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GENOTYPE X ENVIRONMENT INTERACTION AND STABILITY YIELD PERFORMANCE AMONG DIFFERENT VARIETIES OF CHICKPEA *KABULI*

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ABSTRACT

Eight genotypes of chickpea (NCS-0609, CH38/00, DCK-110-1, NCS-0530, CC121/00, NCS-0608, DCK-112-2 and CM-2000) developed by different institutes of Pakistan, were evaluated under eight different locations for various agronomic traits against the prevalent biotic (pests and diseases) and abiotic (drought) stresses in the area. Grain yield of two genotypes (CH38/00 and CC121/00) from Nuclear Institute of Agricultural and Biology, Faisalabad, have shown significantly higher yield than check at National Agricultural Research Centre, Islamabad as well as at all locations. The interaction between the genotypes and environment (G x E) was used as an index to determine the yield stability of genotypes under all different eight locations during 2007-08. Both predictable and unpredictable portion of variation were found to be significant indicating equal importance in determining the stability of grain yield. The two genotypes i.e. CC121/00 and CH38/00 produced average grain yield 1637 Kg ha^{-1} and 1386 Kg ha^{-1} respectively at all locations than the check (1152 Kg ha^{-1}) and thus were the most adapted cultivars in the whole set of environments/locations during 2007-08. The objective of the trial in question was to find out the adaptability range of test genotypes.

Key words: Stability, genotype, drought, pests, *Cicer arietinum* L.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the pulse crops domesticated in the Old World ca 7000 years ago. Most probably, it has originated in an area of south-eastern Turkey and Syria. Three wild annual *Cicer* species, *C. bijugum*, *C. echinospermum*, and *C. reticulatum*, closely related to chickpea, cohabit with the cultivar in this area. Chickpea has been traditionally grown under moisture stress conditions and low soil fertility. In these stressful environments, land races of chickpea are widely cultivated as a post-monsoon winter crop in Pakistan. In the world, Pakistan ranks second to India in terms of area occupied by chickpea Malik and Tufail (1981). Chickpea production has increased during last 30 years from 7.3 to 8.4 million tons because of increase in productivity from 693 to 786 kg ha^{-1} (Anon., 2008). A greater range of cultivars is now available which, if grown with new technologies can allow farmers to achieve higher yield. Two types of chickpea are grown: (1) *desi*, which is thought to have originated first and produces small, brown colored seeds and (2) *Kabuli*, which produces a larger, cream-colored seed and are high yielding as well. Almost all the countries with high chickpea yields are producers of *Kabuli* and is often more prone to climatic and disease stresses. In Pakistan, *Kabuli* chickpea occupies a small proportion of total chickpea cultivated area.

The study of the production profile reveals severe fluctuation highlighting the problem of instability, which may be attributed to three major constraints: (1) Drought or moisture stress and (2) wilt are the twin problems that occur together. The third major constraint to chickpea production is *Ascochyta* blight. Various institutes at federal as well as provincial level have released eight blight resistant varieties of *Kabuli* chickpea. The stability in small-seeded Desi chickpea production has been strengthened by sowing it in canal command areas. However, *Kabuli* chickpea did not receive much attention and as a result, the local consumption requirement is met through import. Because of high risk of attack of blight, cultivation is restricted to limited area as most of the prevailing genotypes of *Kabuli* type are susceptible to blight and require optimum moisture and fertile land compared with hardy *Desi* type. However, lodging during the pod-filling stage in several production areas also damages *Kabuli* chickpea when grown under more favorable soil moisture and soil fertility conditions. Potohar area is more suitable for its cultivation. Canal commanded area is another alternate source to increase its production where we can plant *Kabuli* chickpea. Keeping these priorities into consideration, evaluation of chickpea germplasm over the last two decades has resulted in identification of the strains that are resistant to biotic (pests and diseases) and abiotic (drought and wilt) stresses. Biotic constraints to chickpea productivity in Pakistan caused by *Ascochyta rabiei* (Blight) is the most

devastating disease that occurs frequently, resulting in almost total chickpea crop loss. Wilt and root rot diseases are next stresses that can inflict heavy losses on crop production. Among the insect pests, pod borer appears to be the most widespread and causes serious yield loss in all areas of chickpea production. To overcome these constraints, a breeding program at National Agricultural Research Centre (NARC), Islamabad has been started to utilize available genetic diversity in the genetic improvement of chickpea. In order to find out the stable production capability of the genotypes, we have planted them in eight different agro-climatic regions of Pakistan. The assessment of yield stability can be approached in various ways. According to Finlay and Wilkinson (1963), if the regression coefficient is less than one, it means the genotype has greater resistance to environmental changes having above average stability. Eberhart and Russell (1966) defined a stable variety as one with a regression coefficient (b=1) and a minimum deviation from regression line (S^2 d_i =0). Therefore, a variety with high mean yield at all locations, regression coefficient and deviation from regression line as small as possible (S^2 d_i=0) will be a better choice as a stable variety.

