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Stability for yield and related traits in chickpea (*Cicer arietinum*)*

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Chickpea (*Cicer arietinum* L.) is the most important pulse crop with production ranking third amongst the pulses (FAO 2008) and is a good source of many nutrients in the diet (Wood *et al*. 2007). Chickpea occupies an area of 10.72 million ha with a total annual production of 9.31 million tonnes with an average productivity of 868 kg/ha (FAO 2008).

In India, the production of pulses was 15.12 million tonnes from an area of 23.86 million ha with an average productivity of 638 kg/ha. Chickpea was grown under both rainfed and irrigated conditions over an area of 7.97 million ha with total production of 7.05 million tonnes and productivity of 885 kg/ha (FAI 2009). However, the productivity of chickpea in India is still far below as that in Mexico, Sudan, China, Israel, Lebanan, Yaman, Greece and Italy. The productivity of chickpea is low because of several constraints, like inadequate availability of quality seed of improved varieties, cultivation of pulses on the poor and marginal lands under rainfed conditions without recommended input application.

Chickpea is mainly grown under rainfed conditions. However, in the northern India due to intensive cropping, it is grown with 1 or 2 irrigations. The chickpea crop is being sown after harvest of different *kharif* crops like rice, maize, cotton, *toria* and fodder crops.

Therefore, in the present study, 45 genotypes were evaluated when sown at different times. The importance of genotypes×environment interactions for yield and its component were worked out.

The experimental material comprised 45 diverse genotypes including recommended varieties of chickpea procured from SVBPUA & Technology, Meerut. In all, 12 environments were created by sowing this material on 3 different dates at research farm of Janta Vedic College, Baraut, Baghpat and Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut during 2004–05 and 2005–06. The experiment was laid out in randomized block design with 3 replications. Each genotype was accommodated in 4 m long plot with row-to-row and plant-to-plant distance of 30 cm and 10 cm, respectively. The normal cultivation practices were followed. Observations were made on 5 randomly taken plants of each genotype in each replication for number of primary branches/plant, number of secondary branches/plant, days to maturity, 100-seed weight, biological yield/plant, and grain yield/plant. Statistical analysis was done according to the method proposed by Eberhart and Russell (1966).

Analysis of variance showed significant differences for genotypes and environments for all the 6 characters studied. However, the linear component due to environment was found to be significant for all the characters except secondary branches/plant. It suggests that the environment linear component accounted for the major portion of environment variance. The G×E interaction was highly significant for all the characters except days to maturity depicting the different response of the chickpea genotypes in different environments for this character.

The estimates of stability parameters (Tables 1, 2) for days to maturity, from the mean performance of genotypes across all the environments, it appears that 18 genotypes took lesser days to mature than the general mean (147.42 days). Out of 45 genotypes, 31 genotypes had bi value not significantly different from unity (bi=1) indicating average response over the environments. Among these, 8 genotypes showed b<1 when were least responsive. The stable and desirable genotypes for this character which have low mean value than the overall average, bi=1 and S^2di=0. Using these criteria genotypes, ‘HK 00–290’, ‘H 00–191’, ‘GNG 1573’, ‘CSJ 336’, ‘Sadbhavana’, ‘GNG 1477’, ‘WCG 10’ and ‘BG 2037’ were identified as promising and stable.

For primary branches/plant, mean performance of genotypes averaged over 12 environments it was found that 20 genotypes had higher number of primary branches/plant

*Short note

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Table 1 Estimates of stability parameters for primary branches/plant, secondary branches/plant and days to maturity

