The Andhra Agric. J 58(3):300-305, 2011

Comparision of Different Stability Parameters in Italian Millet

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ABSTRACT

The study of different stability parameters in twenty genotypes of Italian millet over 16 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 GS 480 and GS 489 for productive tillers plant^{-1}; GS 487 and GS 444 for ear length; GS 440 and GS 477 for ear weight; SRL for 1000 grain weight; GS 479 and GS 487 (for straw yield) GS 450 and GS 467 for grain yield plant^{-1} over environments.

Key words : Italian millet, Stability.

Italian millet is an important minor millet belonging to the family Poaceae. It is suited to conditions of low and moderate rainfall area due to early maturity period. It is grown extensively in diverse agro-climatic regions. The grain is a good source of protein and contains β-carotene, which is a precursor of vitamin-A (Murugan and Nirmalakumari 2006). The present study was undertaken to evaluate different stability parameters for the stability of yield and its components in some Italian millet genotypes.

MATERIAL AND METHODS

Twenty genotypes namely GS 440(1), GS 444 (2), GS 445 (3), GS 450 (4), GS 462 (5), GS 463 (6), GS 465 (7), GS 467 (8), GS 477 (9), GS 479 (10), GS 480 (11), GS 482(12), GS 486(13), GS 487(14), GS 488 (15), GS 489(16), Krishnadevaraya (17), Narasimharaya (18), Srilakshmi (19) and Prasad (20) were sown during *kharif* 2009 (four sowing dates) and *rabi* 2009-10 (four sowing dates) with two fertility levels (high fertility N: 80 kg ha^{-1}, P_2O_5 20 kg ha^{-1}, K_2O 20 kg ha^{-1} and normal fertility N : 40 kg ha^{-1}, P_2O_5 20 kg ha^{-1}, K_2O 20 kg ha^{-1}), thus providing 16 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 25 cm and 10 cm was practiced. The observations on number of productive tillers plant^{-1}, ear length, ear weight, 1000 grain weight, straw yield, grain yield plant^{-1}, grain protein content, grain calcium content, carotene content, volume of root at main field (VRM) and weight of root at main field (WRM) 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 a way such that the genotype with 20th rank was the one with maximum mean and the one with first rank with minimum mean. 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. Similarly another parameter mean of ranks over environments was calculated. Mean of ranks over environments may give its consistency over environments. The mean of ranks were calculated such that the genotypes with 20th and 1st rank were the genotypes with greater and least

Table 1. More and less stable genotypes according to different stability parameters in Italian millet

