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ASSESSMENT OF ADVANCED FIELD CORN HYBRIDS AT DIFFERENT LOCATIONS OF BANGLADESH

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Abstract

Fourteen promising crosses of maize and four check varieties (BHM-9, 981, Elite and NK-40) were assessed for genotype environment interaction (GEI) and stability in three agro-ecological zones of Bangladesh. The experiment was laid out in RCB design with three replications during rabi 2018-19. The AMMI (additive main effects and multiplicative interaction) model was used to select desired hybrid having higher yield and other potential attributes. Significant variation among the genotypes was noticed in all the characters except plant height and ear height whereas environment (E) was found significant for all the characters studied. The environment of Gazipur was poor and Dinajpur and Burirhar were suitable for the tested maize hybrids. Considering the mean, bi and S2di value all the genotypes showed differential response to adaptability under different environmental conditions. Hybrids E5 (BIL28×BIL79), E7 (BIL153×BIL95) and E9 (CML161×CML172) exhibited the higher yield as well as stable across location based on response (bi) and stability (S2di) parameter.

Keyword: Maize, single cross, stability, across location.

Introduction

Maize is one of the most important food grains in the world as well as in developing countries like Bangladesh. It is the highest yielding grain crop having various uses. A great combination of high market demand with relatively low production cost, ready market and high yield has generated great interest among the farmers in maize cultivation in Bangladesh. It is gaining popularity in the country due to vast demand, particularly for poultry industry. In 2020-21, maize was cultivated in 4.80 lakh hectare of land and produced 4.11 million tons in Bangladesh (BBS, 2022). Multi-environment yield trials are used commonly to release superior genotypes for target sites in plant breeding programs. GEI is universal phenomenon when different genotypes are tested in a number of environments. The large GEI variation usually impairs the accuracy of yield estimation and reduces the relationship between genotypic and phenotypic values (Nachit *et al.* 1992). Numerous methods for multi-environment trials data have been developed to expose patterns of G×E interaction (Yamada, 1962), joint regression (Finlay and

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Wilkinson, 1963; Eberhart and Russel, 1966), AMMI (Gauch, 1992) and GGE biplot (genotype main effect plus genotype by environment interaction). AMMI model combines the analysis of variance of genotypes and the environment main effects with principal component analysis of the GEI into a unified approach (Gauch and Zobel, 1996). Crossa et al. (1990) indicated that the AMMI model can be used to analyze the GEI and to identify the superior hybrid maize genotypes and the best environment . More precise GEI estimates can be obtained with the AMMI model which makes to easier to interpret the results (Durate and Vencovsky, 1999). The objective of this study was to use the AMMI analysis model to assess the stability of some single cross maize hybrids and verify the influence of a sample of environments at different locations of Bangladesh (Gazipur, Dinajpur and Burirhat) in the productive performance of these hybrids.

