STUDY OF G × E INTERACTION AND STABILITY IN CHICKPEA (*CICER ARIETINUM* L.)

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Abstract : 50 genetically diverse genotypes of chickpea were studied for G x E interaction and stability parameters in 10 quantitative characters Days to 50 % flowering, Days to maturity, Plant height ,No. of branches, Number of pods/plant, No. of seed/pod, 100 seed weight (g), Biological yield/plant, Seed yield per plant and Harvest index. The linear component of genotype x environment interaction (G x E) was significant for plant height, number of branches, number of pods per plant, biological yield and seed yield. The non-linear component of genotype x environment (G x E) interaction was non significant for all the traits when tested against pooled error. three environment, namely E3 (8.28g), E5 (8.31g), E6 (8.32g) were significantly lower yielding and the 3 environments E1 (8.96 g), E2 (9.29g) and E4 (8.88g) were significantly higher yielding than the grand mean (8.70).

Keyword : *Cicer arietinum*, G × E interaction, Stability

Abbereviation : G × E - genotype by environment interaction

INTRODUCTION

Genotype × Environment interaction (GEI) is an important aspect of plant breeding programs. It may arise when certain genotypes are grown in diverse set of environments. A significant for a quantitative trait such as seed yield can seriously limit the efforts on selecting superior genotypes for both new crop production and improved cultivar development. The lack of consistency in performance across environments complicates cultivar selection; it can provide useful information to the researchers (Kang, 1998). For example, it can help justify the need for additional broad-based testing in different environments and predict the variability expected among testing locations. The GEI can be properly exploited to advantage through various approaches (Gauch and Zobel, 1996, Kang, 1998). Most agronomically and economically important traits, such as grain yield, are quantitative in nature and routinely exhibit GEI. This necessitates genotype evaluations across multiple environments (called multi-environment trials [MET]) in the advanced stages of selection. By growing cultivars in different environments, the highest yielding and most stable cultivars can be identified. When selecting genotypes for wide adaptation, plant breeders look for a noncrossover GEI or preferably the absence of GEI. Thus, the estimation of stability of performance becomes important to identify consistent-performing and high-yielding genotypes (Kang, 1998).
The choice of plant breeding methodology which is to be used for upgrading the yield potential, mainly depends on the availability of reliable information about the nature and magnitude of adaptability towards stable performance of various genotypes. By and large moisture stress during different phases of growth of chickpea affects productivity the most.

MATERIAL AND METHODS

The present investigation was carried out at Department of Botany, J.V College, Baraut (Bagpat) Uttar Pradesh.
The experiment material consisted of 50 divergence genotypes of chickpea. The genotypes were obtained from IARI New Delhi Pusa.
Fifty genotypes of chickpea were evaluated in a randomized complete block design with three replications during rabi seasons of 2006-2007 and 2007-2008. In each of the two year, the experiments were repeated over three dates of sowing. The three dates of sowing were 20 October, 05 November, 20 November. In each of the six experiments (3 sowing dates x 2 years), each genotype will be raised in a plot of 1.8 m2 (4 rows x 4m length x 40cm inter row distance) with a plant to plant distance 20 cm. in each replication. All the recommended agronomic practices were followed to raise a good crop. The observations were recorded on five competitive and random plants per replication and mean values expressed per plant basis, at harvest stage. The single plant observations were recorded on different groups of cultivars during both the years both the plantings, respectively. For analysis of seed yield and its component traits, non-destructive sampling was reported at harvesting stage.

The observations on ten morphological traits were recorded on the cultivars at harvest stages Days to 50 % flowering, Days to maturity, Plant height, No. of branches, Number of pods/plant, No. of seed/pod, 100 seed weight (g), Biological yield/plant, Seed yield per plant and Harvest index.

RESULT AND DISCUSSION

The ANOVA results presented in Table suggested that variances due to all different sources excepting environment + (G x E) in the table, such as genotypes, environments, genotype x environment, environment linear, G x E linear and pooled deviation are statistically significant for almost all the traits. This indicated the presence of substantial variation in the mean performance (gi) of all the 50 chickpea varieties over environments and in the environmental means (ej) over test varieties.

Perkins and Jinks Modal (1968a):

The components of genotype x environments interactions (G x E) based on modified form of model develop by Perkins and Jinks (1968). The genotype X environments interactions (G x E) was partitioned into (i) linear (ii) non linear (reminder).

