GENOTYPE X ENVIRONMENT INTERACTION AND STABILITY FOR GRAIN YIELD AND ITS ATTRIBUTES IN PEARLMILLET

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SUMMARY

An experiment was conducted to study the stability of 30 hybrids of prearlmillet during **kharif** season at four locations. Analysis of variance for stability revealed that mean squares due to genotypes and environments+G x E interaction were highly significant, indicating that there existed significant differences among genotypes and also the environments were different from each other and genotypes reacted differently in different environments. For quantitative traits such as yield, the relative performance of different genotypes often varies from one environment to another i. e. G x E interaction plays an important role. Progress of selection is also reduced due to effect of a large G x E interaction. The hybrids studied in the present investigation, in general, did not exhibit uniform pattern of environmental response (linear). This attribute appears to be specific for individuals. It can, therefore, be suggested that while making selection, attention should be paid to the phenotypic stability of the characters and genotypes having average response for different characters could be used in identifying stable hybrids. The results also revealed that the hybrid 97111A x CSSC46-2 was the most ideal. Besides high grain yield, it exhibited stable performance across the environments for harvest index, plant height and ear length. This indicated that the stability of various component characters might be responsible for observed stability of genotype for grain yield.

Key words : Hybrids, genotype x environment interaction, stability, grain yield, pearlmillet

Pearlmillet [*Pennisetum glaucum* (L.) R. Br.] is an important food grain cereal in the arid and semi-arid regions of Africa, India and other Asian countries. India is the largest pearlmillet growing country contributing 42 per cent of production in the world (Arya *et al*., 2009). With its wide ability to adapt to diverse agro-ecological conditions, it has unique position in the world agriculture. The potential of pearlmillet as an excellent forage crop is well known, particularly in arid and semi-arid regions of the world. It is a multipurpose cereal grown for grain, stover and green fodder (Yadav *et al*., 2010). It is highly vigorous, drought and heat tolerant crop. Its grain is rich in starch, protein, fat, iron, calcium, magnesium, phosphorus and carotenoids than some of the other important cereals (Arya *et al*., 2009). The maximum level of production and stability of yield are the two desired features in a commercial hybrid variety. Indeed, development of hybrids showing wide adaptability has received increasing attention in recent years. Considering the above facts in view, the present study was carried out to identify the stable hybrids of pearlmillet for grain yield and its contributing traits.

MATERIALS AND METHODS

The experiment was conducted at different Research Farms of CCS Haryana Agricultural University, Hisar to study the stability of 30 hybrids of prearlmillet during **kharif** season at four locations viz., Plant Breeding Research Area (E_1), Regional Research Station, Bawal (E_2), Plant Pathology Research Area, Hisar (E_3) and Dry Land Research Area, Hisar (E_4). These hybrids were developed by Bajra Section, Department of Plant Breeding, CCSHAU, Hisar. All the 30 hybrids were grown in RBD with three replications in five rows per plot of 4 m length with spacings 50 and 30 cm between and within

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rows at each location. Observations were recorded on five competitive and randomly selected plants of each genotype for effective tillers per plant, ear length (cm), ear girth (cm), biological yield (g/plant), grain yield (g/ plant), harvest index (%) and 1000-grain weight (g). Sability analysis was carried out as per Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Analysis of variance for stability (Table 1) revealed that mean squares due to genotypes and environments+G x E interaction were highly significant, indicating that there existed significant differences among genotypes and also the environments were different from each other and genotypes reacted differently in different environments. Further, the partitioning of mean squares due to G x E interaction into linear and non-linear components revealed that G x E (linear) was predominant for characters like days to ear length, biological yield and 1000-grain weight and performance of genotypes for these characters could be predicted across the environments. However, for other characters, namely, ear girth, total tillers and grain yield both linear and non-linear components of G x E interaction were equally important. Further, character-wise computation of linear and non-linear components of G x E interaction (Table 2) revealed that for most of the characters, linear portion of G x E interaction was in higher magnitude except ear girth, whereas non-linear portion of G x E interaction was higher in magnitude only for ear girth. Therefore, prediction for this character is not possible. These results are in agreement with those of Sharikant *et al.* (2000), Shinde *et al*. (2002), Yahaya *et al*. (2005) and Arya *et al*. (2009).

