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Comparison of Different Stability Parameters in Finger Millet [*Eleusine coracana* (L.) Gaertn]

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ABSTRACT

The study of different stability parameters in eighteen genotypes of finger millet over 14 environments indicated that stability parameters like Wricke's (1962) ecovalence, mean variance due to genotype-environment interaction of Plaisted and Peterson (1959) and variance or information of ranks over environments gave similar results to that of the deviation from regression (S^2d) of Eberhart and Russell (1966) and Shukla's stability variance whose calculation is cumbersome. All these methods indicated more stable genotypes GE 1240, GE 3678 and GE 1287 for productive tillers per plant; GE 1035 and GE 3363 for length of finger; VMEC 219, GE 1240 and GE 1035 for ear weight per plant; GE 1035 and GE 532 for 1000 seed weight; GE 2869, GE 1240 and GE 3363 for grain yield per plant over environments.

Key words : Finger millet, Stability

Finger millet [*Eleusine coracana* (L.) Gaertn] is an important food crop of India grown in diverse agro-ecological conditions. It is the staple food of rural and working people, occupying 2.4 million hectares with a production of 2.6 million tonnes. When varieties are evaluated over a series of environments the relative ranking usually differ. Varieties are known to differ genetically for their stability across environments, knowledge on the genotype-environment interactions is the basic requirement to a plant breeder for successful crop improvement (Shantha Kumar, 2000). The present study was undertaken to evaluate different stability parameters for the stability of yield and its components in some finger millet genotypes.

MATERIAL AND METHODS

Eighteen genotypes namely GE 1035(1), VMEC 219(2), GE 2999(3), VMEC 226(4), GE 4468(5), GE 532(6), GE 3790(7), VMEC 210(8), GE 1240(9), GE 1683(10), GE 3363(11), GE 2869(12), GE 1853(13), GE 4798(14), GE 3986(15), GE 3678(16), GE 1287(17) and GE 1077(18) were sown during *kharif* 2006 (three sowing dates), *rabi* 2006 (three sowing dates) and early summer 2007 (one sowing date) with two fertility levels (high fertility N: 120 kg ha^{-1}, P_2O_5 30 kg ha^{-1}, K_2O 20 kg ha^{-1} and normal fertility N : 60 kg ha^{-1}, P_2O_5 30 kg ha^{-1}, K_2O 20 kg ha^{-1}), thus providing 14 environments at Agricultural College Farm, Bapatla. Material was grown in randomized block design with three replications with 3m long plots of 4 rows per genotype per replication. An inter and intra row spacing of 20 cm and 5 cm was practiced. The observations on plant height, , number of productive tillers per plant, number of fingers per ear, length of finger, ear weight per plant, 1000 seed weight, yield per plant, yield per plot, seed protein content, seed calcium content, weight of root at main field (WRM) and weight of shoot at main field (WSM) were taken. Statistical analysis of phenotypic stability was carried out using regression model (Eberhart and Russell, 1966), stability factor (Lewis, 1954), ecovalence (Wricke, 1962) method, Pair-wise analysis (Plaisted and Peterson 1959), genotypic stability (Hanson, 1970), stability variance (Shukla 1972), variance or information of each genotype over environments, mean of ranks of each genotype over environments and variance or information of ranks of each genotype over environments.Rank correlation coefficients among different stability parameters worked out as per Spearman (1904).

The mean values of genotypes over environments were ranked in order of superiority such that the genotype with 18^{th} rank was the one with maximum mean and the one with first rank with minimum mean. Similarly another parameter mean of ranks over environments was calculated. The mean of ranks were calculated such that the genotypes with 18^{th} and 1^{st} rank were the one with greater and least desirability respectively. Mean of ranks over environments may give its consistency over environments. The variance (or) information values of the ranks over environments were ranked such that the genotype with 18^{th} rank or least variance or maximum information may prove desirable compared to the one with first rank and with maximum variance or least information. Variance (or) information of genotype over environments may indicate the stability of a particular genotype. A genotype with least variance or maximum information over environments may show less fluctuations to the frequent changes in the environments.

