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STABILITY ANALYSIS OF YIELD AND YIELD COMPONENTS IN CHICKPEA (*CICER ARIETINUM* L.) GENOTYPES ACROSS THREE RAINFED LOCATIONS OF PAKISTAN

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Abstract

One approach to improve the chickpea yield is to identify stable genotypes that perform consistently better under diverse environments. Fifteen genotypes of chickpea were evaluated for stability of different yield parameters under three diverse environments (Bhakkar, Chakwal and Rawalpindi) in the Punjab province of Pakistan. Variance due to genotypes, environments, genotype x environment and environment (linear) was highly significant for days to flowering, plant height, number of pods per plant, 100 grain weight and grain yield per plant across the environments. By using Eberhart and Russel method of stability analysis genetic differences among diverse cultivars were calculated. The results showed that different genotype depicts significant genotype x environment (linear) response under contrasting conditions. The present study revealed that genotypes 01067, 3CC-113 and AZC-06 showed stable performance for days to flowering and number of pods per plant. The genotypes CMC211-5 and 3CC-116 depicted stable performance for days to flowering and grain yield per plant. The genotypes Bittal-98 was stable for number of pods per plant and grain yield per plant. The genotype CH24100 was stable for days to flowering and 100 grain weight. The genotype Dasht with the highest grain yield per plant was found stable for 100 grain weight. The present study concluded that in general the genotypes differed for yield components regarding stability in chickpea.

Introduction

Chickpea (*Cicer arietinum* L.) is considered as one of the most important legumes used as food and feed which is cultivated on 10 million hectares in a wide range of environments across the world. It provides an important source of vegetable protein and fixes atmospheric nitrogen into the soil. Since most of the chickpea crop is grown under the rainfed condition in Pakistan, fluctuations in rainfall severely limits its productivity.

Chickpea is an intermediate annual herbaceous grain legume with 2 distinct types; Kabuli and Desi. It is cultivated as winter crop in Pakistan which, at reproductive stage, is exposed to various stresses that limit its yield potential (Ludlow & Muchow, 1990). Consequently, its production in the country is low and unstable. The susceptibility of existing varieties to changes in environment is major factor that is responsible for low yield and yield instability. Because of the wide spread presence of genotype x environment (G x E) interaction, yield stability has taken much louder voice to improve the dropping yield of crops. There are some vital characteristic to measure yield stability as stated by (Ludlow & Muchow, 1990). The plant breeders are doing concerted efforts to to conclude the stability over a range of environments. The genotypes x environment interaction have been studied by different workers in chickpea (Bakhsh *et al*., 1995; Ashraf *et al.*, 2001; Arshad *et al*., 2003; Yaghotipoor & Farshadfar, 2007; Yadav *et al*., 2010; Bakhsh *et al*., 2011; Hamayoon *et al*., 2011) in mungbean (Zubair & Ghafoor, 2001) in lentil (Bakhsh *et al*., 1991) in wheat (Ahmad *et al*., 1996; Sharif *et al*., 1998;) in cotton (Shah *et al*., 2005; Ahuja *et al*., 2008) and in wheat (Noorka *et al.*, 2009). It is very important information that should be available for the future chickpea varieties development program.

The present study was planned to examine the nature and magnitude of genotype x environment interaction on morphological characters in order to identify genotypes with stable performance across various environments and to study the specific adaptability of genotypes to various environments.

Materials and Methods

The present study was carried out during *rabi* 2008-2009 at 3 locations viz. National Agricultural Research Centre (NARC), Islamabad, Arid Zone Research Institute (AZRI), Bhakhar and Barani Agricultural Research Institute (BARI), Chakwal. The soil profile of BARI Chakwal and NARC Islamabad is given in Table 1, whereas the soil profile of AZRI Bhakkar is not available. Fifteen genotypes of chickpea viz. Parbat, CMC-211-5, Bittal 98, 96A4504, BRC-61, 01067, 3CC-113, CH24100, 96A4580, AZC-06, SL03-64, 3CC-116, 93127, Punjab-2000 and Dasht were used. The experiments were conducted following Split Plot Design with four replications. The plot comprised of four rows, each of 4 meter length. The plant to plant (PxP) distance and row to row (RxR) distance was kept 10cm and 30cm respectively. Sowing was done during the month of October, 2008 at all the three locations. The seeds were drilled in rows and seedlings were later thinned out to maintain an inter-plant distance at 10 cm. The fertilizer was applied @ 23-57 kg/ha Nitrogen: Phosphorus respectively at all three locations. The crop was grown on residual moisture and available nutrient material of soil at each location till maturity. Ten plants were selected at random from two central rows of each plot for data recording for days to flowering, plant height, number of pods per plant, 100 grain weight and grain yield per plant. The crop was harvested in the 30th of April 2009. Data obtained from 3 locations were subjected to statistical analysis of variance for the determination of significance of differences among the genotypes for various parameters followed by pooled analysis of variance. Stability parameters were determined according to the methods of Eberhart & Russel (1966).

