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Research Article

Genotype x environment interaction and stability analysis for yield traits in chickpea (*Cicer arietinum* L.)

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Abstract

The present investigation was carried out during *Rabi* 2016-17 at five different locations in Chhattisgarh to determine the stability for days to 50% flowering, days to maturity, plant height, pods per plant, 100-seed weight (g) and seed yield (kg/ha). Analysis of variance revealed significant mean squares due to genotypes for all the traits indicated significant differences among the means. Mean squares due to Genotypes x Env. (linear) were significant for pods/plant and seed yield indicated that the varieties differed genetically for their regression on the environmental index and hence the performance is predictable in nature for pods/plant and seed yield. Mean squares due to individual variety have been tested against pooled error for the traits days to 50% flowering, days to maturity, plant height and 100-seed weight that exhibited significant mean squares due to pooled deviation. Mean squares due to pooled deviation were significant but mean squares due to Genotypes x Env. (linear) for days to 50% flowering, days to maturity, plant height and 100-seed weight indicated that variation in the performance of varieties is entirely unpredictable and hence varieties may perform better in the favorable environment for the traits. In the present investigation, varieties which showed significant regression tested for bi-0 for the traits were near to unity except for 100-seed weight in RG 2009-16, RG 2009-20 and RG 2010-11-1 which exhibited regression significantly differed to the unity (1-bi). For plant height varieties RG 2009-16 and RG 2015-08 exhibited high mean, regression coefficient near to unity and deviation from regression near to zero, hence may be considered as stable for the trait.

Key words
Chickpea, Cicer arietinum, Stability, GxE interaction, seed yield, Chhattisgarh

Introduction

Chickpea is the world's third most important food legume crop grown as rainfed in cool and dry climate in semi-arid regions. During the last few decades, due to increasing demand of the food, world's growing population depend to a large extent on the conservation and use of world's remaining plant genetic resources. Chickpea covers about 11.7 million ha area and 9.3 million tonnes production in over 45 countries of the world. India is the largest chickpea producer accounting a share of about 67% in global chickpea production with about 8.25 million ha area, 7.33 million tonnes production and productivity of 889 kg/ha. Distribution of chickpea in six states *viz*., Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh, Karnataka and Andhra Pradesh together contribute 90.2% of the production and 90.8 % of the chickpea area in the country. Chhattisgarh covers 0.281 million ha area with production 0.290 million tonnes and productivity of 1035 kg ha^{-1} (Anonymous, 2016).

Chickpea thus occupies nearly 40.70% of total area under *rabi* pulses in Chhattisgarh State. The production potential of chickpea is still not exploited fully because most of the area under chickpea is rainfed and suffers due to several biotic and abiotic stresses and lack of high yielding varieties of wider adaptability. The Chickpea crop shows differential performance when grown under different environments after the harvest of rice. Environmental factors such as soil moisture, sowing time, fertility, and temperature and day length have strong influence during various stages of plant growth (Tilahun *et al*., 2015**)**. The environment is changing day-by-day and this implies that it is necessary to evaluate crop genotypes at different environments to assess their performances. The performance of a genotype is not always the same in different environments as it is influenced by environmental factors. To assess yield stability among varieties, multi-location trials with appropriate stability analysis method is required. Therefore the current research was undertaken to examine the magnitude of environmental effect on yield and yield related traits of Desi-type chickpea genotypes, to study the nature and extent of G x E Interaction on seed yield of Desi -chickpea genotypes and to investigate the stability and adaptability of the varieties under different agro-climatic conditions of Chhattisgarh.