The results on estimates of environmental index (Table 3) revealed that E_1 (irrigated condition at Hisar) was most favourable environment for almost all the characters except for harvest index. Grain yield invariably decreased under dryland condition (E_4). These results are in agreement with those of Sharikant *et al.* (2000), Shinde *et al*. (2002), Yahaya *et al*. (2005) and Arya *et al*. (2009).

The assessment of stability parameters (Table 4) revealed that two hybrids viz., 6A x 77/833-2 and 96111A x CSSC46-2 and HHB67-1 were found stable for grain yield over the environments with above average grain yield, unit regression coefficient and non-significant value of S^2di. The above findings were supported by Yahaya *et al*. (2005) and Arya and Yadav (2009).

TABLE 1
Analysis of variance for stability for different characters

Source of variation	d. f.	Grain yield	Plant height	Effective tillers	Ear length	Ear girth	Biological yield	Harvest index	1000-grain weight
Genotype	29	38.69**	568.19**	0.348**	24.81**	1.90**	714.83**	24.40**	2.187**
Env.+(G x E)	90	71.50**	484.06**	0.723**	3.64**	0.30*	1422.52**	47.93**	1.324**
Env. (L)	1	5557.65**	33394.88**	52.956**	146.53**	8.02**	103368.94**	3676.60**	85.551**
G x E (L)	29	11.92	173.34**	0.148	3.21**	0.15*	646.91*	8.24	1.068**
Pooled deviation	60	8.87**	85.72**	0.131**	1.47**	0.25**	98.29*	6.69**	0.044*
Pooled error	232	0.66	12.09	0.050	0.90	0.13	10.08	1.20	0.008

TABLE 2
Magnitude (%) of linear and non-linear component of G x E interaction

S. No.	Characters	Linear	Non-linear
1.	Grain yield	57.83	42.16
2.	Plant height	68.63	31.36
3.	Effective tillers	54.74	45.25
4.	Ear length	80.15	19.84
5.	Ear girth	13.04	86.95
6.	Biological yield	87.83	12.16
7.	Harvest index	56.16	43.88
8.	1000-grain weight	96.71	3.28

TABLE 3
Environmental index for different characters

Character	E_1	E_2	E_3	E_4
Grain yield	7.571	0.608	2.768	-10.949
Plant height	22.309	-5.650	6.582	-23.241
Effective tillers	0.561	-1.120	0.142	0.415
Ear length	1.428	-0.369	0.506	-1.565
Ear girth	0.254	-0.360	0.236	-0.129
Biological yield	40.374	-28.329	25.384	-37.429
Harvest index	0.143	8.454	-1.644	-6.953
1000-grain weight	0.874	-0.254	0.646	-1.266

TABLE 4

Estimates of stability parameters of pearlmillet hybrids for grain yield and its attributes

