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G x E Interaction for Yield and its Attributing Traits in High Altitude Maize Hybrids

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ABSTRACT

The present study was undertaken to evaluate eleven maize hybrids including one check under three different locations of Jammu and Kashmir spreading over different agro-climatic zones during Kharif-2016 for stability parameters with respect to grain yield and other related traits. Analysis of variance was highly significant for hybrids. The mean squares due to environments was also significant for all the traits except Cob height (cm) indicating that the environments selected were random and were different in agro-climatic conditions. Interaction of genotypes with the environment (G × E) was observed to be significant for all the traits, which revealed linear response of the genotypes to environmental changes. Thus the genotypes differed considerably for stability for the traits under investigation over the locations. The variance due to environment (linear) was significant for all the characters indicating that environmental effects were additive. The pooled deviation was also significant for all the traits indicating that non-linear component of hybrid × environment interaction was predominant. Based on the stability parameters of Eberhart and Russell (1966) model, hybrids H2, H4, H5 and H7 had higher mean performance. Highest mean performance for Grain Yield (qha^{-1}) with b_i and S^2d_i non-significant was observed in H2 (81.55 q/ha) which was surpassing the check SMH-1 (76.22) by 7 % which indicated that the hybrid was found promising in all environments.

Key words: *Maize, Hybrids, Genotype x Environment Interaction, Additive, Environment, Hybrids, Stability, Regression.*

INTRODUCTION

Genotype × environment (G x E) interactions are of major importance because they provide information about the effect of different environments on cultivar performance and have a key role for assessment of performance stability of the breeding materials[18].

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Genotype x environment interaction is important in the development and evaluation of plant varieties as it reduces the genotypic stability values under different environments[12]. The improvement of cultivars or varieties, which can be adapted to a wide range of diversified environments, is the ultimate goal of plant breeders in a crop improvement program. The adaptability of a variety over diverse environments is usually tested by the degree of its interaction with different environments under which it is planted. A variety or genotype is considered to be more adaptive or stable if it has a high mean yield but a low degree of fluctuation in yielding ability when grown over diverse environments. G x E interaction causes fluctuations of yield across environments. When productivity is extremely low, it is not even possible to discriminate selectively among genotypes. Large G x E effects tends to be viewed as problematic in breeding because it hinders progress from selection[10]. Significant achievement in crop production may be possible by breeding varieties for their stability for yield and yield components[16,22]. The view of plant breeders is that, environment is a general term that covers conditions under which plants grow and may involve locations, years, management practices or a combination of these factors. Every factor that is a part of the environment of a plant has the potential to cause differential performance that is associated with genotype x environment interaction[11]. When assessing grain yield of a set of cultivars in a multi-environment trial, changes are commonly observed in the relative yield performance of cultivars with respect to each other across sites. This differential yield response of cultivars from one environment to another is called genotype x environment interaction (GEI) and can be studied, described, and interpreted by statistical models. Developing crop cultivars that perform well across a wide range of environmental conditions has long been a major challenge to plant breeders. In practice, genotype x environment interaction complicates the identification of superior genotypes[3] plant breeders, large genotype x environment interaction impedes progress from selection and has important implications for testing and cultivar release. Statistically, G x E interactions are detected as a significantly different pattern of responses among the genotype across environments and biologically, this will occur when the contributions (or level of expression) of the genes regulating the trait differ among environments[5]. High and stable yield of hybrids is highly desirable in maize breeding programme. Stable yield of a hybrid would mean that its rank, relative to other hybrids, remains unchanged in a given set of environments[1]. Therefore, an attempt has been made in the present investigation to evaluate different maize hybrids for their stability performance under varied agro-climatic conditions in Jammu and Kashmir.

MATERIALS AND METHODS

Eleven maize hybrids along with one check (SMH-1) were evaluated in a Randomized Block Design with three replications at each location, having a plot length of 4 m with inter and intra row spacing of 75cm and 20cm respectively during *kharif*-2016 across three locations spreading over different agro-climatic zones of Jammu and Kashmir, *viz*., Mountain Crop Research Station (MCRS), Larnoo, Dryland Agriculture Research Station (DARS), and Main Campus, SKUAST-K, Shalimar in three districts of Anantnag, Budgam and Srinagar respectively. The sowing was completed during the second fortnight of April at all the locations and recommended package of practices was followed to raise the crop. Data were recorded on plot basis for No. of kernels row^{-1}, No. of kernel rows Cob^{-1}, Cob Length (cm), 100 Kernel weight (g), Grain Yield (qha^{-1}). Seed yield of each hybrid was calculated at 15 per cent moisture content and converted into qha^{-1}. Five plants were tagged randomly for recording observations for each entry for all the quantitative characters. Mean of five plants for each entry in each replication was worked out for each character at each location and used for statistical analysis. Stability parameters for different characters were computed using the regression approach of Eberhart and Russell and can be expressed as:

$$\mathbf{x_{ij} = m_i + b_i I_j + \delta_{ij}}$$

Where,

x_{ij} = mean yield of i^{th} genotype in j^{th} environment

m_i = mean of i^{th} genotype over different environments

b_i = regression coefficient of i^{th} genotype on I_j

I_j= Environment index

δ_{ij} = deviation from regression of i^{th} genotype at j^{th} environment

Table 1: Pooled Analysis of variance for stability analysis (Eberhart and Russell, 1966) in maize over three locations