Materials and Methods

The experiment was conducted during the 2016-17 at Research Farms of Agriculture Colleges of Indira Gandhi Agricultural University located at Raipur, Bhatapara, Bemetera, Kabirdham and Korea districts in the State of Chhattisgarh. Fourteen pipelines and two released desi-type chickpea genotypes were included in the study. Planting of the genotypes was done during mid-November to first week of December in Randomized Complete Block Design with three replications at each site under rice based cropping system. Each genotype was planted in four rows of 4 m length. A spacing of 30 cm between rows and 10 cm between plants were used on a plot size of 4.8 m^2. Fertilizer @ 20:50 Kg/ha N:P was applied. Agronomical management practices were done as required for each site. Following the standard procedure the data were recorded on yield traits *viz*. days to 50% flowering, days to maturity, plant height (cm), pods/ plant, 100-seed weight (g) and seed yield (kg/ha). Data were computed by using SPAR 2.0 for analysis of variance and stability analysis.

Result and Discussion

Results of analysis of variance for stability analysis for seed yield and its components (Table-1) revealed that mean squares due to genotype were significant for all the traits indicated significant differences among them. Mean squares due to Genotypes X Env. (linear) were significant for pods/plant and seed yield indicated that the varieties differed genetically for their regression on the environmental index and hence the performance is predictable in nature for pods/plant and seed yield. Mean squares due to individual variety have been tested against pooled error for the traits days to 50% flowering, days to maturity, plant height and 100-seed weight that exhibited significant mean squares due to pooled deviation. Mean squares due to pooled deviation were significant but mean squares due to Varieties X Env. (linear) for days to 50% flowering, days to maturity, plant height and 100-seed weight indicated that variation in the performance of varieties is entirely unpredictable and hence varieties may perform better in the favorable environment for the traits. These findings are in general agreement with the findings reported by Rao (2011), Shivani and Sreelakshmi (2015), Tilahun *et al.* (2015 a), Tilahun *et al.* (2015 b), Yadav *et al.* (2010), Yadav *et al.* (2014) and Rao and Rao (2014).

Eberhart and Russell (1966) defined a stable genotype as the one which showed high mean yield, regression coefficient (bi) around unity and deviation from regression near to zero. Accordingly, the mean and deviation from regression of each genotype were considered for stability and linear regression was used for testing the varietal response. The estimates of stability parameters in respect of six characters that had direct influence on genotypes performance is presented in table 2.

Results of stability parameters revealed that for days to 50% flowering varieties RG-2009-01, RG-2011-01, RG-2011-06, RG-2015-06, RG-2015-04 and JAKI-9218 exhibited the days to 50% flowering early to the average and regression significantly differed from zero. For days to maturity varieties RG-2011-01, RG-2009-20, RG-2009-01, RG-2011-06, JG-16, RG-2011-02, RG-2010-10-5, JAKI-9218 and RG-2015-06 exhibited earliness compared to the average and regression significantly differed from zero. For plant height varieties RG-2009-10, RG-2009-16, RG-2009-01, RG-2015-08, RG-2011-02, RG-2011-04, RG-2015-01and RG-2015-06 showed more plant height to the average and regression significantly differed from zero. For pods/plant varieties JAKI-9218, JG-16, RG-2010-10-5, RG-2009-10, RG-2015-01, RG-2009-01 and RG-2015-08 exhibited more number of pods/plant to the average and non-significant regression and deviation from regression. For 100-seed weight varieties RG-2011-06, RG-2015-08, RG-2011-02, RG-2015-06, RG-2009-01and RG-2011-01 showed above average 100-seed weight. For seed yield varieties JAKI-9218, RG-2015-08, RG-2009-01, RG-2015-06, RG-2015-01, RG-2009-16, RG-2011-06 and RG-2015-04 exhibited seed yield higher to the average and non-significant regression and deviation from regression.

In general, deviation from regression found significant for all the varieties for the traits days to 50% flowering, days to maturity, plant height and 100-seed weight except RG-2015-04 for days to maturity, RG 2009-16, RG 2009-20, RG 2011-04 and RG 2015-08 for plant height and RG 2011-02 for 100 Seed weight. For pods/plant and seed yield all the varieties exhibited desirable non-significant deviation from the regression from zero except RG 2015-06 for pods/plant.