Wricke's ecovalence over environments and variety-environment interaction variance of a genotype proposed by Plaisted and Peterson (1959) also indicate a genotype's contribution to the total interaction variance of genotype and environment. However, these differ from the earlier parameter variance or information of genotype over environments such that these two models take care of the replication and error effects. The high mean ($\overline{X}$) unit regression coefficients (b) and non-significant deviation from regression (S^2d) proposed by Eberhart and Russell (1966) define a stable genotype.

According to Shukla's (σ^2_i) stability variance the genotype with 18th rank or least variance and non-significance may prove stable to fluctuations in environments compared to the genotype with first rank or maximum variance and significant. Hanson (D^2_i) genotypic stability is a measure which combines the information from equivalence and regression into a simple useful measure of yield stability, in this model the genotypes with least variance over environments were considered to be stable and were ranked as 18th and *vice versa*.

RESULTS AND DISCUSSION

A comparison of different stability parameters was made based on rank correlation coefficients between pairs of these parameters (Table1) and by empirically comparing the stable (or) desirable genotypes under each of these parameters (Table 2).

In the present study, the mean and mean of ranks were significantly and positively correlated for all characters (except for length of finger) considered in the study as they (Table 1) are similar calculations and have same criteria for defining a stable genotype. The genotypes classified as more or less stable are the same in both these cases (Table2). In the same way variance (or) information over environments and Hanson's genotypic stability, ecovalence, regression coefficient and deviation from regression with Shukla's variance were significantly and positively correlated for characters considered in the study (Table 1) as they have same criteria for defining a stable genotype. The genotypes classified as more or less stable are the same in case of variance or information over environments with Hanson genotypic stability (genotypes 6,9 and3 for yield per plot) and ecovalence with Shukla's stability variance (genotypes 17,16 and9 for productive tillers per plant) (Table 2).

Lewis stability factor and Hanson's genotypic stability showed positive significant association for all the characters under study except for length of finger. Ecovalence with Hanson's genotypic stability also showed significant association with all characters except for productive tillers per plant. Similarly D^2_i with b positively significant (for length of finger), D^2_i with S^2d (for ear weight per plant, 1000 seed weight and yield per plant) D^2_i with variance or information of ranks (for 1000 seed weight and yield per plant),showed significant positive associations.

Variance or information over environments showed positive association with Shukla's variance for characters like length of finger, 1000 seed weight and yield per plant. Lewi's stability factor indicated positive significant association with σ^2_i for length of finger, 1000 seed weight and yield per plant. The 'b' and S^2d also showed positive association with σ^2_i for all characters. The genotypes 9, 12 and 9, 11 and 12 and 9, 11 and 12 are classified as most stable according to b, S^2d and σ^2_i , respectively where as the genotypes 17 and 10 were considered as less stable according to these 3 parameters.

σ^2_i showed significant positive association with variance or information of ranks for all characters except ear weight per plant and σ^2_i with D^2_i also expressed significant positive association for all characters except productive tillers per plant

Thomson and Cunningham (1979) ranked cotton cultivar yields in individual environments and calculated standard deviation of these ranks for each cultivar as a measure of consistency of performance denoted by CI (consistency index). This provides a measure of consistency resulting from changes in the ordering of the genotypes from one environment to the next. Huhn and Leon (1985) worked out "mean rank difference" (according to Huhn, 1979) for judging the stability of genotypes of *Brassica napus.* The variance or information over environments and stability factor showed close association among stable or unstable genotypes for different characters. This was confirmed by the genotypes ranked as stable under these two parameters. For example, for yield per plot genotypes 6,3 and 9 and 6, 9, 4 and 14 according to variance and stability factor were ranked as stable respectively. Similarly the genotypes marked as less stable for yield per plot were 2,8 and 15 and 2,8 and 7 according to variance and stability factor, respectively.

