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Evaluation of Different Pearl Millet Genotypes For Stability and Yield Performance

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Abstract

Pearl millet (*Pennisetum typhoideum L*) genotypes (fourteen) wereevaluated for stability of grain yield performance across (five) locations in the country. The yield ranking of the varieties varied across the locations. Mean squares due to variety x environment interaction were highly significant indicating genetic differences among varieties for linear response to different environments. Pearl millet variety IC 8206 gave the highest average grain yield (1881 kg ha^{-1}) indicating response to only favourable environments and was less stable across the locations. Based on the parameters of stability, the local varieties were the most adaptive and stable, followed by PARC MS-4 and Ghana White. The varieties PARC MS-5 and PARC MS-6 were found suitable for growing in good environments while varieties PARC MS-2 and ICMV 96101 were suitable for poor environments.

Introduction

Considerable importance is being given by plant breeders to the genotype x environment (GXE) interactions in the crop improvement programmes. The relative performance of cultivars for quantitative traits such as yield, varies from one environment to another. There is a general agreement amongst plant breeders that interaction between genotype x environment has an important impact on the improvement of varieties. However, it is much more difficult to find out genotype x environment interactions in terms of population or individual buffering (Allard and Bradshaw 1964). Accordingly, extensive testing is needed to identify genotype that shows minimum interaction with the environment.

The breeders are aware of the problems of environmental variation and GXE interactions for a long time (Sprague and Federer 1951; Mather 1953). Several procedures have been developed to specify and estimate the parameters of genotype stability from GXE interactions. Two main approaches are very important. The first one is purely of statistical nature, initially proposed by Yates and Cochran (1938) for analysing group experiments, which was improved by Finlay and Wilkinsen (1963) in their study of barley. Similar technique was presented by Eberhart and Russell (1966) for the detection of magnitude of GXE interactions in maize. The second approach is based on fitting models which specify the genetic, environmental and GXE interaction contributions to generation means and variances which allow for the contributions of additive, dominance, epistatic gene action to the genetic and interaction components (Bucio-Alanis 1966). The analyses procedure suggested by Finlay and Wilkinsen (1963) can be applied to any number of varieties/strains grown in any number of environments. They computed regression coefficient, one for each cultivar, by regressing cultivar means from several experiments on environmental means. This regression index was considered as the only parameter for stability by Eberhart and Russel (1966). They showed that both the regression coefficients and deviations from regression of a cultivar on the environmental indices should be considered as parameters for measuring the yield stability of a cultivar. Shukla (1972) and Freeman (1973) have also proposed several techniques for computing stability parameters and partitioning of total variation due to GXE interaction components assignable to individual cultivar.

Saeed and Francis (1983) while studying the yield stability in relation to maturity in grain sorghum, estimated GXE interactions for 54 grain sorghum genotypes in Nebraska and Kansas across 48 environments. It was observed that more than 50 percent variation in the linear responses for genotypes to environments was attributable to wide differences in maturity among the genotypes. Significant GXE interactions were detected for yield.

Witcombe (1989) from a study on variability in the yield of pearl millet varieties and hybrids reported regression analyses using data for the experiments conducted over several years in high, medium and low-yielding environments. When hybrids and varieties were compared, hybrids tended to be higher yielding but less stable. Regression analysis of variance revealed that environment was the largest component of variation and genotype the least, with genotype-environment interaction being intermediate.

In field trials conducted by Mishra *et al.* (1988), *Echinochloa frumentacea* genotypes were assessed for yield and yield related characters. Analysis of variance revealed that there were significant differences in stability among the genotypes for all the characters except days to maturity. Sundaram *et al.* (1986) studied genotype environment interaction in ragi (*Eleusine coracana* Gaertn) and reported that there was a strong genotype x environment interaction for 1000-grain weight and the yield was highly correlated (r = 0.959) with dry matter production.

Consequently, release of sorghum genotypes with consistent performance over a range of environment (years, locations etc) is important to achieve stable production in the country. The present research paper is aimed at to know genotype x environment interaction for stability in yield performance across environments.

Materials and Methods

Fourteen pearl millet genotypes were included in this study namely ICMV 96774, ICMV 96493, ICMV 96101 and ICMP 96491 from the ICRISAT India; PARC MS-1, PARC MS-2, PARC MS-3, PARC MS-4, PARC MS-5 and PARC MS-6 from the NARC Islamabad; Ghana white and IC 8206 from the MMRI Yousafwala; BARI S-98 from BARI Chakwal and check varieties were those different at each site. The names of the sites where the trial was conducted and the check varieties used at each site were: Kohat (Giant Bajra), Bahawalpur (Chlistani Bajra), Chakwal (Chakwal local), Dadu (18 BY) and Islamabad (Pot. Local). The varieties were evaluated in a randomized complete block experiment with four replications at each location. At all the locations the genotypes/ varieties were grown in a plot size of four rows five meter long with 75cm row to row distance maintaining plant to plant distance of 15cm. Planting was carried out from first week of July to 3rd week of July according to the agro-climatic conditions of each location. Fertilizer was applied @ 90-45-0 kg NPK/ha. Half of the N with full dose of P2 O5 was incorporated in the soil at sowing and the other half of N was applied when the crop was at six-leaf stage. Grain yield was recorded from the middle two rows of each plot measuring 7.5 m2. Grain yields per plot and per hectare were calculated at 15 percent moisture level.

