



Research Article

A comparison of different stability models for genotype x environment interaction in pearl millet

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Abstract:

Twenty four genotypes (hybrids) of pearl millet were tested under eight environments in Gujarat. The models of Eberhart and Russell (1966), Perkins and Jinks (1968) and Freeman and Perkins (1971) applied to study genotype x environment interaction and were compared for their efficiency empirically. The genotypes GHB-788, GHB-832 and GHB-840 were observed as most stable and widely adapted over environments in all three models. On the basis of simplicity and computational convenience, Eberhart and Russell (1966) model was recommended.

Key words:

Stability models, adaptability, genotype x environment interaction, pearl millet.

Introduction

The performance of any crop variety is the resultant effect of its genotype and environment in which it grows. It is observed that the relative performance of different genotypes varies in different environments; there exists a genotype x environment interaction. This interaction is a result of changes in cultivar's relative performance across environments, due to differential responses of the genotype to various edaphic, climatic and biotic factors (Dixon and Nukenine, 1997). Therefore, the analysis of genotype x environment interaction becomes an important tool employed by breeders for evaluating varietal adaptation. Choice of appropriate statistical models and their validation are fundamental steps which should precede any study of G x E interaction and analysis of stability. An early attempt to obtain measurement of the stability of individual lines was made by Plaisted and Peterson (1959), but their method becomes cumbersome when a large number of genotypes are tested. Recently breeders frequently employ joint regression analysis in the assessment and categorization of yield stability. It was originally

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suggested by Yates and Cochran (1938) and modified by different workers *viz.* Eberhart and Russel (1966), Perkins and Jinks (1968) and Freeman and Perkins (1971) for use in breeding experiments. The regression of genotype on environment provides two simple measures of the genotypic changes to environments, namely, regression coefficient and deviation from regression slope. In all field trials, one has to choose the analysis of variance for testing the significance of varietal performance under the given set of conditions in which experiments are conducted. It is easy to conceive that calculation would be simple if we have a method which was based on the information available directly from such analysis of variance for estimating the stability of the variety.

With these points in view, stability analysis models developed by Eberhart and Russell (1966), Perkins and Jinks (1968) and Freeman and Perkins (1971) were compared for their efficiency empirically, so that an efficient procedure could be recommended for the stability analysis.

Materials and Methods

An experiment was conducted with twenty-four hybrids of pearl millet *viz.*, GHB-715 (G₁), GHB-

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719 (G₂), GHB-732 (G₃), GHB-744 (G₄), GHB-757 (G₅), GHB-770 (G₆), GHB-785 (G₇), GHB-788 (G₈), GHB-797 (G₉), GHB-807 (G₁₀), GHB-817 (G₁₁), GHB-819 (G₁₂), GHB-830 (G₁₃), GHB-832 (G₁₄), GHB-833 (G₁₅), GHB-840 (G₁₆), GHB-841 (G₁₇), GHB-843 (G₁₈), GHB-847 (G₁₉), GHB-852 (G₂₀), GHB-558 (G₂₁), GHB-577 (G₂₂), GHB-538 (G₂₃) and MH-169 (G₂₄) at eight different locations of Gujarat state *viz.*, Jamnagar, Anand, Mahuva, Kothara, Sardarkrushinagar, Nanakandhasar, Amreli and Jam-khambhalia during *kharif* 2007. This experiment was carried-out in a Randomized Block Design (RBD) with three replications. The spacing was 60 cm x 15 cm and net plot size was 5.0 m x 2.4 m for all the environments. Data from all the locations were collected for grain yield and subjected to analysis of variance. Stability parameters were worked out according to Eberhart and Russell model (1966), Perkins and Jinks model (1968) and Freeman and Perkins model (1971).

Eberhart and Russell's model: The methodology suggested by Eberhart and Russell (1966) was used for estimating three parameters of stability *viz.*, mean (\bar{Y}_i), regression coefficient (b^{Ei}) and mean square deviation [$\bar{S}_{d_i}^2$ (E)] for each genotype.

Perkins and Jinks' model: Three stability parameters *viz.*, mean (\bar{Y}_i), regression coefficient (b_i) and deviation from regression ($\bar{S}_{d_i}^2$) were estimated using the methodology given by Perkins and Jinks (1968) in which a regression of G x E interaction on environmental index was obtained rather than regression on mean performance.

Freeman and Perkins' model :

The joint regression analysis proposed by Freeman and Perkins (1971) was carried out for obtaining three stability parameters *viz.*, mean (\bar{Y}_i), regression coefficient (b^{Fi}) and mean square deviation from regression [$\bar{S}_{d_i}^2$ (F)] in which environment is completely independent of phenotype and giving correct partitioning of sum of squares due to different components.

