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Evaluation of Chickpea Genotypes Under Different Environments for Stability of Quantitative Traits

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Abstract: The present study was aimed to screen 19 elite genotypes and three check strains of chickpea for genotype x environment interaction (G x E) at four locations with varying micro and macro climatic conditions for yield associated phenotypic characters. The Randomized Complete Block Design (RCBD) with four replications was selected to conduct experiment. The means were used to compute pooled analysis of variance followed by regression analysis to measure G x E. The regression analysis revealed significant genotype x environment interaction for all the phenotypic characters. The mean values of crude protein (%) and 100-seed weight were highly significant for linear as well as non linear component of G x E, whereas for number of seeds per pod only non linear component was highly significant (p <0-05, p<0-01). The studied genotypes exhibited varying adaptability at different environments. Protein content, 100-seed weights were the highly sensitive trails for environmental stress. Genotypes 90280 and 94014 were stable genotype over wide range of environments are promising candidate Chickpea varieties.

Keywords: Chickpea, G x E interaction, Grain yield, Protein content

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) belong to family *Fabaceae.* Its stands fist for consumption in Pakistan and Asia. Chickpea contributes for 20% of global food production (Broughton *et al.*, 2003). Chickpeas is not only excellent source of fiber, minerals and rich in protein but also used to reduce cholesterol and blood sugar levels. Chickpea contains fat in trace amounts. The most famous medicinal uses of chickpea are stimulant, tonic, aphrodisiac, anthelmintic, diuretic, anti-stress, anti-hyperlipidemic and stamina building agent. It is also used to treat skin diseases. Chickpea is mainly grown in rainfed areas of Pakistan. Chickpea varieties released so far are only adaptable to only favorable environments therefore most of them have narrow adaptability as reflected by reduced gene expression of yield associated traits. Generally in multi environmental evaluation of genotypes instability account less for low potential of crops rather than low productivity. Thus we can defined stability as the repeatability of performance in different locations. Alterations in phenotypic characters of crops has been reported by many workers due to soil physicochemical composition and environment interaction (Arunkumar *et al.*, 2014; Shivani and Sreelakshmi 2014). Tolessa *et al*. (2013) define G x E interaction as variable phenotypic expression of genotypes in response of environmental changes.

This can be achieved by evaluation of genotypes in different environments. Majority of researchers do not rely upon better mean performance of crop at one site but they prefer multi environmental evaluation of genotypes (Kinlua 1992, Liu *et al.*, 1992). All over the world genotype x environment interaction has been studied in different crops before final recommendation of genotype as candidate variety. (Sreelakshmi *et al*. 2010) reported significant variation for G x E interaction for grain yield in Pigeonpea, Abo-Hegazy *et al*. (2013) in lentil and Christopher *et al*. (2014) in common bean. Chickpea also exhibit high level of instability in performance with change in climatic conditions. Bala *et al.*, (1994) (Hameed and Al-badrany 2007) reported altered protein content of same chickpea genotype at different locations. Singh *et al*. (1987) found strong association of least number of grains with stability. Although Bakhsh *et al*. (1995) (Singh and Singh 2013) found some stable chickpea genotypes observed for grain. Keeping in mind the influence of G x E interaction it is compulsory to develop widely adapted elite varieties with stability in yield and yield associated traits and protein content under diverse agro-ecological conditions of Pakistan. As Pakistan is world's sixth populous country and in 2012-2013 its population was **184.35 million** (Pakistan Economic Survey, 2012-13) therefore it is obligatory to develop stable varieties for diverse agro-ecological conditions.

In present work newly developed genotypes of chickpea grown at four different environments were studied for the nature and magnitude of G x E interaction and categorization of genotypes in to specific and wide adaptable on the bases of regression coefficient and deviation from regression coefficient.

