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Stability analysis for yield and related traits in maize (*Zea mays* L.) hybrids grown under different moisture regimes in terai region of West Bengal

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ABSTRACT

A study was undertaken with eight maize hybrids in three different environments, characterized by having different moisture regime with different irrigation scheduling, in the experimental farm of Uttar Banga Krishi Viswavidyalaya located under terai region of West Bengal to assess the extent of genetic variability of the different hybrids and to analyse the stability performance for yield and other yield related traits. There existed substantial variation in the mean performance of all the genotypes over environments for most of the characters and for yield r under moisture regime-1 was the rich environment and the two other were poor . But for plant height, number of tassel branches, ears per plant and width of ear the g x e (linear) and pooled deviation were both significant indicating differential performance of genotypes under diverse moisture regimes environments and with varying reaction norms and they were positively and significantly correlated with the yield. Hence selection may be made for related traits under poor environments (stress) and then for yield under rich environments and under optimum conditions with emphasis on the related traits. The hybrids Deccan and 900-M-Gold had the negative phenotypic stability with high deviation from linearity while the hybrid KMH-3712 showed negative deviations from linearity with a low but positive phenotypic stability for grain yield. Ganga Safed and Pinnacle could be recommended for the rich environments as better yielding ones but none of the hybrids were found to be stable over all the environments. That moisture regime during crop growth is an important factor is thus found to be an important factor in this region for the studied genotypes as found in similar such studies.

Keywords **:** Maize, moisture, stability

Maize (*Zea mays* L.) is an important multipurpose cereal and has many beneficial uses including the industrial ones besides being the food supplement. It creates greater flexibility as it fits in various intensive cropping systems where sometimes more than two crops are taken during the year. Moreover, the spring and rabi maize are day by day gaining popularity with the farmers primarily because of the higher yield potential owing to assured irrigation facilities because among the various constraints for low grain yield, inadequate supply of water at its critical developmental stages and high sensitivity of different maize cultivars to water stress are of immense importance (Link *et al*., 1999; Shakhatreh *et al.* 2001).

In North Bengal there has been a substantial change in agricultural practices with maize being accorded greater importance as a crop to be of worth. Alone in Jalpaiguri district there has been a 426.1% increase in area under maize during a period of 16 years from 1989-90 to 2005-06 while the production has increased by 605.7% during the same (Sarkar, 2011). All these changes have been possible due to the introduction of high yielding varieties and improved management practices. Understanding the nature of the higher grain potential and enhanced yield stability especially in stress prone environments will provide opportunities to improve the breeding process. Though the yield is impeded by many factors, increment in production will have to come from hybrid maize. It is generally accepted that modern hybrids show an increased level of stress tolerance that counters the potential water limitations with significantly improved levels of productivity. Moreover, a very careful analysis of the factors that contribute maximum towards the yield need to done before embarking upon any ambitious programme on maize (Quayyum, 2002).

Similar to drought stress, excess of moisture also affects the crop growth. Besides reducing leaf growth water stress also has an effect on the cell turgour. In a study by Tripathi *et al*. (2003) in inbred lines of maize it was observed that waterlogging reduced the plant height, ear height, cob length and diameter and number of kernel rows/ ear and 100 seed weight besides decreasing the mean grain yield of all the lines under study. A similar study has been reported by Puste *et al.* (2014) where they have studied the growth, yield and other yield related traits of green gram-sesame intercropping under different moisture regimes in new alluvial zone of West Bengal. It has also been observed that early maturing maize hybrids could yield similarly to late maturing hybrids under dry land conditions (Maiti and Wesche-Ebeling, 1998). A similar such study

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was undertaken during 2012-13 with maize hybrids to assess their genetic variability *vis-à-vis* stability under different moisture regimes as influenced by the absence or presence of different irrigation schedules.