Huhn and Leon (1985) reported numerically low (or) intermediate rank correlation coefficients between

Table 1 : Rank correlation coefficient between pairs of different stability parameters in finger millet [*Eleusine coracana* (L.) Gaertn]

		Variance	Stability factor	Ecovalence	Mean variance due to g x e	Regression coefficient	Deviation from regression	Mean of ranks	Variance of ranks	Hanson genotypic stability	Shukla's variance
Mean	Productive tillers / plant	0.22	0.51*	-0.25	-0.26	-0.25	-0.19	0.99**	0.49	-0.08	-0.24
	Length of finger	-0.08	0.67**	0.16	-0.01	-0.14	-0.05	0.00	0.29	-0.01	0.15
	Ear weight /plant	-0.08	0.41	-0.65**	-0.61	-0.44	-0.30	0.99**	0.52*	-0.42	-0.35
	1000 seed weight	-0.09	0.09	-0.06	-0.03	0.38	-0.19	0.96**	0.26	-0.09	-0.10
	Yield /plant	0.15	0.39	-0.06	-0.05	0.017	-0.15	0.99**	0.41	0.09	0.33
Variance	Productive tillers / plant		0.61**	0.11	0.28	0.22	0.29	-0.15	0.32	0.88**	0.28
	Length of finger		0.62**	0.82**	0.52*	0.45	0.58*	0.04	0.46	0.85**	0.82**
	Ear weight /plant		0.78**	0.23	0.21	0.22	0.41	-0.07	0.30	0.88**	0.23
	1000 seed weight		0.65**	0.86**	0.84**	0.28	0.88**	-0.21	0.75**	0.96**	0.86**
	Yield /plant		0.89**	0.72**	0.69**	0.09	0.65**	0.18	0.59*	0.99**	0.68**
Stability factor	Productive tillers / plant			0.09	0.06	-0.02	0.12	0.51*	-0.10	0.69**	0.05
	Length of finger			0.73**	0.67**	0.23	0.58*	0.67**	0.56*	0.42	0.73**
	Ear weight /plant			-0.21	-0.22	-0.18	-0.15	0.41	0.54*	0.49*	-0.21
	1000 seed weight			0.58*	0.60**	0.11	0.70**	0.07	0.51*	0.59**	0.58**
	Yield /plant			0.61*	0.60**	-0.11	0.58*	0.40	0.67**	0.88**	0.61**
Ecovalence	Productive tillers / plant				0.96**	0.81	0.86**	-0.25	0.83**	0.12	0.99**
	Length of finger				0.78**	0.49*	0.68**	0.84**	0.56*	0.52*	1.00**
	Ear weight /plant				0.99**	0.76**	0.94**	-0.67**	-0.16	0.57*	1.00**
	1000 seed weight				0.97**	0.58*	0.89**	-0.19	0.67**	0.76**	1.00**
	Yield /plant				0.99**	0.21	0.94**	-0.02	0.78**	0.76**	0.99**
Mean variance due to g x e	Productive tillers / plant					0.65**	0.83**	-0.21	0.83**	0.09	0.99**
	Length of finger					0.38	0.51*	0.09	0.35	-0.16	0.001
	Ear weight /plant					0.71**	0.95**	-0.67**	-0.14	0.08	0.28
	1000 seed weight					0.59**	0.88**	-0.15	0.64**	-0.38	0.19
	Yield /plant					0.24	0.92**	-0.02	0.77**	-0.09	-0.17
Regression coefficient	Productive tillers / plant						0.42	-0.21	0.73**	0.09	0.79**
	Length of finger						0.25	-0.14	0.38	0.68**	0.49**
	Ear weight /plant						0.32	-0.55*	-0.05	0.43	0.76**
	1000 seed weight						0.31	0.26	0.30	0.11	0.58**
	Yield /plant						-0.05	0.01	0.23	0.05	0.24
Deviation from regression	Productive tillers / plant							-0.13	0.59**	0.07	0.83**
	Length of finger							0.07	0.30	0.37	0.68**
	Ear weight /plant							-0.43	-0.08	0.58**	0.94**
	1000 seed weight							-0.33	0.58*	0.80**	0.89**
	Yield /plant							-0.11	0.67**	0.59**	0.94**
Mean of ranks	Productive tillers / plant								0.40	-0.08	-0.20
	Length of finger								0.29	-0.01	0.16
	Ear weight /plant								0.50*	-0.42	-0.37
	1000 seed weight								0.17	-0.17	-0.19
	Yield /plant								0.43	0.17	-0.05
Variance of ranks	Productive tillers / plant									0.16	0.83**
	Length of finger									0.28	0.56**
	Ear weight /plant									0.01	-0.12
	1000 seed weight									0.77**	0.67**
	Yield /plant									0.64**	0.77**
Hanson genotypic stability	Productive tillers / plant										-0.09
	Length of finger										0.52*
	Ear weight /plant										0.57**
	1000 seed weight										0.76**
	Yield /plant										0.68**

