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GENOTYPE - ENVIRONMENT INTERACTION FOR GRAIN YIELD IN CHICKPEA (*CICER ARIETINUM* L.)

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Abstract

Twenty-five genotypes of chickpea were evaluated for stability of grain yield under 12 diverse environments within Pakistan. The interaction between the genotypes and environments (G X E interaction) was used as an index to determine the yield stability of genotypes under all the environments. The G X E interaction was highly significant and both linear as well as non-linear components were equally important for determining the yield stability. Since the regressions (bi) were not significantly different from linearity, therefore, stable performance of the varieties could not be predicted on 'bi' alone. In this case, deviations from regression and the cultivars yield were used to judge the superior genotypes. The genotypes; '96051', '90280', 'C44', '91A039', 'NCS95004', 'NCS950010', 'NCS950180', '99101', 'A-16', '91A001', 'NCS950012' and '93009' produced above average yield. The genotypes '96051' and '98280' gave highest grain yield but their high deviation from regression showed fluctuation in the performance under different environments. The genotypes 'C44', 'NCS950183' and '93009' had also above average yield but their low deviation from regression revealed more stable performance compared to others.

Introduction

The development of cultivars or varieties, which can be adapted to a wide range of diversified environments, is the ultimate goal of plant breeders in a crop improvement program. The adaptability of a variety over diverse environments is usually tested by the degree of its interaction with different environments under which it is planted. A variety or genotype is considered to be more adaptive or stable one if it has a high mean yield but a low degree of fluctuation in yielding ability when grown over diverse environments. Eberhart & Russel (1966) proposed a model to test the stability of varieties under various environments. They defined a stable variety as having unit regression over the environments (b= 1.00) and minimum deviation from the regression (S^2d_i= 0). Therefore, a variety with a high mean yield over the environments, unit regression coefficient (b=1) and deviation from regression as small as possible (S^2d_i= 0), will be a better choice as a stable variety.

The genotype x environment interaction was studied by different researchers in various crops (Singh *et al*., 1987; Jain & Pandya 1988; Rao & Suryawanshi 1988; Ashraf *et al*., 2001; Zubair & Ghafoor, 2001). The stability parameters have also been studied in grain legumes for measuring phenotypic stability (Khan *et al*., 1987; Khan *et al*., 1988; Bakhsh *et al*., 1995, Sharif *et al*., 1998, Qureshi, 2001), but still it is very important information that should be available for the forth-coming chickpea varieties. Therefore, present investigation was aimed to evaluate some genotypes of chickpea for their yield stability under different agro-climatic conditions within the country.

Materials and Methods

The genotypes viz., 92CC079, 92CC076, 9280C, 96051, 90280, 90261, 94014, A-16, 93012, 93009, 99101, 99102, 99103, 91A001, 91A039, CMNK287-3, BRC-14, NCS95004, NCS950183, NCS950012, NCS96002, NCS96003, NCS950010, C44 and Punjab-91 candidate varieties developed by various plant breeders at different research institutes/stations within the country including released two varieties were used in this study. The yield performance of these varieties was tested at 12 locations (Table 1) that represented different agro-climatic conditions of the country. The experiment at each location was conducted during *rabi* season 1999-2000 in a randomised complete block design with four replications. The experimental plots consisted of six rows of 4 meter length. Row to row and plant-to-plant distances were kept at 30cm and 10cm respectively at all the locations. Stability parameters for grain yield were worked out as suggested by Eberhart & Russell (1966), using computer software written in "BASIC".

Table 1. Various Locations of the experiments conducted for stability study.

S. No.	Research Institutes/stations (Location)	Location in the country
1	Regional Agricultural Research Institute, Bahawalpur.	Southern Punjab
2	Arid zone Research Institute D. I. Khan.	Southern NWFP
3	Agricultural Research Institute, Ratta Culachi, D. I. Khan.	Southern NWFP
4	Nuclear Institute for Food & Agriculture, Peshawar.	Southern NWFP
5	Arid Zone Research Institute, Bhakkar.	Southern Punjab
6	Nuclear Institute for Agriculture & Biology, Faisalabad.	Central Punjab
7	National Agricultural Research Center, Islamabad.	Northern Punjab
8	Barani Agricultural Research Institute, Chakwal.	Northern Punjab
9	Ayub Agricultural Research Institute, Faisalabad.	Central Punjab
10	Gram Research Station, Kaloor Kot.	Southern Punjab
11	Agricultural Research Institute, Sariab, Quetta.	Northern Baluchistan
12	Pulses Research Station, Rice Research Institute, Dokri, Sindh.	Northern Sindh

Table 2. Pooled analysis of variance of grain yield (Kg/ha^{-1}) in 25 chickpea genotypes.