Table 1. Soil profile of experimental sites (BARI Chakwal and NARC Islamabad).

Determinations	Research Sites	
	BARI Chakwal	NARC Islamabad
EC (dS m^{-1})	0.62	0.22
pH	8.1	8.26
Organic matter (%)	0.58	0.65
Textural class	Sandy clay loam	Sandy clay loam
Bulk density (g cm^{-3})	1.49	1.45
Available P (mg kg^{-1})	6.7	6.71
Extractable K (mg kg^{-1})	128	72.54
Total N (%)	0.03	0.031

Results and Discussion

Analysis of variance for various yield components in fifteen chickpea genotypes evaluated across 3 diverse environments revealed highly significant differences among various genotypes (Table 2). The experimental results concerning genotype x environment interaction, genotypic stability and adaptability of various genotypes across different agro-climatic conditions are discussed as follows:

Table 2. Analysis of variance displaying mean squares for various traits of 15 chickpea genotypes over three locations.

S. #	Traits	Islamabad	Chakwal	Bhakkar
1.	Days to flowering	48.18**	23.78**	10.12**
2.	Plant height (cm)	64.49**	79.04**	73.94**
3.	Number of pods per plant	37.47**	42.66**	06.70**
4.	100- grain weight (g)	06.57**	20.25**	8.52**
5.	Grain yield per plant	8.85**	34.94**	12.35**

Days to flowering: The result revealed significant differences not only for genotypes but also high magnitude of genotype environment interaction, reflecting genetic variability in experimental material as well as difference in the environmental conditions (Table 3). The comparison of mean values showed that enough range for genetic variability existed for number of days taken to flowering (Table 4). The mean values varied from 110.44 (Punjab-2000) to 117.24 (Dasht). The genotypes viz. CMC211-5, 01067, 3CC-113, CH24100, AZC-06 and 3CC-116 were found to be fairly stable with regression coefficient close to unity (bi = 1.0) and had a non significant deviation from regression. The present findings are in accordance with those of Mathur & Mathur (1996) and Saleem *et al.,* (1999). They observed positive G x E interaction between days taken to flowering and ultimately grain yield per plant Higher vegetative growth may be obtained by interaction of days taken to flowering and grain yield per plant. However, higher vegetative growth generally influence grain yield per plant negatively, but it is difficult to mark the threshold level of vegetative growth. So according to the present results high stability is associated with number of days taken to flowering.

Table 3. Pooled analysis of variance for yield components of 15 chickpea genotypes across three locations.

Source of variation	d.f.	Mean squares				
		Days to flowering	Plant height	No. of Pods per plant	100-grain weight	Grain yield per plant
Genotypes	14	232.223**	48.160**	9.413**	5.453**	11.249**
Variety + Environment	28	8.235^{NS}	26.716**	9.412**	3.200**	5.150^{NS}
Environment + (GxE)	30	335.513**	62.530**	9.078**	5.488**	12.574**
Environment (Linear)	1	9834.783**	1127.838**	8.807**	75.062**	233.031**
GxE (Linear)	14	7.020^{NS}	21.108**	11.206**	0.933^{NS}	3.340^{NS}
Pooled deviation	15	8.820^{NS}	30.169**	7.109^{NS}	5.102**	6.495^{NS}
Pooled error	88	8.813	19.426	8.81	2.430	3.166

Plant height (cm): The present results revealed significant differences not only for genotypes but also high magnitude of genotype environment interaction, reflecting genetic variability in experimental material as well as difference in the environmental conditions (Table 3). It could be concluded from results that plant height is sensitive to environmental fluctuations and indicated that relative performance of genotypes was markedly inconsistent over the locations. These results are consistent with the findings of Malik *et al.*, (1988) in chickpea, Sharif *et al.*, (1998) in wheat who found high magnitude of G x E interaction and concluded that plant height may be influenced by environment.

