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Stability analysis in medium maturity maize (*Zea mays* L) hybrids for yield attributing traits under different ecology of Kashmir

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Abstract
Ten maize hybrids along with two checks were evaluated across three locations spread over different agro-climatic zones of Jammu and Kashmir that differ in soil type, altitude and mean annual rainfall during Kharif 2020. The experiment was laid out in a randomized complete block design with three replications. Stability parameters such as mean (X), regression coefficient (bi) and deviation from regression (S^2di) were evaluated in order to assess the stability of these hybrids for various characters under consideration. Analysis of variance revealed that the hybrids possessed highly significant variability for all the traits viz., No. of kernel rows cob^{-1}, No. of kernels row^{-1}, number of cobs plant$^{-1,}$ Shelling percentage and grain yield plant^{-1}. Interaction of genotypes with the environment (GxE) linear 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 of the traits under investigation over the locations. The hybrids H05, H23 and H32 were identified as most stable, H-11 and DHM-117 and PMH-10 were adapted to poor environments respectively in terms of grain yield stability. Highest mean performance for grain yield (q/ha) was observed to be in H05 (97.43 q/ha) in contrast to the checks DHM-117(92.73 q/ha) and PMH-10 (93.27 q/ha).

Keywords: Environment, genotype, maize, hybrids, stability

Introduction

Maize (*Zea mays* subsp. *mays*) also known as corn is a cereal grain first originated in southern Mexico about 10,000 years ago and belongs to family Poaceae (De Wet and Harlan, 1972) [9]. Due to its plasticity the suitability of maize to diverse environments is unmatched by any crop as the expansion of maize to new areas and environments still continues. It is grown in such areas where yearly rainfall ranges from 250 to 500 mm and from 580° N to 400° S latitude (Dowswell *et al*., 2019) [11]. The area under this crop is mostly in the warmer parts of temperate regions and in sub-tropical climate. All varieties of maize have 10 chromosomes (n=10). Some of the maize chromosomes have chromosomal knobs which are highly repetitive heterochromatic domains that stain darkly.

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 (Crossa, 1990; Vargas *et al*., 1999) [8, 21]. Developing crop cultivars that perform well across a wide range of environmental conditions has long been a major challenge to plant breeders. Genotype × environment interaction is important in the development and evaluation of plant varieties since it reduces the genotypic stability values under diverse environments (Hebert *et al*., 1995) [13]. For plant breeders, large genotype × environment interaction impedes progress from selection and has important implications for testing and cultivar release. Genotype × environment 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 (Moldovan *et al*., 2000) [17]. 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 crop improvement program. Consistent performance of a genotype across different sites or years are referred as stability. Environmental stratification to minimize G × E interaction has to be effectively tested.

Materials and Methods

The seed material was sown in a Randomized Complete Block Design with three replications during Kharif-2020 across three locations spreading over different agro-climatic zones of Jammu and Kashmir, viz., Mountain Research Centre for Field Crops, Khudwani (MRCFC), Dry land Agriculture Research Station (DARS), Rangreth and Faculty of Agriculture (FoA) Wadura. Data were recorded on plot basis for number of kernel rows cob^{-1}, number of kernels row^{-1}, number of cobs plant^{-1}, shelling percentage, and grain yield plant^{-1} (g).

Seed yield of each hybrid was calculated at 15 percent moisture content and converted into q/ha. 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.

Table 1: List of hybrids which were used in experiment are mentioned

Hybrids	Pedigree
H02	KML-225 x BML-6
H04	BML-6 x LM-13
H05	BML-6 x LM-14
H10	CML-451 x BML-6
H11	CML-451 x LM-13
H18	IML-187 x BML-6
H23	BML-6 xCML-425
H24	KDM-914A x BML -6
H32	CM212 x CML-451
H25	QML-16 x DQL-364-1
CHECKS	
DHM-117	BML-6 x BML-7
PMH-10	LM-23 x LM-24

Results and Discussion

Genotype environment interaction which is associated with the differential performance of genetic materials, tested at different locations in different years. Its influence on the selection and recommendation of genotypes has long been recognized in various studies (Crossa *et al*., 1990) [8]. The evaluation of genotypic performance at a number of locations provides useful information to determine their adaptation and stability. Analysis of variance for stability in the performance of different hybrids across locations revealed that mean square due to genotypes were highly significant for all the traits indicating the presence of genetic variability in the experimental material under investigation. The mean square due to environment (linear) was also significant for all the traits, indicating that the environments selected were random and were different in agro-climatic conditions. The interaction of genotype with the environment (G × E linear) were observed to be significant for all the traits, indicating differential response of the hybrids to the varying environments. Based on the performance of hybrids, the stability of hybrids for different traits was worked out. Analysis of variance (ANOVA) for stability performance across three random locations (Table-2) revealed that the hybrids possessed highly significant variability for all the traits viz., number of kernel rows cob^{-1}, number of kernels row^{-1}, number of cobs plant^{-1}, shelling percentage and grain yield plant^{-1}.

The mean squares due to GxE (linear) were significant for all the traits viz., number of kernel rows per cob, number of kernels per row, number of cobs per plant, test weight and grain yield. The mean square due to environment (E-linear) were significant for all the traits viz., number of kernel row cob^{-1}, number of kernels row^{-1}, number of cobs plant^{-1}, test weight and grain yield plant^{-1}.