Source	D.F	MS
Genotypes (G)	24	271736.9**
Environment + (G X E)	275	570989.3**
Environment (Linear)	1	114661900.5**
G X E (Linear)	24	116245**
Pooled Deviation	250	158279.4**
Pooled error	900	32234.24

Results and Discussion

Pooled analysis of variance showed highly significant differences among the genotypes and environments for grain yield (Table 2), indicating the presence of genetic variability among the genotypes as well as the environments under study. The genotype x environment (G X E) interaction was further partitioned into linear and non-linear (pooled deviation)

components. Mean Square for both these components were found highly significant, indicating that the both predictable and un-predictable components shared G X E interaction. The G X E (linear) interaction was highly significant when tested against pooled deviation, which revealed that there are genetic differences among genotypes for their regression on the environmental index.

Finlay & Wilkinson (1963), Perkins & Jinks (1963), Perkins & Jinks (1968a) and Fripp & Caten (1973) found that linear response is positively associated with mean performance. Eberhart & Russell (1966), Paroda & Hayes (1971), Westerman (1971), Gautam (1974) and Saxena (1975), however, emphasized that both linear (b_i) and non-linear (S^2d_i) components of G X E interaction should be considered in judging the phenotypic stability of a particular genotype and their responses were independent from each other. Jain & Pandya (1988) also suggested that the desired genotype in any practical situation is one with high mean performance, desired linear response (b_i) and low non-linear sensitivity coefficients (S^2d_i). If these aspects are controlled by different genetic systems then in that case such desirable genotype may be bred through standard breeding procedures. Further, Samuel *et al*., (1970) suggested that the linear regression could simply be regarded as a measure of response of a particular genotype which depends largely upon a number of environments, whereas the deviation from regression line was considered as a measure of stability, genotype with the lowest or non-significant standard deviation being the most stable and vice versa.

Zubair *et al*., (2002), suggested that if regression coefficients of the genotypes are not significant different from 1, the stability of these genotypes should be judged upon other two parameters i.e., X and S^2d_i.

In the present investigation, the regression coefficients of all the varieties were not significantly different from 1, therefore, the stable performance of the varieties in this case, is predicted on the basis of other two parameters, i. e., deviation from regression and average yield over all the environments.

The simultaneous consideration of three parameters of stability (Table 3) for the individual genotype revealed that the genotypes '96051' and '90280' gave the highest yield (1980.79 and 1962.25 kg/ha) over the grand mean yield with the regression values 0.96 and 0.88, respectively and highly significant deviation from regression. Due to high values of S^2di, these genotypes are expected to give good yield under favorable environmental conditions.

The variety 'C44' is even good under unfavorable environmental conditions having grain yield of 1838.56 kg/ha and the regression value (1.09) with non-significant standard deviation, indicating the stability over all the locations. The genotypes '91A039', 'NCS95004', 'NCS950010', '99101', 'A-16', '91A001' and 'NCS950012' were high yielders (between 1700-1800 Kg/ha). They had high values of S^2di showing sensitivity to environmental changes. These varieties gave higher yield when the environmental conditions were conducive.

The genotypes 'NCS950183' and '93003' had also promising average grain yield i. e., 1751.5 and 1711.5 kg/ha, respectively. They showed non-significant deviation from regression, thereby revealing stable performance across the environments. The genotypes '9280C' and '93012' produced average grain yield. Both these varieties had high deviation from regression revealing sensitivity to environmental fluctuations. Whereas, the genotypes '92CC076', which also produced almost average grain yield, had non-significant deviation from regression, thereby exhibiting less sensitivity to environmental changes.

Table 3. Stability parameters for grain yield in 25 chickpea varieties grown in 12 environments.

Genotypes	Genotypes (code)	Mean (x_i)	$b_i^{\blacklozenge}$	S^2d_i
92CC079	V1	1571.98	1.20 ± 0.20	190528.4**
92CC076	V2	1657.73	1.18 ± 0.094	40426.76
9280C	V3	1667.94	0.90 ± 0.123	70235.28*
96051	V4	1980.79	0.96 ± 0.138	88197.81**
90280	V5	1962.25	0.88 ± 0.156	111740.5**
90261	V6	1557.42	0.83 ± 0.465	99443.91**
94014	V7	1552.5	1.03 ± 0.251	288708.1**
A-16	V8	1730.9	1.09 ± 0.168	130622**
93012	V9	1677.58	0.92 ± 0.015	107840.9**
93009	V10	1711.5	0.99 ± 0.093	39403.46
99101	V11	1731.96	1.24 ± 0.150	103962.4**
99102	V12	1365.87	0.94 ± 0.233	251021.9**
99103	V13	1451.67	0.70 ± 0.179	147072.9**
91A001	V14	1718.42	1.11± 0.244	273752.6**
91A039	V15	1780.6	1.15 ± 0.165	124318.9**
CMNK287-3	V16	1565.65	1.02 ± 0.1022	48002.76
BRC-14	V17	1399.54	0.58 ± 0.294	397150.4**
NCS95004	V18	1767.15	1.05 ± 0.121	67389.31*
NCS950183	V19	1751.5	1.05 ± 0.110	56041.36
NCS950012	V20	1714.06	1.18 ± 0.1380	87616.41**
NCS96002	V21	1622.35	1.02 ± 0.113	58866.71
NCS96003	V22	1552.21	0.87 ± 0.144	95219.06**
NCS950010	V23	1765.15	1.15 ± 0.159	116766.2**
C44	V24	1838.56	1.09 ± 0.101	47187.96
PUNJAB-91	V25	1594.87	0.88 ± 0.154	109613.3**
Mean		1667.60	1.00	126045.17

$\blacklozenge$ = No regression coefficient is significantly different from unity.
**, * = Significant at the 1% and 5% levels, respectively.

