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Research Article

Stability Analysis for Quality Traits in Maize (*Zea mays* L.)

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Abstract

Fifty five genotypes consisting of 10 parents and 45 hybrids were evaluated under four environments to test their stability. Variance due to genotype, environments and genotype x environments interaction were found significant for oil content, protein content, tryptophan content and lysine content. Among the hybrids, GWQPM 5-1 x GWQPM 40-3 and GWQPM 5-1 x GWQPM 17-1 were found stable for protein content as well as tryptophan content under the wide range of environments. Hybrid GWQPM 40-3 x GWQPM 26-3 for protein and lysine content found stable for all the environments. For oil content hybrid GWQPM 55-2 x GWQPM 46-2 had high *per se* performance. The hybrids GWQPM 5-1 x GWQPM 40-3, GWQPM 5-1 x GWQPM 17-1 and GWQPM 40-3 x GWQPM 26-3 appeared promising for protein, tryptophan and lysine content.

Key words
Maize, stability parameter, yield, and quality traits.

Introduction

Maize (*Zea mays* L.; 2n=20) is one of the most important cereal crops as a food for human being and a feed for animals. There is no cereal on the earth, which has such an immense potential as maize and therefore, it occupies the unique place as “Queen of Cereals”. It accounts 15 to 56 per cent of the total daily calories of the people in many developing countries. A genetic approach to improve the nutritional quality of maize protein yielded the quality protein maize which contains opaque-2, a single gene mutation that alter the protein composition of the endosperm protein and nearly double the essential amino acid (Akande and Lamidi, 2006). Quality protein maize (QPM) contains high quality amino acids lysine and tryptophan, which are two times higher in QPM than normal maize. Development and adaptation of QPM would increase the nutritional quality of food and feed as well. In order to diversify the uses of maize, it is desirable to develop maize hybrids having high oil and protein content with stable performance over environments. Therefore, need for identification of stable genotype is obvious. In the present study an attempt was made to assess stability parameters of the crop under four different environments.

Materials and method

Forty five single cross hybrids developed by crossing 10 diverse inbred lines of quality protein maize (GWQPM 6-3, GWQPM 5-1, GWQPM 55-2, GWQPM 47-4, GWQPM 46-2, GWQPM 40-3, GWQPM 26-3, GWQPM 22-5, GWQPM 17-1 and GWQPM 11) using half diallel crossing system during *kharif* and *Rabi* 2011-12. The 45 hybrids along with their parents and checks (HQPM 1 and DHM 117) were evaluated in Randomized Block Design with three replications in four different environments *viz.*, E1: *Kharif* (1st forth night of July, 2012), E2: Semi *rabi* (2nd forth night of October, 2012), E3: *Rabi* (1st forth night of December, 2012) and E4: Summer (2nd forth night of January, 2013) at Agricultural Research Station, Anand Agricultural University, Sansoli, Mahemdavad taluk, Kheda district (Gujarat). Each entry was consisted of a single row of 5.0 m length with distance of 60 cm between rows and 30 cm between plants within row. The data were recorded for oil content (by Soxhlet method AOAC, 1995), protein content (Microkjeldahl method by Hawk 1951), tryptophan content (Colorimetric method by Hernandez and Bates 1969) and lysine content (Colorimetric method by Tsai *et al.* 1972). The data obtained were analyzed for stability parameters as per method proposed by Eberhart and Russell (1966).

Result and discussion

The analysis of variance revealed that variance due to genotype, environments and genotype x environment were found significant (Table 1) for all the four quality characters *viz.*, oil content, protein content, tryptophan content and lysine content. Pooled deviation, the non-linear component of G x E interaction was observed highly significant for all the traits studied. Further, the non-linear effect which was observed to be significant were of lower magnitude than linear component. Therefore, to find out stable genotypes for different characters stability analysis as suggested by Eberhart and Russell (1966) was employed. Accordingly, high mean, $S^2di=0$ and three kinds of linear responses (bi) *viz.*, bi <1, bi=1 and bi>1 have been considered, and interpreted as bi=1, average stability and widely adaptable to different environments; bi>1, below average stability, increasing sensitivity to environmental changes and well adapted to favourable environment and bi<1, above average stability, greater tolerance to environmental changes; thereby genotypes would have specific adaptability to poor yielding environment.