The combined analysis of variance over all the environments was first computed in a conventional manner, with varieties considered fixed and environments assumed random. In the analysis of variance sources of variation of environment and genotype x environment interactions were partitioned into environment (Linear). Genotype x environment (Linear) and deviations from linear regression. Significance of genotype x environment (Linear) mean squares was tested throu ratio against the corresponding deviation mean sq However, to test the deviation mean squares, the av pooled error mean square from the combined analy variance was used as a denominator in the F-test.

The performance of the genotypes (varieties) in dif environments was analyzed by using the meth Eberhart and Russel (1966). An environmental inde computed for each testing site by subtracting the mean of all experiments from the mean of all variet each environment. By regressing the mean of each v in each environment upon the environmental ind regression coefficient and the deviations from regr were obtained as parameters for evaluating the stabi yield over environments.

Results and Discussion

The mean yield performance of 14 pearl millet varie the five locations revealed large fluctuations with environment as well as between environments (Table Kohat variety PARC MS-5 produced the highest yi 2186 kg ha^{-1} followed by ICMV 9674 which pro 1965 kg ha^{-1} in comparison with the check variety Bajra). All the thirteen varieties gave significantly (P< higher grain yields than the check variety which pro 1215 kg ha^{-1}. At Bahawalpur, ICMP 9649 outyielded varieties by yielding 2479 kg/ha. As compared to large variation in yield was observed at Bahawalpur the varieties ranging from 1292 kg ha^{-1} for IC 820 2479 kg ha^{-1} for ICMP 96491. It was further reveale the check variety (Cholistani Bajra) ranked 7th i performance by yielding 2196 kg ha^{-1} at Bahawalpu

Table 1: Mean grain yield (kg/ha) of fourteen pearl millet varieties at five locations during 1997

	Kohat		Bahawalpur		Chakwal		Dadu		Islamab	
Variety	Yield (kg)	Rank (kg)	Yield (kg)	Rank (kg)	Yield (kg)	Rank (kg)	Yield (kg)	Rank	Yield	R
PARC MS-1	1417ef	13	2367a	3	1209ab	3	2222ab	2	1896bc	[illegible]
PARC MS-2	1586cde	11	1625bc	11	1271ab	2	1681fg	8	1926bc	[illegible]
PARC MS-3	1612cde	9	2051ab	10	1042b	4	1167jk	13	2282b	[illegible]
PARC MS-4	1791bcd	5	2365a	4	708defg	9	1625gh	9	1837bc	[illegible]
PARC MS-5	2186a	1	2117a	9	625fg	13	2000cd	4	1822bc	[illegible]
PARC MS-6	1604cde	10	1446c	12	646fg	12	1458hi	10	2015bc	[illegible]
ICMV 96493	1736bcde	8	2296a	6	958bc	5	1056k	14	2074b	[illegible]
ICMV 96101	1770bcd	6	1392c	13	838cd	6	1792efg	7	1837bc	[illegible]
ICMV 96774	1965ab	2	2458a	2	1688a	6	1305hi	12	1748bc	[illegible]
ICMP 96491	1858abc	3	2479a	1	688efg	11	1847def	6	2311b	[illegible]
IC 8206	1800bcd	4	1292c	14	833cde	7	1975cde	5	3956a	[illegible]
Ghana white	1750bcde	7	2134a	8	729def	8	1390i	11	2193b	[illegible]
BARI SL-48	1465def	12	2317a	5	1297ab	1	2333a	1	2207b	[illegible]
Check	1215f	14	2196a	7	563g	14	2056bc	3	933c	[illegible]

Means followed by the same letter in a column do not differ significantly from each other by DMRT.

able 2: Analysis of variance for stability based on means.

ources of variation	D.F.	Sum of square	Means square
otal	111	30,484,610	
enotypes	13	1,674,432	128,802.5
nv. + G X Env.	98	28,810,180	293,981.5
nvironment (linear)	10	17.930,950	17,930,950.0
X Env. (linear)	13	1,187,214	91,324,16
ooled deviation	84	9,692,042	115,381.5
ooled error	336	13,314,880	39,627.62

able 3: Mean yield (kg/ha) and estimates of stability parmeters for 14 pearl millet varieties across five environment.