Genotype	Primary branches/plant			Secondary branches/plant			Days to maturity		
	Mean	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean	Regression coefficient (bi)	Mean square deviation (S^2di)
‘GNG 1519’	2.49	0.35**	0.00	3.76	1.92**	0.00	147.44	1.12	–96.95
‘WCG 4 –1’	2.56	0.70	–0.01	4.41	–2.72**	0.27**	148.08	1.10	–93.68
‘BG 256’	2.50	–0.10**	0.00	4.02	0.43	0.14	147.17	0.57	93.34
‘WCG 97–28’	2.61	1.11	0.00	4.51	–2.61**	0.21**	146.31	1.04	–97.81
‘PFGK 1218’	2.69	1.89**	0.00	4.43	–2.90**	0.10	146.67	1.06	–102.50
‘GJG 0104’	2.80	2.11*	0.00	4.23	–0.77	0.03	146.58	1.09	–94.55
‘IPC 2001–1’	2.71	1.74**	0.00	4.12	–0.49*	0.14*	146.19	1.10	–97.97
‘CSJ 340’	2.71	1.96**	0.02	3.61	3.72**	0.00	145.56	1.04	–95.07
‘GNG 1573’	2.49	0.70	0.01	3.58	2.86**	0.01	145.56	1.03	–100.65
‘CSJ 336’	2.45	0.68	0.00	3.46	3.58**	0.08	145.89	0.93	–101.39
‘HK 00–299’	2.50	0.83	0.00	3.38	4.22**	0.03	146.17	1.01	–101.59
‘BGD 1020’	2.72	1.75**	0.00	3.70	2.91*	0.10	146.42	0.98	–100.26
‘IPC 2001–12’	2.76	1.89**	0.02	3.86	1.74*	0.02	148.25	1.02	–100.36
‘BG 2023’	2.57	0.72	0.00		4.58	–2.80**	0.40**	146.61	1.05
–96.23									
‘GNG 1577’	2.54	0.58	0.00	4.32	–1.24	0.01	146.58	0.99	–101.58
‘IPCK 305’	2.51	0.67	–0.01	3.90	2.07*	0.05	146.64	1.03	–100.53
‘HK 00–290’	2.52	1.01	0.01	3.88	1.33	0.01	144.94	1.05	–96.40
‘H 00–191’	2.56	0.71	0.00	3.84	1.54	0.04	144.89	1.08	–99.85
‘CSJK 9’	2.54	0.54	0.00	4.06	0.44	0.01	145.78	1.08	–93.78
‘BG 2030’	2.53	0.43**	–0.01	4.50	–2.88**	0.15	146.42	1.01	–101.82
‘SCS 16’	2.49	0.25**	0.01	3.60	4.02**	0.08	147.22	1.04	–102.22
‘BG 2027’	2.70	1.18	–0.01	3.54	3.72**	0.08	146.17	1.05	–99.26
‘CSJK 11’	2.76	1.60**	0.01	3.74	2.72	0.05	147.67	1.05	–95.20
‘GJG 0106’	2.76	1.57**	0.00	4.06	0.67**	0.10	146.81	0.95	–92.34
‘W’CG 2000–2’	2.79	1.63**	–0.01	3.52	4.32	0.04	147.33	0.95	–101.81
‘BGD 1017’	2.65	1.07	0.00	4.23	–0.02**	0.01	148.36	1.00	–99.18
‘GLK 21159’	2.53	0.87	0.00	4.27	–0.12**	0.03	147.17	1.02	–98.64
‘BG 1053’	2.59	0.84	0.00	4.01	0.71	0.03	146.22	1.10	–99.76
‘PBG 233’	2.72	1.15	–0.01	4.21	–0.40	0.00	147.11	1.08	–96.05
‘GNG 469’	2.61	0.89	0.00	3.95	2.17**	0.14*	148.03	1.05	–101.21
‘GLK 21143’	2.61	0.87	–0.01	4.18	0.38	0.00	147.44	1.05	–99.19
‘L 550’	2.61	1.28**	–0.01	4.15	1.26	0.03	146.94	1.05	–98.08
‘BG 2031’	2.51	0.69	0.01	4.08	1.49	0.04	146.81	1.01	–99.92
‘IPCK 306’	2.48	0.53*	0.00	3.80	2.15**	0.03	147.19	0.96	–99.74
‘HK 98–155’	2.65	0.87	0.00	3.84	1.67*	0.00	147.75	1.08	–100.99
‘WCG 3’	2.51	0.69	0.01	4.09	0.30*	0.00	147.81	1.06	–97.40
‘Surya’	2.60	0.88	0.00		3.98	1.28	0.00		147.06
1.04	–92.48								
‘PFGK 1221’	2.65	0.89	0.00	4.17	0.69	0.01	147.33	1.05	–96.06
‘BGM 548’	2.63	0.88	–0.01	4.22	0.33*	0.00	147.58	1.01	–96.71
‘H 00–212’	2.59	1.09	–0.01	4.08	1.50	0.04	146.39	1.03	–98.23
‘BG 1003’	2.56	0.59	0.00	4.10	1.25	0.01	146.89	0.99	–96.49
‘Sadbhavana’	2.57	1.06	–0.01	4.01	1.73*	0.10	146.53	1.04	–93.91
‘GNG 1477’	2.58	0.92	0.00	4.29	0.50	0.00	146.86	1.02	–101.37
‘WCG 10’	2.54	1.23**	0.01	4.24	0.06**	0.00	146.44	1.07	–98.70
‘WCG 97–15’	2.55	1.22**	0.00	3.90	2.29**	0.06	147.69	1.01	–101.52
Pop. (mean)		2.60			4.01			147.42	
SEm±		0.87			0.60			3.45	
SE of B		0.34			0.40			0.27	