MATERIALS AND METHODS

The present experiment was carried out with eight hybrids including one local genotype of maize (*Zea mays* L.) during the rabi and pre-*kharif* season of 2012 and 2013 under three different moisture regimes (Table 1) in the experimental farm of Uttar Banga Krishi Viswavidyalaya located under terai region of West Bengal . The experiment was laid out in Randomized Block Design with three replications, each replication being divided into as many plots as the number of the cultivars for each moisture regime spanning over the rabi and pre-kharif season during 2012-13. [It appears that you have conducted one RBD experiment with 8 treatments (*viz*. varieties), it is also not clear how did you maintained different environments (*viz*. moisture regimes). For stability analysis you need to have three experiments for three moisture regimes (if moisture regimes are taken as different environments!) Which type of stability model you have used? Experimental procedure is not at all clear. It seems that experiment has been conducted for two years *i.e.* 2012 and 2013. Analysis does not reflect the same.] In each of the three experiments,the plots were separated from each other by a 50cm channel while irrigation channels were prepared at a distance of 1 m between each row of plots (replication). The row to row and plant to plant spacing was maintained at 75cm and 50cm respectively. A pre-planting irrigation was given in all the trials to ensure that the soil is fully wet prior to sowing. The seeds were chemically treated where required and subsequently soaked overnight in water to facilitate early emergence of seedlings. Otherwise the crops were raised by following the standard cultural practices including fertilization, weed control except in case of water management as the difference in the nature of the environments used in the investigation was due to the difference in their water regime. The moisture content of soil in different moisture regime was determined by the Gravimetric method**.**

Table 1 : The environments used in the experiment

Moisture regime- 1	Moisture regime -2	Moisture regime -3
Completely Rainfed Average Soil Moisture Content – 27.32% Range of soil moisture – 7.22% to 47.42%	Two irrigations viz. one at knee high stage and another at anthesis stage Average Soil Moisture Content **-** 27.09 % Range of soil moisture – 7.16% to 46.80%	Irrigated from emergence to anthesis stage (complete submergence) and followed by rainfed. Average soil moisture content - 40.14% Range of soil moisture – 23.28% to 46.82%

Observations were recorded on five randomly selected plants in each replication on the following characters *viz.*, plant height(cm), days to tasseling, days to silking , days to milking, number of tassel branches, days to 80% maturity , ear height(cm), number of ears per plant ,length of ear(cm), width of ear(cm), number of kernel rows ,100 seed weight(g) and grain yield (g) per plant. For stability analysis the yield was later converted into g/unit area. The observations were analysed by following the IndoStat package and stability analysis was done following Eberhart-Russel model.The rationale behind stability analysis was to find out the stable genotype under the moisture regime tested as maize is generally cultivated during the period of experimentation in this region of West Bengal.

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) revealed significant variances due to genotypes for the characters number of tassel branches, number of ears per plant, width of ear, 100-seed weight and grain yield per plant (Table 2). It also showed significant genotype × environment for almost all the characters except for days to silking, days to milking, days to maturity, and number of kernel rows. The ANOVA further revealed significant variation due to environment (linear) and significant pooled deviation for almost all the characters except days to silking and number of ears per plant. Thus there existed substantial variation in the mean performance of all the genotypes over environments for most of the characters. As far as grain yield per plant was concerned, the environmental index values showed the moisture regime 1 being the rich environment in having a positive index value (18.93) while the other two moisture regimes were poor ones in having negative index values (-14.48 and - 4.45 respectively) thereby indicating an incremental change in the performance of the environment with every unit change in the environment (Table 3). Significant genotype x environment interaction suggested differential performance of the maize genotypes (hybrids) under different environments. Significant linear (environment) performance indicated linear change in environmental index for each unit change of the environment (here

Table 2 : Analysis of variance (ANOVA) of genotype × environment interaction of maize hybrids grown under different moisture regimes