Table 1. Analysis of variance (M.S) for G x E interaction for various quantitative traits of chickpea genotype during 2006-2008.

Source	d.f	Days to flowering	Days to maturity	Plant height	No of branches	No of Pod/plant	No of Seed/pod	100-seed weight	Biological yield	Seed yield	Harvest index
Genotype(G)	49	19.91**	7.67*	84.20**	4.87*	12.28**	5.38*	62.90**	7.31**	5.25**	14.43**
Environment(E)	5	6061.48**	1013.79**	598.01**	23.65**	397.47**	19.36**	41.21**	93.37**	9.17**	121.01**
G X E	245	13.71**	3.27**	30.90**	3.76	9.68*	2.41	21.02**	5.33	3.86*	10.68**
Eberhart & Russell Model (1966)											
Environment (Linear)	1	303081.79**	5072.06**	2984.07**	118.28**	1987.56**	96.08**	206.11**	467.13**	45.88**	605.26**
G X E (linear)	49	7.81*	2.65	37.04**	26.54**	19.74**	1.89	15.03**	7.80*	5.88	7.04**
Pooled deviation	200	14.88	3.34	28.80	39.27	7.02	2.58	22.07	4.61	3.26	11.36
Perkins & Jinks Model (1968a)											
Heterogeneity between regression	49	7.18**	2.65	37.04**	13.00	19.74**	9.27	15.03**	7.80**	5.88**	7.04**
Reminder	196	15.18	3.41	29.39	4.03	7.16	5.17	22.52	4.71	3.32	11.25
Pooled error	588	9.38	4.52	4.60	1.11	2.41	4.69	1.45	2.08	1.01	5.16

*,**: Significant at 5% and 1% levels, respectively

The linear component of genotype x environment interaction (G x E) was significant for plant height, number of branches, number of pods per plant, biological yield and seed yield. The non-linear component of genotype x Environment (G x E) Interaction was non significant for all the traits when tested against pooled error. The distribution of genotype on the basis of different stability parameters combination for the six quantitative traits/ characters are also depicts the distribution of 50 chickpea genotypes based on stability parameters, only genotypes found suitable for different situations have been given serial number for identification and result described character wise. Eberhart and Russell (1966) and Perkins and Jinks (1968a) pattern are given in Table Significant genotypic differences were observed for days to flowering, days to maturity, plant height, number of branches, number of pods, seeds/pod, 100 seed weight, biological yield, seed yield and harvest index. Genotype x environment component was also significant for these seven characters days to flowering, plant height, number of branches, seeds/pod, 100 seed weight, biological yield and harvest index, however, the G x E interaction (linear) was found to be significant for days to flowering, plant height, number of branches, seeds/pod, 100 seed weight, biological yield and harvest index. The heterogeneity between regressions was found to be significant for days to flowering, plant height, 100 seed weight, biological yield, seed yield and harvest index.

Significant genotypic difference were observed for all the 10 quantitative traits viz., plant height, number of branches, number of pods per plant, number of seeds per pod, days to 50 per cent flowering, days to maturity, 100-seed weight, biological yield, seed yield and harvest index. The (G x E) component was also significant for plant height, number of branches, number of pods per plant, days to flowering, biological yield and harvest index. However, the G x E interaction (linear) was found to be significant for these traits also.

Interestingly, the heterogeneity between regressions was also found to be significant for all these traits except days to 50 per cent flowering. Genotype x environment interaction was found to be significant for productive branches per plant and seed yield per plant by Sharma and Maloo (1989) and for days to 50 per cent flowering, days to maturity and 100-seed weight by Singh and Kumar (1994). Significance of G x E interaction has been reported for different characters by various workers. However, all the characters studied may not show both linear and non-linear components of G x E.

In the present study two genotypes BG2023 and BG 1072 had mean lower days to 50% flowering than average, b=l and $S^2d=0$ would be ideal variety. Whereas seven genotypes viz. BG 2027, PUSA 1053, BG 1107, BG 1109, BGD 1004, BG2046 and BG 2045had lower mean value for days to maturity indicating that early maturity than the over all mean. only one genotypes BG 2056 for pods/plant and two genotypes BG 2027 and ICRISAT3074 for seeds/plant were desirable and stable identified on the basis higher grand mean, b=1 and $S^2di = 0$. The only one genotype PUSA1088 had significantly higher grain yield than grand mean (μ =12.22) which suggested that these genotypes showed stable performance for this trait over six environments used in present study.