*P=0.05 and ** P=0.01

Table 2 Estimates of stability parameters for biological yield/plant, 100-seed weight and grain yield/plant

Genotype	Biological yield/plant (g)			100–seed weight (g)			Grain yield/plant (g)		
	Mean	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean	Regression coefficient (bi)	Mean square deviation (S^2di)	Mean	Regression coefficient (bi)	Mean square deviation (S^2di)
'GNG 1519'	27.58	1.31**	5.13**	21.89	1.07	0.25	9.28	0.86	0.40
'WCG 4 –1'	28.04	1.05	10.02**	25.27	1.44	0.02	9.33	0.68	0.32
'BG 256'	25.64	0.85	1.42	25.79	1.37	0.18	8.54	0.99	0.10
'WCG 97–28'	29.77	0.61	4.30**	24.48	–0.07	0.14	9.99	0.07**	–0.03
'PFGK 1218'	27.22	0.55	0.19	26.72	0.17	0.45	9.28	0.21**	1.46
'GJG 0104'	27.25	1.30**	2.47	20.58	–0.39	0.77	8.74	1.61**	1.29
'IPC 2001–1'	24.70	0.56	2.10	25.17	1.60	0.06	8.82	–0.02**	0.00
'CSJ 340'	23.17	0.76	2.47	21.29	–0.05	0.14	7.68	1.12	0.13
'GNG 1573'	22.43	0.83	6.54**	27.04	2.26	0.51	7.77	1.02	1.22
'CSJ 336'	20.88	0.67	1.57	19.94	1.36	4.19	6.93	0.95	0.20
'HK 00–299'	26.64	1.09	3.54	27.20	1.75	0.10	8.97	0.99	0.43
'BGD 1020'	23.63	0.57	6.38**	26.32	1.26	0.16	8.43	0.37**	0.73
'IPC 2001–12'	27.29	0.98	9.83**	20.34	–0.05	0.18	9.15	0.94	0.43
'BG 2023'	26.32	1.20*	2.87	21.34	1.18	0.67	9.02	0.99	0.31
'GNG 1577'	24.83	0.77	2.61	26.28	1.77	0.18	8.05	0.78	0.07
'IPCK 305'	23.02	0.79	8.16**	25.24	1.43	0.01	8.11	1.10	0.89
'HK 00–290'	23.85	0.83	5.05**	24.23	0.99	0.13	7.75	1.13*	0.50
'H 00–191'	25.94	1.07	2.81	25.05	1.66	0.09	9.16	0.75	0.23
'CSJK 9'	26.30	0.91	0.62	24.34	0.99	0.02	9.17	0.77	0.16
'BG 2030'	24.16	1.00	6.32**	20.86	0.74	0.09	8.42	1.00	0.63
'SCS 16'	24.69	0.90	2.41	25.26	1.38	0.08	8.44	0.83	0.37
'BG 2027'	25.78	0.97	0.72	25.11	0.98	0.03	8.31	1.06	0.24
'CSJK 11'	28.00	0.71	3.85	29.15	1.82	1.21	9.70	0.13	0.05
'GJG 0106'	26.44	1.26**	0.46	22.52	0.75	0.04	9.01	1.15*	0.12
'WCG 2000–2'	26.14	1.08	4.31*	21.30	0.91	–0.02	8.90	1.02	0.09
'BGD 1017'	26.58	1.14	5.73*	23.33	1.69	0.52	8.96	0.95	0.19
'GLK 21159'	23.70	0.79	8.73**	21.30	0.29	0.00	7.75	0.83	0.76
'BG 1053'	26.94	0.95	2.64*	24.83	0.65	0.24	8.75	1.08	0.50
'PBG 233'	28.65	1.38**	21.68**	23.93	0.17	0.27	8.65	1.25	0.02
'GNG 469'	25.48	0.92	3.57		23.31	0.53	–0.03	8.40	1.17
0.09									
'GLK 21143'	25.68	0.67	7.00*	25.26	–0.75	11.79	8.74	0.59	0.39
'L 550'	24.19	1.08	6.67**	20.56	0.50	0.07	7.87	1.59**	0.16
'BG 2031'	23.67	1.04	9.29**	27.07	0.97	0.20	7.84	1.40	0.35
'IPCK 306'	23.16	1.05	9.30**	23.17	1.10	0.17	7.53	1.42	0.39
'HK 98–155'	23.93	1.03	9.08**	26.31	1.20	0.00	8.24	1.32	0.22
'WCG 3'	25.70	1.24**	3.93	25.16	3.70	8.97	8.29	1.31	0.66
'Surya'	25.10	1.23**	2.92	23.13	1.27	2.94	8.07	1.48	0.33
'PFGK 1221'	26.18	1.02	2.38	26.94	1.74	0.36	8.62	0.91	0.19
'BGM 548'	27.26	1.17	1.31	26.41	1.63	0.27	8.76	1.06	0.01
'H 00–212'	24.48	1.29**	3.20	22.58	0.75	–0.02	7.72	1.64	0.09
'BG 1003'	23.28	1.07	1.87	21.84	0.73	0.02	7.47	1.06	0.36
'Sadbhavana'	24.21	1.39**	2.75	21.73	0.87	1.08	7.88	1.84**	0.23
'GNG 1477'	26.82	1.24**	1.11	24.68	0.48	1.91	9.10	0.84	0.07
'WCG 10'	26.08	1.47**	2.11	23.53	1.10	–0.03	8.52	1.49	0.43
'WCG 97–15'	25.76	1.19**	1.69	22.51	0.07	0.02	8.54	1.28	0.05
Pop. (mean)		25.74			24.07			8.80	
SEm±		2.04			2.28			0.77	
SE of B		0.45			0.72			0.25	

