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STABILITY ANALYSIS OF WHEAT GENOTYPES TESTED IN MULTI-ENVIRONMENTAL TRIALS (METs) IN SINDH PROVINCE

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Abstract

Yield being a polygenic character is influenced by genotypes, environments and genotype x environment (G x E) interactions. Ten wheat (*Triticum aestivum* L.) genotypes developed at Nuclear Institute of Agriculture Tando Jam viz. SD-4085/3, SD-4047, SD-66, SD-1200/11, SD-1200/19/1, SD-1200/51, 7-03, 15-10, RWM-9313, ESW-9525 were evaluated along with two local checks Kiran-95 and Sarsabz in multi-environmental trials (METs) over 11 locations having different agroclimatic conditions of Sindh province. Normal agronomic practices were followed at each location. Grain yield data were recorded on 6 m^2 plots and subjected to statistical analysis. Stability parameters measured were regression coefficient (b) and variance due to deviation from regression (S^2d). Genotype SD-4047 produced the highest grain yield (2.64 kg) with unit regression (b=1.09) and lowest standard error of regression s.e (b) = 0.09 and S^2d (0.024) confirming wide adaptability and stability. SD-4085/3 proved to be the second highest yielding (2.59 kg) genotype but had high regression (b=1.187 and s.e.(b) = 0.262 and variance due to deviation from regression (S^2d = 0.22) value suggesting specific adaptation particularly in high yielding environments. Regression values on environmental index ranged from 0.763 in genotype 7-03 to 1.187 in SD-4085/3. Pooled analysis of variance overall environments indicates that the genotype, environment and genotype x environment (GxE) interaction mean squares were highly significant ($P \leq 0.01$) for grain yield. Therefore, an understanding of G x E interaction provides a valid insights into the selection of new stable genotypes in the diversified environmental conditions prevailing in a region.

Introduction

World wheat production has increased from 249 million tonnes in 1960 to 586.7 million tonnes in 2000. Pakistan has also made a quantum jump in wheat production from 3.6 million tonnes to 21.8 million tonnes in this period. However the increasing global population will continue to demand more wheat grains. Horizantal increase by bringing more area under wheat seems to be limited and the option left is through the vertical increase, i.e. by enhancing productivity per unit area. The cultivars can contribute to higher productivity only when they consistently produce higher yield across a broad array of environmental conditions. Stability analysis is a useful mathematical device which is helpful in assessing the cultivars under different environmental conditions.

Genotypic stability, in terms of GxE can be described in two components: Linear response to environmental yield potential and deviation from that response (Eberhart and Russell 1966, Lin and Binns, 1988, Ahmad *et al.,* 1996). As environmental factors have strong influence on various stages of crop growth (Bull *et al.,* 1992), genotypes differ widely in their response to environments. Preferred genotypes generally show low GxE interaction variances (Peterson *et al.,* 1997, Sial *et al.,* 1999). The joint regression analysis (JRA) of cultivar yield on an environmental index derived from the mean of all or subset of cultivars has been the most widely used stability analysis method (Finaly and Wilkinson, 1963, Eberhart and Russell, 1966, Perkins and Jinks, 1968 and Freeman, 1973). The objectives of present study were to examine newly developed wheat genotypes over a range of environments and to assess the potetial yield and stability under varying environments in Sindh.

Materials and Methods

To confirm the effects of G, E and GxE interaction, ten advanced wheat genotypes along with two check varieties viz, Kiran 95 and Sarsabz were evaluated in multi environmental trials (METs). These trials were grown over a diverse range of 11 locations having different agroclimatic conditions i.e. N.I.A. Tando Jam (normal sowing), N.I.A. Tando Jam (late sowing), N.I.A. Tando Jam, Experimental Farm (normal sowing), Tando Allah Yar, Petaro (Dadu), Sanghar, Nawabshah, Naushahro Feroze, Khairpur, Shahdadkot (Larkana) and Lallo Ranek (Larkana) during growing season 1999-2000. The trials were grown in randomized complete block design (RCBD) with four replications. Each genotype was sown with six rows, 5 meter long and spaced 30 cm apart. Data for grain yield (kg/plot) was collected from central 4 rows ($6m^2$ plot size) at maturity and statistically analysed by using analysis of variance method in which average yield of each genotype at each location was used as an environmental index for subsequent regression analysis. Stability parameters calculated were regression coefficient (b) and deviation from regression (S^2d). The joint regression analysis for grain yield was calculated as follows:

Yijk	=	$\mu_i + b_i I_j + b_{ij} + e_{ijk}$, where,
Y_{ijk}	=	Yield genotype (i) at site (j) and replicate (k)
μ_i	=	Mean of the ith genotype over all environments
b_i	=	Regression coefficient of the ith genotype
I_j	=	Environmental index
b_{ij}	=	Regression coefficient of the ith genotype at jth environment
e_{ijk}	=	Residual error of genotype (i) at site (j) and in replicate (k).

Results and Discussion

Combined analysis of variance showed significant difference among genotypes over environments for mean grain yield (Table 1). Genotypes x environment (GxE) interaction was also highly significant showing significant role of environments in the expression of grain yield in wheat. The significance of genotypes, environments and their interaction was attributable to variations in different climatic and edaphic conditions over different locations, indicating the necessity of testing at multiple locations over time for accurate characterization of genotypic performance over divergent regions. The average genotypic grain yield on environmental index ranged from 2.243 kg in Kiran 95 to 2.645 kg in SD-4047. Genotypes SD-4047 and SD-4085/3 grouped together had similar grain yield and produced significantly higher yield than rest of the genotypes, when the means were compared over 11 different sites; whereas 3 genotypes SD-66, SD-1200/11 and RWM9313 had statistically similar grain yield (Table 2). Site mean yields differed significantly (P≤0.01) ranging from 1.390 kg at Tando Jam (late sowing) to 3.227 kg at Sanghar. The possible reason for the highest mean yield at Sanghar site might be due to the favourable environments i.e. the fertile soil and good agronomic practices. Besides Sanghar other high yielding locations were Sial Agriculture Farm Naushahro Feroze (3.032 kg), Shahdadkot (2.858 kg) and Laloo Ranek (2.668 kg) and Nawabshah (2.571 kg). This was reflected by the change in ranking order of genotypes under different environments (Table 2). Sindh province has very diversified environments, southern Sindh is relatively more humid and warm in comparison to central and northern Sindh, therefore, crop mostly faces very high temperature during grain filling periods. The inconsistent differences among cultivars from one environment to another may enhance the difference in response of the same set of genes to different environments, and the expression of different sets of genes in different environments (Falconer 1952, Basford and Cooper, 1998). There are two types of GxE interaction (Baker, 1988) qualitative (crossover) and quantitative (non crossover) interactions, the former involves change in genotype ranking order from one environment to another and the latter interactions reflect heterogeneity of genotype differences over environments. The breeder has to select one genotype for one set of environments and a different genotype for another environment in the presence of crossovers and the performance of a genotype remains consistent over all the environments when there is absence of crossovers (Matus *et al.,* 1997). The present sutdy suggested non crossover (quantitative) interactions by reflecting the heterogeneity of genotypic differences across environments.

Stability analyses (b and S^2d) calculated for each wheat genotype are presented in Table 3. Mean grain yield of individual genotype was regressed on the mean of all genotypes at each location according to method proposed by Eberhart and Russell (1966). The regression coefficient (b) ranged from 0.763 in 7-03 to 1.187 in SD-4085/3. The genotype SD-4047 produced the highest mean yield (2.645 kg) with regression (b=1.091) and lowest s.e (b) 0.090 and S^2d (0.024) value suggesting that this genotype is high yielding as well as generally adapted to all the environments. Regression (b) around 1.00 means less responsive to environmental changes, hence more adaptive (Finlay and Wilkinson 1963).

Another line SD-4085/3 produced mean yield of 2.595 kg but had high value of b (1.187), s.e (b) 0.262 and S^2d (0.223) indicating specific adaptation particularly in high yielding environments. RWM9313 and SD-66 gave better yield with low S^2d value which show better stability, and specific adaptation to favourable environments, whereas SD-1200/11 and 7-03 produced reasonable mean yield had higher deviation from regression (S^2d) value indicating less stability. There is always room for improvements. New computerized stability analyses methods such as cluster analysis (Allard, 1996, Nachit *et al.,* 1992; Crossa, 1990), AAMI analysis (Gauch, 1988) have been introduced. These multivariate techniques by minimizing the GxE interaction are more efficient than linear regression (univariate analysis). Moreover, these techniques differentiate the high yielding (HY) and low yielding (LY) environments into groups and sub groups based on genotypic mean yield performance over environments.