Materials and Methods

The experiment was conducted at three locations namely Gazipur, Dinajpur and Burirhat during rabi 2018-19. Fourteen single cross maize hybrids namely, E1 (BIL28 × BIL95), E2 (BIL50(1) × BIL28), E3 (BIL51(1) × BIL28), E4 (Lmly08 × BILl79), E5 (BIL28 × BIL79), E6 BIL121 × BIL95), E7 (BIL153 × BIL95), E8 (BIL26 × BIL79), E9 (CML161 × CML172), E10 (CML172 × CML191), E11 (CML193 × CML161), E12 (CML193 × CML162), E13 (CML491 × CML502), E14 (CLQRCWQ10 × CLQRCWQ26) and four check varieties (BHM-9, 981, Elite and NK-40) were evaluated in this study. The experiment was laid out in RCB design with 3 replications. Seeds of each entry were sown in two rows, 4m long plots with 60 cm and 25 cm spacing between rows and hills, respectively. Seeds were sown at Gazipur on 25 November, Dinajpur on 29 November and Burirhat on 19 November, 2018. One healthy seedling per hill was kept after thinning. Fertilizers were applied @ 250, 55, 110, 40, 5 and 1.5 kg/ha of N, P, K, S, Zn and B respectively. Standard agronomic practices and plant protection measures were taken as required. Two border rows at both end of each replication were used for minimize the border effect. Data on days to pollen shedding, days to silking was recorded on whole plot basis. Ten randomly selected plants were used for recording observations on plant and ear height. All the plants in two rows were considered for plot yield and converted to t/ha. The analysis of variance (ANOVA) was used and the GE interaction was estimated by the AMMI model (Zobel et al. 1988). In this procedure, the contribution of each genotype and each environment to the GE interaction is assessed by use of the biplot graph display in which yield means are plotted against the scores of the first principal component of the interaction (IPCA1). The computational program for AMMI analyses is supplied by Duarte and Vencovsky (1999). The stability parameters, regression coefficient (bi) and deviation from regression (S2di) were estimated according to Eberhart and Russel (1966). Significance of differences among bi value and unity was tested by t-test while between S2di and zero by F-test. All the data were processed and analyzed using PB Tools program.

Results and Discussion

Results of combined analysis of variance for five characters of eighteen hybrids at three environments are presented in Table 1. The mean sums of squares for the genotypes were significant for days to pollen shedding, days to silking and yield which revealed the presence of genetic variability in the material under studied. Environments mean sum of squares were highly significant for all of the characters. The highly significant effects of environment indicate high differential genotypic response across the different environments. The variation in soil structure and moisture across the different environments were considered as a major underlying causal factor for the G×E interaction. Environment relative magnitude was much higher than genotypic effect all trails suggesting that performance of each genotype is influenced more by environmental factors. Stability analysis for days to pollen shedding, days to siliking, plant height, ear height and yield were presented in Table 2-6. Results of stability and response of the genotypes under different environments according to Eberhart and Russell (1966) are discussed character-wise as follows; Stability parameter i.e. regression coefficient (bi) and deviation from regression (S2di) for days to 50% pollen shedding (DPS), days to 50% silking (DS), plant height (PH), ear height (EH), and grain yield (GY) were presented in Table 2, 3, 4, 5 and 6.

Table 1. Full joint analysis of variance including the partitioning of the G×E interaction of maize hybrids over 3 locations during 2018-19

Source of variation	Df	Mean sum of squares				
		Days to pollen shedding	Days to silking	Plant height (cm)	Ear height (cm)	Grain yield (t/ha)
Genotypes (G)	17	9.28*	9.87*	359.05	269.28	2.70*
Environment (E)	2	606.85**	512.35**	19079.4**	7695.62**	23.51**
Interaction G×E	34	9.72*	4.58	232.96	138.98	2.67*
AMMI Component 1	18	5.91	6.09	210.25	218.16	1.03
AMMI Component 2	16	1.26	2.88	46.01	49.90	0.26
G×E (Linear)	17	2.50	3.72	88.36	89.36	0.90
Pool deviation	17	4.94	5.44	177.57	188.36	0.44
Pooled error	106	6.61	7.30	284.65	222.30	1.28

*P<0.05, **P<0.01

In Eberhart and Russel (1966) model, regression coefficient (bi) was considered as an indication of the response of the genotype to varying environments while deviation from regression (S2di) was used as the criterion of stability. In the present study these two criteria were considered simultaneously to identify stable hybrids. A genotype with unit regression coefficient (bi=1) is said to be average responsive to environment and suitable for all environment therefore, more adaptive. If bi>1 is said to be highly responsive and suitable for favorable environment. If bi<1 is said to be less responsive and the genotype is suitable for unfavorable environment (Nadarajan and Gunasekaran, 2005).

