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Linear regression model for stability analysis in blackgram (*Vigna mungo* L. Hepper) Germplasm

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Abstract
Twenty-one blackgram genotypes were evaluated over three seasons to identify stable genotypes for eleven quantitative characters in blackgram. The stability analysis was carried out by Eberhart and Russell method where, analysis of variance showed significant differences among the genotypes for all the characters indicating the presence of inherent genetic variability. Genotype × environment interaction, showed significant variance for all the characters indicating considerable effect of seasons on genotypes. The seasonal indices stated that among the three seasons studied, season 1 and 3 was found as favourable, season 2 was fair, thus stating that Markazhi - Thaipattam (Winter irrigated) was found to be suitable for blackgram production. For seed yield per plant, none of the genotypes were found as stable. Genotypes KU-11680, VBG-12062 and ADT-5 were suitable for favourable environment and KGB-28 was suitable for unfavourable environment.

Keywords: Blackgram, stability, Eberhart & russell

Introduction
Pulses belong to one of the largest family Fabaceae. Blackgram (*Vigna mungo* L. Hepper), is mainly cultivated in Indian subcontinent. India is major producer and consumer of blackgram. It is the best source of protein, fat and carbohydrates and also contains iron, folic acid, calcium, magnesium, potassium and vitamin B. According to Shanthi *et al*. (2007) [2], though several improved varieties in blackgram have been developed, most of them show inconsistent performance under varied environmental conditions due to genotype x environment interaction. Genotype x Environment interaction is an important and essential component of plant breeding programs dedicated to cultivar development (Natarajan, 2001) [1].
Further, Genotype X environment interaction, an essential source of phenotypic variation, is of great importance in the development and evolution of plant cultivars. As it is under the control of genes, the breeders are able to select suitable genotypes in advance generations by growing them under different environmental conditions. The yielding ability of a crop variety over a wide range of environments is as important as its yielding potential *per se* especially so, when the crop is grown under wide range of environmental conditions. Developing a stable variety in blackgram is very important to meet out the climate change in future. In view of these, twenty-one blackgram genotypes were evaluated under three seasons to identify the stable genotypes.

Materials and Methods
In this experiment, twenty-one blackgram genotypes were grown in Plant Breeding Farm, Department of Genetics & Plant Breeding, Annamalai University in three seasons (Jan-2017, Jul-2017 & Jan-2018). The experiments were conducted in Randomized Block Design with two replications. Standard agronomical practices were followed to raise the crop. The mean value of two replications over seasons were used for statistical analysis. The observations were recorded for eleven quantitative characters *viz.*, days to first flowering, plant height, number of branches, number of clusters per plant, number of pods per plant, pod length, pod weight, number of seeds per pod, seed size, 100 seed weight and seed yield per plant. The data for all the traits were subjected to analysis of variance and stability parameters using statistical package TNAUSTAT. The stability of the genotypes for each trait was calculated by regression of the mean of individual genotypes in environmental index and deviation from the regression coefficient from unity as per methodology of Eberhart and Russell model (1966) [3].

Results and Discussion
Environment is the sum total of physical, chemical and biological factors. Genotype x environment interaction is important for plant breeding because it affects the genetic gain and

recommendation and selection of cultivars with wide adaptability (Deitos *et al.*, 2006; Souza *et al.*, 2009) [4, 5]. G x E interactions have major importance to plant breeder in developing improved varieties. According to Nath and Dasgupta (2013) [6], low levels of interactions are useful for some characters so as to maximize the stable performance over a number of environments and for some situation high interactions are beneficial and can be explored.

The mean data averaged over replications for genotypes from three seasons for each eleven characters were subjected to pooled analysis and the results are presented in Table 1. The mean squares due to genotypes, environments and G × E were tested against mean square due to pooled error and they were significant for all the characters and satisfied the requirement of stability. The analysis was therefore extended further to estimate the stability parameters for all the traits. The results revealed that variance due to genotypes and environment + (G × E) were significant for all the traits studied except number of branches. It is therefore evident that, the characters that are significant in all the seasons may give more reliable results on genetic parameters (Anandan, 2001) [7].

Table 1: Analysis of variance of 21 blackgram genotypes pooled over seasons

Source	Df	Days to first flowering	Plant height (cm)	Number of branches	Number of clusters per plant	Number of pods per plant	Pod length (cm)
Genotypes	20	39.28**	1230.89**	2.57**	4.66**	56.56**	0.25**
Environment	2	497.33**	3932.13**	0.54*	9.91**	8.27**	0.30**
G×E	40	13.63**	282.14**	0.20*	2.26**	12.28**	0.07**
Environment + G×E	42	36.66**	455.95**	0.22	2.63**	12.09**	0.08**
Environment (Linear)	1	994.65**	7864.27**	1.08**	19.81**	16.53**	0.59**
G×E (Linear)	20	27.03**	536.17**	0.07	3.76**	21.36**	0.11**
Pooled Deviation	21	0.2132	26.76	0.31**	0.73*	3.05*	0.03
Error	60	0.52	123.65	0.28	0.71	3.03	0.03
Source	**Df**	**Pod weight (g)**	**Number of seeds per pod**	**Seed size (mm)**	**100 seed weight (g)**	**Seed yield per plant (g)**	
Genotypes	20	0.004**	0.71**	0.001**	0.56**	2.75**	
Environment	2	0.04**	3.98**	0.003**	1.01**	2.81**	
G×E	40	0.002**	0.22**	0.0001**	0.12**	0.70**	
Environment + G×E	42	0.003**	0.40**	0.0002**	0.17**	0.80**	
Environment (Linear)	1	0.07**	7.96**	0.007**	2.02**	5.61**	
G×E (Linear)	20	0.003**	0.31**	0.0001**	0.24**	1.26**	
Pooled Deviation	21	0.0002	0.13	0.0001	0.0003	0.12**	
Error	60	0.005	0.23	0.0001	0.01	0.07	