A perusal of Table 3 presented a wide range of mean values for plant height that varied from 65.07 (93127) to 75.30 (3CC-116). The coefficient of regression (bi) varied from 2.047 (3CC-113) to 0.236 (3CC-116). The genotypes Parbat, CMC211-5, AZC-06, SL03-64 and 01067 with high mean value for plant height showed trend of specially adapted to better environment while genotypes 96-A4504 and Punjab 2000 with above average height showed adaptability over wide range of environment as suggested by Eberhart & Russell (1966) and described by Singh & Chaudhry (2004) and Finaly & Wilkinson (1963). The genotypes (BRC-61 and Punjab 2000) with coefficient of regression value close to 1.0 and non-significant deviation from regression were found fairly stable across the environments for plant height.

Number of pods per plant: Number of pods per plant is an important selection criterion for the development of high yielding genotypes and is strongly influenced by environment in chickpea (Malik *et al.*, 1988). Marked variation was observed in the performance of genotypes over three locations. Similar results were recorded by Sanghi & Kandalkar (2001) in cowpea. A perusal of Table 4 revealed that mean values for number of pods per plant varied from 23.51 (93127) to 36.77 (Parbat). The coefficient of variation (bi) varied from 9.421 (96-A4580) to 1.020 (3CC-113) indicating differential response of genotypes to different environments. The highest mean number of pods per plant was recorded by genotypes i.e. Parbat (36.77) followed by Dasht (36.45), CMC211-5 (35.11) and SL03-64 (35.00). These results are consistent with the investigations of Singh & Bains (1984) and Malik *et al.*, (1988). These results indicated variability for number of pods per plant and that this trait was sensitive to environmental fluctuations.

The genotypes Bittal-98, 01067, 3CC-113, with above average mean pods per plant were found relatively stable as they had bi value close to unity (1.0) and small deviation from regression (S^2d) whereas, genotypes (Parbat and 96A4504) are expected to give better pods per plant in favourable environments as explained by Zubair *et al*., (2002).

100-grain weight (g): Hundred-grain weight is an important yield component which is genetically controlled (Singh & Bains (1984); Khan *et al.*, (1987, 1988). However, Bains *et al.*, (1988) found considerable range of variations for this character. Statistically significant variance was observed for genotype, genotype and environment, pooled deviation and response of genotypes to varying environments (Table 3). It was further indicated that relative performance of genotypes is quite inconsistent across the locations. Significant pooled deviation for 100-grain weight suggested that these genotypes differ considerably with respect to their suitability for this character. The present results are in agreement with the findings of Singh & Singh (1974), Sanghi & Kandakar (2001). In the present investigation highly significant genotypic variation over the locations was observed (Table 3). The results are consistent with the findings of Singh & Bains, (1984) and Rao & Suryawanshi (1988) in chickpea. Differential response of genotypes at each location suggested that 100-grain weight, which corresponds to the seed size is genetically controlled character, therefore each genotype behave differently not only across environments but also exhibits significant inter genotypic variations. The values of regression co-efficient (bi) showed a range (0.468 to 1.727 indicating stability in the performance of genotypes (Table 4). Similar results were also obtained by Patil & Narkhede (1989) in black gram. The genotypes Parbat, CMC211-5, Bittal-98 and 3CC-113 having regression co-efficient above 1.00 indicated that their seed size increases in favourable environments. On the other hand genotypes BRC-61, 01067, 96-A4580, Punjab-2000 with regression co-efficient below 1.00 are adaptive to less favourable environments. The genotypes Dasht and CH24100 with highest mean value for 100-grain weight had regression coefficient close to unity (bi = 1.0) and also had a non significant deviation from regression (S^2d), thus possessing fair stability and can be grown under diverse environments.

Grain yield per plant (g): The results, pooled analysis of variance for gain yield per plant, indicated highly significant differences for genotype environment interaction (Table 3). The grain yield per plant varied from 18.50 (SL03-64) to 23.76 (93127 and Dasht) as given in Table 4. The regression coefficient (bi) values ranged from 2.020 (96-A4504) to 0.239 (BRC-61), whereas deviation from regression (S^2d) ranged from 6.133 to 0.022. The highest yields were recorded for genotypes 93127 and Dasht i.e. 23.76 each. Yield and its components are multigenic traits and are strongly influenced by environment in chickpea. Significant variation was observed for grain yield in chickpea by Khan *et al.*, (1987, 1988). The mean squares due to genotypes x environment interaction were also significant exhibiting the differential response of genotype in various environments. Similar results were obtained by Khan *et al.*, (1987, 1988), Bains *et al.*, (1988). The bi values exhibit range (0.239 to 2.020) indicating stability among the genotypes (Table 4). Similar findings were recorded earlier by Khan *et al.*, (1987, 1988); Bakhsh *et al.*, (1991) in Lentil & Aslam *et al.*, (1993) in soya bean. The highest yielding genotype Dasht and 93127 (23.76 each) showed unpredictable performance and were unstable. These results are in agreement with those reported by Khan *et al.*, (1987, 1988) in chickpea. It can be concluded from present results that highest yielding genotypes were sensitive to environmental fluctuations.