Days to 50% pollen shedding along with the value of phenotypic indices (Pi), environmental index (Ij), regression coefficient (bi) and deviation from regression (S2di) were presented in Table 2. The genotypic mean value over the location ranges from 95 (E18) to 101 (E3 & E14) days. The genotypes which showed positive pi index took longer period and genotypes showing negative pi index took shorter period for day to 50% pollen shedding. The range bi and S2di values for days to 50 % pollen shedding were 0.09 (E2) to 1.38 (E3) and 0 (E12) to 15.57 (E17) respectively.

Table 2. Stability analysis for days to 50% pollen shedding of maize hybrids over three environments

Genotype	Locations			Overall mean	Pi	bi	S2di
	Gazipur	Dinajpur	Burirhat				
E1	95	103	90	96	-2.19	1.08	7.21
E2	94	104	96	98	-0.41	0.09	4.62
E3	100	110	94	101	2.80*	1.38	8.50
E4	96	106	97	100	1.02	0.95	1.53
E5	97	102	92	97	-1.42	0.81	5.89
E6	94	102	97	98	-0.97	0.63	8.27
E7	97	108	95	100	1.58	1.13	0.26
E8	97	107	94	99	0.91	1.19	1.37
E9	96	106	95	99	0.24	1.03	0.01
E10	97	106	93	99	0.02	1.18	3.57
E11	96	106	95	99	0.46	1.05	0.11
E12	97	108	96	100	1.91	1.13*	0.00
E13	98	104	97	100	1.02	0.71*	0.02
E14	97	108	97	101	2.02	1.10	0.43
E15 (BHM-9)	95	106	97	99	0.80**	0.97	3.00
E16 (981)	95	103	89	96	-2.86**	1.09	13.13
E17 (Elite)	92	103	97	97	-1.42	0.78	15.57
E18 (NK-40)	90	101	94	95	-3.53**	0.81	10.60
Mean	96	105	95	99	-	-	-
E. Index (Ij)	-2.77	6.67	-3.90	-	-	-	-
LSD (0.05)	1.92	3.99	3.30	-	-	-	-

Pi= Phenotypic Indices, bi= regression co-efficient and S2di=deviation from regression.

Days to 50% silking along with the value of phenotypic indices (Pi), regression coefficient (bi) and deviation from regression (S2di) are presented in Table 3. The genotypic mean ranged from 99 (E1, E16, E17 & E18) to 104 (E3, E7 & E14). Nine hybrids showed positive Pi index while the rest nine showed negative Pi index for days 50% silking. Genotypes showed positive Pi index took longer period and negative Pi index took shorter period for day to 50% silking. The bi and S2di values for days to 50% silking ranged from 0.64 (E6) to 1.49 (E14) and 0.19 (E12) to 18.15 (E17), respectively.

Table 3. Stability analysis for days to 50% silking of maize hybrids over three environments

Genotype	Locations			Overall mean	Pi	bi	S2di
	Gazipur	Dinajpur	Burirhat				
E1	98	107	94	99	-1.89	1.17	6.56
E2	96	105	99	100	-1.22	0.79	5.65
E3	102	113	98	104	2.99*	1.40	10.65
E4	98	107	100	102	0.43	0.79	2.06
E5	99	105	96	100	-1.34	0.81	4.41
E6	96	104	100	100	-1.34	0.64	11.00
E7	103	110	99	104	2.88*	0.94	7.86
E8	100	108	98	102	0.54	0.99	1.33
E9	99	109	99	102	0.88	1.04	0.20
E10	99	109	96	101	-0.22	1.22	3.44
E11	99	105	98	100	-0.89	0.68	0.21
E12	99	111	99	103	1.54	1.26	0.19
E13	100	107	100	102	0.99	0.75	0.20
E14	99	113	100	104	2.77*	1.49	0.56
E15 (BHM-9)	97	109	100	102	0.77	1.06	4.62
E16 (981)	97	105	94	99	-2.34	1.02	4.39
E17 (Elite)	94	104	100	99	-1.89	0.68	18.15
E18 (NK-40)	93	106	97	99	-2.67**	1.19	11.10
Mean	98	108	98	101	-	-	-
E. Index (Ij)	-3.06	6.16	-3.09	-	-	-	-
LSD (0.05)	1.69	4.23	3.03	-	-	-	-