* Significant at 5 percent level; ** Significant at 1 percent level

The seasonal indices of five characters were negative in season 1, where as in season 2, seven characters were negative (Table 2). In season 3, seasonal indices of days to first flowering, plant height, number of clusters per plant and number of pods per plant were in negative direction. Among the three seasons, season 1 and 3 were found to be favourable and season 2 was fair, thus stating that Markazhi – Thaipattam (Winter irrigated) was found to be suitable for blackgram cultivation.

Table 2: Seasonal indices for eleven characters

S. No.	Characters	S1	S2	S3
1	Days to first flowering	-3.21	5.60	-2.39
2	Plant height	-9.78	15.64	-5.86
3	Number of branches	-0.05	-0.13	0.18
4	Number of clusters per plant	-0.15	0.75	-0.60
5	Number of pods per plant	-0.18	0.70	-0.52
6	Pod length	0.07	-0.14	0.07
7	Pod weight	0.03	-0.05	0.02
8	Number of seeds per pod	0.38	-0.48	0.10
9	Seed size	0.01	-0.01	0.003
10	100 seed weight	0.13	-0.25	0.13
11	Seed yield per plant	0.24	-0.42	0.19

S1 – Season 1; S2 – Season 2; S3 – Season

The mean performance of a genotype along with two parameters viz., regression coefficient (bi) and deviation from regression (S2di) considered simultaneously representing a measure of adaptability of the genotype. A genotype with desirable mean, deviation from regression line (S2di = 0) not significantly deviating from zero and unit regression coefficient (bi = 1) not significantly deviating from 1 is said to be average responsive and suitable for all the environments. Yield being the most important criteria for selection in any breeding programme identification of genotype with high mean value and non-significant bi and S^2di value is essential. However, in the present study, the magnitude of the regression coefficient and deviation from regression varied from genotype to genotype. Out of 21 genotypes studied, 17 genotypes were found stable for grain yield over seasons as indicated by the regression coefficient (bi). Among these 17 stable genotypes, none of the genotypes was stable as indicated by their bi value (Table 3).

Table 3: Stability parameters of genotypes for seed yield per plant

Genotypes	Seed yield per plant		
	Mean	Bi	S^2di
IC-343943	2.72	2.07	-0.02
IC-343947	3.18	2.25**	-0.03
IC-343962	2.66	0.12	-0.02
ABG-11013	3.62**	1.58	0.57**
KU-11680	4.20**	3.56	0.09
TBG-104	2.16	0.80	0.30**
VBG-10010	5.46**	6.88**	-0.01
VBG-11011	4.50**	2.66	0.67**
VBG-12005	2.71	-0.41	-0.02
VBG-12062	4.24**	4.02	0.05
VBG-13017	2.17	0.31	0.22**
ADT-5	4.16**	3.25	-0.01
RU-16-9	2.69	-1.48	-0.01
RU-16-13	2.14	-0.74	-0.03
RU-16-14	2.65	-1.52	-0.02
KGB-28	3.43*	0.57	0.01
T-9	2.37	-1.17	0.06
VBN(Bg)-4	2.15	-0.16	0.03
VBN(Bg)-6	2.16	-0.76	-0.02
VBN(Bg)-7	2.27	-1.15	0.07
MDU Local	2.65	0.33	0.04

The other 3 genotypes *viz.*, KU-11680, VBG-12062 and ADT-5 were identified as suitable genotypes for favourable environment as indicated by their high bi value (>1.0). On the other hand, low regression coefficient value (<1.0) was recorded by genotype KGB-28. Thus, indicated it suitability for unfavourable environments.

The genotype VBG-10010 which recorded highest mean for yield were recorded highest bi value but it showed significant value with S^2di. It indicates genotype VBG-10010 had high variation over the seasons. The other genotype VBG-11011 had shown high mean yield were found to be unstable in their performance over as season indicated by their significant deviation from regression for seed yield per plant. Sirohi and Singh (2013) [8], observed significant G × E interaction for seed yield per plant in blackgram.

The results suggested that no single genotype was stable for seed yield per plant. On the basis of mean performance and stability parameters, the genotypes namely KU-11680, VBG-12062, ADT-5 and KGB-28 can be considered as stable one. These genotypes may be recommended for commercial cultivation or used as parent in crossing programme aimed at breeding a high yielding variety with general adaptability.

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