* = Significant at 0.05 level ** = Significant at 0.01 level

Table 2. More and less stable genotypes according to different stability parameters in finger millet [*Eleusine coracana* (L.) Gaertn]

	Mean		Variance		Lewlis' stability factor		Wricke's ecovalence		Mean variance due to g x e (Plaisted & Peterson)		Regression coefficient	
	More stable	Less stable	More stable	Less stable	More stable	Less stable	More stable	Less stable	More stable	Less stable	More stable	Less stable
Days to 50% flowering	16,15,4	11,2,5	17,7,8	6,3,15	17,7,16,1	6,3,15,2	12,4,5	6,3,15	-	-	4,7,16	1,13,18
Productive tillers per plant	12,5,6	9,2,7	10,4,14,5	12,11,18	17,10,14	18,,2,,7,13	17,16,9	13,12,14	17,9,16	13,14,12	6,16,17	12,13,8
Fingers per ear	18,13,4	15,10,12	9,7,5,12	18,6,18	9,6,3	18,16,7	9,3,12	18,13,16	-	-	5,9,12	6,2,17
Length of finger	3,13,4	12,15,8	1,11,18	14,17,9	13,1,4	14,8,9	1,11,16	14,9,3	1,11,13	14,18,2	11,1,4	3,5,10
Ear weight per plant	14,6,13	10,7,1	17,2,13	16,18,11	17,6,13	16,11,18	2,1,9	14,13,12	2,9,1	14,13,6	2,4,15	14,12,6
1000 seed weight	14,15,16	8,9,4,13	9,12,17	4,5,3	6,17,11,14	4,18,15	1,6,8	4,5,10	6,1,8	4,5,10	6,1,11	5,15,4
Yield per plant	14,6,4	9,8,7	6,3,9	15,8,5	6,14,3	8,2,7	12,9,11	17,15,2	12,11,9	17,15,2,10	9,12	17,10,7
Yield per plot	14,6,4	9,8,7	6,3,9	15,2,8	6,14,4,9	2,8,7,	9,11,1	17,15,2	-	-	12,6,9	8,7,3
Protein content	7,3,9	14,4,13	6,17,2	9,3,14	6,7,17	9,14,3	1,2,11	9,3,10	-	-	1,2	5,15,18
Calcium content	3,10,15	9,1,17	4,8,11	6,13,5	4,8,11	6,17,9	1,2,3	6,13,17	-	-	-	1 to 18
WRM	14,17,16	7,13,11	6,17,4	15,7,11	4,17,18	15,7,11	9,5,16	15,7,10	-	-	5,9,16	3,9
WSM	14,6,18	7,8,11	2,14,17	18,13,4	14,5,1,7	18,15,13	17,8,9	18,13,16	-	-	3,6,9	18,15,13