Table 2: Analysis of Variance for stability of different traits in maize over locations

		Mean Sum of Squares				
Source of Variation	**df**	**No. of kernel rows^{-1}cob**	**No. of kernels^{-1} row**	**No. of cobs plant^{-1}**	**Test weight (g)**	**Grain yield plant^{-1}**
Genotypes	11	29.19***	1.45***	0.252***	16.1***	31.9***
E+(G*E)	21	32.2	109	0.08	77.9	341
E (Linear)	1	26.513**	4.421 ***	0.021**	1632**	7731***
G*E (Linear)	11	1. 732**	7.99 **	0.003**	19.4***	17.1 ***
Pooled deviation (non-linear)	12	0.355	8.12	0.003	2.00	21.9
Pooled error	72	1.272	0.171	0.007	1.53	3.80

*** Significant at 0.001 level.
**Significant at 0.01 level, *significant at 0.05 level.

Based on Eberhart and Russell's model (1966) [12], a wide adaptable genotype is defined as the one with b_i=1 and high stability as one with s^2di=0. As per the results obtained during present investigation the genotype demonstrated early maturity were H05 followed by H32 but based on stability parameters the genotypes viz H05, H32, H23, H11 and H24 were found the most stable across the locations/environments with non-significant linear (b_i) and non-linear (s^2di) components approaching to 1 and 0 respectively. For number of cobs plant^{-1}, the hybrids H02, H05, H10, H24 were found stable because of high mean and non-significant deviation. For number of kernels row $^{-1}$ hybrid H05, H11, H23, H25 and H32 were having high mean value but hybrids H05, H32 and H23 were found stable across the locations. For number of kernel rows cob^{-1}, the stable hybrids were H05, followed by H10 and H04 with high mean value. For grain yield plant^{-1} the hybrids H05, H32 and H23 were stable across the locations.

Stability analysis for most important trait i.e., grain yield revealed that the mean square deviation from regression was non- significant for all the genotypes, except H10, H11, H18 and H24. Based on the mean performance H05, H32 and H23 were high yielding hybrids across the locations and were average in stability while based on stability parameters the hybrids H11, PMH-10, DHM-117 were poorly adapted. The genotypes having significant and more than unit b_i values, were suited for better environment only for this trait. Significant mean square have been reported for most of the traits in maize genotypes over environments), Abera *et al*. (2013) [1] and Puttaranmanaik *et al*. (2016) [19]. The variance due to genotype x environment (linear), genotype, and environments were found significant for various straits by Nadagoud *et al*. (2012) [18]. Significant mean square for pooled deviation (non-linear) regarding various traits have been reported by Puttaranmanaik *et al.* (2016) [19], Sain *et al.* (1987) [20], Arun and Singh (2004) [6] and Kaundal and Sharma (2006) [14].

Based on the findings of the present study, it could be summarized as:

- Hybrids H05, H32 and 23 were identified as most stable hybrids based on stability analysis across locations for yield and other desirable traits, however further both spatially and temporally should be done with increased number of locations to validate the stability. Genotypes selected in the present study were diverse and random. These genotypes possessed significant variation for all the traits.
- Stability of grain yield (g) across the environments revealed that the genotypes H11, PMH-10 and DHM-117 were poorly adapted to all the environments respectively.

Table 3: Stability parameters for Number of kernel rows cob^{-1}. Number of kernels row$^{-1,}$ Number of cobs plant^{-1}, Shelling percentage and grain yield plant^{-1}

Hybrids	Number of kernel rows cob^{-1}			Number of kernels row^{-1}			Number of cobs plant^{-1}			Shelling percentage		
	(X)	b_i	S^2di	(X)	b_i	S^2di	(X)	b_i	S^2di	(X)	b_i	S^2di
H02	16.25	1.08	0.49	42.04	1.18	2.47	1.56	4.61	1.70	82.26	0.80	5.96
H04	16.87	1.18	2.40	42.86	0.85	3.29	1.53	1.44	-2.00	83.36	1.00	1.32
H05	17.44	1.06	0.20	44.61	0.89	0.06	2.00	1.15	0.04	85.30	0.94	0.23
H11	16.93	0.62	0.99	41.54	1.14	0.81	1.56	2.32	2.09	82.19	0.91	0.01
H18	17.18	1.15	0.48	43.43	0.97	1.22	1.48	8.07	3.84	82.23	1.24	1.26
H23	15.67	1.02	1.53	42.14	1.01	9.42	1.48	-4.61	1.70	81.76	0.91	-0.09
H24	15.56	0.85	0.05	43.95	0.90	0.80	1.45	1.29	0.23	84.42	1.07	0.60
H25	15.82	0.66	1.18	41.33	1.06	2.93	1.71	-2.69	4.27	83.07	0.79	1.34
H32	16.40	1.35	3.30	43.59	1.32	3.88	1.44	2.69	4.27	82.37	0.91	7.61
DHM-117	16.85	1.31	0.35	45.08	1.03	0.01	1.48	1.44	0.09	84.16	1.18	0.36
PMH-10	14.68	1.81	0.81	42.34	0.85	4.95	1.44	1.77	-2.20	81.41	1.16	5.99
MEAN	15.56	1.05	0.88	41.79	0.67	2.22	1.43	1.39	-0.001	81.01	1.08	0.88
SE (m)	16.26	-	-	42.89	-	-	1.54	-	-	82.62	-	-

Hybrid	Grain yield plant $^{-1}$		
	(X)	b_i	S^2di
H02	145.19	1.06	4.85
H04	145.84	1.10	-1.22
H05	147.63	0.92	0.39
H11	144.80	0.99	3.12*
H18	142.09	0.78	5.75*
H23	144.88	0.71	2.47*
H24	146.12	0.93	0.98
H25	145.83	1.17	2.69*
H32	143.27	1.31	-1.22
DHM-117	146.78	0.92	0.57
PMH-10	140.51	1.08	5.98
MEAN	141.33	0.99	-1.37
SE (m)	145.89	-	-

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