Table 1. Pooled analysis of variance (ANOVA) for grain yield (kg/plot) of 12 wheat genotypes evaluated in METs over 11 locations in Sindh.

Source of variation	DF	Mean square	F value	Probability
Genotypes (G)	11	0.797	6.94	.000
Environments (E)	10	14.526	126.50	.000
Genotypes x Environments (G x E)	110	0.452	3.94	.000
Error	393	0.115	-	-

Table 2. Stability analysis of wheat genotypes.

Genotypes	Mean yield kg/plot	Regression coefficient b□ s.e (b)	Variance due to deviation from regression (S^2d)
SD-4085/3	2.595	1.187 ± 0.262	0.223
SD-4047	2.645	1.091 ± 0.090	0.024
SD-66	2.499	1.148 ± 0.114	0.034
SD-1200/11	2.468	1.153 ± 0.295	0.289
SD-1200/19/1	2.299	0.919 ± 0.164	0.089
SD-1200/51	2.332	0.969 ± 0.173	0.096
7-03	2.405	0.763 ± 0.179	0.103
15-10	2.284	0.903 ± 0.122	0.056
RWM-9313	2.456	1.115 ± 0.181	0.099
ESW-9525	2.320	1.059 ± 0.199	0.136
Kiran-95	2.243	0.794 ± 0.249	0.207
Sarsabz	2.255	0.900 ± 0.121	0.045

Table 3. Mean grain yield (kg/plot) performance of wheat genotypes tested in multi environmental trials (METs) over 11 locations in Sindh during growing season 1999-2000.

	LOCATIONS												
Genotypes	NIA T. Jam I	NIA T. Jam II	NIA T. Jam III	T. Allah Yar	Petaro	Sanghar	Nawabshah	N. Feroze	Khairpur	Shahdad Kot (Larkana)	Laloo Raenk (Larkana)	Mean	Ranked order
SD-4085/3	1.868	1.375	2.625	1.625	2.675	3.917	2.037	3.250	2.925	3.183	3.062	2.595 AB	2
SD-4047	1.837	1.618	2.453	2.625	2.300	3.662	2.679	3.125	2.500	2.850	3.437	2.645 A	1
SD-66	1.681	1.275	2.349	2.250	2.250	3.575	2.638	2.762	2.487	3.017	3.212	2.499 ABC	3
SD-1200/11	1.568	1.237	1.970	2.125	2.325	3.167	4.000	3.350	2.275	2.608	2.505	2.468 BCD	3
SD-1200/19/1	1.743	1.450	2.153	1.875	1.825	3.250	3.146	2.637	2.212	2.450	2.550	2.299 E	7
SD-1200/51	1.837	1.262	2.211	2.250	1.825	3.150	3.196	2.987	2.037	2.550	2.350	2.332 DE	5
7-03	1.893	1.412	2.445	2.250	2.665	2.920	2.042	3.187	2.487	2.250	2.900	2.405 CDE	4
15-10	1.606	1.287	1.992	2.375	1.850	2.582	2.605	3.037	2.362	2.724	2.700	2.284 E	7
RWM-9313	1.643	1.643	2.039	2.425	1.800	3.575	3.184	3.375	2.325	2.325	2.687	2.456 BCD	3
ESW-9525	1.850	1.400	1.905	2.650	1.500	3.075	2.000	3.462	2.137	2.641	2.900	2.320 DE	6
Kiran-95	1.806	1.387	2.277	2.375	1.725	2.850	1.308	2.625	2.487	2.792	3.037	2.243 E	8
Sarsabz	1.556	1.330	2.289	2.325	1.825	3.000	2.017	2.587	2.325	2.625	2.925	2.255 E	8
Mean	1.741	1.390	2.226	2.262	2.048	3.227	2.571	3.032	2.380	2.668	2.858	-	-
Ranked order	G	H	E	E	F	A	D	B	E	D	C		

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