	Deviation from regression		Mean of ranks		Variance of ranks		Hanson's genotypic stability		Shukla's stability varian ce	
	More stable	Less stable	More stable	Less stable	More stable	Less stable	More stable	Less stable	More stable	Less stable
Days to 50% flowering	3,12,15	13,18,10	16,15,14	16,15,14	11,9,12	2,15,18	17,7,8	6,3,15	12,4,5	6,3,15
Productive tillers per plant	18,16,17	13,12,3	5,12,6	5,12,6	1,16,9	3,12,13	10,14,4	12,1,1,18	17,16,9	13,12,14
Fingers per ear	9,3,5	18,14,1	6,13,4	6,13,4	6,17,15	14,18,1	5,10,4	18,1,6,8	9,3,12	18,13,16
Length of finger	17,1,11	9,3,14	3,13,4	3,13,4	4,12,13	9,14,17	1,18,12	14,1,7,6	1,11,16	14,9,3
Ear weight per plant	2,1,9	14,13,6	14,6,13	14,6,13	14,6,1	16,11,8	17,2,10	14,1,6,18	2,1,9	14,13,6
1000 seed weight	1,6,9	4,5,15	14,16,15	14,16,15	14,8,9	4,5,3	17,9,12	4,5,3	1,6,8	4,5,10
Yield per plant	12,9,11	17,2,10	14,6,13	14,6,13	14,4,6	2,15,10	6,9,3	13,8,2	12,9,11	17,15,2
Yield per plot	12,6,9	17,2,10	14,6,4	14,6,4	14,4,6	15,10,3	6,9,3	15,2,8	12,9,11	17,15,2
Protein content	1,2,5,6	3,9,10	7,3,8	7,3,8	1,15,16	9,10,3,14	2,6,1	9,3,10	1,2,5,6	9,3,10
Calcium content	1,3,8	6,17,13	18,3,10	18,3,10	-	10,11,12,16	8,11,4	6,13,5	3,1,2	6,13,17
WRM	16,5,11	15,3,14	14,17,6	14,17,6	14,5,17	10,4,15	6,4,17	15,7,11	16,5,9	15,7,4,10
WSM	17,8,9	18,13,4	14,6,5	14,6,5	14,6,17	18,15,16	16,14,5	18,1,3,4	17,8,9	18,13,16

1 GE 1035 2 VMEC 219 3 GE 2999 4 VMEC 226 5 GE 4468 6 GE 532 7 GE 3790 8 VMEC 210 9 Ge1240
10 GE 1683 11GE 3363 12 GE 2869 13 GE 1853 14 GE 4798 15 GE 3986 16 GE 3678 17 GE 1287 18 GE 1077

mean of the lines and different stability parameters like variance, ecovalence, genotypic stability, regression coefficient, sum of squared deviations from the regression and mean rank difference.

The ecovalence showed positive association with variance of genotype- environment interaction according to Plaisted and Peterson (1959), regression coefficient, deviation from regression and variance or information of ranks (Table 1). Similarly the variance due to genotype and environment of Plaisted and Peterson (1959) showed positive association with regression coefficient, deviation from regression and variance (or) information of ranks (except for ear weight per plant). For yield per plant the most stable genotypes were 12, 9, 11 and 12, 9, 11 according to ecovalence and variance due to genotype and environment of Plaisted and Peterson (1959) respectively. The more stable genotypes according to 'b' were 9 and 12 for yield per plant. The stable genotypes with less deviation form regression for yield per plant were 12, 9 and 11 where as the least stable genotypes for yield per plant were 17, 2,15 and 10 under parameters ecovalence, variance due to genotype and environment of Plaisted and Peterson (1959) and also the deviation from regression where as the least stable genotypes according to variance (or) information of ranks were 2, 15 and 10.

The S^2d showed positive association with variance (or) information or ranks for productive tillers per plant, length of finger, 1000 seed weight and yield per plant. For productive tillers per plant the genotypes 18, 16, 17 and 1, 16 and 9 were classified as most stable according to S^2d and variance (or) information or ranks respectively. Where as the genotypes 3, 12 and 13 were considered as less stable according to both parameters.