**P*=0.05 and ** *P*=0.01

than general mean (2.60). The regression coefficient ranged from –0.10 (‘BG 256’) to 2.11 (‘GJG 0104’). Among 45 genotypes, 18 genotypes had bi values close to unity showing average response over the environments. The genotypes ‘PFGK 1218’, ‘GJG 0104’, ‘IPC 2001–1’, ‘CSJ 340’, ‘BGD 1020’, ‘IPC 2001–12’, ‘CSJK 11’, ‘GJG 0106’ and ‘L 550’ had bi>1 showing better adaptability to favourable environment and identified as promising and stable across the environments.

The mean performance of genotypes for number of secondary branches/plant ranged from 3.38 (‘HK 00–299’) to 4.58 (‘BG 2023’) with a population mean of 4.01. Among 45 genotypes, 24 genotypes had bi values close to unity showing average response over the environment. The genotype ‘BG 1053’, ‘H 00–212’, ‘BG 2031’, had bi>1 show better adaptability to favourable environments and remaining 2 genotypes ‘PFGK 1218’ and ‘BG 2030’ had bi<1 show least response. Thirtyone genotypes had S^2di=0 indicating that these were stable across the environments. Considering high mean, bi=1 and S^2di=0 as the stability criteria, the genotype ‘L 550’, ‘BG 2031’, ‘H 00–212’ and ‘BG 1003’, were identified as promising and stable across the environments.

The mean performance of genotypes for biological yield/ plant ranged from 20.88 g (‘CSJ 336’) to 29.77 g (‘WCG 97–28’) with the population mean of 25.74 g. The regression coefficient ranged from 0.55 (‘PFGK 1218’) to 1.47 (‘WCG 10’). Twelve genotypes had bi=1 indicating average response. Twelve genotypes had bi>1 indicate better response under favourable environments and the 21 genotypes had bi<1 indicating least response over the environments. Considering the criteria of desirable and stable genotypes, i e high mean, bi=1 and S^2di=0, 5 genotypes ‘GJG 0106’, ‘BGM 548’, ‘GNG1477’, ‘CSJK 9’ and ‘WCG 97–15’ were identified as promising and stable for biological yield.

The mean performance of genotypes for 100-seed weight ranged from 19.94 g (‘CSJ 336’) to 29.15 g (‘CSJK 11’) with a population mean of 24.07 g. The regression coefficient ranged from –0.75 (‘GLK 21143’) to 3.70 (‘WCG 3’). Out of 45 genotypes, 8 genotypes had bi=1, 15 genotypes had bi>1 indicate highly responsive for favourable environment and 22 genotype had bi<1 indicate least responsive and 34 genotypes showed S^2di=0, hence be considered stable for this trait. Considering the criteria of promising and stable genotype, ie high mean, bi=1 and S^2di=0, only 4 genotypes, ie ‘IPC 2001–1’, ‘IPCK 305’, ‘WCG 4–1’ and ‘HK 98–155’ were screened as promising and stable.

