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Estimation of Stability Performance in Seed Yield and its Components in Pearl Millet (*Pennisetum glaucum* [L.] R. Br) Hybrids of Semi-arid Eastern Plains of Rajasthan

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ABSTRACT: During *kharif* 2018, a study on genotype × environment interaction for seed yield in Pearl Millet (*Pennisetum glaucum* L.) was carried out using a randomized block design with three replications in three artificially created environments having varied doses of fertilizers. A total of eighteen hybrids were chosen to estimate their stability with respect to different morphological characters as well as identify the best hybrid with respect to high yield. The environment indices for all the characters, were found in between -2.85 (environment-III) and 1.76 (environment-I), indicating an enough diversity provided to run the experiment satisfactorily. A significant portion of the genotype × environment interaction was explained by non-linear regression on the environment means. The linear component was significant, but its magnitude was lower than the non-linear component, indicating the importance of environmental effects on genotypes. Three hybrids (MPMH-17 followed by HHB-197 and RHB-177) were found to be environmentally stable. With a slope of unity and a mean square due to deviation from regression equal to zero, they produced more than the average mean yield among all the genotypes under test.

Keywords: Pearl millet, Stability, Regression coefficient, Environmental indices, Standard deviation.

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.], popularized as bajra (2n = 14) belongs to the family *Poaceae* (earlier *Gramineae*) and is highly cross-pollinated crop with protogynous condition (Animasaun *et al.,* 2019). It is heterogenous as well as heterozygous in nature. In India, pearl millet ranks fourth amongst the most widely cultivated food crop after rice, wheat, and maize. Total cultivable area covers 6.93 million ha throughout the nation and secures 8.61 million tons of annual production and 1,243 $kgha^{-1}$ of productivity (Directorate of Millets Development, 2020). Pearl millet is thought to be originated in West Africa (Vavilov, 1950). Although it is grown all over the world, Nigeria, Pakistan, Sudan, and Saudi Arabia contribute as the major pearl millet growing countries throughout the globe. In India, the major pearl millet growing states are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana, covering nearly 90% acre.

Breeders have recognized the importance of evaluating many potential hybrids in different environments before selecting desirable ones for release and commercial cultivation (Gupta and Ndoye, 1991). Many researchers have used a variety of approaches to determine genotype stability across a wide range of environments. Finlay and Wilkinson (1963) estimated barley stability using a regression technique first proposed by Yates and Cochran (1938). As a measure of stability, they used linear regression with a high mean yield. Average stability and general adaptation are indicated by genotypes with a regression coefficient of 1.0 and a high mean yield. A stable genotype, according to Eberhart and Russell (1966), must shows a slope of unity and a deviation from regression of zero. The deviation from regression, a second stability parameter, appears to be very important, as the genotype × environment interaction (linear) sum of squares was only a small part of the genotype × environment interaction. Several breeders (Singh and Gupta, 1978;

Pethani and Kapoor, 1985; Virk, *et al*., 1985) have used this approach extensively, emphasizing that linear regression should be regarded as a measure of genotype response, whereas deviation from regression should be regarded as a measure of genotype stability, with the lowest deviation being the most stable. Eagles *et al*. (1977) found that different regression values accounted for less than 20% of the genotype × environment sum of squares for oat lines. In some circumstances, such as deviation from regression caused by differences in disease resistance, Witcombe (1988) suggested that mean squares from deviation from regression as a measure of stability is invalid.

In agricultural field, study on Genotype × Environment interaction (G × E) is a common phenomenon (Abdelrahman and Abdalla 2002). When environment changes, gaps between genotypic values may increase or decrease which may cause genotypes to even rank differently between environments. Stability means stable performance of a hybrid in wide range of environmental condition. Usually, no hybrids can perform equally in all environments due to their particular genetic barriers. In adverse conditions, unlike the pure lines, hybrids show reduced performance rather than total crop failure. Yield is a complicated attribute, influenced by a number of morphological and physiological characteristics, including maturity, panicle length, panicle diameter, test weight, and so on. As those parameters inherit very simply, their exploitation looks so easy. Many scientific reports have already demonstrated a positive association with the final outcome *i.e.,* seed yield.