Sources of variation	d.f.	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
Rep. within Env	6	98.91	0.22	18.24	0.19	0.55	0.36	29.18	0.004	0.23	0.01	0.01	0.17	0.42
Varieties	7	522.39	14.57	23.54	14.24	31.23**	10.23	289.27	0.06**	3.32	0.17**	0.05	49.87**	1067.69**
Env.+ (Var.* Env.)	15	1738.90**	644.53**	802.67**	751.62**	18.21*	947.08**	460.57	0.01**	9.53**	0.24*	0.18*	5.79	643.79
Environment	2	11810.15**	4993.01**	6215.79**	5833.22**	62.95**	7365.04**	2362.16**	0.35**	67.23**	1.50**	0.92**	6.37	2351.53*
Var.* Env.	14	300.15**	23.32*	29.37	25.68	11.82**	30.23	188.92**	0.06**	1.28**	0.06**	0.07	5.71**	399.83**
Environments (Lin.)	1	23620.30**	9986.03**	12431.59**	11666.45**	125.90**	14730.09**	4724.33**	0.69**	134.47**	3.05**	1.85**	12.74	4703.06
Var. *Env(Lin.)	7	382.53	24.85	34.05	31.16	19.26*	39.77	173.30	0.12**	1.14	0.09*	0.08	2.27	431.93
Pooled deviation	8	190.54**	19.07**	21.60	17.68**	3.83**	18.10**	178.36**	0.01	1.25**	0.02*	0.05**	8.01**	321.76**
Pooled Error	42	21.85	0.29	17.33	0.33	0.94	0.33	8.20	0.01	0.14	0.01	0.01	0.37	0.28
Total	23	1368.66	452.8	565.54	527.20	22.18	661.95	408.44	0.09	7.64	0.22	0.14	19.21	772.80

** = Significant at 5% level of significance ** = Significant at 1% level of significance*

X1- Plant height (cm), X2 -Days to tasseling, X3- Days to silking, X4- Days to milking, X5- Number of Tassel branches, X6- Days to 80% maturity, X7- Ear height (cm), X8- Number of ears per plant, X9- Length of ear (cm), X10-Width of ear (cm), X11-Number of kernel rows, X12-100 seed weight (gm) & X13- Grain yield per plant (gm).

moisture content). But non-significant genotype x environment (linear) performance for yield indicated that linear sensitivity of different genotypes was not variable. Significant pooled deviation for yield indicated that different genotypes fluctuated significantly from their respective linear path of response to environments. But for plant height, number of tassel branches, ears per plant and width of ear the genotype x environment (linear) and pooled deviation were both significant thereby indicating differential performance of the maize genotypes under diverse moisture regimes and with varying reaction norms.

Hence selection might be made for related traits under poor environments (stress) and then for yield under rich environments and under optimum conditions with emphasis on the related traits. Similar findings were observed by Lata *et. al*. (2010) in a study with fifteen genotypes of maize at three locations where significant variances for yield and related attributes due to genotypes, environment and genotype × environment interaction had been noted and most of the genotypes showed significant deviation from mean square or regression coefficient(bi) and four out fifteen hybrids showed high mean performances for grain yield in addition to average regression coefficient(b_i=1) and least deviation from regression coefficient (σ^2di).

The stability parameters used in the present investigation were the mean performance, phenotypic stability (β_i) and deviation from linearity (σ^2_{di}). When analysed for the characters with significant genotype X environment interaction the values showed variation from genotype to genotype for grain yield. The hybrids 900-M-Gold, Pinnacle, Ganga safed and the Local genotype were the top performers and KMH-3712 was identified as the least performing one in the present investigation (Table 3).And for the same character, the hybrids Deccan and 900-M-gold had negative phenotypic stability but very high deviation from linearity (Table 4). On the other hand, the hybrid KMH-3712, showed negative deviations from linearity for grain yield with a low but positive phenotypic stability. For other hybrids, the phenotypic stability values were close to 1.00 (except 2.09 for Sugar -75) and they showed moderately high to very deviation from linearity.. For the other yield related traits, phenotypic values ranged from negative to positive values with low to moderate and very high values for deviations from linearity. Ganga Safed and Pinnacle may thus be recommended as better yielding genotypes for rich environment in the present study as the genotypes were having P_i>0 , b_i >1.0 and σ^2di being very high. But none of the hybrids could be recommended for overall environments (P_i>0, b_i=1.0 and σ^2di low). The results found resemblance with the findings of Uddin *et. al.* (2010) where in the experiment with four maize hybrids tested over nine different locations of Bangladesh significant variances due to environment and genotype X environment had been observed but the hybrids were found to be non-significant. In the same study, the environment linear component and pooled deviation were also found to be significant and the two hybrids were identified as being stable for kernel yield identical to a common grown variety pacific 11.

Table 3 : Genotypic, environmental, genotype × environment and environmental and phenotypic index for yield of maize hybrids grown in three different moisture regimes.