	Mean		Variance		Lewis stability factor		Wricke's ecovalence		Mean variance due to g × e (Plaisted & Peterson)		Regression coefficient		Deviation from regression		Mean of ranks		Variance of ranks		Hanson genotypic stability factor		Shukla's stability variance	
	More stable	Less stable	More stable	Less stable	More stable	Less stable	More stable	Less stable	More stable	Less stable	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%	18,17	7,6	2,4,	5,13	2,4	5,13	2,4	5,13	2, 4,	5,13	10,2	5,17	8,18	1,6	4,8	17,18	2,14	2,14	17,7,8	6,3	2,4	5,13
flowering	13	13	8	15	8	15	8	15	8	15	6	19	20	13	11	19	18	17		15	8	15
Productive	2.4	7,8	9,11	1,6	11,16	1,6	9,11	1,6	11, 9	1,13	6,16	12,13	4,11	3,13	7,8	2,4	8,17	1,13	11,16	1,6	9,11	1,6
tillers plant $^{-1}$	10	17	16	13	20	13	16	13	16	6	17	8	8	15	17	10	9		19	13	16	13
Ear length	2,10	8,12	6,8	1,11	2,6	1,11	6,8	1,11	6,8	1,11	11,17	6,8	6,8	11,17	8,12	2,10	2,10	1,11	6,9	1,11	6,8	1,11
	14	20	9	17	14	17	15	17	15	17	16	14	13	20	20	14	14	17	8	16	15	17
Ear weight	2,4	13,15	1,9	3,6	1,9	3,6	1,9	3,6	1,9	3,6	2,13	8,7	15,18	3.6	2,4	13,15	1,2	3,6	1,9	3,6	1,9	3,6
	14	16	10	19	17	19	17	19	17	19	19	5	12	19	14	16	10	19	10	19	8	19
Straw weight	2,10	7,9	10,14	1,3	2,4	3,11	10,14	1,3	10,14	1,3	5,12	11,19	12,18	1,3	7,12	2,4	10,17	3,14	10,14	1,3	10,14	1,3
	14	12	20	11	14	17	20	11	20	11	13	16	4	11	8	10	19	16	20	11	20	11
1000 grain	2,10	1,12	2,10	3,7	2,10	1,3	2,10	1,3	2,10	1,3	4,10	6,13	12,18	1,3	1,12	2,4	14,10	7,9	2,10	13,3	2,10	1,3
weight	14	16	14	9	14	7	14	9	14	9	2	3	4	11	18	10	19	16	14	9	14	9
Grain yield	2,4	7,8	4,8	1,10	2,4	1,13	7,8	1,10	7,8	1,10	4,8	1,13	4,7,8	1,10	7,8	4,2	4,7,	1,11	4,8	1,6	7,8	1,10
plant $^{-1}$	10	17	17	13	5	18	17	13	17	13	19	16	17	13	17	10	12	13	17	13	17	13
Protein	9,15	5,7	9,10	3,6	9,10	1,3	7,10	3,6	-	-	4,8	3,13	5,8	3,6	5,7	15,9	7,9,	3, 6	9,10	3,6	7,10	3,6
content	17	10	12	13	18	6	12	13			19	9	11	13	10	17	15	13	14	13	12	13
Calcium	6,11	13,14	1,9	14,17	1,10	14,17	2,5	14,17	-	-	1,20	7,9	5,8	3,6,	17,13	11,6	11,14	7,10	1,9	14,17	2,5	14,17
content	16	17	20	18	11	18	20	18			8	13	11	13	14	16	20	18	20	18	20	18
Carotene	3,6	5,8	10,14	6,9	5,8	6,13	5,8	2,12	-	-	10,9	18,4	5,4,8	2,13	17,3	8,2	5,9	13,12	4,5	11,12	5,8	2,12
content	17	20	20	11	20	15	10	14			16	15		19	6	5	11	15	10	15	10	14
VRM	4,14	9,15	1,5	11,18	1,2	11,18	1,5	11,18	-	-	1,4	10,11	15, 12	18,19	14,4	15,9	14,5	11,18	1,3	11,18	1,5	11,18
	10	16	13	19	5	19	8	19			14	12	20	11	2	16	13	19	13	19	8	19
WRM	2,4	9,11	1,12	9,13	1,3	9,13	1,14	9,12	-	-	3,12	15,7		20,13	11,12	14, 2	14,12	18,13	1,12	9,13	1,12	9,13
	14	12	15	18	15	18	15	13			10	,9	2,3,17	9	9	10	10	20	15	20	14	20

1. GS 440 2. GS 444 3. GS 445 4. GS 450 5. GS 462 6. GS 463 7. GS 465 8. GS 467 9. GS 477 10. GS 479
11. GS 480 12. GS 482 13. GS 486 14. GS 487 15. GS 488 16. GS 489 17. KDR 18. NSR 19. SRL 20. PRD

Table 2. Rank correlation coefficient between pairs of different stability parameters in Italian millet.