Plant breeders have long sought to create genotypes with a wide range of adaptability. A huge range of genotype-environment (G × E) interactions, many a times creates complexities while determining the genetic influence on variability. Plant breeding programs strive to create genotypes that are phenotypically stable and adaptable to a variety of settings. Multi-environment testing aids in the selection of genotypes that excel in terms of yield and other traits. This study looked into G × E interactions for ultimate outcomeas well as important yield-contributing aspects in pearl millet.

MATERIAL AND METHODS

For the current study, eighteen hybrids of pearl millet (Table 1) were collected from the Rajasthan Agriculture Research Institute, Durgapura, Jaipur under the supervision of S.K.N.A.U, Jobner. Hybrid seeds were carefully sown with proper spacing (45cm × 10cm) in three artificially created environments along with varied doses of fertilizers.

Table 1: Hybrids chosen for the current study.

Sr. No.	Number of Hybrids	Sr. No.	Number of Hybrids
1.	RHB-173	10.	HHB-67
2.	RHB-177	11.	HHB-197
3.	RHB-223	12.	HHB-299
4.	RHB-233	13.	9450
5.	RHB-234	14.	9001
6.	GHB-538	15.	86-M-86
7.	GHB-558	16.	MCPH-17
8.	GHB-744	17.	MARU-TEJ
9.	GHB-905	18.	KBH-108

The environments for this study were created using a variety of fertilizer doses in the following manner:

Table 2: Different environments studied under the current investigation.

Sr. No.	Environment	N_2(kg ha^{-1})	P_2O_5(kg ha^{-1})	K_2O (kg ha^{-1})
1.	E-I (150% D.O.F)	90	45	45
2.	E-II (100% D.O.F)	60	30	30
3.	E-III (50% D.O.F)	30	15	15

*D.O.F represents doses of fertilizers

In each replication, hybrid seeds were sown in two rows in a plot of 4.0 × 0.6 m^2. Row to row distance was managed at 45 cm, while two adjacent plants were grown at 10 cm apart. From each plot, ten random plants, excluding the border ones were selected for recording the observations. On the field note book, we have recorded grain yield, days to 50% flowering, panicle diameter, ear length and test weight for each and every representative plants. The importance of variation owing to variations, environments, and varieties × environments interaction was compared to pooling error.

Statistical analysis. The data on each character for the variations was subjected to standard statistical analysis of variance for each habitat independently (Panse and Sukhatme, 1985). After that, a pooled analysis of variance was run on the data from each group (Singh, 1985).

RESULTS AND DISCUSSION

Earliness is a desirable character in kharif crops where erratic rains or lack of rains, particularly in later part is very common. The early hybrids may escape the adversities and mature before the onset of various stresses. This is the reason why breeders prefer early varieties most, despite of the negative correlation between earliness and the grain yield. In the current study, we found the average values of days to 50% flowering ranging from 44.56 (RHB-177) to 57.11 days (KBH-108) with the regression coefficient in the range of 0.19 (GHB-558) to 1.64 (HHB-299) (see in Table 5 and Fig. 1) and a wide range of environmental indices (-3.50 to 3.01) (Table 3), which reflect immense difference between the environments created for this character. The S^2d_i values for all the hybrids were found non-significant (Table 5). Of eighteen hybrids, RHB-177 was found best to perform as an early variety followed by HHB-67 and MARU-TEJ (44.78 days to reach 50% flowering). Grain yield per plant was found to have negative association with days to 50% flowering just alike the expounding of Abuali *et al.* (2012); Ezeaku, *et al*., (2015); Govindraj *et al*. (2009).