For oil content, linear component of G x E and pooled deviations were found to be significant (Table 1). This indicated that genotypes under study differed from each other with respect to their response to environments. All the parents and hybrids exhibited significant deviation due to regression (S^2di) which proved them to be unstable across the environments. Among the parents GWQPM 6-3, GWQPM 40-3, GWQPM 17-1 and GWQPM 11 possessed high oil content than parental mean. However, out of 45 hybrids, 25 showed high mean value for oil content than hybrid mean and among them hybrid GWQPM 55-2 x GWQPM 46-2 recorded high oil content.

For protein content parent GWQPM 40-3 was found stable and adaptable to all the environments (bi=1). Out of 45 hybrids, 9 were found stable with high mean value and non-significant standard deviation. The hybrids GWQPM 5-1 x GWQPM 46-2, GWQPM 5-1 x GWQPM 40-3, GWQPM 5-1 x GWQPM 17-1, GWQPM 40-3 x GWQPM 26-3 and GWQPM 22-5 x GWQPM 17-1 were reported to be stable with high protein content and suitable for all environments (bi=1). While, hybrids GWQPM 47-4 x GWQPM 26-3, GWQPM 47-4 x GWQPM 17-1, GWQPM 46-2 x GWQPM 40-3 and GWQPM 46-2 x GWQPM 17-1 had high protein content and adaptable to better environment (bi>1).

For tryptophan content, 11 hybrids were stable and 34 were found unstable. The hybrids GWQPM 5-1 x GWQPM 40-3, GWQPM 5-1 x GWQPM 17-1, GWQPM 55-2 x GWQPM 40-3, GWQPM 47-4 x GWQPM 46-2, GWQPM 47-4 x GWQPM 17-1, GWQPM 40-3 x GWQPM 17-1 and GWQPM 26-3 x GWQPM 11 exhibited stable performance with high tryptophan content and adaptable to all the environments (bi=1). However, the hybrids GWQPM 6-3 x GWQPM 22-5 and GWQPM 40-3 x GWQPM 11 were found stable and suitable for better environment (bi>1). The hybrids which found suitable for poor environment were GWQPM 5-1 x GWQPM 46-2 and GWQPM 46-2 x GWQPM 17-1 (bi<1).

Among the parents, GWQPM 6-3 and GWQPM 40-3 were stable and adapted to the better environment (bi>1) for lysine content whereas, hybrids GWQPM 47-4 x GWQPM 22-5, GWQPM 46-2 x GWQPM 40-3, GWQPM 40-3 x GWQPM 26-3 and GWQPM 26-3 x GWQPM 11 possessed high lysine content and also proved to be stable for all the environments (bi=1). However, the hybrid GWQPM 22-5 x GWQPM 17-1 was found stable and well adapted to poor environment (bi<1). The results were in accordance with findings reported by Pixley and Bjarnason (2002), Nirala and Jha (2003), Babic *et al*. (2006), Soliman (2006), Dadheech and Joshi (2007), Rahman *et al*. (2010) and Beyene *et al*. (2011).

Among the four environments, *rabi* season proved as Better environment followed by *semi-rabi* as well as *kharif* season (Average); whereas, summer season identified as Poor environment (Table 2).

Among the above hybrids found stable for different quality characters, GWQPM 5-1 x GWQPM 40-3 and GWQPM 5-1 x GWQPM 17-1 were found stable for protein content as well as tryptophan content under the wide range of environments whereas, hybrid GWQPM 40-3 x GWQPM 26-3 for protein and lysine content were found stable for all the environments. For oil content hybrid GWQPM 55-2 x GWQPM 46-2 possessed high *per se* performance. Thus, hybrids GWQPM 5-1 x GWQPM 40-3, GWQPM 5-1 x GWQPM 17-1 and GWQPM 40-3 x GWQPM 26-3 appeared promising for protein, tryptophan and lysine content. However, it is suggested that these hybrids may be tested in multilocation trials for confirmation of results.