Results and Discussion

The pooled analysis of variance for grain yield displayed highly significant differences among genotypes (G), environments (E) and G x E

interactions (Table 1). This showed that genotypes did not differ only genetically but also some of these exhibited differential response to variable environments. The results indicated that the presence of ample genetic variability for grain yield and presence of genotype x environment interaction. The estimates of stability parameters obtained for grain yield data using three models *viz.*, Eberhart and Russell's (ER), Perkins and Jinks' (PJ) and Freeman and Perkins' (FP) are presented in Table 2 and the correlations among them are shown in Table 3.

In the table 2, Y_i stands for mean grain yield of i^{th} genotype; b^{Ei} , B_i and b^{Fi} are the regression coefficients for i^{th} genotype as per Eberhart and Russell's (ER), Perkins and Jinks' (PJ) and Freeman and Perkins' model (FP), respectively. Similarly, $\bar{S}_{d_i}^2$ (E) and $\bar{S}_{d_i}^2$ (F) represent mean square deviation from the regression under ER model and FP model, respectively.

The mean grain yield ranged from 1473 kg (G₂₄) to 2745 kg (G₃), the differences being significant. The b^{Ei} and B_i were significant for G₄ and G₁₇. The genotype G₄ exhibited high grain yield and was responsive to favourable environments ($b^{Ei} > 1$ and $B_i > 0$). While G₁₇ gave lower yield than overall mean and was responsive to poor environments ($b^{Ei} < 1$ and $B_i < 0$). Further, genotypes G₁, G₂, G₃, G₆, G₇, G₁₀, G₁₁, G₁₃, G₁₅, G₁₈, G₁₉, G₂₀, G₂₂, G₂₃ and G₂₃ deviated significantly from linearity as $\bar{S}_{d_i}^2$ (E) > 0 for these genotypes. These deviation from regression indicated that they were unstable genotypes and their performance was not stable in varied environmental conditions. On the other hand genotypes G₃, G₆, G₁₁, G₂₀ and G₂₃ also deviated significantly from linearity as $\bar{S}_{d_i}^2$ (F) were significant for these five genotypes and gave unstable performance over environments studied. While comparing $\bar{S}_{d_i}^2$ (E) and $\bar{S}_{d_i}^2$ (F) values, many genotypes were skipped from significant deviation from regression as calculated from Freeman and Perkins' model (1971) and was very sensitive approach as compared to Eberhart and Russell's model (1966). Similarly, while comparing regression coefficient from all the three models revealed that regression coefficient calculated from b^{Ei} and b^{Fi} were very close as compared to B_i values for most of the genotypes, but test of significance of b^{Ei} and B_i gave same results.

On the basis of grain yield performance ($>$ average yield) and stability parameters ($b^{Ei} = 1$, $B_i = 0$, $b^{Fi} = 1$, $\bar{S}_{d_i}^2 = 0$), the hybrid G_8 (GHB-788), G_{14} (GHB-832) and G_{16} (GHB-840) were considered as stable and widely adapted over all the environments. These results are in agreement with those reported by Shinde *et al.* (2002), Chikurte *et al.* (2003) and Yahaya *et al.* (2006).

Correlation matrix showed that the ranking patterns for b^{Ei} and B_i were similar ($r = 1.000$) suggesting that both the methods (ER and PJ) were identical. The ranking pattern of genotypes using b^{Fi} values was also very close to the ranking pattern done under previous two models ($r = 0.9655$, Table 3). In ER model G_4 had the highest regression value ($b^{Ei} = 1.323$) followed by G_{19} ($b^{Ei} = 1.269$), and G_7 ($b^{Ei} = 1.323$) and the lowest b^{Ei} was observed for G_{24} ($b^{Ei} = 0.652$), whereas in FP model, G_4 had the highest regression value ($b^{Fi} = 1.358$), followed by G_7 ($b^{Fi} = 1.288$), and G_8 ($b^{Fi} = 1.243$) and the lowest b^{Fi} was observed for G_{24} ($b^{Fi} = 0.662$). This showed that ranking pattern of genotypes on the basis of responsiveness in FP model was not similar to the ranking pattern in ER and PJ models and also the $\bar{S}_{d_i}^2$ (F) showed predictable performance for all the genotypes barring G_3 , G_6 , G_{11} , G_{20} and G_{23} . It can be seen from the table 3, that b^{Ei} ($r = 0.8018$), B_i ($r = 0.8018$) and b^{Fi} ($r = 0.8145$) were significantly associated with mean grain yield (\bar{Y}_i), while non-significant association of grain yield was observed with $\bar{S}_{d_i}^2$ (E) and $\bar{S}_{d_i}^2$ (F). It was also observed that $\bar{S}_{d_i}^2$ (E) was significant and positively associated with b^{Ei} , B_i and b^{Fi} , while $\bar{S}_{d_i}^2$ (F) was positive but non-significant with b^{Ei} , B_i and b^{Fi} .