Harer and Karad (1998) Abuali *et al.* (2012); Kanatti *et al.*, (2014) reported positive association between panicle length (cm) and seed yield per plant (g) in pearl millet. In the present study, mean value of panicle length ranging from 18.95 (MARU-TEJ) to 25.26 cm (RHB-233) with the regression coefficient in the range of -0.29 (MPMH-17) to 2.28 (RHB-233) (Table 6 and Fig. 2) and a wide range of environment indices (-1.25 to 1.95) (Table 3), indicating a remarkable distinction among the all environments created. The S^2d_i estimates of all the hybrids were found non-significant except of HHB-299, GHB-558, 9450, 9001 and KBH-108 (Table 6). Many of the hybrids have shown non-significant deviation from regression line for panicle length. Based on mean and regression coefficient, 9001, RHB-173 and GHB-538 were found most stable among all the hybrids, whereas GHB-905, HHB-67, HHB-197 being found with below average stability looked congruent for improved management practices like high fertility and proper irrigation. High mean and regression coefficient less than 1 in RHB-233, RHB-234 indicate their stability indices exceeding the average value.

The mean panicle diameter ranged from 1.89 (MARU-TEJ) to 2.93 cm (86-M-86). The regression coefficient ranged from -1.21 (MARU-TEJ) to 3.02 (9001). The S^2d_i estimates were non-significant for most of the hybrids except HHB-67, HHB-299, 9450, MARU-TEJ (see in Table 6 and Fig. 3). The environmental indices varied from -0.16 to 0.09 (Table 3). Kulkarani *et al*., (2000); Anuradha *et al*. (2018); Sobha Rani *et al*. (2019) were reported positive association between the panicle diameter and grain yield in pearl millet. In our study, mean panicle diameter was found maximum in 86-M-86 (2.94 cm) followed by HHB-299 (2.59 cm), RHB-233 (2.55 cm), and GHB-744 (2.27 cm) where the b_i values were obtained close to 1, indicating their stable performance (Table 6).

The test weight ranged from 8.69 (RHB-173) to 10.62 (GHB-744). The regression coefficient ranged from -0.55 (9001) to 2.61(RHB-223). The S^2d_i estimates were all the hybrids were non- significant (Table 7 and Fig. 4). The environmental indices ranged from -0.57 to 0.84 (Table 3), indicating differences among the environments. Irshad-ul-haq *et al*. (2015); Choudhary *et al*. (2012); Bidinger *et al.* (1987**)** were reported positive correlation between test weight and seed yield per plant, hence high mean of test weight is desirable. The S^2d_i estimates of most of the hybrids for test weight were non- significant. Because of high mean in 86-M-86 (10.51), RHB-538 (10.31 g), and RHB-234 (9.43 g) along with regression coefficient close to 1, these have been considered as stable for test weight.

The average seed yield per five plants ranged from 23.17 (RHB-173) to 30.73 g (KHB-108). The regression coefficient ranged from -0.49 (RHB- 173) to 2.14 (86-M-86) (Table 7 and Fig. 5). The environment indices ranged from -2.85 to 1.76 (Table 3), reflecting noticeable differences among the environments created. The S^2d_i associated with most of the hybrids were non-significant barring HHB-67, GHB-744, RHB-538 (Table 7).

For all parameters, an environment-by-environment analysis of variance revealed substantial differences between hybrids in each environment. For all of the characters, the pooled analysis revealed substantial differences across the hybrids, demonstrating that actual differences exist between hybrids. For all of the qualities that are comparable to the vast range of environmental indicators, the environmental influence was likewise extremely significant. This suggested that the surroundings had a significant impact on hybrid performance. Except for days to 50% blooming and panicle length, genotype × environment interactions were significant for the majority of the characteristics, hence stability parameters were determined for all of them. Except for plant height, panicle length, and panicle diameter, the environment plus genotype x environment interactions were significant for the majority of the traits (Table 4). The linear component of the G × E interaction was significant for test weight and seed yield per plant, indicating that hybrids had divergent linear responses to environmental changes for these characters, according to stability analysis by joint regression analysis (Eberhart and Russell, 1966).The pooled deviations for panicle length, panicle diameter, and seed yield per plant were found so significant (Table 4), that indicate that departures from linear regression also contributed significantly to the variations in hybrid stability for these traits.

The hybrids RHB-177, HHB-197, and MPMH-17 were found to be stable for the majority of the traits, making them suited for ever-changing environmental circumstances.