References

Akande, S.R. and Lamidi, G.O. 2006. Performance of quality protein maize varieties and disease reaction in the derived savanna agro- ecology of S. W. Nigeria. *Afr. J. Biotech.*, **5**(19): 1744-1748.

AOAC - Association of Official Analytical Chemists. 1995. Vitamins and other nutrients. In: AOAC (ed.) Official methods of analysis. 16th ed. Vol. **2**, *AOAC International, Arlington*, pp**.** 58-61.

Babic, V., Babic, M. and Delic, N. 2006. Stability parameters of commercial Maize (*Zea mays* L.) hybrids. *Genetika,* **38**(3):235-240.

Beyene, Y., Stephen, M., Charles, M., Tadele, T., Haron, K., Sammy, A., Jackson, S., Regina, T. and Vincent, K. 2011. Genotype by environment interactions and yield stability of stem borer resistant maize (*Zea mays* L.) hybrids. *Afr. J. Biotechnol.,* **10**(23): 4752-4758.

Dadheech, A. and Joshi, V.N. 2007. Stability analysis for quality traits in maize (*Zea mays* L.). *Agric. Sci. Dig.,* **27**(1): 26-29.

Eberhart, S.A. and Russel, W.A. 1966. Stability parameters for comparing varieties. *Crop Sci.,* **6**: 36-40.

Hawk, P.B. 1951. *Practical Physiological Chemistry* (12th Edition). McGraw Hill, New York, pp**.** 814.

Hernandez, H.H. and Bates, L.S. 1969. A modified method for rapid tryptophan analysis of maize. CIMMYT, Mexico City, Mexico.

Nirala, R.B.P. and Jha, P.B. 2003. Phenotypic stability for fodder traits in maize (*Zea mays* L.). *Range Management and Agroforestry,* **24**(1): 9-13.

Pixley, K.V. and Bjarnason, M.S. 2002. Stability of grain yield, endosperm modification and protein quality of hybrid and open pollinated quality protein maize (QPM) cultivars. *Crop Sci.,* **42**(6): 1882-1890.

Rahman, H., Durreshawar, Ali, S., Iftikhar, F., Khalil, I.H., Shah, S.M.A. and Ahmad, H. 2010. Stability analysis of maize (*Zea mays* L.) hybrids across north west of Pakistan. *Pak. J. Bot.,* **42**(2): 1083-1091.

Soliman, M.S.M. 2006. Stability and environmental interaction of some promising yellow maize genotypes. *Res. J. of Agric. and Biological Sci.,* **2**(6): 249-255.

Tsai, C.Y., Fiansel, L.W. and Nelson, O.E. 1972. A colorimetric method for screening maize seeds for lysine content. *Cereal Chem*., **49**: 572-579.

Table 1. Analysis of variance for phenotypic stability for different quality characters

S.No.	Characters	Mean sum of squares							
		Genotypes (G)	Environments (E)	Genotypes x environments (G X E)	E+(G X E)	Environments (linear)	G X E (linear)	Pooled deviation	Pooled error
	df	56	3	168	171	1	56	114	448
1	Oil content (%)	0.33 **	0.20 **	0.033 **	0.036 **	0.59 **	0.034 **	0.033 **	0.001
2	Protein content (%)	0.84 **	15.76 **	0.11 **	0.39 **	47.28 **	0.15 **	0.09 **	0.02
3	Tryptophan content (%)	0.008 **	0.019 **	0.0004 **	0.001 **	0.058 **	0.0004 **	0.0004 **	0.0001
4	Lysine content (%)	0.14 **	0.22 **	0.006 **	0.010 **	0.66 **	0.009 **	0.005 **	0.001

Table 2. Environmental index (I) for different quality characters in maize

S.No.	Characters	I_1	I_2	I_3	I_4
1	Oil content (%)	-0.02	0.05	-0.08	0.04
2	Protein content (%)	-0.54	-0.06	0.72	-0.11
3	Tryptophan content (%)	-0.020	-0.004	0.025	-0.002
4	Lysine content (%)	-0.074	0.007	0.078	-0.010

I_1, I_2, I_3 and I_4 environmental index for environments E_1, E_2, E_3 and E_4 respectively.