The yield performance of the genotypes; '92CC079', '90261' '94014', '99102', '99103', 'CMNK287-3', 'BRC-14', 'NCS96002', 'NCS96003' and 'Punjab-91' was poor. They produced below average grain yield. All these varieties except 'CMNK287-3' had high deviation from regression indicating sensitivity to environmental changes. These varieties cannot be recommended due to their overall poor performance.

The deviation from regression for majority of the genotypes was highly significant that revealed the response of these genotypes was unpredictable and that they were more suitable for sites with better environments. Two genotypes V4 and V5 with maximum grain yield and highly significant deviation from linearity may be recommended for better environments. On the other hand among candidate genotypes with non-significant deviation from regression, two genotypes V24 (Check) and V19 had significantly higher grain yield than grand mean. Therefore, they appeared to be the best varieties with regard to stability. The difference for grain yield between these two genotypes was non significant. Hence, these two genotypes may be recommended for cultivation in different environment across the country. V19 also possess high level of resistance against *Ascochyta* blight (personal observation).

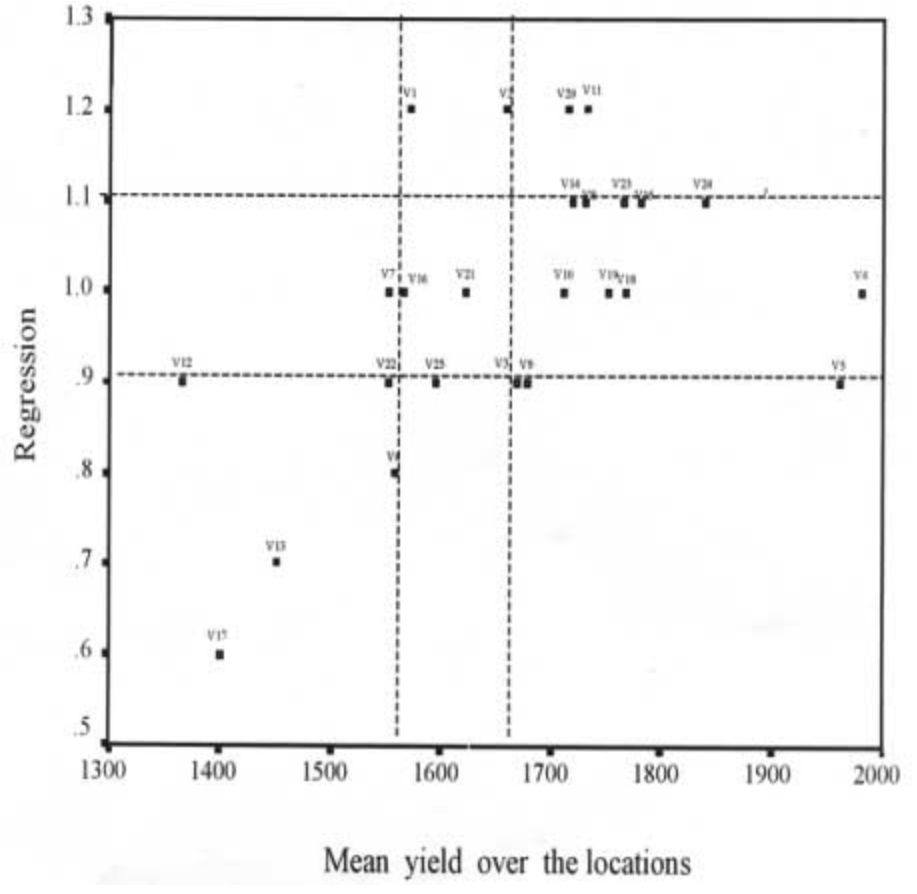

Fig. 1. Scattered diagram for mean grain yield and regression coefficient.

The diagrammatic presentation (Fig. 1) of stability parameters also showed that four genotypes viz. V4 (96051), V5 (90280) V24 (C44) and V19 (NCS950183) excelled in yield performance. As regression coefficients for all the varieties were not significantly different from 1, the performance regarding stability was judged on the basis of deviation from regression. Therefore, high yielding varieties V4 (96051) and V5 (90280) are recommended for favourable environments, whereas V24 (C44) and V19 (NCS950183) were found better varieties for all the environments.

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