Genotype	Grain yield (g/plant)			Plant height (cm)			Biological yield (g/plant)		
	X	bi	S^2di	X	bi	S^2di	X	bi	S^2di
6A x 77/833-2	19.72	0.88	0.126	169.683	0.438**	-2.871	106.849	0.393	326.666**
9A x G73-107	20112	1.263	39.147**	190.703	0.735	150.598**	129.735	1.344	711.540**
16A x HTP3/ 13	19.829	1.100	7.333**	182.845	1.465	139.116**	128.365	1.508	61.007**
16A x MRC	19.038	1.356	8.175**	181.320	1.206	19.988**	166.392	1.385	90.592**
18A x 1704	16.55.	0.918	0.294	175.851	1.187	33.988**	107.687	1.038	89.219**
23A x G-73-107	15.246	1.103	14.265**	191.561	1.233	4.166	111.46	1.455	141.129**
36A x 77/371	23.393	1.31	6.343**	175.703	1.201*	101.692**	121.024	1.361	212.249**
843-22A x htp94 /54	23.391	1.34	44.059**	167.822	0.774	86.142**	129.542	1.570	81.329**
94111A x 1250	19.03	0.938	5.734**	202.839	0.810	18.885*	16.796	1.229	30.931**
94111A x 77/371	17.403	0.805	1.476*	174.472	1.050	34.732**	102.643	1.102	30.783**
94222A x INB87/74-3-2	20.105	1.273	2.875**	167.908	0.886	14.431*	103.197	1.750	29.603**
94222A x 1305	18.055	0.613	2.558**	153.631	1.293	72.168**	94.057	0.522	49.700**
94444A x 77/371	26.294	1.394	4.655	154.287	0.557	123.401**	128.235	1.002	59.407**
94555A x H77/833-2	24.052	1.323	3.718**	169.202	1.028	34.684**	126.583	1.384	34.467**
94555A x HTP92/80	20.023	0.771	3.029**	172.938	0.659	218.630**	137.881	1.435	144.213**
94555A x HTP3/20	19.633	.1029	4.248**	186.979	1.396	20.382**	124.133	1.401	32.754**
96111A x (G73-107 x bsectcp-1)	20.635	0.811	24.821**	198.354	1.385	26.324**	112.417	1.325	79.514**
97111A x CSSC46-2	19.088	0.974	0.602	176.713	1.481	11.271	97.839	0.788*	16.051**
97111A x HTP3/2	17.468	0.909	21.202**	176.578	1.649	276.116**	110.642	0.884	81.115**
97111A x HBL-11	26.813	1.558	4.649**	158.254	1.295	10.128	127.282	1.404*	17.228**
ICMA97444A x H77/833-2	20.548	1.067	7.484**	174.788	1.337	82.987**	121.189	1.464	50.400**
ICMA97444A x ICMRO/035	19.895	0.972	4.632**	182.284	0.629*	0.0269	114.530	0.789	5.926
ICMA97444A x ICMRO2041	18.166	0.985	2.661**	175.710	0.788	42.069**	13.311	0.627*	1.9000
ICMA97444A x icmro/46	15.135	0.924*	-0.107	164.308	0.656	205.670**	93.299	0.374**	1.938
HBB-67	16.479	0.708	8.957**	160.742	0.690	46.766**	89.436	0.212*	115.148
HHB-94	14.117	0.658*	-0.191	160.094	1.093	31.798**	95.234	0.692*	43.479**
HHB-67=11 1mpr.	16.924	0.686	14.819**	174.939	0.026	118.084**	96.618	0.111**	11.259
HHB-67-1	19.372	0816	0.566	163.581	0.500*	7.221	105.81	0.479*	26.105**
HHB-117	15.615	0.843	0.103	174.683	0.808	67.209**	116.049	0.962	45.082**
General mean	19.20			174.68			112.59		

Genotype	Ear girth (cm)			Ear length (cm)			Effective tillers/plant		
	X	bi	S^2di	X	bi	S^2di	X	bi	S^2di
6A x 77/833-2	8.100	0.845	-0.007	22.568	-0.069	1.054*	2.625	1.266	0.005
9A x G73-107	9.105	-0.630	0.208**	24.853	1.536	2.276**	2.895	1.770	0.100**
16A x HTP3/ 13	9.188	0.431	0.191*	21.733	0.851	-0.169	2.525	0.888	0.229**
16A x MRC	8.513	0.464	0.130	19.898	0.351	0.671	2.736	1.370	0.186**
18A x 1704	7.721	0.733	0.005	290.637	0.676	0.122	2.398	1.365	0.415**
23A x G-73-107	6.360	1.982	0.094	21.380	1.025	0.943*	2.414	1.267	-0.006
36A x 77/371	7.805	1.658	0.181*	21.344	-0.155*	-0.098	2.353	1.203	0.163**
843-22A x htp94 /54	8.608	1.640	1.150**	26.076	1.964	2.703**	2.434	1.060	-0.066*
94111A x 1250	8.907	0.078	0.512**	23.103	1.254	0.854	2.064	0.510**	-0.014
94111A x 77/371	8.543	1.274	0.098	21.415	0.924	-0.107	2.292	0.896	0.037
94222A x INB87/74-3-2	8.361	1.629	0.320**	23.267	0.845	1.939**	2.133	0.971	0.020
94222A x 1305	9.191	0.528	0.239**	21.238	0.780	-0.266	2.471	0.940	0.107**
94444A x 77/371	8.719	1.145	0.245**	20.172	0.403	0.181	1.408**	2.471	0.032
94555A x H77/833-2	8.343	1.424	0.087	23.037	0.644	3.427**	2.797	1.642*	0.000

Contd.

TABLE 4 contd.