Table 3: Environment indices for different characters of pearl millet hybrids.

Environments	Days to 50% flowering	Panicle length	Panicle diameter	Test weight	Seed yield/plant
I	-3.5	1.95	0.09	0.84	1.764
II	0.48	-0.72	0.06	-0.27	1.088
III	3.01	-1.25	-0.16	-0.57	-2.853
Grand mean	50.06	21.23	2.39	9.88	26.0

Table 4: Joint regression analysis for the parameters tested in three different environments.

Source of variation	d.f.	Days to 50% flowering	Panicle length (cm)	Panicle diameter (cm)	Test weight (g)	Seed yield/plant (g)
Hybrids	17	56.89**	9.12	0.19*	1.14**	14.91**
Env. + (Gen.x Env.)	36	15.36*	6.20	0.08	0.97*	13.49**
Env. (Linear)	1	388.68**	107.20**	0.70**	19.72**	223.89**
Gen. x Env. (Linear)	17	4.04	2.41	0.04	0.79*	10.89**
Pooled deviation	18	5.32	4.17**	0.07**	0.11	4.25*
RHB-173	1	6.26	0.20	0.06	0.01	3.72
RHB-177	1	0.88	0.19	0.05	0.01	0.01
RHB-223	1	1.05	0.52	0.01	0.13	1.62
RHB-233	1	0.03	0.02	0.03	0.68	0.13
RHB-234	1	4.79	1.00	0.07	0.30	0.48
RHB-538	1	11.28	0.66	0.01	0.17	13.29*
GHB-558	1	10.11	14.56**	0.04	0.01	12.09*
GHB-744	1	18.38	2.95	0.04	0.05	1.94
GHB-905	1	0.58	1.79	0.07	0.17	6.27
HHB-67	1	10.58	3.78	0.22**	0.03	12.26*
HHB-197	1	2.38	1.80	0.03	0.01	7.46
HHB-299	1	11.88	6.70*	0.21**	0.05	0.05
9450	1	6.36	6.76*	0.12*	0.01	2.67
9001	1	2.63	16.36**	0.03	0.06	9.49
86-M-86	1	5.07	1.22	0.02	0.03	0.46
MPMH-17	1	2.68	1.13	0.01	0.23	3.84
MARU-TEJ	1	0.15	0.32	0.24**	0.02	0.08
KBH-108	1	0.60	15.04**	0.07	0.01	0.70
Pooled error	102	15.52	4.26	0.06	0.81	7.46
Total	53	28.68	7.14	0.11	1.03	13.94

*, ** = significant at 5% and 1% levels, respectively

Table 5: Mean values and stability parameters (b_i and S^2d_i) of the Pearl millet hybrids for days to 50% flowering.

Days to 50% flowering			
Hybrids	**Mean**	**b_i**	**S^2d_i**
RHB-173	52.44	1.21*	1.09
RHB-177	44.56	0.43*	-4.28
RHB-223	45.11	0.79**	-4.14
RHB-233	50.56	0.46**	-5.16
RHB-234	52.22	1.39**	-0.37
RHB-538	45.89	0.81	6.12
GHB-558	50.67	0.19	4.94
GHB-744	50.56	1.21	13.21
GHB-905	49.11	1.05**	-4.59
HHB-67	44.78	1.09	5.41
HHB-197	44.89	1.44**	-2.79
HHB-299	53.67	1.64*	6.71
9450	54.67	1.30*	1.19
9001	56.22	0.97*	-2.54
86-M-86	55.56	1.29*	-0.10
MPMH-17	48.22	1.63**	-2.49
MARU-TEJ	44.78	0.57**	-5.05
KBH-108	57.11	0.53**	-4.56
S.Em+	1.63	0.49	
Pop. Mean	50.61	1	