Genotype	Grain yield per plant (g)				
	Moisture regime			Mean	Phenotypic index
	E1	E2	E3		
KMH-3712	80.98	69.77	73.64	74.80	-25.96
Local(Pundibari)	124.83	104.30	88.90	106.01	5.25
Deccan	91.50	81.69	126.08	99.76	-1.00
Ganga Safed	134.88	88.49	88.84	104.07	3.31
Sugar-75	128.37	58.96	78.05	88.46	-12.30
900-M-Gold	137.52	144.86	123.45	135.28	34.52
Pinnacle	146.46	98.63	95.31	113.46	12.70
KMH - 22168	112.96	43.49	96.21	84.22	-16.54

Table 4 : Estimates of stability parameters for different characters in maize hybrids grown in three environments(moisture regimes)

Genotype	X1			X2			X5			X7		
	Mean(μ)	**$ß_i$**	**$σ^2_{di}$**	**Mean(μ)**	**$ß_i$**	**$σ^2_{di}$**	**Mean(μ)**	**$ß_i$**	**$σ^2_{di}$**	**Mean(μ)**	**$ß_i$**	**$σ^2_{di}$**
KMH - 3712	168.544	0.830	96.290	73.556	1.080	1.820	15.311	1.750	14.770	45.600	0.900	99.700
Local(Pundibari)	186.700	113.000	346.150	74.444	1.110	15.260	18.611	2.880	1.860	60.489	1.310	485.350
Deccan	186.600	0.700	722.870	71.000	0.790	13.680	11.300	-0.570	7.880	50.389	1.160	321.670
Ganga Safed	188.211	1.190	-19.650	73.222	0.950	9.050	11.678	1.300	-0.520	53.367	0.640	69.210
Sugar-75	189.311	0.640	-29.010	71.778	1.130	5.230	18.311	0.480	0.630	40.656	0.570	19.160
900-M-Gold	205.711	0.970	-31.420	74.667	1.090	-0.270	18.233	0.610	-0.890	57.189	0.800	81.120
Pinnacle	2011.956	1.750	216.610	68.000	0.790	98.070	19.200	1.690	0.260	70.422	2.140	263.890
KMH -22168	187.089	0.800	-29.340	71.333	1.070	7.520	18.318	-0.050	0.170	43.822	0.470	5.060
Popl. mean	**190.603**			**72.250**			**16.369**			**52.742**		

Table 4 contd.....

Genotype	X8			X9			X10			X12			X13		
	Mean(μ)	**$ß_i$**	**$σ^2_{di}$**	**Mean(μ)**	**$ß_i$**	**$σ^2_{di}$**	**Mean(μ)**	**$ß_i$**	**$σ^2_{di}$**	**Mean(μ)**	**$ß_i$**	**$σ^2_{di}$**	**Mean(μ)**	**$ß_i$**	**$σ^2_{di}$**
KMH - 3712	1.422	0.300	0.010	16.222	0.590	0.040	4.090	1.130	0.040	19.812	2.790	0.510	124.67	0.41	- 0.17
Local(Pundibari)	1.667	0.550	-0.010	18.643	1.160	4.450	4.134	0.520	-0.010	22.783	0.280	13.640	176.68	0.93	299.02
Deccan	1.811	0.380	0.000	18.511	0.940	-0.110	4.389	0.820	0.060	25.426	1.910	9.850	166.27	-0.11	1096.3
Ganga Safed	1.567	0.130	0.000	17.018	1.330	0.050	4.321	0.230	-0.010	24.778	1.810	10.140	173.45	1.59	119.08
Sugar-75	1.822	2.410	0.000	17.340	1.020	-0.080	4.534	1.540	0.000	15.381	-0.030	-0.260	147.43	2.21	2.01
900-M-Gold	1.778	-0.300	0.010	19.494	1.190	-0.040	4.851	0.860	-0.010	22.408	1.750	0.100	225.47	-0.12	251.06
Pinnacle	1.700	2.890	0.010	17.251	1.120	-0.010	4.279	1.380	0.030	25.873	-0.290	27.510	189.10	1.73	203.09
KMH -22168	1.811	1.630	0.000	17.563	0.660	4.510	4.368	1.520	0.010	16.172	-0.220	-0.190	140.37	2.13	653.11
Popl. mean	**1.697**			**17.555**			**4.371**			**21.579**			**167.93**		

ii = Phenotypic stability $σ^2_{di}$ = *Deviation from linearity*

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