The deviation observed between ranking patterns of genotypes (based on stability parameters) in FP model and other two models was primarily due to the fact that FP model used part of the experimental data (two replications in present study) and not full set of data as in ER and PJ models. FP model did not reflect actuality existing in the full set of data. Theoretically, FP model is sound but precision point of view ER and PJ are good. This study revealed the empirical association among all the three models.

The variation in sample size (replications) affected the estimates causing deviation in ranking pattern of genotypes in ER and FP models, very specifically with reference to $\bar{S}_{d_i}^2$ estimates of both the models. Any estimate based on full set of data is more reliable and precise than that with partial data set. Therefore, it is advisable not to use FP model for stability analysis. It is concluded that ER model can be used for stability analysis. Luthra and Singh (1974) and Prajapati *et al.* (1998) also recommended ER model on the ground of simplicity and computational convenience.

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Table 1. Pooled analysis of variance of grain yield in pearl millet

Source of Variation	DF	SS	MS
Genotypes (G)	23	57582749.4	2503597.8**
Environments (E)	7	480251169.2	68607309.8**
G x E	161	78427463.9	487127.1**
Error	384	54919138.5	143018.5

** Significant at 0.01 probability level

Table 2. Estimates of stability parameters based on eight environments using various models for grain yield in pearl millet.

Genotypes	\bar{Y}_i	b^{Ei}	B_i	b^{Fi}	$\bar{S}_{d_i}^2 (E)$	$\bar{S}_{d_i}^2 (F)$
G ₁	2328	0.935	-0.065	0.919	66359.7*	-60681.4
G ₂	2520	1.096	0.096	1.070	108223.5**	-12375.8
G ₃	2745	1.068	0.068	1.135	241238.1**	369707.4**
G ₄	2732	1.323*	0.323*	1.358	33569.0	-6150.3
G ₅	1939	0.888	-0.112	0.913	-13994.1	-22528.5
G ₆	2250	1.145	0.145	1.163	299571.5**	403894.5**
G ₇	2679	1.258	0.258	1.288	337250.6**	239213.1
G ₈	2709	1.170	0.170	1.243	39721.8	-21937.0
G ₉	2014	0.972	-0.028	0.956	39976.5	64980.7
G ₁₀	2490	1.076	0.076	1.142	127555.5**	-736.3
G ₁₁	2052	0.915	-0.085	0.978	248755.5**	307406.3*
G ₁₂	1760	0.832	-0.168	0.837	4707.0	-41994.6
G ₁₃	2006	0.821	-0.179	0.782	71406.3*	156714.0
G ₁₄	2323	1.006	0.006	1.054	798.0	27434.5
G ₁₅	2371	1.147	0.147	1.149	69746.8*	53712.4
G ₁₆	2331	0.839	-0.161	0.789	-515.0	-47649.6
G ₁₇	1994	0.707*	-0.29*	0.735	37681.4	-65385.2
G ₁₈	2078	0.928	-0.072	0.931	58185.7*	-45149.3
G ₁₉	2519	1.269	0.269	1.182	156991.5**	166346.7
G ₂₀	2318	1.131	0.131	1.086	184477.2**	374871.1**
G ₂₁	2205	0.918	-0.082	0.894	10625.5	-87216.2
G ₂₂	2425	0.903	-0.097	0.868	84796.4*	16544.0
G ₂₃	1990	1.000	0.000	0.893	150759.9**	384656.5**
G ₂₄	1473	0.652	-0.348	0.662	87982.3*	7335.6
C. D. at 5%	394					
Average	2260					

* Significant at 0.05 probability level, ** Significant at 0.01 probability level



Table 3. Correlation matrix among various stability parameters for grain yield in pearl millet.

	\bar{Y}_i	b^{Ei}	B_i	b^{Fi}	$\bar{S}_{d_i}^2 (E)$
b^{Ei}	0.8018**				
B_i	0.8018**	1.000**			
b^{Fi}	0.8145**	0.9655**	0.9655**		
$\bar{S}_{d_i}^2 (E)$	0.2934	0.4282*	0.4282*	0.4306*	
$\bar{S}_{d_i}^2 (F)$	0.1267	0.3506	0.3506	0.3012	0.8224**

* Significant at 0.05 probability level, ** Significant at 0.01 probability level