94555A x HTP92/80	8.443	0.557	0.038	26.938	2.448	3.691**	2.493	0.877	0.077**
94555A x HTP3/20	9.217	1.652	0.057	29.400	3.052*	0.756	2.042	1.081	0.092**
96111A x (G73-107 X bsectcp-1)	9.080	0.740	0.547**	23.738	0.0.591	0.365	2.021	0.884	0.094**
97111A x CSSC46-2	8.710	1.996	0.036	24.113	2.058	0.330	2.292	1.062	0.013
97111A x HTP3/2	9.320	1.054	0.368**	26.623	2.941*	0.747	2.078	0.837	0.036
97111A x HBL-11	9.118	3.342*	-0.15	21.155	1.201	2.534**	2.327	0.893	0.464**
ICMA97444A x H77/833-2	9.671	1.144	0.029	21.49	0.437	0.991*	2.405	1.108	0.397**
ICMA97444A x ICMRO/035	8.683	0.998	0.031	20.365	0.436	2.849**	2.298	1.015	0.076*
ICMA97444A x ICMRO2041	8.960	0.481	0.203*	20.277	1.349	0.739	1.877	0.789	0.035
ICMA97444A x icmro/46	8.258	0.934	0.069	22.790	1.313	-0.127	1.856	0.485*	0.012
HBB-67	8.098	0.333*	-0.37	21.698	0.886	1.274	1.954	0.681	0.56
HHB-94	7.843	0.240	0.054	22.830	1.038	-0.223	1.931	0.749	0.402**
HHB-67=11 1mpr.	7.834	1.512	0.013	21.297	0.290	5.7600	2.344	0.817	-0.013
HHB-67-1	0.379	0.888	0.155	22.403	0.381	1.299	2.032	0.726	0.026
HHB-117	7.191	0.548	0.105	23.005	0.189	0.150	2.774	1.345	0.037
General mean	8.49			22.99			2.29		0.303

Genotype	1000-grain weight (g)			Harvest inde x (%)		
	X	bi	S^2di	X	bi	S^2di
6A x 77/833-2	9.463	0.061	0.203**	21.765	1.379	11.730**
9A x G73-107	8.123	1.000	0.005	18.957	1.277	0.630
16A x HTP3/ 13	7.077	0.311*	0.011*	18673	0.960	5.956**
16A x MRC	6.803	0.839	0.026**	19.098	1.328	8.480**
16A x 77/833-2	7.169	1.317	0.189**	18.744	0.714	8.324**
18A x 1704	6.457	0.123*	0.098**	18.750	0.730	0.458
23A x G-73-107	7.245	1.508	0.067**	16.349	0.667	0.528
36A x 77/371	8.637	1.781*	0.081**	23.415	1.005	6.532**
843-22A x htp94 /54	8.595	1.083	.021**	21.673	0.521*	0.071
94111A x 1250	6.523	1.089	0.013*	23.040	1.013	7.068**
94111A x 77/371	7.217	0.886	0.005	22.198	1.009	17.006**
94222A x INB87/74-3-2	8.285	1.203*	0.002	24.303	1.578	2.134**
94222A x 1305	7.719	1.494*	0.005	24667	0.955	1.909**
94444A x 77/371	8.165	1.257	0.035**	23.962	1.096	5.575**
94555A x H77/833-2	7.767	0.801	0.026**	22.989	1.220	5.438**
94555A x HTP92/80	8.338	2.009*	0.050**	18.101	0.898	12.3861**
94555A x HTP3/20	7.985	2.369*	0.067**	18.638	1.073	0.913
96111A x (G73-107 x bsectcp-1)	7.519	1.202	0.017**	23.215	0.587	14.867**
97111A x CSSC46-2	6.523	0.222*	0.087**	22.934	1.188	0.024
97111A x HTP3/2	7.052	0.908*	-0.002	21.097	1.273	0.936
97111A x HBL-11	8.362	1.462	0.035**	25.004	0.983	1.084
ICMA97444A x H77/833-2	8.445	0.960	0.000	21.278	0.892	5.747**
ICMA97444A x ICMRO/035	8.568	1.207**	-0.002	22.523	0.759	3.996**
ICMA97444A x ICMRO2041	7.757	1.124	0.001	21.383	1.119	13.675**
ICMA97444A x icmro/46	7.426	0.911	-0.001	20.228	0.712	17.042**
HBB-67	7.143	1.519*	0.011*	23.215	0.869	0.017
HHB-94	7.398	1.123	0.069**	21.200	1.081	14.245**
HHB-67=11 1mpr.	7.622	0.440	0.053**	21.837	1.072	2.442**
HHB-67-1	8.340	0.378*	0.013*	20.493	1.405	0.348
HHB-117	6.978	0.586**	0.045**	15.970	0.685	
General mean	7.69			21.07		

For biological yield only one hybrid 97444A x ICMR0/35 was found stable over the environments because it had high mean value, bi value was less than one and S^2di equal to zero, remaining hybrids were unstable for all the environments. Similar findings have been also reported by Kumar (2006) and Arya *et al.* (2010).