Plant heights along with the value of phenotypic indices (Pi), regression coefficient (bi) and deviation from regression (S2di) are presented in Table 4. The genotypic overall mean for plant height ranged from 212 cm (E18) to 252 cm (E3 and E16). Nine genotypes showed positive Pi index while the rest nine showed negative Pi index for plant height. The genotypes showed positive Pi index represent taller and negative Pi index represent shorter plant height. The bi and S2di values range for plant height were 0.54 (E1) to 1.35 (E18) and 0.05 (E12) to 769.20 (E18), respectively.

Table 4. Stability analysis for plant height of maize hybrids over three environments

Genotype	Locations			Overall mean	Pi	bi	S2di
	Gazipur	Dinajpur	Burirhat				
E1	202	247	220	223	-15.35*	0.54	410.54
E2	184	257	246	229	-9.46	1.19	127.18
E3	225	268	263	252	13.54	0.71	34.00
E4	197	252	247	232	-6.35	0.93	37.71
E5	191	248	240	226	-12.02	0.93	64.38
E6	199	243	284	242	3.64	1.16	692.47
E7	214	271	267	251	12.20	0.96	25.46
E8	213	262	261	245	7.09	0.85	11.12
E9	203	275	257	245	6.75	1.11	242.18
E10	204	253	279	245	6.98	1.12	257.57
E11	208	253	252	238	-0.68	0.78	10.06
E12	189	255	260	235	-3.46	1.21*	0.05
E13	199	258	274	244	5.31	1.20	76.82
E14	194	245	261	233	-5.13	1.05	70.97
E15 (BHM-9)	207	256	251	238	-0.46	0.80	31.18
E16 (981)	214	265	278	252	14.09	1.02	50.23
E17 (Elite)	209	273	262	248	9.42	1.02	107.61
E18 (NK-40)	163	215	259	212	-26.13**	1.35	769.20
Mean	201	255	259	238	-	-	-
E. Index (Ij)	-37.54	16.98	20.56	-	-	-	-
LSD (0.05)	28.27	21.64	20.14	-	-	-	-

Ear height along with the value of phenotypic indices (Pi), regression coefficient (bi) and deviation from regression (S2di) are presented in Table 5. The genotypic mean for ear height 112 cm (E1) to 142 cm (E2). Eight genotypes showed positive pi index while rest ten showed negative Pi index for ear height. The genotypes showed positive Pi index represent taller and negative pi index represent shorter ear height. The bi and S2di values for ear height ranges from 0.43 (E11) to 10.50 (E6) and 1.58 (E5) to 624.89 (E9), respectively.

Yield along with the value of phenotypic indices (Pi), regression coefficient (bi) and deviation from regression (S2di) are presented in Table 6. The genotypic mean for yield ranged from 10.67 (t/ha) (E2) to 12.71 (t/ha) (E10). Ten genotypes had positive Pi index while the rest eight exhibited negative pi index for grain yield. The genotypes showed positive Pi index represented higher and negative Pi index represented lower yield. The bi and S2di values for yield ranged from -0.12 (E4) to 2.14 (E2) and 0.04 (E15) to 1.61 (E6), respectively.