Analysis of Mean Performance

The mean yields of 50 chickpea genotypes over six environments, their marginal means (environment means over genotypes and genotype means over environment), FW regression coefficients for genotypes, and IPCA1 scores for genotypes and environments. It can be noticed from this Table that yield ranged from 6.47g/ plant (genotype no. 43 inE5) to 10.34g/ plant (genotype no. 4 in E4) with an average of 8.70g/ plant. However, the genotype means averaged over six environments ranged from 46.63g / plant (genotype no. 37) to 57.63g / plant (genotype no. 1) and the environment means ranged from 8.31gper plant (E6) to 9.29 g per plant (E2). This indicated that the genotypes and the environments were diverse and as is apparent from their extent of range, environments seem to be far more diverse than the genotypes.

Among genotypes considering their mean yields over environments, only six genotypes, namely (BG 1063, PUSA 1108, PUSA 2024, PUSA 1003, BG 2046 and BG 5019) were yielding lower (though not significantly) than the check variety PUSA 362 used at all environments. However, 20 genotypes, namely BG1087, BGD1019, CSG 9505, GJG 9807, ICC 12237, ICC 11224, JG 62, BG 2023, BG 2027, BG 2066, BG 2049, CSG 8962, ICRISAT 3070, PUSA 1088, ICCV 5, BG 1072, BG 2054, BG2045.

Table 2. Mean yield , grand mean in gram per plant , IPCA1 score for 50chickpea genotype tested at six environments

Sl .No	**Genotypes**	**Environments Code**								
		E1	**E2**	**E3**	**E4**	**E5**	**E6**		**IPCA1**	
1	BG1087	7.22	9.19	7.93	10.32	7.78	9.19	9.66	-10.08	
2	BGD1017	9.86	9.52	8.36	8.97	7.77	8.52	8.83	2.96	
3	BGD1019	8.88	9.50	8	9.32	9.56	9.04	9.05	12.00	
4	CSG9505	9.28	9.58	8.39	10.34	9.11	9.24	9.32	3.26	
5	GJG9807	9.46	10.26	9.11	9.94	8.22	7.45	9.24	1.28	
6	GCP9504	9.67	9.52	8.36	10.07	7.15	7.69	8.74	22.40	
7	ICC12237	10.29	9.36	8.33	9.26	8.36	7.94	8.92	-4.12	
8	ICC11224	9.47	9.56	8.13	9.13	8.20	8.96	8.91	-20.34	
9	ICC11332	9.57	9.71	7.64	9.62	7.60	7.72	8.64	-14.54	
10	JG62	8.81	9.43	7.96	10.07	9.06	8.84	8.02	-11.23	
11	BG1075	8.63	8.34	8.23	9.82	8.44	7.80	8.54	2.40	
12	BG1077	9.23	8.40	8.30	9.27	7.68	7.86	8.45	5.37	
13	BG2023	9.69	9.69	8.24	9.98	7.76	8.29	8.94	1.34	
14	BG2025	8.40	9.83	7.86	7.98	8.72	8.62	8.56	-15.05	
15	BG2027	10.12	9.86	7.82	9.74	8.66	8.67	9.14	11.03	
16	BGD1016	9.66	9.35	7.60	9.81	6.79	8.10	8.55	6.48	