Source of variation	d.f.	Cob length (cm)	No. of kernels row^{-1}	No. of kernel rows cob $^{-1}$	100 grain weight (g)	Grain yield (qha^{-1})
Hybrid (H)	10	3.058 **	1.4677 **	29.191**	1.649 **	23.73 **
Environments (E)	22	0.299	0.3934 *	2.1720**	1.969 **	24.04 **
Hybrid x environment (H x E)	2	0.263	2.2122 **	13.2551**	19.892**	245.26**
Environment + (H x E)	20	0.303	0.2122	1.0633*	0.177	1.945 *
Environment (linear)	1	0.526	4.4244 **	26.5110**	39.78**	490.5 **
H x E (linear)	10	0.416	0.2970	1.7335**	0.267 *	3.288 **
Pooled deviation (non linear)	11	0.172	0.1150	0.3577	0.079	0.547
Pooled error	60	0.196	0.3579	1.2929	0.321	0.462

*Significantat p=0.05; ** Significant at p=0.01

RESULTS AND DISCUSSION

The analysis of variance of pooled data (Table 1) indicated significant differences among hybrids for all the traits studied suggesting the presence of variability among hybrids. The mean squares due to environments were also significant for all the traits except Cob length (cm) indicating that the environments selected were random and were different in agro-climatic conditions. Interaction of hybrids with the environment (H × E) were observed to be significant for the traits viz., No. of kernel rows cob^{-1}, No. of kernels row^{-1}, 100 Kernel weight (g), and Grain yield (qha^{-1}) revealed that the hybrids were having, by large significant differential response to the changing environments. The variance due to environment + (genotype × environment) was significant for all the characters except Plant height (cm). Partitioning of (Environment + (G × E)) interaction into environment (linear), G × E (linear) and pooled deviation, further confirmed the existence of significant variation among the environments with regard to their effect on the performance of hybrids for all the traits and had shown that environment effects were additive. G × E (linear) was significant for traits *viz.,* No. of kernel rows cob^{-1}, 100 Kernel weight (g) and Grain Yield (q/ha) which revealed linear response of the genotypes to environmental changes. The mean squares due to pooled deviation (non-linear) were significant for all the traits revealing that the non-linear component was important for these traits except Cob length (cm) which contributed to total H × E interaction. Thus the genotypes differed considerably for stability for the traits under investigation over the environments. Both linear and non linear components of H x E interactions were highly unpredictable and thus, required to be confirmed in more environments for their stability performance. The significant differences among genotypes, environments and H x E interaction for grain yield and yield related traits have also been reported by other researchers[2,8,9,14,17,20,21,22]. Once the G x E interactions was found to be significant, the next test is to identify stable genotypes. Many stability models have been developed to identify the stable hybrid. Eberhart and Russelll model is the one which has been used in maize and in other crops by several workers. Accordingly an ideal genotype is the one possessing high mean performance, with regression coefficient around unity (b_i = 1) and deviation from regression (S^2d_i) close to zero. The results of stability are representing in

Table 2.Among the hybrids H6 and H10 for cob length recorded high mean value with regression coefficient less than unity and non-significant deviation from regression indicating average stability across the locations and better adapted to poor conditions. The hybrid H2, H4 and H5 exhibited high mean for cob length with regression coefficient higher than unity and non-significant deviation from regression except H3 that showed significant deviation from regression revealing that they were specifically suited to favourable environments. Similar finding on identifying stable genotype for cob length using Eberhart and Russel's stability analysis was reported by Kaundal and Sharma[14], Nadagoud *et al*[19], Karadavut and Akilli[14].

Table 2: Estimate of stability parameters for yield traits in maize hybrids grown at three locations during Kharif 2016