No relationship existed between $\overline{x}$ and b, and S^2d, b and S^2d, variance (or) information and b, variance (or) information and mean of ranks, stability factor and b, and S^2d and mean of ranks, $\overline{x}$ and D^2_i, $\overline{x}$ and σ^2_i, mean variance due to g x e and D^2_i, mean variance due to g x e and σ^2_i, mean of ranks and D^2_i mean of ranks σ^2_i indicating that these are independent estimates.

The study indicates similarity of results for spotting stable genotypes according the ecovalence, variance due to genotype – environment interaction of Plaisted and Peterson, b and S^2d of Eberhart and Russell and variance (or) information of ranks, D^2_i and variance (or) information over environments ecovalence and σ^2_i. Kang *et al.* (1987) observed perfect correlation between σ^2_i and W_i. The study also indicated as far as the spotting of stable genotypes simple methods like ecovalence, variance due to genotype environment interaction of Plaisted and Peterson and variance or information of ranks shall give similar results like S^2d whose calculation is cumbersome. The above simpler techniques may be applied as per suitability of experiment and convenience of the experimenter.

In the present study the significant rank correlation between ecovalence, S^2d and variance due to genotype – environment interaction of Plaisted and Peterson was noticed because the genotypes classified as more and less stable are almost same under both these methods. Where as in the experiment of Luthra and Singh (1974) though the stable genotypes were same according to both methods, the two methods differed in spotting less stable genotypes resulting in low rank correlation coefficient between the ranking of genotypes.

The other parameters like mean, stability factor, mean of ranks and variance or information over environments may not specify the same genotypes as in case of other parameters like b and S^2d and may not be very useful due to the fact that, the first three parameters employ the mean which is a first order statistic and, the partitioning of treatment and error effects was not there in calculation of these parameters.

LITERATURE CITED

Eberhart S A and Russell W A 1966 Stability parameters for comparing crop varieties. Crop Science 6 : 36- 40.

Hanson W D 1970 Genotypic stability. Theoritical and Applied Genetics 40: 226-231.

Huhn M and Leon J 1985 Genotype ´ environment interactions and phenotypic stability of *Brassica napus*. Z.pf-lan Zen zuchtg. 95: 135-146.

Huhn M 1979 Beitrage zur Erfassung der phanotypischen stablitat. I. Voyschlag einiger auf Ranginformationen beruhenden stabilitat-sparameter. EDV in medizin und Biologie 10: 112-117.

Kang M S, Miller J D and Darrah L L 1987 A note on relationship between stability variance and ecovalence. Journal of Heredity, 78: 107.

Lewis D 1954 Genotype-environment interaction: A relationship between dominance, heterosis, phenotypic stability and variability. Heredity 8 : 333 – 356.

Luthra O P and Singh R K 1974 Comparision of different stability models in wheat. Theoretical and Applied Genetics 45 : 143 – 149.

Plaisted R L and Peterson L C 1959 A technique of evaluating the ability of selections to yield consistentcy in different seasons or locations. American Potato Journal 36 : 381 – 385.

Shanthakumar G 2000 Stability analysis for yield and yield influencing traits in finger millet (*Eluesine coracana*). Indian Journal of Agricultural Sciences 70 (7): 472-474.

Shukla 1972 Some statistical aspect of partitioning GE components of variability. Heridity 29: 237-245.

Spearman C 1904 Rank correlations. *In* Statistical methods by Snedecor G W (1946). Iowa state college press, Ames. Iowa.U.S.A

Thomson N J and Cunningham R B 1979 Genotype x environment interactions and evaluation of cotton cultivars. Australian Journal of Agricultural Research. 30: 105-120.

Wricke O 1962 Uber eine Method Zur Erffassung derkologi schen strenb reite in Feldversuchen. Z pflan zen zuchtung 47 : 92 – 96.

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