17	BG2066	9.68	10.17	7.91	9.34	8.46	8.81	9.06	6.67	
18	BLAK936	8.08	9.48	8.06	7.74	8.17	8.04	8.26	26.88	
19	BG2049	9.09	10.15	8.72	8.92	8.18	7.92	8.83	12.54	
20	PUSA372	8.35	8.43	8.81	7.87	8.67	8.32	8.40	7.75	
21	BG1063	8.46	9.71	8.23	7.98	8.14	8.12	8.44	-3.87	
22	BGD112	8.24	8.38	8.10	8.07	8.81	9.58	8.53	-11.96	
23	C-235	9.03	8.28	7.65	7.86	9.08	9.29	8.54	-11.56	
24	CSG8962	8.71	9.75	8.07	8.37	9.03	9.22	8.85	1.22	
25	ICRISAT3070	8.92	9.93	7.51	8.64	9.05	8.76	8.08	-18.25	
26	ICRISAT3074	8.66	9.69	8.44	7.96	8.24	8.32	8.53	-4.05	
27	ICRISAT3077	8.95	8.44	8.71	8.23	8.95	7.77	8.50	-6.86	
28	PUSA362	8.44	8.48	9.10	7.97	8.64	8.07	8.54	-16.95	
29	PUSA391	8.78	8.53	9.23	9.08	8.60	7.65	8.64	-6.35	
30	BG1103	8.57	7.98	9.58	8.55	8.32	8.10	8.52	5.11	
31	PUSA1053	9.08	9.47	8.12	9.33	7.33	8.23	8.59	1.37	
32	PUSA1088	9.04	9.61	8.32	9.71	8.85	8.81	9.15	-20.72	
33	BG1107	8.55	9.36	8.08	8.04	8.87	8.72	8.60	-21.62	
34	PUSA1108	9.17	9.76	8.35	7.45	7.79	7.84	8.39	4.80	
35	BG1109	9.07	9.29	8.08	8.09	8.60	7.91	8.50	9.41	
36	PUSA2024	8.62	9.58	7.99	7.66	9.18	7.60	8.43	15.35	
37	PUSA1003	8.30	8.13	7.82	8.03	6.53	7.82	7.77	1.25	
38	BGD1004	8.90	9.61	8.62	8.96	7.91	7.86	8.64	-2.32	
39	ICCV-5	9.29	9.75	8.29	9.04	8.29	8.14	8.93	15.59	
40	BG2060	8.86	9.38	7.86	8.67	8.20	8.20	8.52	-0.85	
41	BG1072	9.05	10.07	8.49	9.17	8.10	8.23	8.85	10.67	
42	BG2046	8.59	8.13	7.72	8.52	7.63	7.96	8.09	8.95	
43	BG2051	8.84	9.40	8.96	8.99	6.47	8.84	8.58	0.67	
44	BG5019	8.89	9.30	7.94	9.48	7.37	7.40	8.39	9.84	
45	BG2054	8.57	9.79	7.69	9.41	8.77	8.33	8.76	4.05	
46	BG2062	8.33	9.24	7.45	9.46	9.26	8.36	8.68	0.69	
47	BG2045	8.25	8.33	9.24	9.02	8.68	9.11	8.77	14.23	
48	BGD1035	8.80	8.37	9.04	7.68	8.76	8.39	8.51	-0.85	
49	BG2056	9.81	9.63	8.52	7.65	8.80	8.00	8.73	2.36	
50	PUSA1105	9.94	10.10	9.19	9.54	9.33	8.36	9.41	12.28	
	Mean	8.96	9.29	8.28	8.88	8.31	8.32	8.70		
	IPCAI	12.24	8.57	1.46	15.64	10.92	2.45			

BG 2056 and PUSA 1105 had significantly higher yields than the check variety. Similarly, three environment, namely E3 (8.28g), E5 (8.31g), E6 (8.32g) were significantly lower yielding when compared with grand mean (8.70g). On the other hand, of the 3 environments which had higher mean yields than the grand mean, only three. E1 (8.96 g), E2 (9.29g) and E4 (8.88g) were significantly higher yielding than the grand mean.

REFERENCES

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

Gauch,H.G.and R.W.Zobel.(1996). Ammi analysis of yield tgrials. In:M.S.Kan g and H.G. Gauch (eds). Genotype by environment interaction. CRC. Bocaration Florida,USA.pp.85-22

Kang, M.S. (1998). Using genotype by environment interaction for crop cultiverdevelopment.Advances in agronomy**. 62:**199-246.

Perkins, J.M. and Jinks, J.L. (1968a). Environmental and genotype-environmental components of variability III. Multiple lines and crosses. *Heredity,* **23**: 339-356.

Sharma, P.P. and Maloo, S.R. (1989). Phenotypic stability in chickpea *(Cicer arietinum* L.). *Madras Agric. J., India,* **76**(7): 400-405.

Singh, O. and Kumar, S. (1994). Phenotypic stability of yield and related characters in des/gram *(Cicerarietinum L). Indian J. Agric. Sci.,* **64**(12): 815-820.