Hybrids 9711A x HTP3/2, 97111A x CSSC46-2, 97111A x HBL-11 and HHB-94 were stable for harvest index because of having high mean, bi value equal to one and S^2di equal to zero and non-significant. The hybrid 843-22A x HTP94/54 having high mean, below average response and non-significant deviation from regression was found to be ideal for favourable environment. None of the hybrids was found suitable for favourable environment. Above findings were also supported by Kumar (2006) and Arya *et al.* (2010).

Regarding ear length as many as 16 hybrids showed stability but only six hybrids viz., 97111A x CSSC46-2, 18A x 1704, 94111A x 1250, 96111A x (G73-107 x bsectcp-1), ICMA97444A x ICMRO/46 and HHB94 were ideal in performance as they expressed high mean value, unit regression value and deviation from regression zero. Two hybrids, namely, 94555A x HTP3/20 and 97111A x HTP3/2 were found stable for favourable environment because of high mean value, regression value above unity and deviation from regression equal to zero. For ear girth as many as 16 hybrids were found stable. However, only six hybrids viz., 16A x MRC, 94111A x 1250, 94555A x HTP92/80, 96111A x (G73-107 x bsectcp-1), 97111A x HBL-11 and ICMA97444A x ICMR02041 were ideal in performance as they expressed high mean value, unit regression value and deviation from regression zero. Above findings were also supported by Kumar (2006) and Arya and Yadav (2009).

In case of effective tillers hybrids 18A x 1704, 94111A x 1250, 96111A x (G73-107 x bsectcp-1), ICMA97444A x ICMR0/035, 6A x 77/833-2 and HHB67-II were found stable in all four environments. The hybrid 9444a x 77/371 was stable for favourable environment, while none of the hybrids was found ideal for poor environment. Above findings were also supported by Kumar (2006), Arya *et al.* (2009) and Arya and Yadav (2009).

For 1000-grain weight, only three hybrids viz., 9A x G73-107, ICMA97444A x H77/833-2 and ICMA97444A x ICMR02041 were found ideal for all the four environments. Hybrids 94222A x INB87/74-3-40, 94222A x 1305 and ICMA97444A x ICMR0/035 were found suitable for favourable environment. Above findings were also supported by Kumar (2006) and Arya and Yadav (2009).

From the forgoing discussion on estimates of stability parameters of individual hybrid, it could be concluded that the hybrid 97111A x CSSC46-2 was the most ideal. Besides high grain yield, it exhibited stable performance across the environments for harvest index, plant height and ear length. This indicated that the stability of various component characters might be responsible for observed stability of genotype for grain yield. These results are in agreement with those of Yahaya *et al*. (2005) and Arya *et al*. (2009).

The distribution of 30 hybrids on the basis of different stability parameters (Table 5) revealed that ear length possessed the maximum predictable genotypes followed by ear girth, effective tillers, harvest index, 1000-grain weight, grain yield and biological yield. The hybrids studied in the present investigation, in general, did not exhibit uniform pattern of environmental response (linear). This attribute appears to be specific for individuals. It can, therefore, be suggested that while

TABLE 5
Distribution of 30 hybrids on basis of stability parameters

Character	Predictable		Unpredictable	
	Both bi & S^2di	Only bi	Only S^2di	Both bi & S^2di
Grain yield	5	2	23	0
HI	9	1	20	0
Ear length	16	3	11	0
Ear girth	16	2	12	0
Effective tillers	12	3	15	0
1000-grain weight	5	4	12	9
Biological yield	1	3	21	

making selection, attention should be paid to the phenotypic stability of the characters and genotypes having average response for different characters could be used in identifying stable hybrids. Similar findings were also reported by Kumar (2006) and Yadav *et al*. (2010).

For quantitative traits such as yield, the relative performance of different genotypes often varies from one environment to another i. e. G x E interaction plays an important role. Progress of selection is also reduced due to effect of a large G x E interaction, as shown by Comstock and Moll (1963). The knowledge of nature and relative magnitude of various types of G x E interaction is important in making any decisions concerning breeding methods, selection programmes and testing procedures in crop plants (Baker, 1969).

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