In the present investigation, varieties which showed significant regression tested for bi-0 for the traits were near to unity except for 100-seed weight in RG 2009-16, RG 2009-20 and RG 2010-11-1 which exhibited regression significantly differed to the unity (1-bi). For plant height varieties RG 2009-16 and RG 2015-08 exhibited high mean, regression coefficient near to unity and deviation from regression near to zero, hence may be considered as stable for the trait.

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Table 1. Analysis of variance for stability analysis

Source of Variation	df	Mean sum of squares					
		Days to 50% flowering	Days to maturity	Plant height (cm)	Pods/ plant	100-seed weight (g)	Seed yield (Kg/ha)
Total	79	83.63	47.83	47.46	430.36	13.35	867299.9
Varieties	15	98.51**	32.21**	82.20**	349.35**	40.70**	213018.6*
Env. + (Varieties X Env.)	64	80.14	51.49	39.32	449.34	6.94	1020647.1
Environment (linear)	1	4014.71	2708.58	1269.98	21867.19	235.44	58349671.9
Varieties X Env. (linear)	15	14.75	7.74	9.67	196.52*	2.75	172252.4*
Pooled Deviation	48	18.61**	9.81**	22.95**	82.14	3.49**	91415.7
1. JAKI-9218	3	4.05**	19.42**	71.72**	36.25	3.44**	305335.69
2. JG-16	3	6.33**	9.54**	70.99**	90.79	6.10**	138970.32
3. RG-2009-01	3	17.93**	5.87*	29.78**	24.21	12.18**	85961.17
4. RG-2009-10	3	24.60**	13.15**	6.39	44.23	2.81**	6615.03
5. RG-2009-16	3	24.61**	9.97**	5.50	34.97	1.66*	11982.82
6. RG-2009-20	3	23.97**	7.03*	5.18	56.13	2.43**	21518.38
7. RG-2010-10-5	3	24.94**	2.70	7.94	252.05	1.08	32472.40
8. RG-2010-11-1	3	16.34**	7.50*	60.79**	133.06	7.15**	78836.64
9. RG-2011-01	3	29.82**	6.78*	34.11**	349.12	2.48**	44565.31
10. RG-2011-02	3	34.73**	6.68*	21.50**	7.14	0.27	53131.75
11. RG-2011-04	3	14.71**	14.66**	1.72	27.15	2.12**	318620.42
12. RG-2011-06	3	15.60**	7.98*	11.06	9.61	1.89*	18163.97
13. RG-2015-01	3	13.13**	11.23**	7.40	89.35	4.74**	77357.86
14. RG-2015-04	3	6.46**	1.07	14.43	58.00	0.76	62498.83
15. RG-2015-06	3	16.00**	10.38**	14.44	9.29	4.04**	9207.47
16. RG-2015-08	3	24.52**	22.96**	4.18	92.97	2.61	197413.77
Pooled Error	160	0.83	2.16	5.45	100.46	0.54	168232.7

* Significant at 5% level. ** Significant at 1% level.