ariety	Yield (kg/ha)	S_d^2	bi	R^2
ARC MS-1	1714	535793.6	0.84	0.62
ARC MS-2	1611	49934.66	0.46	0.84
ARC MS-3	1617	409232.9	0.80	0.67
ARC MS-4	1676	236317.5	1.05	0.86
ARC MS-5	1677	441884.6	1.24	0.82
ARC MS-6	1477	532686.8	1.16	0.76
CMV 96741	1568	561676.5	1.08	0.72
CMP 96493	1555	527054.5	1.09	0.74
CMV 96101	1560	343179.0	0.59	0.56
CMP 96491	1734	322299.3	1.20	0.85
C 8206	1881	3513074.0	1.48	0.44
hana white	1696	226829.1	1.15	0.88
ARI SL-48	1814	479182.3	0.88	0.67
heck	1407	1512897.0	1.01	0.46

id not differ significantly from PARC MS-1, PARC MS-3, ARC MS-4, PARC MS-5, ICMV 96774, ICMV 96493, CMP 96491, Ghana white and BARI SL-48 at Bahawalpur. t Chakwal BARI SL-48 took Ist position by yielding 1297 g ha^{-1} followed by PARC MS-2 which yielded 1271 kg a^{-1}. There was no significant difference in yield performance between BARI S-48, PARC MS-2 and PARC MS-2. Though the difference in yield was there but it was non-significant (P<0.05). Variety BARI SL-48 took 5th position at Bahawalpur by yielding 2317 kg ha^{-1}. At Dadu, the same variety BARI SL-48 out-yielded rest of the varieties by yielding 2333 kg ha^{-1} and took 1st position. At Dadu, the 2nd ranking variety was PARC MS-1, which yielded 2222 kg ha^{-1}. Having a look over the yield performance of the rest of the varieties at Dadu, there were significant (P<0.05) differences among the varieties.

At Islamabad, variety IC 8206 gave the maximum yield of 3959 kg ha^{-1} and took 1st position. ICMP 96491 took 2nd position by yielding 2311 kg ha^{-1}. Ghana white and BARI SL-48 produced statistically similar yields, though there were differences in the yields but these were non-significant (P>0.05) except IC 8206. There were no significant (P>0.05) differences among rest of the varieties. The location specific analyses indicates that at Chakwal and Dadu, the millet variety BARI S-48 gave higher yields whereas at Kohat, Bahawalpur and Islamabad it gave lower yields showing the effect of environmental changes on the yield performance. Similarly, IC 8206 which gave highest yield at Islamabad, produced lower yields at Bahawalpur, Kohat and Chakwal.

The regression coefficients (slopes) ranged from 0.46 to 1.48 (Table 3). One of the top eight yielding varieties IC 8206 had the highest regression coefficient of 1.48. PARC MS-4, PARC MS-5, PARC MS-6, ICMV 96471, ICMV 96493, ICMP 96491, Ghana white and Check had b>1.0. PARC MS-1, PARC MS-2, PARC MS-3, ICMV 96101 and BARI S-48. Mean yield of the varieties and their regression coefficients were positively correlated (r=0.44) which implied that more productive varieties were also most sensitive to changing environments. For the evaluation of responsiveness to different environmental conditions, a stable variety is defined as one that has a regression coefficient around 1.0 and small deviations from regression (Eberhart and Russell, 1966). A high mean yield is also a desired attribute, although not an indicator of yield stability, millet variety PARC MS-4 showed a regression coefficient of 1.05 with the smallest value of deviations from regression. Hence, it seems relatively responsive to environmental changes, therefore, it ranked differently for mean yield across all environments. Varieties PARC MS-1, PARC MS-2, PARC MS-3, ICMV 96101 and BARI SL-48 with lower "b" values (b<1.0) seem to be suitable for poor environments. PARC MS-2 which gave the lowest "b" value of (0.46) can only be cultivated in poor environments. The genotypes which had regression coefficients greater than 1.0, (b>1.0) indicate that these cultivars are more responsive and suitable for cultivation under favourable conditions. The comparison of deviation mean squares from regression and regression coefficients showed more stable yield performance by respective local checks, followed by PARC MS-4, ICMV 96741, ICMP 96493, Ghana white, PARC MS-6, ICMP 96491 and IC 8206.

The results indicate that yield ranking of all the varieties changes across locations. An examination of the stability parameter (sd2) and the parameter of responsiveness "b" showed that the local varieties were the most adaptive and stable cultivars followed by PARC MS-4, Ghana white, ICMP 96491, PARC MS-5 and BARI SL-48. On the other hand, varieties PARC MS-2, ICMP 96101, PARC MS-3, PARC MS-1 and BARI S-48 demonstrated suitability for poor environments only. It is however important to test these millet cultivars across environments for few more years, before their release for general cultivation is recommended. Moreover, since stability in yield is genetically controlled (Eberhart and Russell 1966, Perkins and Jinks 1968); variety PARC MS-4 may be used as parents in the breeding programme for developing stable varieties.

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