Hybrids	Cob length (cm)			No. of Kernels row^{-1}			No of Kernel rows cob^{-1}			100 Kernel weight(g)			Grain yield (qha$^{-1)}$		
	(X)	b_i	S^2d_i	(X)	b_i	S^2d_i	(X)	b_i	S^2d_i	(X)	b_i	S^2d_i	(X)	b_i	S^2d_i
H1	24.27	3.08	-0.20	36.11	0.86	-0.90	16.66	0.60	-0.25	24.00	0.74	-0.28	76.33	1.07	-0.54
H2	25.66	4.01	-0.09	38.11	1.56	-1.19	15.88	0.25	-0.28	24.75	1.10	-0.29	81.55	0.70	-0.42
H3	23.55	5.10	0.85*	41.00	0.80	-1.17	16.22	0.85	-0.33	25.30	0.89	-0.28	75.55	1.18	-0.44
H4	26.16	2.00	-0.18	40.00	2.20	0.73	16.00	1.88	-0.20	24.16	0.69*	-0.32	78.33	1.32**	-0.58
H5	26.55	3.15	0.01	45.66	-0.90	-0.27	15.11	0.35	-0.08	25.33	1.13	-0.30	76.66	1.17	-0.57
H6	25.22	-0.54	-0.09	35.22	1.13	-1.08	15.11	-0.10	0.18	26.00	1.38	-0.31	72.00	0.80	0.20
H7	24.61	-2.62	-0.18	38.66	0.00*	-1.20	15.22	1.46	-0.22	24.33	0.64	-0.25	80.77	1.03	-0.58
H8	24.05	-3.08	-0.20	37.44	1.76	-1.02	15.66	0.68	-0.29	24.88	0.70	0.21	73.88	1.16	0.09
H9	24.05	2.62	-0.18	41.00	1.39*	-1.20	17.00	2.64	-0.24	24.66	1.23	-0.22	76.33	0.38	3.49*
H10	25.05	0.30	0.03	39.77	1.06	-1.16	15.33	1.96	-0.32	26.11	1.27	-0.26	74.50	0.98	-0.57
SMH-1	23.66	-3.00	-0.14	43.77	1.16	-0.79	14.77	0.43	-0.33*	25.00	1.13	-0.30	76.22	1.18	-0.44
Mean	**24.80**	-	-	**39.70**	-	-	**15.72**	-	-	**24.89**	-	-	**76.56**	-	-
SE (±)	**0.29**	**1.89**	-	**0.42**	**0.38**	-	**0.24**	**0.54**	-	**0.19**	**0.14**	-	**0.52**	**0.110**	-

For kernel row^{-1}, the regression coefficient and deviation of regression were non-significant for most of the hybrids except H7 and H9 suggesting that these hybrids are responsive and found suitable for all environments under study. Among these, H3 and H5 had higher mean than the population mean and regression coefficient (bi <1) from unity and non-significant deviation from regression revealing that they were average in stability specifically adapted to widely differing conditions for unfavourable environments. Whereas the hybrids H4, H10 and SMH1 showed higher mean value regression coefficient (bi >1) from unity and non-significant deviation from regression. Similar findings were obtained by Arunkumar and Singh[4] and Kaundal and Sharma[14].For kernels rows per cob^{-1}, stability parameters revealed that H4 and H9 recorded higher mean performance, deviation of regression coefficient (b_i >1) from unity and non-significant deviation from regression except SMH1, which revealed their adaptation to all the favourable environments. However, hybrids H1, H2, H3 and H8 showed higher mean value, regression coefficient (b_i < 1) from unity and non-significant deviation from regression. revealing that they were average in stability specifically adapted to widely differing conditions for unfavourable environments Similar findings were obtained by Choukan R.[6], Arunkumar and Singh[4] and Kaundal and Sharma[14], Singh *et al*.[22], and Vijay *et al*.[23].The stability parameters for 100 kernel grain weight revealed that the two Hybrids H6 and H10 recorded high mean value with b_i value greater than one and non-significant deviation from regression. This suggests that these two hybrids are more suitable for favourable environments with good crop management. However, H4 had significant deviation from regression coefficient indicating their below average sensitivity to environments with unpredictable performance. H3 and H5 had high mean with regression coefficient (b_i < 1) and non-significant deviation from regression revealing that they were average in stability. Hybrid H2 recorded mean value comparable to population mean with b_i value nearer to unity and non significant deviation from S^2d_i value, suggested that it was most stable for this across locations. The other set of genotypes were found to be unstable for expression of this trait as they are showing significant deviation from regression values. Arun *et al.*[4] also reported same results in their studies.For the yield (qha^{-1}) trait all the hybrids except H4 showed non-significant b_i values indicating stable performance of the genotypes over the environments. The values of S^2d_i were non-significant for all the crosses except H9. Hybrids H1 and H7 were stable hybrids across locations based on stability parameters of regression coefficient and non-significant nearer to 1 and zero and The hybrids H2, H5 were average in stability exhibited adaptability to poor environment because high mean performance and the value of regression coefficient lower than the unity indicating that these genotypes exhibit average performance over the environments. The hybrids H6, H9 and H10 were having low mean value and regression coefficient less than 1 showed greater G x E interactions over locations, results are in agreement with the result of Arunkumar and Singh[4], Karadavut and Akilli[13] and Nadagaud *et al*.[19]. In conclusion, hybrids H1, H2, H5 and H10 were identified as most stable hybrids based on stability analysis across locations for yield and yield related traits, however further evaluation both spatially and temporally should be done with increased number of locations to validate the stability. Hybrids selected in the present study were diverse and random. These hybrids possessed significant variation for all the traits. Stability of Grain Yield (qha-^{1}) across the environments revealed that two hybrids H2 and H5 were average adapted to poor and high input environments respectively. Highest mean performance for Grain Yield (qha^{-1}) was observed to be in H2 (81.55 q/ha) which was surpassing the check SMH1 (76.22) by 7%. Some elite hybrids (H1, H5, H7) showing higher productivity need to be tested at large number of locations across over years to further analyse their stability in identifying some hybrids for commercial cultivation. Some hybrids whose mean performance was better than the check but stability parameters as per Eberhart and Russell's model were not favourable need to be further analysed.

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