*, ** = significant at 5% and 1% levels, respectively

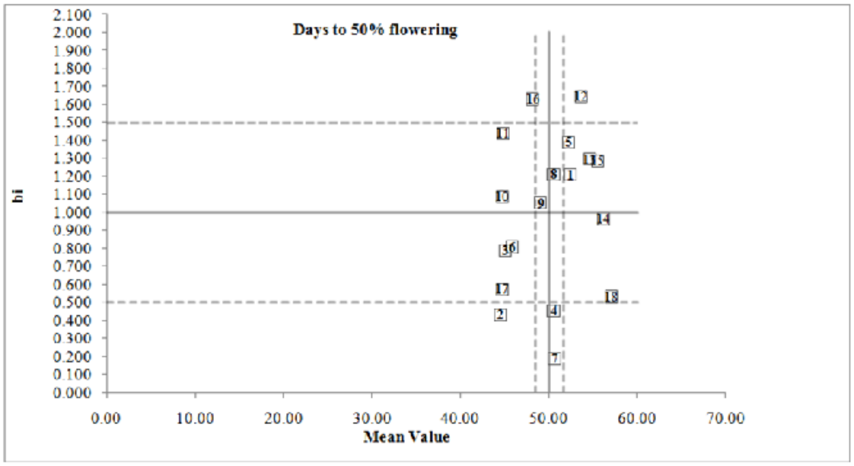

Fig. 1. bi vs mean value for days to 50% flowering.

Table 6: Mean values and stability parameters (b_i and S^2d_i) of the pearl millet hybrids for panicle diameter and panicle length (cm).

	Panicle length (cm)			Panicle diameter (cm)		
Hybrids	**Mean**	**b_i**	**S^2d_i**	**Mean**	**b_i**	**$S2d_i$**
RHB-173	23.08	0.88**	-1.21	2.35	2.14	0.05
RHB-177	20.21	0.73**	-1.22	2.15	0.53	0.02
RHB-223	20.10	0.78*	-0.91	2.49	1.48**	-0.02
RHB-233	25.26	2.28**	-1.41	2.54	0.91	0.02
RHB-234	20.92	1.47*	-0.41	2.33	0.16	0.04
RHB-538	19.79	1.58**	-0.77	2.22	1.52**	-0.02
GHB-558	21.11	0.97	13.13**	2.42	-0.07	0.03
GHB-744	20.85	1.15	1.54	2.26	0.86	0.01
GHB-905	22.38	1.17	0.38	2.34	0.74	0.06
HHB-67	19.50	1.71*	2.37	1.99	-0.45	0.21**
HHB-197	21.02	1.21*	0.39	2.46	2.58**	0.02
HHB-299	19.31	0.48	5.27*	2.60	1.21	0.20**
9450	23.49	1.10	5.35*	2.58	1.43	0.09*
9001	22.29	0.16	14.93**	2.57	3.02**	0.01
86-M-86	23.35	-0.02	-0.20	2.93	0.09	0.02
MPMH-17	19.59	-0.29	-0.29	2.21	1.88**	-0.02
MARU-TEJ	18.95	1.22**	-1.11	1.89	-1.21	0.23**
KBH-108	22.90	1.42	13.63**	2.64	1.23	0.05
S.Em+	1.44		0.83	0.19	1.36	
Pop. Mean	21.22		1	2.38	1	