Table 2. Stability parameters for yield traits in chickpea

S.No.	Varieties	Days to 50% flowering			Days to maturity			Plant height (cm)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	JAKI-9218	54.67	0.84**	3.22**	104.3	1.09*	17.26**	53.66	1.15	66.27**
2	JG-16	57.27	0.71*	5.50**	103.0	1.07**	7.38**	52.05	0.14	65.55**
3	RG-2009-01	48.80	1.18*	17.10**	101.6	0.71**	3.71**	62.25	1.21*	24.34**
4	RG-2009-10	59.87	1.09	23.77**	107.9	1.13**	10.99**	65.88	0.93**	0.94**
5	RG-2009-16	61.07	0.99	23.78**	107.9	1.09**	7.81**	62.53	1.52**	0.05
6	RG-2009-20	50.87	0.96	23.14**	101.3	0.84**	4.87**	50.67	1.17**	-0.27
7	RG-2010-10-5	60.93	0.42	24.11**	104.1	0.87**	0.54**	53.88	0.79*	2.49**
8	RG-2010-11-1	59.53	0.65	15.51**	105.4	0.82**	5.34**	56.37	0.66	55.34**
9	RG-2011-01	50.53	1.24*	28.99**	101.1	0.69*	4.62**	56.43	0.80	28.66**
10	RG-2011-02	52.60	1.23	33.90**	103.7	0.60*	4.52**	59.20	1.26*	16.06**
11	RG-2011-04	60.13	1.11*	13.88**	107.8	1.14**	12.50**	59.08	1.55**	-3.72
12	RG-2011-06	51.60	1.10*	14.77**	102.7	1.23**	5.82**	56.31	0.75*	5.62**
13	RG-2015-01	59.67	1.02*	12.30**	107.5	1.30**	9.07**	58.87	1.10**	1.96**
14	RG-2015-04	54.27	1.21**	5.63**	105.4	1.17**	-1.09	55.95	0.99*	8.98**
15	RG-2015-06	52.60	1.30**	15.17**	104.4	1.10**	8.22**	58.57	1.19**	9.00**
16	RG-2015-08	61.53	0.94	23.69**	108.7	1.16*	20.80**	60.68	0.80**	-1.26
		56.00			104.8			57.65		

For b_i (bi-0): * Significant at 5% level. ** Significant at 1% level.
For b_j (1-bi): # Significant at 5% level.
For s^2d_i (s^2d_i-0): * Significant at 5% level. ** Significant at 1% level.

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Table 2. Contd.,

S.No.	Varieties	Pods/ plant			100-seed weight (g)			Seed yield (Kg/ha)		
		Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
1	JAKI-9218	71.23	1.00	-64.21	22.20	0.94**	2.89**	2684.4	1.33	137103.0
2	JG-16	62.95	1.94	-9.67	18.11	1.75**	5.56**	2078.1	1.03	-29262.3
3	RG-2009-01	54.81	0.96	-76.25	23.92	0.38	11.64**	2494.7	1.02	-82271.5
4	RG-2009-10	60.43	1.29	-56.23	20.80	1.03**	2.27**	2252.0	0.89	-161617.6
5	RG-2009-16	48.16	0.93	-65.49	21.62	0.65**#	1.11**	2365.9	1.05	-156249.8
6	RG-2009-20	47.83	0.83	-44.33	20.13	0.65**#	1.88**	2300.6	0.88	-146714.3
7	RG-2010-10-5	60.59	1.33	151.59	15.26	1.05**	0.54**	2033.1	1.21	-135760.3
8	RG-2010-11-1	46.24	0.51	32.60	22.18	0.36#	6.61**	2033.9	0.98	-89396.0
9	RG-2011-01	48.13	0.62	248.66	23.58	1.09**	1.93**	2120.2	0.82	-123667.4
10	RG-2011-02	42.79	0.39	-93.32	25.03	1.37**	-0.27	2275.3	0.76	-115100.9
11	RG-2011-04	42.28	0.72	-73.31	20.38	0.81**	1.57**	2061.1	0.79	150387.8
12	RG-2011-06	48.15	1.20	-90.85	26.69	1.17**	1.34**	2345.0	0.58	-150068.7
13	RG-2015-01	59.27	1.17	-11.11	21.93	0.76**	4.20**	2396.4	1.33	-90874.8
14	RG-2015-04	42.93	0.77	-42.46	21.65	0.72**	0.22**	2339.1	0.98	-105733.8
15	RG-2015-06	52.03	1.03**	-91.17	24.14	1.66**	3.50**	2415.7	1.01	-159025.2
16	RG-2015-08	52.57	1.31	-7.49	25.43	1.63**	2.06**	2673.5	1.34	29181.1
		52.52			22.07			2304.3		

For b_i (bi-0): * Significant at 5% level. ** Significant at 1% level.
For b_i (1-bi): # Significant at 5% level.
For s^2d_i (s^2d_i-0): * Significant at 5% level. ** Significant at 1% level.