		Variance	Stability factor	Ecova-lence	Mean variance due to G × E	Regres-sion coefficient	Deviation from regression	Mean of ranks	Variance of ranks	Hanson genotypic stability	Shukla's variance
Mean	Productive tillers plant^{-1}	0.31	0.11*	0.33	-0.03	0.14	-0.03	0.96**	0.16	0.41	0.33
	Ear length	0.09	0.07	0.10	0.20	-0.12	-0.01	0.98**	-0.14	0.04	0.10
	Ear weight	-0.12	0.20	-0.54**	-0.43	-0.06	-0.13	0.95**	0.53*	-0.16	-0.05
	1000 grain weight	-0.68	-0.64	-0.67	-0.15	0.22	-0.37	0.98**	0.41	0.18	0.42
	Grain yield plant^{-1}	0.16	0.28	0.18	0.51*	-0.03	0.20	0.98**	0.15	0.17	0.18
Variance	Productive tillers plant^{-1}		0.84**	0.99**	0.28	0.81	0.30	0.40	0.75**	0.96**	0.31
	Ear length		0.89**	0.98	0.17	-0.39	0.93**	0.11	0.89**	0.89**	0.41
	Ear weight		0.89**	0.99**	0.31	0.11	0.41	-0.09	0.36	0.95**	0.81**
	1000 grain weight		0.95**	0.92**	0.74**	-0.07	0.88**	-0.62**	0.81**	0.94**	0.91**
	Grain yield plant^{-1}		0.78**	0.99**	0.57*	0.09	0.92**	0.16	0.95**	0.97**	0.99**
Stability factor	Productive tillers plant^{-1}			0.85**	0.45**	0.57	0.42	0.16	0.70	0.86**	0.85**
	Ear length			0.90**	0.20	-0.48	0.84*	0.62**	0.82**	0.68**	0.90**
	Ear weight			-0.42	-0.30	-0.27	-0.20	0.41	0.54*	0.41	0.84**
	1000 grain weight			0.89**	0.73**	0.26	0.84**	0.32	0.82**	0.97**	0.64**
	Grain yield plant^{-1}			0.79	0.58**	0.47	0.77*	0.27	0.73**	0.77**	0.79**
Ecova-lence	Productive tillers plant^{-1}				0.92**	0.75**	0.34	0.41	0.74**	0.96**	0.99**
	Ear length				0.79**	0.53*	0.92**	0.78**	0.82**	0.64*	0.99**
	Ear weight				0.70**	0.75**	0.99**	-0.04	-0.07	0.91**	0.99**
	1000 grain weight				0.81**	0.54*	0.97**	-0.66	0.77**	0.92**	1.00**
	Grain yield plant^{-1}				0.89**	0.67	0.99**	0.19	0.94**	0.96**	0.99**
Mean variance due to G x E	Productive tillers plant^{-1}					0.58**	0.73**	0.01	0.35	0.29	0.29
	Ear length					0.33	0.59**	0.19	-0.14	0.07	0.19
	Ear weight					0.72**	0.76**	-0.57**	0.78**	0.16	0.71**
	1000 grain weight					0.67**	0.81**	-0.20	0.60**	-0.005	0.16
	Grain yield plant^{-1}					-0.25	0.72**	-052	0.68**	0.01	0.06
Regres-sion coefficient	Productive tillers plant^{-1}						-0.003	0.24	0.66**	0.77**	0.75**
	Ear length						-0.40	-0.14	-0.58	0.56**	0.53**
	Ear weight						-0.17	-0.52*	-0.15	0.23	0.76**
	1000 grain weight						0.46	-0.62**	0.60	0.75**	0.63**
	Grain yield plant^{-1}						-0.10	0.69**	0.79**	0.08	0.67**
Deviation from regression	Productive tillers plant^{-1}							0.03	0.44**	0.31	0.63**
	Ear length							-0.01	0.86**	0.81**	0.92**
	Ear weight							-0.03	-0.21	0.89**	0.99**
	1000 grain weight							-0.66	0.79**	0.91**	0.86**
	Grain yield plant^{-1}							0.21	0.94**	0.96**	0.99**
Mean of ranks	Productive tillers plant^{-1}								0.29	0.49	0.41
	Ear length								-0.13	0.05	0.13
	Ear weight								0.56*	-0.18	-0.03
	1000 grain weight								-0.75**	-0.80**	0.40
	Grain yield plant^{-1}								0.14	0.15	0.19
Variance of ranks	Productive tillers plant^{-1}									0.75**	0.74**
	Ear length									0.71**	0.92**
	Ear weight									0.82**	-0.22
	1000 grain weight									0.87**	0.58**
	Grain yield plant^{-1}									0.84**	0.94**
Hanson genotypic stability factor	Productive tillers plant^{-1}										0.96**
	Ear length										0.82**
	Ear weight										0.90**
	1000 grain weight										0.68**
	Grain yield plant^{-1}										0.96**