MATERIALS AND METHODS

National Uniform Yield Trial –*Kabuli* was comprised of eight entries including one check and conducted in 2007-08 (Table 1 and 2). The candidate lines were planted in Randomized Complete Block Design with three replications at eight different locations in the Punjab and Balochistan. Each replication contained six rows (4m long) of each entry. Row spacing and plant spacing were maintained as 30 cm and 10 cm, respectively. Detailed data including seed yield per hectare and yield components were recorded at each location. The data recorded at NARC included: Days to flowering, plant height, dry matter, grain yield, and harvest index were statistically analyzed using Statistical Package "Mstat 4 C". 1.

RESULTS AND DISSUSIONS

The total dry matter and grain yield of genotypes # 2 (CH 38/00) and # 5 (CC 121/00) received from NIAB were significantly higher than the check ($P<0.05$) at NARC Islamabad (Table 1). Genotype # 5 (CC 121/00) produced maximum mean grain yield of 1,637 kg ha^{-1} than the check (1,152 kg ha^{-1}) at all eight locations in Table 5 but its yield performance was not satisfactory (361 kg ha^{-1}) at ARI, Sariab-Quetta due to extreme drought conditions. An attractive grain color and good cooking quality were also exhibited by this genotype. General conditions of the trial were not satisfactory at all locations due to dry weather conditions. One of the main reasons for growing genotypes in a wide range of environments is to estimate their stability. Wricke (1962) considered equivalence, that it is the contribution of a genotype to the GE interaction sum of squares. Shukla (1972) also partitioned the GE interaction sum of squares into components for each genotype separately by considering the stability variance of the specific genotype. Finlay and Wilkinson (1963) used two parameters a) mean performance over environments, and b) regression of performance in different environments over the respective environmental mean. A variety which is the lowest yielding in all environments will necessarily show b value of less than one. According to stability table 3, varieties no 2 and 5 having b=1 and a high mean would be considered as the most widely adapted, while b value of 1 and low mean yield (over the environments) would indicate a poorly adapted genotype. In nut shell, genotype 2 (CH38/00) along with genotype 5 (CC121/00) from NIAB, Faisalabad performed as per our goals in terms of drought, cold (Appendix 1). Considering the three parameters of stability in (Table 3) the genotypes 2 and 5 (CC121/00) from NIAB, Faisalabad showed regression closer to unity, grain above the average and low deviation from regression. Hence, these genotypes can be considered as stable genotypes. The disease aspect of entry 2 and 5 with special reference to *Ascochyta* blight needs to be looked into (Table 5) because during the reporting year, stress did not occur in nature at the test sites. However, under controlled conditions the two genotypes showed moderately susceptibility to the Blight by using 1-9 scale for scoring where 1 = Highly resistant and 9 = Highly susceptible (Table 5). These are best controlled by using good quality seed, proper crop rotations, proper tillage practices to bury diseased residue and disease resistant varieties if available. It is therefore, recommended that the genotype 2 (CH 38/00) and 5 (CC121/00) and may be released in the chickpea region. Pooled analysis of variance showed highly significant difference among the genotypes and environments for grain yield (Table 4).

Table 1. Parameters of *Kabuli* Chickpea growth National Uniform Yield Trial, 2007/08, NARC, Islamabad.

S. No.	Variety	Plant eight (cm)	50% Days to flowering	Bio. Yield (kg/ha)	Grain Yield (kg/ha)	H.I. %
1	NCS 0609	50	131	2916	856	29.36
2	CH 38/00	45	133	4722	1810*****	38.33
3	DC-K-110-1	52	135	4074	1689	41.46
4	NCS 0530	48	134	1481	625	42.20*
5	CC121/00	57*	131	6342*****	2523******	39.78
6	CNS-0608	44	135	694	375	54
7	DC-K-112-2	54	135	3564	1541	43.24
8	CM-2000	46	134	3750	1736	46.30
	Mean squares	12.03	2.97	804099.6	99930.8	91.49
	$LSD_{0.05}$	6.69	3.32	1731	610	18.47

***** = Significant at 0.05 level of significance; ** = Significant at 0.01 level of significance

Table 2. Locations in Pakistan where genotypes were tested.