Table 5. Stability analysis for ear height of maize hybrids over three environments

Genotype	Locations			Overall mean	Pi	bi	S2di
	Gazipur	Dinajpur	Burirhat				
E1	97	128	110	112	-15.51*	0.56	223.76
E2	122	152	152	142	-13.29	0.92	188.49
E3	102	135	120	119	14.82*	0.82	8.33
E4	90	131	135	119	-8.06	0.66	173.87
E5	114	127	167	136	-8.51	1.21	1.58
E6	115	157	148	140	8.93	10.50	614.15
E7	115	136	129	127	12.93	1.02	110.65
E8	112	169	139	140	-0.51	0.44	44.48
E9	105	138	175	139	12.82	1.08	624.89
E10	116	139	127	127	12.15	1.55	421.37
E11	93	137	141	123	0.26	0.43	103.90
E12	103	140	156	133	-3.62	1.29	5.09
E13	107	133	145	128	5.93	1.28	40.11
E14	104	132	142	126	1.26	0.92	25.70
E15 (BHM-9)	91	123	157	124	-1.06	0.95	10.73
E16 (981)	97	126	143	122	-3.40	1.47	339.80
E17 (Elite)	90	117	144	117	-4.84	1.08	60.59
E18 (NK-40)	90	133	118	114	-10.29**	1.20	208.75
Mean	103	136	142	127	-	-	-
E. Index (Ij)	-23.68	9.19	17.51	-	-	-	-
LSD (0.05)	24.68	5.04	12.51	-	-	-	-

The AMMI biplot provide a visual expression of the relationship between the first interaction principal component axis (AMMI component 1) and mean of genotypes and environment (Fig. 1) as well as relationship of IPCA1 and IPCA 2. The fig 1 depicted that hybrids E5, E7 and E9 were high yielder as well as stable across locations because they had low interaction effects and suitable for all environments. The entries E10, E16, E17 and E18 had high mean value and negative interactions which were suitable for unfavorable environment and the rest of the genotypes were low yielding.

Table 6. Stability analysis for grain yield of maize hybrids over three environments

Genotype	Locations			Overall mean	Pi	bi	S2di
	Gazipur	Dinajpur	Burirhat				
E1	10.13	13.16	12.2	11.83	-0.12	1.33	0.11
E2	7.78	12.00	12.24	10.67	-1.23**	2.14	0.55
E3	10.03	12.79	11.73	11.52	-0.43	1.19	0.20
E4	11.58	11.43	11.14	11.38	-0.56	-0.12	0.06
E5	10.53	12.9	12.91	12.11	0.16	1.18	0.10
E6	10.03	12.15	13.45	11.88	-0.07	1.29	1.61
E7	9.81	13.23	12.90	11.98	0.02	1.14	0.04
E8	11.12	12.53	11.93	11.86	-0.9	0.59	0.08
E9	10.89	13.44	12.28	12.21	0.25	1.06	0.11
E10	12.07	13.00	13.04	12.71	0.75	0.87	0.22
E11	11.16	12.85	11.89	11.97	0.01	0.67	0.26
E12	10.35	12.97	12.93	12.08	0.12	1.30	0.10
E13	8.98	12.74	13.20	11.64	-0.31	1.95	0.73
E14	11.11	12.11	13.19	12.13	0.18	0.69	0.91
E15 (BHM-9)	10.24	12.70	12.54	11.83	-0.12	1.19	0.04
E16 (981)	12.07	13.72	12.15	12.65	0.25	0.54	0.96
E17 (Elite)	12.38	13.53	12.09	12.67	0.71	0.31	0.90
E18 (NK-40)	11.46	12.95	11.74	12.05	0.09	0.53	0.53
Mean	10.65	12.79	12.42	11.95	-	-	-
E. Index (Ij)	-1.30	0.83	0.46	-	-	-	-
LSD (0.05)	2.14	1.08	1.31	-	-	-	-