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2. MATERIALS AND METHODS

In order to screen elite chickpea genotypes for wide adaptability four different locations (Islamabad, Bhakkar, Fateh Jung and Kotli) were selected for contrasting climatic conditions (Table-1a, b, c). Therefore nineteen advance genotypes subjected to stability analysis were 94014, NCS950012, NCS950010, 92CC076, 93009, NCS95003, NCS95002, NSC95004, 96051, 90280, NCS950183, 90261, 93012, 82080, 92CC079, A001, 91A039, BRC-14 and CMNK 28-3 that were compared with three check strains (Paidar-91, A-16, C44) for their stability across different environments. Randomized Complete Block Design (RCBD) with four replications was used for planting. Each plot comprised of four meter long rows (four rows). The distance between the plants was 10 cm and that of row was 30cm. No irrigation was supplied during cropping rather crop totally relayed on residual moisture. Five seedlings from middle rows of each replication were selected at random for mean data. The data for grain yield per plant, number of seeds per plant was collected at four locations where as for pod length, 100-seed weight and crude protein (%) at three locations while. The replicated data was computed for pooled analysis of variance as suggested by Steel and Torrie 1960. Eberhart and Russell (1966) method was utilized to measure of stability performance of genotypes. Seed total protein content was measured by Kjeldahl's method (A.O.A.C., 1990).

3. RESULTS AND DISCUSSION

Highly significant differences were observed among genotypes and genotype into environment interaction (G x E) for all the studied parameters (Table 1). These results not only reflects presence of genetic variability in tested genotypes but also clearly indicated that most of the traits were responsive to environmental fluctuations therefore the relative performance of genotypes was markedly inconsistent over the locations. Malik *et al.,* (1988) also observed similar trends of stability among their tested material and declared number of seeds per plant, 100-seed weight and yield per plant as environment sensitive parameters. Differences ($p=<0.01$) among the varietal means at various locations are presented in Table (2). The non significant differences for some characters may be due to soil type at Islamabad (Slity) and Bhakkar (Sandy), basic pH with less available organic matter that altered the gene expression of nutrient responsive genotypes at these locations (Table 1a, b &c). Genotype into environment interaction is always partitioned into linear and non linear components (pooled deviation). It is clear from results that main factor of genotype into environment interaction is pooled deviation (Table. 3). The differential responses of most of genotypes at same location indicated that the parameters were genetically controlled and exhibited variations under certain set of conditions. 100-seed weight and crude protein (%) were the most environment sensitive parameters as they exhibited maximum significant variations ($p=.01$) across the locations. The varietal means, regression coefficient (bi) and deviation from regression coefficient (S^2d) values are complied in Table (4). Mean pod length varied from 2.09 (cm) (Paidar-91) to 2.64 (cm) (NCS950010). The bi value ranged from 0.12 (Paidar-91) to 2.51 (94014). It was clear that genotypes 93009 and 92CC079 with above average bi value .96 and 1.01 respectively with non-significant deviation from linearity were stable over wide range of environments. It is obvious from the non-significant values of linear and non linear interactions pod length (cm) that this character did not play important role for the adaptability of a genotype. The number of seeds per pod (Table 3) varied from 1.96 (91A001) to 1.35 (BRC-14). The bi value ranged from 0.28 (NIFA CMNK 287-3) to 1.39 (91A001). For the number of seeds per pod; genotype 92CC076 was least affected by the varying agro climatic conditions (Soil typr, pH. organic matter, temperature and rain fall) all tested locations (Table 1a, b &c) where as genotype 91A001 was suitable only to favorable environments. Mean 100-seed weight (Table-3) varied from 16.98 g / plant (Paidar-91) to 24.44 g / plant (BRC-14). The bi values varied from -0.42 (Paidar-91) to 2.248 (NCS95003). No genotype was found ideally stable for 100 seed weight as non of the tested genotype posses above average regression coefficient (bi=1) with non-significant deviation (S^2 di=0) from regression coefficient according to Eberhart and Russell 1966, Finaly and Wilkinson 1963. Although genotypes 'NCS959183' with above average mean with bi= 0.91 and non-significant deviation from linearty. The variation observed for 100 seed weight in this study and in the previous studies (Bala *et al*., 1994) indicated an opportunity for the improvement of this character. High proteins content is the most important heritable qualitative characteristic of chickpea crop that is strongly influenced by environment. (add some text). Mean crude protein % varied from 17.5 (A-16 and 90261) to 21.2 (91A001). The bi value ranged from 8.44 (A-16) to 7.88 (91A001). Again no genotype was found stable for crude protein. The genotype'91A001' show unpredictable gene expression as evident from highly significant non linear component. The grain yield / plant varied from 6.27 (NCS-95002) to 11.65 g / plant (Piadar-91). The bi values for grain per plant ranged from .99 (90280) to 1.01 (94014). While deviation from regression coefficient S^2d value ranged from (0.16 to 59.43). Regarding grain yield per plant genotypes 90280, and 94014 showed comparative stability for this character over a wide range of locations. From the results it was clear that the genotypes having the highest mean value (Table. 4) were less stable as compared to

