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Consistency of Barnyard Millet (*Echinochloa frumentacea*) Genotypes for Plant Height, Duration and Grain Yield over Environments

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Barnyard millet is hardy crop being cultivated in varied environments for food and fodder. Eighteen breeding lines were evaluated in three diverse environments of Tamil Nadu namely Coimbatore, Madurai and Chettinad. Among the three locations, Coimbatore and Chettinad turned out to be high and low yielding environment respectively. The variance analysis inferred that the performance of barnyard millet lines was influenced by the growing environment. The entries TNAU 130 and TNAU 146 performed well in favourable environment for grain yield. High grain yield was observed in the genotypes of VL 222, VL 232, VL 221, VL 224 and VL 230 at Coimbatore location. On the contrary, the stability parameters indicated that these entries were not consistent in yield performance. The variety CO(kv) 2 performed well in unfavourable condition with mean yield of 16.44 q ha^{-1}. The present study revealed that early maturing genotypes were poor yielders and *vice versa*. Based on the results it is suggested that, focused breeding efforts are required to identify high yielding stable barnyard millet genotypes.

Keywords: Barnyard Millet, Stability, Genotype x Environment.

Barnyard millet [*Echinochloa frumentacea* (Roxb.) Link] is one of the hardiest millets being cultivated for food and fodder in all types of soils and sustains adverse climatic conditions. Nutritionally barnyard millet is a fair source of digestible protein but an excellent source of dietary fibre. The carbohydrate content is low and slowly digestible, which makes the barnyard millet a nature's gift for the modern mankind who is engaged in sedentary activities (Ugare, 2008). The grains of barnyard millet are low in phytic acid and rich in iron and calcium contents (Sampath *et. al.,* 1990). The yield level of barnyard millet is as high as 10 t ha^{-1} in Japan, where as in India it is 1.5 to 2 t ha^{-1}. So there is a greater scope for exploiting its potential in Indian condition (Channappagoudar *et. al.*, 2008). There are indications that diversity in barnyard millet is fast eroding and area under barnyard millet is gradually decreasing in many states (Gupta *et.al.,* 2009). The literature indicates that efforts are in progress to collect and characterize the barnyard millet genotypes (Gupta *et.al.,* 2009; Jayaramegowda *et.al.,* 2009). There was limited study on stability performance of barnyard millet. Hence, present investigation was carried out to assess stability and adaptability performance of barnyard millet genotypes in different environments of Tamil Nadu.

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Materials and Methods

Seventeen advanced barnyard millet breeding lines were received from All India Coordinated Small Millets Improvement Project (AICSMIP), Bengaluru. These genotypes were evaluated in a Randomized Block Design with three replications. The variety CO(kv) 2 was used as local check. The study was conducted during Kharif 2010 in three diverse locations which vary with environmental factors, elevation and soil properties. The locations are Dryland Agricultural Research Station, Chettinad (10º10'N, 78º47'E, 115m aMSL); Agricultural College and Research Institute, Madurai (9º54'N, 78º80'E, 147m aMSL) and Department of Millets, TNAU, Coimbatore (11º1'N, 76º55'E, 441m aMSL). Chettinad location has typical alfisol sandy clay loam; Madurai with Verti-clay loam soil type and Coimbatore has red soil. The crop was grown under rainfed condition at Chettinad and as irrigated condition at Coimbatore and Madurai locations. The observations on days to maturity, plant height (cm) and grain yield (q ha^{-1}) were recorded in all the three locations. The data was analyzed for stability parameters of linear regression coefficient (b values) and deviation from regression (S_d^2) of genotype means over environment index. This was followed as per Eberhart and Russell (1966) method using GENRES 7.01 software.

Results and Discussion

Environmental mean of grain yield ranged from 5.24 to 20.45 q ha^{-1}, plant height from 79.36 to 114.38 cm and days to maturity from 80 to 100 days. The highest grain yield was recorded at Coimbatore location and the lowest yield was at Chettinad location. The location wise highest yielding genotypes were VL 232 (27.39 q ha^{-1}) at Coimbatore, VL 222 (27.42 q ha^{-1}) at Madurai and CO(kv) 2 (14.14 q ha^{-1}) at Chettinad. The low yield at Chettinad was attributed to soil constraints of alfisol in this region mainly surface crusting, which affects the root development, water infiltration, water holding capacity and low soil fertility status.

Analysis of variance across locations in all traits found significant differences among genotypes. The interaction of genotype-environment (GxE) was significant for all traits, which necessitated estimating the stability parameters (Table 1). The significant E+(GxE) infers the differential reaction of barnyard millet lines across environments. The genotypes x environment effects were further partitioned into linear and nonlinear components. The genotype x environment (linear) was non significant for all the characters studied. The non linear components were significant for the three characters studied. The environment linear was significant indicating the larger macro environmental differences at three locations.