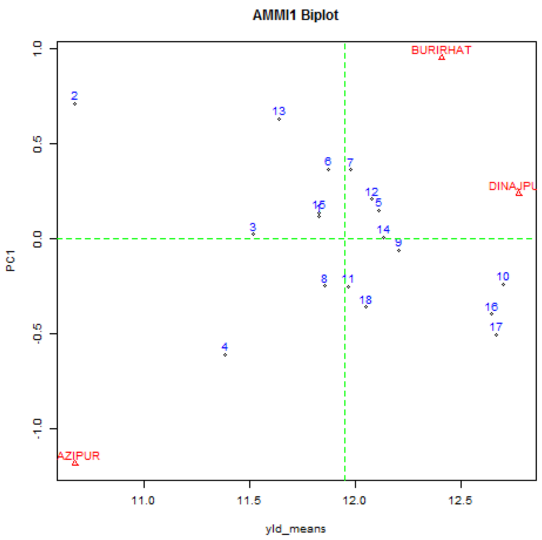

Fig.1. Biplot of the first AMMI interaction (IPCA1) score (Y –axis) plotted against mean yield (X- Axis) of eighteen maize hybrids and three environments

IPCA2 scores also play a significant role in explaining the GEI, the IPCA1 scores were plotted against the

IPCA2 score for further explanation of adaptation (Fig 2). The hybrid E15 was stable over locations for

yield as located within and near the circle. The performances of other hybrids were unstable due to their

dispersed position.

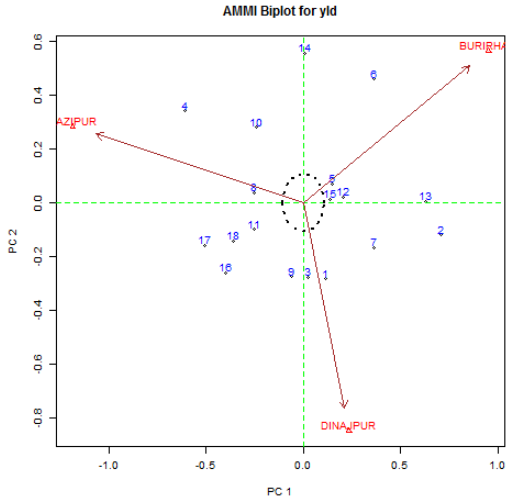

Fig. 2. Biplot of the first AMMI interaction (IPCA2) score (Y –axis) plotted against AMMI interaction (IPCA1) (X-Axis) of eighteen maize hybrids and three environments.

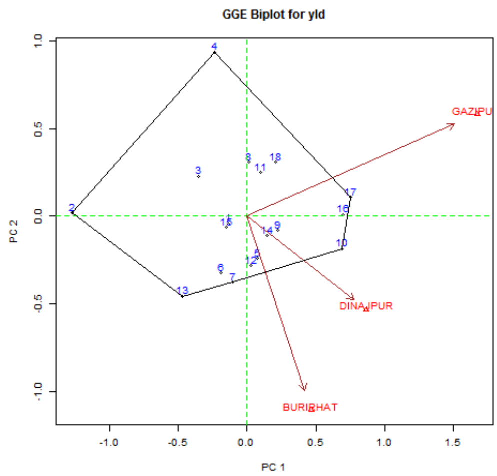

Fig.3. GGE biplot showing "which won where" for yield of eighteen maize hybrids and three environments

The graph "which-won-where" (Fig. 3) enables to identify potential mega-environments (Yan, et al. 2000 and Yan and Hunt, 2001). The genotypes that are utmost from the origin are connected with a straight line forming a polygon. The lines starting from the origin divide the polygon into several sectors. The genotype at the vertex of the polygon performs the best in the environment falling within the sectors (Yan 2002; Yan and Tinker, 2006). The locations within one sector are the ones where the certain genotype had the best yield and can be considered as mega-environments only for that genotype. The hybrid E17 was high yielder and suitable only at Gazipur location. On the other hand the genotype E10 was found high yielder and stable at Dinajpur and Burirhat locations.

Conclusion

Considering the yield potentially and stability parameters, three tested hybrids viz. E5 (BIL28 × BIL79), E7 (BIL153×BIL95) and E9 (CML161×CML172) showed the higher yield as well as stable for overall environments and need to be evaluated further in large plots before release as commercial hybrids across different ecological zones in Bangladesh.

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