The mean performance of genotypes for grain yield/plant ranged from 6.93 g (‘CSJ 336’) to 9.99 g (‘WCG 97–28’) with a population mean of 8.80 g. The regression coefficient ranged from –0.02 (‘IPC 2001–1’) to 1.84 (‘Sadbhavana’). Among 45 genotypes, 9 genotypes had bi=1 indicating average response, 15 genotypes had b>1 indicating better adaptation to rich environment and remaining 21 genotypes had bi<1 indicating least responsive over the environments. Thirtyseven genotypes showed S^2di=0 and could be considered stable for this trait. Considering the criteria of desirable and stable genotypes, ie high mean, bi=1 and S^2di=0, only 5 genotypes i e ‘GJG 0106’, ‘PBG 233’, ‘GNG 469’, ‘H 00–212’ and ‘WCG 97–15’ were screened as desirable and stable. Many other workers also found linear and non-linear components of genotype×environmental condition for expression of grain yield and its traits (Kumar *et al*. 2005, Prakash 2006, Singh, Sandhu 2006 and Yoghotipoor and Farshadfar 2007).

The regression analysis partitions the G×E interaction into 2 components, regression coefficient and deviation from regression. Significant differences among slope on regression coefficients indicate the response of each genotype to a change in the environment, while significant deviation from regression indicate non-linear responses, ie G×E interactions gets unexplained by additive environmental effects.

In the present investigation, the linear component of G×E interaction was highly significant for all the characters, while as non-linear components of G×E interaction was highly significant for all the characters except days to maturity. The significant of non-linear components of G×E interaction indicate that a large number of genotypes might exhibit S^2di>0. However, in this study in spite of significant non-linear component a good proportion of genotype exhibited S^2di=0.

The significance of G×E interaction for various characters indicates that the performance of chickpea genotype is very much influenced by environmental variations indicating scope for agronomical manipulations. The regression analysis was very useful in assessing the adaptation of various genotypes in terms of predictability of variations in performance over environment. Joint consideration of pooled analysis of variance and response of individual genotypes suggests that one should directly attempt to see the response of a genotype in respect of the information obtained from pooled analysis. Since latter one provides a clear picture of material individually, this may be more useful.

SUMMARY

A set of 45 genotypes of chickpea was studied during 2004–06 for stability parameters for grain yield and its components over 12 environments created by different sowing dates at two locations. The pooled analysis of variance revealed that mean square due to genotypes were highly significant for all the 6 characters exhibiting enough genetic variability among the genotypes, the mean square due to environment were also highly significant for all the characters. The linear component of environment was highly significant for the characters. The genotypes, viz ‘GJG 0104’, ‘GJG 0106’, ‘PBG 233’, ‘GNG 469’ and ‘WCG 97–15’ yield/ plant were suitable for rich environment as far as seed yield

was increased, while the genotypes, viz 'BG 1003', 'L 550', 'BG 2030' and 'GNG 1573' were suitable for poor environmental conditions.

REFERENCES

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

FAI 2009. *Fertilizer Statistics* 2008–2009, Fertilizer Association of India, New Delhi.

FAO 2008. *FAOSTAT Database*. Food and Agriculture Organization of the United Nations, Rome.

Kumar H, Kumar S and Devraj. 2005. Phenotypic Stability of yield in *Kabuli* chickpea. *Indian Journal of Pulses Research* **18**: 161–3.

Prakash P. 2006. Divergence analysis in *kabuli* chickpea (*Cicer arietinum* L.). *Indian Journal of Genetics and Plant Breeding* **66**: 241–2.

Singh A and Sandhu J S. 2006. Genotype×environments interaction in chickpea. *Crop Improvement* **33**: 67–9.

Wood J A and Grusak M A. 2007. Nutritional value of chickpea. (*in*) C*hickpea breeding and Management*. Yadav S S, Redden, B, Chen W and Sharma B (Eds). CABI, Wallingford, UK.

Yoghotipoor A and Farshadfar E. 2007. Non-parametric estimation and component analysis of phenotypic stability in chickpea (*Cicer arietinum* L.). *Pakistan Journal of Biological Sciences* **10**(6): 2646–52.