genotype with above average value. Present results are consistent with Chaturvedi *et al.* (2013) who also reported high level of G X E interaction in chickpea for all the quantitative traits. Similar response for grain yield was observed by Arunkumar *et al*. (2014) in pigeon pea and Shivani and Sreelakshmi 2014 in sorghum. So it was concluded that genotypes having a regression coefficient equal to or close to unity level with above average value were stable over a wide range of environmental conditions (Eberhart and Russell 1966, Finaly and Wilkinson 1963). Genotypes above unity level were high yielding only in favorable environments, while genotypes below unity expressed unpredictable performance

Table 1a: Soil Properties of locations

Locations	Soil texture	pH	Organic matters (%)
Islamabad	Slity clay loam	8.20	1.30
Bahakker	Sandy Loam	8.00	0.86
Fateh Jung	Loam	7.50	0.86
Kotli	Clay Loam	7.60	1.00

Source: Soil fertility laboratory. Rawalpindi.

Table 1b: Monthly rainfall (mm) at locations

Locations	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total
Islamabad	20.6	0	111.7	61.2	21.8	0.6	6.3	213.2
Bhakker	0	0	8.0	4.3	1.8	0	Tr.	14.1
Fateh Jung	22.6	0	135.9	51.0	18.8	4.5	8.2	241.1
Kotli	24.0	0	119.0	81.0	11.0	Tr.	55.5	290.5

Source: Pak. Met. Deptt. Govt. of Pakistan, Islamabad. (Tr: Traces)

Table 1c:Temperatures (C^{o}) of location during the experiment conducted

Locations	Islamabad		Bhakker		Fateh Jung		Kotli	
Month	Min.	Max.	Min.	Max.	Min.	Max.	Min	Max.
Nov.	24.7	9.3	28.1	12.7	24.6	8.4	25.5	9.0
Dec.	22.1	3.5	24.2	6.7	22.0	2.2	23.0	1.9
Jan.	16.9	4.6	20.2	5.5	16.9	3.2	18.0	3.1
Fab.	18.1	5.3	21.6	7.4	18.4	3.6	18.5	6.2
Mar.	24.5	10.3	27.8	12.9	24.1	12.7	25.5	11.6
Apr.	33.7	17.1	38.1	20.7	33.2	14.0	34.8	18.7
May.	39.4	24.7	42.8	27.5	34.8	21.8	39.9	24.6

Source: Pak. Met. Deptt. Govt. of Pakistan, Islamabad.

Table 2: Pooled analysis of variance (mean squares) for various traits

S. O. V.	Pod length / plant	Seeds/ pod	100-seed weight	Crude protein (%)	Grain yield / plant
Genotypes	.049**	000.11**	8.094**	3.16**	5.46**
Environment+(G x E)	.070**	0.177**	7.876**	3.42**	29.82**
Environment (linear)	2.05**	7.203**	140.177**	5.05**	1705.39**
G x E (linear)	.023^{ns}	0.026^{ns}	4.33**	3.51**	2.93^{ns}
Pooled deviation	.021^{ns}	0.91**	5.22243**	3.26**	4.57^{ns}

(** = P<0.01, ns= Non significant, df=21)

Table 3: Analysis of variance over the locations for different quantitative characters (mean squares)

Location	Pod length / plant	Seed / pod	100-seed weight	Crude protein (%)	Grain yeild / plant
Islamabad	1.55**	3.17**	7.74**	6.01**	1.32^{ns}
Bhakkar	1.01^{ns}	1.74^{ns}	3.42**	5.87**	1.01^{ns}
Fateh jung	2.05*	3.70**	1.19**	219965.79**	17.74**
Kotli	-	21.67**	-	.6747**	0.67**

(** = P<0.01, * = P<0.05, ns= Non significant, df =21)

Table 4: Mean stability performance of chickpea genotypes for quantitative traits over locations