The genotype CMC211-5 and Bittal-98 with regression value close to unity and non significant deviation from regression were found to be stable for the trait across the diverse environments.

Table 4. Stability parameters for various yield traits of 15 chickpea genotypes over three locations.

S. #	Traits / Genotypes	Days to flowering			Plant height (cm)			No. of Pods per plant			100-grain weight (g)			Grain yield per plant (g)		
		$\bar{X}$	Bi	S^2d	$\bar{X}$	bi	S^2d	$\bar{X}$	bi	S^2d	$\bar{X}$	bi	S^2d	$\bar{X}$	bi	S^2d
1.	Parbat	115.22	1.093	0.565ns	69.56	1.582	3.626**	36.77	1.414	7.94**	23.88	1.694	0.725ns	21.71	0.858	3.045**
2.	CMC211-5	114.44	0.984	0.016 ns	70.83	0.673	2.441**	35.11	2.484	1.36**	22.43	1.162	1.303ns	20.85	1.067	0.871ns
3.	Bittal - 98	112.77	0.822	1.997**	73.58	0.731	0.886ns	33.11	1.113	0.178ns	21.20	1.367	0.646ns	18.86	0.907	1.000ns
4.	96 - A4504	115.66	1.101	0.140 ns	72.62	0.576	1.410**	31.22	1.879	1.943**	20.94	0.908	2.563**	20.48	2.020	4.257**
5.	BRC - 61	110.88	0.909	1.758**	71.12	1.176	0.076ns	30.8	6.071	0.274ns	23.24	0.176	7.549**	20.22	0.239	1.822ns
6.	01067	117.22	1.070	0.045 ns	70.81	1.100	3.113**	34.22	1.113	0.178ns	22.21	0.785	0.560ns	22.51	0.571	1.473ns
7.	3CC - 113	114.77	1.066	0.087 ns	69.20	2.047	1.178**	31.77	1.020	0.544ns	20.13	1.349	0.014ns	22.01	0.761	0.917ns
8.	CH24100	115.66	1.053	0.170 ns	69.32	0.829	1.586**	24.78	2.982	0.020ns	23.61	1.038	0.441ns	19.74	1.221	3.560**
9.	96-A4580	111.77	0.899	0.357ns	72.78	1.001	0.409**	23.85	9.421	1.521ns	22.25	0.468	1.023ns	22.01	0.969	6.133**
10.	AZC - 06	114.22	1.021	0.328 ns	71.15	1.960	2.334**	27.41	1.110	1.569ns	22.00	1.109	6.610**	21.24	1.430	2.726**
11.	SL03 - 64	113.55	1.141	0.628**	68.20	1.245	4.052**	35.00	3.646	0.760ns	22.30	0.821	0.041ns	18.50	0.499	0.354ns
12.	3CC - 116	115.66	1.071	0.036 ns	75.30	0.236	9.16**	31.22	4.408	0.532ns	21.24	0.526	0.073ns	18.54	0.924	1.370ns
13.	93127	114.22	1.054	1.496**	65.07	0.455	0.019ns	23.51	8.964	0.970ns	18.23	1.727	6.833**	23.76	1.566	0.022ns
14.	Punjab-2000	110.44	0.860	0.933ns	73.40	0.779	0.016ns	33.32	3.787	0.517ns	23.24	0.829	3.081**	19.67	1.366	2.362**
15.	Dasht	117.24	0.857	6.478**	72.30	0.609	2.132**	36.45	2.022	1.723ns	25.88	1.041	0.022ns	23.76	0.583	0.711ns

** significant at $p<0.01$ level

ns = Non-significant

Conclusion

The stable genotypes identified for various yield components as discussed earlier can be used for developing future genotypes that could show wider adaptability and stability under diverse environments. The information obtained from present study could be exploited in breeding programs for the development of genotypes with combination of stable traits. The hybridization followed by target selection would be a suitable strategy for this purpose. Since performance of characters were extremely uneven across the environment. It is however enviable to look at the climatic changes in occurrence of precipitation, fluctuation in temperature and degradation in soil fertility and even in the interface of differential response of target genotypes.

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