*, ** = significant at 5% and 1% levels, respectively

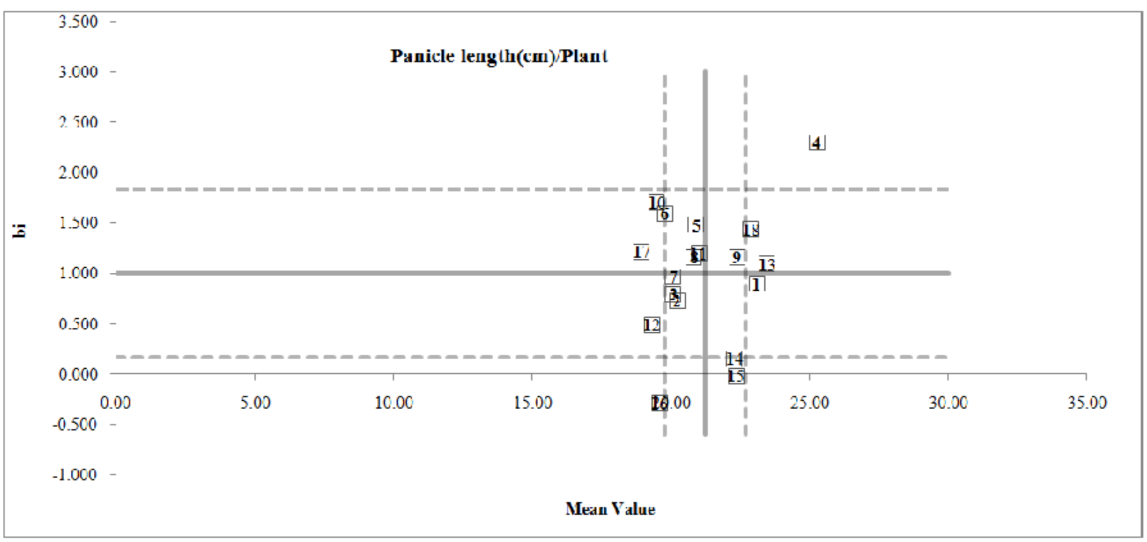

Fig. 2.

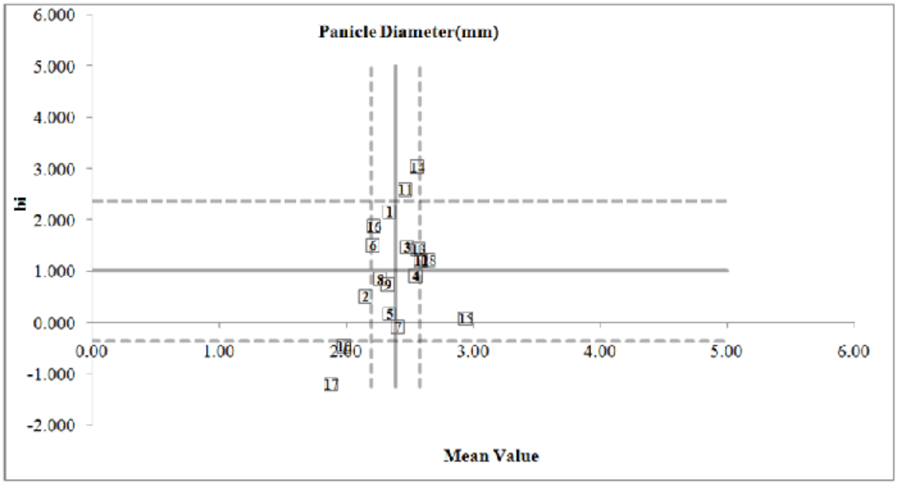

Fig. 3.

Table 7: Mean values and stability parameters (b_i and S^2d_i) of the pearl millet hybrids for test weight (g) and seed yield (g).

	Test weight (g)			Seed yield/plant (g)		
Hybrids	**Mean**	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**
RHB-173	8.69	2.34**	-0.27	23.71	-0.49	1.23
RHB-177	9.39	1.22**	-0.27	27.09	1.89**	-2.49
RHB-223	9.56	2.61**	-0.14	27.86	2.10**	-0.87
RHB-233	8.95	1.47	0.41	28.84	-0.32	-2.36
RHB-234	9.43	1.06	0.03	23.80	0.01	-2.01
RHB-538	10.31	1.10*	-0.10	24.65	0.49	10.80*
GHB-558	10.06	0.57**	-0.26	23.61	0.54	9.60*
GHB-744	10.62	0.40	-0.24	24.51	0.47	-0.55
GHB-905	10.55	1.11*	-0.11	25.51	0.33	3.78
HHB-67	10.17	0.75**	-0.23	24.26	0.54	9.77*
HHB-197	10.17	0.22**	-0.27	27.99	1.78*	4.97
HHB-299	10.09	0.68**	-0.22	26.59	2.09**	-2.44
9450	10.27	1.61**	-0.27	25.78	0.11	0.18
9001	9.51	-0.55	-0.21	28.28	2.05*	7.00
86-M-86	10.51	1.25**	-0.24	28.36	2.14**	-2.03
MPMH-17	8.84	-0.44	-0.03	24.19	1.69**	1.35
MARU-TEJ	10.15	1.36**	-0.26	23.17	0.63**	-2.41
KBH-108	10.50	1.27**	-0.28	30.73	1.96**	-1.79
S. Em+	0.23	0.31		14.538	0.584	
Pop. mean	9.87	1		26.05	1	