Table 3. Stability parameters for quality characters in maize

Sr. No.	Parents	Oil content (%)			Protein content (%)			Tryptophan content (%)			Lysine content (%)		
		Mean	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**	**Mean**	**b_i**	**S^2d_i**
1	GWQPM – 6-3	4.20	1.28	0.053**	12.54	0.77**	0.018*	0.78	2.92**++	0.0003**	2.51	2.29**++	0.0002
2	GWQPM – 5-1	3.96	0.71	0.002**	12.53	0.58**++	-0.003	0.81	1.36	0.00312**	2.57	0.70*	0.0005*
3	GWQPM – 55-2	4.14	1.41	0.005**	12.25	0.59**++	0.00	0.77	0.76	0.00025**	2.30	0.59	0.0009**
4	GWQPM -47-4	3.91	2.08	0.013**	12.82	0.08	0.206**	0.78	2.34*	0.00107**	2.46	1.63**	0.0026**
5	GWQPM -46-2	4.14	0.66	0.005**	12.90	0.64*	0.045**	0.83	2.1**	0.00053**	2.57	2.85**	0.0102**
6	GWQPM -40-3	4.20	-0.25	0.039**	12.93	0.68**	0.008	0.87	1.22	0.00162**	2.70	1.32**++	-0.0005
7	GWQPM -26-3	4.14	-2.57	0.069**	12.70	0.27	0.104**	0.82	0.92	0.00029**	2.40	1.53*	0.005**
8	GWQPM -22-5	4.17	-0.30	0.119**	12.69	1.10**	0.01*	0.83	0.67	0.00035**	2.58	3.49**++	0.0016**
9	GWQPM -17-1	4.59	7.70**++	0.001*	12.81	0.92**	0.067**	0.84	1.98**	0.00034**	2.72	1.61**	0.0009**
10	GWQPM -11	4.34	4.70	0.147**	12.30	0.48**++	-0.018	0.73	0.70**	-0.00005	2.23	1.10	0.0033**
	Parental Mean		**4.18**			**12.65**			**0.80**			**2.50**	
	Crosses												
11	GWQPM – 6-3 x GWQPM – 5-1	4.15	0.64	0.038**	12.30	0.75	0.10**	0.74	0.78	0.00022**	2.46	1.88**++	0.0007*
12	GWQPM – 6-3 x GWQPM – 55-2	4.68	0.16	0.108**	12.69	1.15	0.98**	0.78	1.59	0.00192**	2.51	1.51	0.0223**
13	GWQPM – 6-3 x GWQPM -47-4	4.49	4.14	0.08**	12.90	1.27	0.455**	0.81	0.88	0.00026**	2.49	2.43*	0.0125**
14	GWQPM – 6-3 x GWQPM -46-2	4.26	0.24	0.01**	12.89	1.25**	0.067**	0.82	0.91	0.00045**	2.53	1.34	0.0071**
15	GWQPM – 6-3 x GWQPM -40-3	4.42	-0.31	0.021**	12.59	1.06**	0.09**	0.78	0.41	0.00053**	2.57	0.74*	0.0007*
16	GWQPM – 6-3 x GWQPM -26-3	4.84	-0.91	0.053**	11.96	0.25++	-0.004	0.70	0.17+	0.00003	2.19	-1.33++	0.0079**
17	GWQPM – 6-3 x GWQPM -22-5	4.66	-1.90	0.061**	13.28	1.34**	0.059**	0.84	1.47**+	-0.00004	2.71	2.89**	0.0104**
18	GWQPM – 6-3 x GWQPM -17-1	4.90	-0.08	0.014**	12.18	1.10**	-0.005	0.78	1.03**	0	2.48	1.27	0.007**
