7.8 c	9.4 a	8.9 b	8.1 c	8.1 c	9.1 ab	8.1 c	8.0 c	7.2 d	8.8 b	8.3
Dadu	9.2 e	11.6 a	9.8 d	9.8 d	9.7 d	11.1 b	9.0 ef	9.6 d	8.8 f	10.6 c	9.9
Larkana	9.4 de	10.9 a	9.7 cd	9.5 cd	9.0 ef	10.8 a	8.9 f	10.1 b	8.7 f	9.8 bc	9.7
Shikarpur	8.3 cd	9.5 a	8.4 bc	8.5bc	7.5 e	9.2 a	7.0 f	7.9 d	7.0 f	8.7 b	8.2
Jacobabad	9.3 d	12.1 a	9.3 de	9.9 c	9.9 c	10.7 b	8.9 ef	10.1 c	8.8 f	10.4 b	10.0
Mean values	8.7	10.6	8.9	9.1	8.8	9.9	8.3	9.0	8.0	9.53	

Table 3. Regression coefficient 'b' and variance due to deviation from regression for paddy yield (kg/plot) of 10 non-aromatic rice mutants / varieties grown over 8 locations of Sindh, Pakistan during 2004 and 2005.

Non-aromatic rice mutants / varieties	Mean paddy yield (kg/plot) of all locations	b ± S.E	S^2d
IR6 Parent	8.7	0.91 ± 0.152	0.15
IR6-15/A	10.6	1.10 ± 0.159	0.03
IR6-15/B	8.9	0.66 ± 0.206	0.16
IR6-15/E	9.1	0.85 ± 0.088	0.17
IR6-15-18	8.8	1.12 ± 0.138	0.16
IR6-20-2	9.9	1.15 ± 0.102	0.20
IR6-25/B	8.3	0.78 ± 0.177	0.04
IR6-1.0-2	9.0	1.11 ± 0.147	0.16
Shadab	8.0	0.96 ± 0.070	0.13
Sarshar	9.5	1.05 ± 0.120	0.18

The highest paddy of yield 10.0 kg plot^{-1} was produced at location Jacobabad followed by Dadu and Larkana with an average paddy yield of 9.9 and 9.7 kg plot^{-1} respectively whereas, the lowest paddy yield (8.2 kg plot^{-1}) was recorded at Shikarpur and Tando Jam, followed by Sanghar (8.3 kg plot^{-1}). As explained by Eberhart & Russell (1966), linear (b_i) and non-linear (S^2d) should be considered while judging the phenotypic stability of a variety. They also emphasized that an ideal variety should have high mean performance, "b" value near to unity and S^2d close to zero. Regression coefficient is a measure of response and deviation from it is a measure of stability (Shadakshari *et al*., 2001; Ise *et al*., 2001). In the present investigation, the regression of varietal average yield on the environmental index resulted in regression coefficients ranging from 0.66 (IR6-15/B) to 1.15 (IR6-20-2). The highest mean paddy yield was observed for IR6-15/A followed by IR6-20-2, Sarshar and IR6-15/B with coefficient values of 1.10, 1.15, 1.10 and 0.66 respectively. The deviation from regression coefficient (S^2d) close to zero was observed in case of IR6-15/A, IR-25/B and Shadab. The check varieties Shadab & Sarshar showed 0.96 and 1.10 coefficient values with low deviation from regression coefficients (S^2d) 0.13, and 0.18 respectively. Lin & Binns (1985) suggested that genotypes with lowest regression coefficient values were considered unresponsive to different environments or had above average stability and those with more than regression coefficients were considered responsive to favourable environments or had below average stability. The mutant IR6-15/A produced significantly the highest mean paddy yield than rest of the entries, with regression coefficient value close to unity (1.09) and deviation from regression coefficient value near to zero (0.03). These findings indicate that this mutant is high yielding as well as stable over environments. Finlay & Wilkinson (1963) showed that the genotype with maximum yield potential over environments, regression coefficient equal to one would be stable. Whereas, Eberthart & Russell (1966) proposed that the deviation from regression (S^2d) is the parameter of stability and regression coefficient is the parameter of response. Fan *et al*., **(**2007) also reported that the consideration should be given to those varieties, which produced higher mean yield with small deviation from regression coefficient and regression coefficient equal to one.

The commercial check variety Sarshar had regression coefficient (b) value 1.05 with small deviation from regression coefficient (0.18) proved to be the most stable variety in this group of comparison. Yang *et al*., (2001) suggested that the exceptionally small deviation from regression coefficient would be the highly stable over different environments. Similar results of genotype x environments interaction analysis for yield and other associated characters have also been reported in many other crop plants by other investigators (Kaundal & Sharma, 2006; Kaya *et al*., 2006; Sabaghnia *et al*., 2006. and Lafitte & Courtois, 2006**).** The mutant IR6-15-18 and IR6-1.0-2 had low mean yield, highest regression coefficient (1.12 and 1.11) with deviation values 0.16 of both, indicated that these mutants had below average stability and are specifically adapted to favourable environments (Hulmel & Lecomte 2003).

Conclusion

The present study provided an evaluation of genotypic and environmental performance of newly developed rice advanced mutants over a range of environments. Stability analysis demonstrated that newly developed mutant IR6-15/A is less responsive to changed environmental conditions and can be grown over a range of environments in the province of Sindh.

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