Table 1. Pooled analysis of variance for phenotypic stability in barnyard millet

Source of variation	Df	Mean sum of squares		
		Grain yield	Plant height	Maturity
Genotype	17	44.09**	1484.87**	115.16**
Environment	2	1057.59**	6108.24**	1933.97**
Genotype x Environment	34	26.47**	137.57**	28.93**
Environment (linear)	1	2115.18**	12216.50**	3868.05**
Genotype x Environment (linear)	17	17.68	120.00	22.82
Environment + (Genotype x Environment)	36	83.75**	469.27**	134.76**
Pooled deviation	18	33.30	146.51	33.09
Pooled error	108	0.24	24.05	0.54

The genotypes TNAU 130 and TNAU 146 recorded high significant regression coefficient (bi) and non-significant mean square deviation (S^2_{di}) for grain yield. These two accessions performed in favorable environment with mean grain yield of 16.7 q ha^{-1} and 13.32 q ha^{-1} respectively (Table 2). High mean performance was observed in VL 222 (18.97 q ha^{-1}), VL 232 (18.63 q ha^{-1}), VL 221 (16.07 q ha^{-1}), VL 224 (15.78 q ha^{-1}) and VL 230 (15.38 q ha^{-1}). These genotypes were considered as unstable due to significant mean square deviations. The culture VL 223 was found to be stable with mean grain yield performance of 10.09 q ha^{-1}. CO(kv) 2 had significant lower regression coefficient and non-significant mean square deviation with higher mean grain yield

Table 2. Stability parameters of grain yield, plant height and maturity in barnyard millet

Genotype	Grain yield			Plant height			Days to maturity		
	Mean (q/ha)	Response (bi)	Stability (S^2_{di})	Mean (cm)	Response (bi)	Stability (S^2_{di})	Mean (days)	Response (bi)	Stability (S^2_{di})
PRB 901	7.41	0.82	71.33**	72.23	1.45*	-13.83	78.11	1.32**	-0.46
PRB 903	11.27	0.69	169.96**	76.63	0.75	387.04**	84.66	1.11	315.26**
PRB 9404	7.422	0.45	18.28**	50.27	0.04	940.99**	73.44	1.34	21.35**
RBM 2	10.75	0.92	7.72**	65.88	0.23	5.21	87.11	0.38*	3.60**
TNAU 130	16.70	1.22*	0.06	118.57	0.79	-11.08**	92.55	0.825	-0.42
TNAU 141	6.30	0.20	50.86**	71.91	1.09	-7.21	84.44	0.70	5.97**
TNAU 146	13.32	1.24**	-0.22	109.77	0.86	194.17**	91.00	0.48*	1.57
TNAU 149	16.55	1.56*	1.18*	108.57	0.93	113.13**	91.22	0.55**	-0.47
VL 172	13.37	1.26	12.87**	108.83	1.23	176.45**	91.11	1.27	68.61**
VL 207	13.32	1.02	10.18**	112.75	0.99	-21.04	89.11	1.60	10.14**
VL 221	16.07	1.21	16.55**	112.74	1.31	59.54	93.77	1.15**	0.9
VL 222	18.97	1.41	71.39**	106.84	0.98	256.59**	88.55	1.13	1.41
VL 223	10.09	0.953	0.69	105.65	1.73	37.21	84.44	0.84	0.45
VL 224	15.78	1.101	83.97**	111.27	1.28	8.44	87.88	1.03	104.56**
VL 230	15.38	1.03	49.06**	117.83	1.32	-4.68	95.11	0.79	20.71**
VL 231	13.58	1.01	14.07**	117.83	0.75	9.94	91.44	1.17	9.06**
VL 232	18.63	1.53	16.95**	105.88	1.41**	-24.04	93.44	1.14	10.74**
CO(kv)2	16.44	0.30**	0.12	129.64	0.77	97.43*	99.77	1.09	12.78**
Overall mean	13.41	-	-	100.17	-	-	88.73	-	-

*, ** = bi and S^2_{di} are significantly different from 1 and 0 respectively at 0.05 and 0.01 probability levels

of 16.44 q ha^{-1}. The variety CO(kv) 2 may be considered suitable for unfavourable environments. Bandyopadhyay (2000) studied the stability of barnyard millet genotypes at varied levels of fertilizer treatments and found that the cultivars possessed wide adaptation over different soil fertility levels at high altitude.

Near unity regression coefficient and non-significant mean square deviation was observed for the genotypes VL 207 and TNAU 141 for plant height. These lines were considered stable in plant height expression, with VL 207 as tallest (112.75 cm) and TNAU 141 as shortest (71.91 cm). The culture VL 232 had significant high bi value and non-significant S^2_{di}. This culture grew taller (105.88 cm) in favorable environment. The mean squares deviations were significant for tall phenotypes of CO (kv) 2 (129.64 cm) and TNAU 130 (118.57 cm), which revealed unstable expression.

Based on the stability parameters for duration, the cultures TNAU 149 and TNAU 146 matured in 91 days under unfavorable environment and VL 221 matured in 93 days in favorable conditions. Further, these entries recorded high grain yield. The entry, PRB 901 recorded high significant bi value and non-significant $S^2_{di.}$ It was early maturing (78.11 days) in favorable conditions and a poor yielder (7.41 q ha^{-1}).

The present investigation revealed that the performance of barnyard millet genotypes depends on the growing environment. It showed that there is a possibility of identifying the high yielding genotypes specific to the given environment. High yielding genotypes identified in this study were unstable and early maturing types were poor yielders. However, further investigations are required to assess the performance over environments and seasons to develop high yielding barnyard millet genotypes.

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