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

desirability, respectively. The variance (or) information values of the ranks over environments were ranked such that the genotype with 20th rank or least variance or maximum information may prove desirable compared to the one with first rank and with maximum variance or least information. 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, thise 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 20th 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 20th 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 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 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 4, 8 and 17 for yield per plant) and ecovalence with Shukla's stability variance (genotypes 9,11 and 16 for productive tillers per plant) (Table 2).

Variance or information over environments showed positive association with Shukla's variance for characters like productive tillers per plant, ear length, ear weight, 1000 grain weight and grain yield $plant^{-1}$. Lewi's stability factor indicated positive significant association with s^2_i for all the characters. The 'b' and S^2d also showed positive association with σ^2_i for all characters. The genotypes 4, 8 and 4, 7, 8 and 17 and 7, 8 and 17 are classified as most stable according to b, S^2d and σ^2_i, respectively where as the genotypes 1, 10 and 13 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.

Lewi's stability factor and Hanson's genotypic stability showed positive significant association for all the characters under study except for ear weight. Ecovalence with Hanson genotypic stability has also showed significant association for all characters. Similarly D^2_i with b positively significant (for productive tillers $plant^{-1}$, ear length and 1000 grain weight), D^2_i with S^2d (for for ear length, ear weight, 1000 grain weight and grain yield per plant) D^2_i with variance or information of ranks (for productive tillers $plant^{-1}$, ear length, ear weight, 1000 grain weight and grain yield $plant^{-1}$),showed significant positive associations.

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

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 grain yield plant^{-1} genotypes 4, 8 and 17 and 2, 4, 5 and 17 according to variance and stability factor were ranked as stable respectively. Similarly the genotypes marked as less stable for grain yield plant^{-1} were 1, 10 and 13 and 1, 13 and 18 according to variance and stability factor, respectively.

The S^2d showed positive association with variance (or) information or ranks for productive tillers plant^{-1}, ear length, 1000 grain weight and grain yield plant^{-1}. For productive tillers per plant the genotypes 8, 18, 17 and 20 and 8, 17 and 9 were classified as most stable according to S^2d and variance (or) information or ranks respectively. Where as the genotypes 1 and 13 were considered as less stable according to both parameters.

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 productive tillers plant^{-1} and ear length). For yield per plant the most stable genotypes were 7, 8, 17 and 7, 8, 17 according to ecovalence and variance due to genotype and environment of Plaisted and Peterson (1959) respectively. The more stable genotypes according to 'b' were 5, 8, 11 and 19 for grain yield plant^{-1}. The stable genotypes with less deviation form regression for grain yield plant^{-1} were 5, 9, 11 and 15 where as the least stable genotypes for grain yield plant^{-1} were 1, 10 and 13 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 1, 11 and 13.

No relationship existed between $\overline{X}$ and b $\overline{X}$ 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 ´ e and D^2_i, mean variance due to g xe 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 useing 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 and 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 simple methods like ecovalence, variance due to genotype using environment interaction of Plaisted and Peterson and variance or information of ranks which give similar results like S^2d whose calculation is cumbersome. The above simpler techniques may be applied as per suitability of the experiment and convenience of the Exeperimenter.

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.

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 ´ 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.

(Received on 18.10.2010 and revised on 09.11.2010)