19	GWQPM – 6-3 x GWQPM -11	4.73	2.20	0.02**	12.50	1.38**	0.053**	0.80	0.72	0.00079**	2.68	1.07	0.0304**
20	GWQPM – 5-1 x GWQPM – 55-2	4.37	1.39	0.019**	12.67	0.98**	0.029**	0.78	0.70*	0	2.64	1.15	0.0076**
21	GWQPM – 5-1 x GWQPM -47-4	4.29	2.23	0.028**	12.36	0.62**+	-0.001	0.76	0.95**	-0.00005	2.36	0.18++	0.0003
22	GWQPM – 5-1 x GWQPM -46-2	4.38	1.90	0.01**	12.64	0.90**	-0.018	0.81	0.61**++	-0.00007	2.48	0.96*	0.0012**
23	GWQPM – 5-1 x GWQPM -40-3	4.67	0.86	0.007**	12.61	1.06**	0.008	0.80	0.88**	-0.00003	2.44	0.97**	-0.0003
24	GWQPM – 5-1 x GWQPM -26-3	4.63	0.82	0.059**	12.81	1.18**	0.086**	0.83	0.77	0.00019**	2.66	0.28	0.0097**
25	GWQPM – 5-1 x GWQPM -22-5	4.21	-0.19+	0.002**	12.21	1.10**	0.052**	0.78	0.63	0.00011*	2.54	1.23*	0.0032**
26	GWQPM – 5-1 x GWQPM -17-1	4.28	1.37	0.074**	12.84	0.89**	-0.014	0.83	0.94**	-0.00004	2.58	0.97*	0.0019**
27	GWQPM – 5-1 x GWQPM -11	4.23	1.46**	0.002**	12.67	0.68**	0.037**	0.84	1.09	0.00028**	2.68	-0.22++	0.0018**
28	GWQPM – 55-2 x GWQPM-47-4	4.51	2.38*	0.008**	12.15	1.16**	0.044**	0.75	0.62	0.00006*	2.42	-0.02++	0.0003
29	GWQPM – 55-2 x GWQPM-46-2	4.96	2.69**++	0.003**	12.17	1.24**	0.062**	0.78	1.51**	0.00006*	2.39	1.37**	0.001**
30	GWQPM – 55-2 x GWQPM-40-3	4.15	0.06	0.007**	12.50	1.33**	0.136**	0.82	0.71*	0.00003	2.51	3.15**++	0.0065**
31	GWQPM – 55-2 x GWQPM-26-3	4.54	-0.10	0.024**	12.22	1.47**	0.088**	0.78	1.75**++	-0.00007	2.45	0.91	0.0022**
32	GWQPM – 55-2 x GWQPM-22-5	4.53	2.23	0.016**	12.36	0.46	0.061**	0.77	0.82	0.00038**	2.34	0.55	0.0057**
33	GWQPM – 55-2 x GWQPM-17-1	4.29	2.59	0.036**	12.34	1.56**	0.25**	0.80	1.97*	0.0006**	2.43	0.44	0.0062**
34	GWQPM – 55-2 x GWQPM -11	4.38	0.51	0.033**	11.62	0.26++	0.001	0.70	-0.22++	-0.00001	2.18	0.38	0.0061**
35	GWQPM -47-4 x GWQPM -46-2	4.73	-2.85+	0.031**	12.67	1.62**+	0.041**	0.81	1.56**	0.00004	2.62	1.18*	0.0025**
36	GWQPM -47-4 x GWQPM -40-3	4.70	2.37	0.037**	12.28	1.01**	0.026*	0.75	0.70**++	-0.00008	2.44	0.27	0.0122**
37	GWQPM -47-4 x GWQPM -26-3	4.56	1.23	0.02**	12.59	1.36**++	-0.019	0.83	0.13	0.00012*	2.57	1.38**	0.0023**