Genotypes	Pod length / plant			Seeds / pod			100-seed weight			Crude protein (%)			Grain yield / plant		
	x	bi	S^2d	x	bi	S^2d	x	bi	S^2d	x	bi	S^2d	x	bi	S^2d
NCS950183	2.46	0.90	-0.00ns	1.89	0.81	-0.02ns	21.23	0.91	3.34ns	19.54	-3.09	4.17**	6.63	0.84	-4.25ns
NCS950012	2.28	0.97	-0.02ns	1.57	0.96	-0.15ns	20.66	0.66	1.46ns	17.79	-2.25	5.20**	7.22	0.64	2.15ns
NCS95003	2.25	1.19	-0.02ns	1.74	0.96	-0.06ns	23.71	2.48	-1.83ns	18.96	-3.64	0.23ns	7.08	0.98	-4.40ns
NCS95002	2.36	0.87	-0.02ns	1.48	1.15	-0.08ns	20.85	0.01	-2.02ns	19.25	5.90	20.43**	6.27	0.70	-2.10ns
NCS950010	2.64	2.27	-0.02ns	1.42	1.08	-0.06ns	22.78	0.77	-2.01ns	18.96	3.25	1.72**	8.29	1.10	-1.19ns
NCS95004	2.45	0.88	-0.14ns	1.52	1.37	-0.09ns	22.17	0.771	2.10ns	19.88	-1.79	2.19**	7.08	9.78	-3.23ns
Paidar-91	2.09	0.12	-0.01ns	1.73	0.47	-0.07ns	16.98	-0.42	16.06**	18.93	3.96	-0.25ns	11.56	1.40	59.43*
A-16	2.55	1.07	-0.01ns	1.46	1.25	-0.07ns	23.52	2.41	.077ns	17.50	-8.44	3.23**	8.47	0.95	-2.98ns
C-44	2.40	1.03	-0.01ns	1.56	0.96	-0.01ns	23.52	0.19	-1.44ns	19.53	0.27	0.21ns	8.74	1.16	-4.29ns
92CC076	2.38	0.76	-0.01ns	1.58	0.99	-0.02ns	20.84	0.19	23.97**	21.05	0.045	11.14**	7.15	0.81	-3.92ns
96051	2.42	0.81	-0.00ns	1.87	1.11	-0.02ns	21.22	1.75	-0.11**	18.96	6.48	-0.19ns	9.15	1.37	-3.60ns
90280	2.63	1.09	-0.01ns	1.51	1.14	-0.01ns	23.98	1.40	7.9ns	18.65	-0.54	3.06**	7.44	0.99	-4.31ns
93009	2.44	0.96	-0.01ns	1.72	0.76	-0.05ns	20.90	1.13	-0.62ns	19.54	-2.25	5.20**	6.59	0.85	-4.20ns
94014	2.33	2.51	-0.01ns	1.76	1.19	-0.05ns	22.57	0.62	-1.77ns	17.93	3.41	0.32ns	6.76	1.01	-3.55ns
90261	2.53	0.69	-0.00ns	1.78	1.10	-0.02ns	21.12	0.65	-1.77ns	17.50	-0.01	-0.25ns	6.33	0.78	-2.06ns
93012	2.48	0.79	-0.01ns	1.74	0.97	-0.08ns	23.80	0.38	6.19ns	118.91	-0.37	5.62**	7.84	1.08	-4.36ns
82080	2.56	0.74	-0.01ns	1.71	1.02	-0.05ns	23.22	2.18	1.86ns	20.15	2.65	0.17ns	7.48	1.12	-3.99ns
92CC079	2.44	1.01	-0.02ns	1.61	1.02	-0.08ns	22.17	1.94	0.7ns	118.27	0.75	1.7**	6.97	1.03	-2.98ns
91A001	2.47	0.85	-0.02ns	1.96	1.39	-0.27ns	22.53	0.77	-145ns	21.29	7.88	10.43**	7.24	1.08	-0.16ns
91A0039	2.36	1.14	-0.00ns	1.76	0.85	-0.06ns	22.71	0.34	-.88ns	18.89	1.34	10.03**	7.85	1.24	-0.45ns
BRC-14	2.54	0.78	-0.01ns	1.35	1.21	-0.03ns	24.44	2.14	15.07*	18.37	-0.54	3.06**	7.62	0.96	-2.7ns
CMNK28-3	2.35	0.48	-0.01ns	1.56	0.28	-0.13ns	21.62	0.72	0.75ns	18.38	1.66	0.62ns	6.92	0.97	0.57ns

(** = P<0.01, * = P<0.05, ns= Non signifiant, df =21)

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