*, ** = significant at 5% and 1% levels, respectively

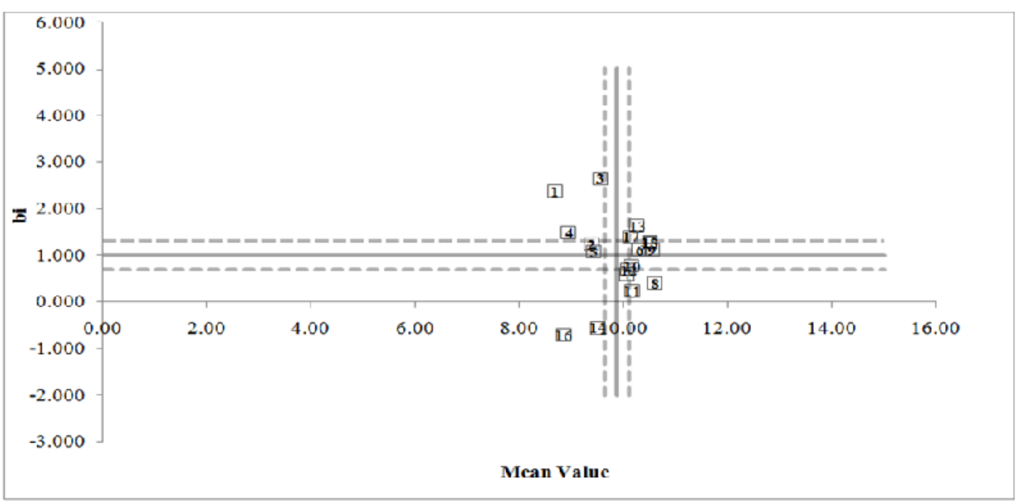

Fig. 4.

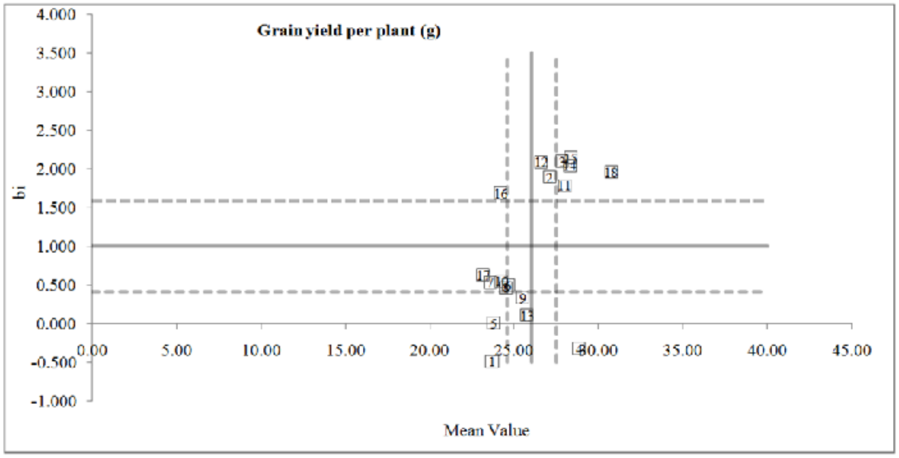

Fig. 5.

CONCLUSION

In the final conclusions by the use of Eberhart and Russell model, out of eighteen the three hybrids of pearl millet namely, MPMH-17, HHB-197 and RHB-177 were indicated high stable seed yield over the environments. Therefore, above mentioned all the three hybrids are recommended for cultivation on large scale.

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Conflict of Interest. None.

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