Contd.,

Table 3. Contd.,

Sr. No.	Crossess	Oil content (%)			Protein content (%)			Tryptophan content (%)			Lysine content (%)		
		Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
38	GWQPM -47-4 x GWQPM -22-5	4.52	4.20**++	0.009**	12.61	1.47**	0.084**	0.82	0.99*	0.00014**	2.58	0.80**	0.0002
39	GWQPM -47-4 x GWQPM -17-1	4.40	-0.74++	0.003**	12.67	1.43**++	-0.015	0.81	1.35**	0.00002	2.57	0.13	0.0057**
40	GWQPM -47-4 x GWQPM -11	4.57	1.70*	0.004**	12.15	0.98*	0.118**	0.74	0.79**	-0.00005	2.27	-0.46**++	-0.0004
41	GWQPM -46-2 x GWQPM -40-3	4.15	-1.13++	0.004**	12.72	1.50**++	0.006	0.82	0.79	0.0001*	2.63	0.72**	0.000
42	GWQPM -46-2 x GWQPM -26-3	4.47	2.03	0.022**	11.65	1.16*	0.2**	0.70	0.62	0.00006*	2.19	0.47	0.0009**
43	GWQPM -46-2 x GWQPM -22-5	4.14	0.63	0.006**	12.02	1.38**	0.078**	0.77	1.04**	-0.00001	2.38	0.28	0.0036**
44	GWQPM -46-2 x GWQPM -17-1	4.54	0.98	0.037**	13.45	1.42**+	0.01	0.87	0.37**++	-0.00009	2.79	0.96	0.0031**
45	GWQPM -46-2 x GWQPM -11	4.06	-0.20	0.012**	12.36	0.31++	0.011*	0.74	0.58	0.00008*	2.31	0.58	0.0017**
46	GWQPM -40-3 x GWQPM -26-3	4.16	-1.29++	0.005**	12.70	1.09**	-0.017	0.80	1.25	0.00063**	2.56	0.81**	-0.0004
47	GWQPM -40-3 x GWQPM -22-5	4.26	0.40	0.017**	12.41	1.41**	0.079**	0.78	1.22**	-0.00007	2.50	0.83	0.0037**
48	GWQPM -40-3 x GWQPM -17-1	4.15	1.19	0.016**	13.33	1.00**	0.074**	0.85	1.00**	-0.00004	2.72	0.83	0.0039**
49	GWQPM -40-3 x GWQPM -11	4.47	0.87	0.024**	12.62	1.75**++	0.036**	0.82	2.15**++	-0.00005	2.62	1.72**	0.0015**
50	GWQPM -26-3 x GWQPM -22-5	3.74	-2.07**++	0.004**	12.34	0.74**	0.02*	0.73	1.7**+	0.00001	2.34	-0.07++	-0.0005
51	GWQPM -26-3 x GWQPM -17-1	3.86	1.35	0.013**	12.31	0.98**	0.012*	0.77	0.74	0.00023**	2.49	0.18+	0.0009**
52	GWQPM -26-3 x GWQPM -11	3.71	-0.15	0.003**	12.59	1.43**	0.044**	0.81	0.72**	-0.00005	2.58	0.79**	0.0001
53	GWQPM -22-5 x GWQPM -17-1	4.14	2.1**+	0.001*	12.67	0.90**	-0.006	0.78	1.17	0.00058**	2.49	0.37++	-0.0001
54	GWQPM -22-5 x GWQPM -11	4.08	3.15	0.17**	12.76	1.19**	0.066**	0.81	0.82	0.00076**	2.55	1.38**	0.0009**
55	GWQPM -17-1 x GWQPM -11	4.16	0.84	0.012**	12.25	1.80**+	0.097**	0.74	1.11**	-0.00008	2.55	1.69*	0.0048**
56	HQPM 1	4.45	2.57	0.125**	13.23	0.60	0.098**	0.85	0.25+	0.00002	2.75	1.30*	0.0041**
57	DHM 117	3.76	0.01	0.035**	10.39	-0.08++	0.01*	0.62	-0.70**++	-0.00005	1.66	-0.28**++	-0.0005
	Hybrid Mean		**4.37**			**12.47**			**0.79**			**2.49**	

*, ** Significant at 0.05 and 0.01 per cent level, respectively when H_0: b=0
+, ++ Significant at 0.05 and 0.01 per cent level, respectively when H_0: b=1