Locations	Research Institutes
Northern Punjab	National Agricultural Research Centre, Islamabad
Northern Punjab	Ayub Agricultural Research Institute, Faisalabad
Northern Punjab	Nuclear Institute for Agricultural and Biology, Faisalabad
Southern Punjab	Agricultural Research Institute, Dera Ismail Khan
Northern Punjab	Barani Agricultural Research Institute, Chakwal
Northern Punjab	Barani Agricultural Research Station, Fateh Jang
Southern Punjab	Arid Zone Research Institute, Bahakar
Upland Balochistan	Agricultural Research Institute, Sariab. Quetta

Table 3. Stability Parameters for Grain Yield (kg. ha^{-1}) of Chickpea Genotypes

Variety Name	MS	bi	Mean
NCS 0609	326438.250	0.618	731
CH 38/00	518516.500	1.585	1386
DC-K-110-1	485999.000	1.011	887
NCS 0530	425752.000	0.004	604
CC121/00	464914.750	0.971	1637
CNS-0608	611583.000	0.320	499
DC-K-112-2	452354.500	2.562	850
CM-2000	116305.461	0.930	1152

Table 4. Pooled Analysis of Variance for grain yield.

Source	df	M.S	Mean
Total	63	43306224	687400.375
Environments	7	12789056	1827008.000
Varieties	7	3091312	441616.000
Var. x Env.	49	27425856	559711.375
Env.+ Var.x Env	56	40214912	718123
Env. (Lin.)	1	12789072	1002094 2.357
Var.x Env.(Lin)	7	7014660	12789072
Pooled Dev	48	20411180	425232 10.956
Pooled error	112	4347188	38814.180
:Deviation from Regression = Pooled Dev.MS / Pooled Error MS			
:Var.x Env.(Lin) = Var. x Env.(Lin) MS / Pooled Dev.MS			
:Varieties = Varieties / Pooled Dev.MS			

Table 5. Consolidated Results of Kabuli Chickpea-National Uniform Yield Trial 2007-08 across the country Grain Yield (kg/ha).

Entry No.	Entry Name	Source	NARC	AARI F.abad	NIAB F.abad	ARI DIK	BARI Chakwal	BARS F.Jang	AZRI Bhakkar	ARI, Sariab, Quetta	Mean	Blight Scale (1-9, suscept -ibility Ascend -ing Scale)
1	NCS-0609*	NARC	859	99	427	538	2276	931	469	245	731	7
2	CH38/00	NIAB	1815	606	2186	1579	2578	833	1182	311	1386	5
3	DCK-110-1	ARI, DIK	1680	549	475	1014	2174	729	300	176	887	5
4	NCS-0530*	NARC	618	428	57	317	2185	882	192	151	604	5
5	CC121/00	NIAB	2520	616	2161	1566	3796	907	1168	361	1637	5
6	NCS-0608*	NARC	371	16	00	469	1815	805	318	195	499	5
7	DCK-112-2*	ARI, DIK	1535	90	474	915	2459	880	266	182	850	7
8	CM-2000	CHECK	1733	477	116	727	4315	611	1053	182	1152	7
	Co. V (%)	-	22.5	22.5	32	31.8	4.3	25	13	32.9	-	-
	LSD (0.05)	-	550	129	418	496	204	362	141	129	-	-

* Very poor germination percentage at most of the locations.
Coefficient of variation=20.07% Genotypes (G), Location (L) and G x L interactions are highly significant.

Appendix 1. Met (Rainfall) data of Test Sites in Punjab, KPK and Balochistan For the Growth Season (2007/08).

Test Sites	Nov.,07 (mm)	Dec,07 (mm)	Jan., 08 (mm)	Feb., 08 (mm)	March, 08 (mm)	April, 08 (mm)	May, 08 (mm)	Total (mm)
Islamabad	13.35	0.00	122.06	45.37	24.35	80.88	10.14	296.15
Faisalabad	0.00	09.00	45.70	18.20	0.00	35.00	67.60	175.50
Chakwal	16.00	01.00	40.60	29.90	02.90	68.30	12.3	170.30
Fatehjang	0.00	52.00	42.00	24.50	0.00	91.50	0.00	210.00
Bhakkar	0.00	03.00	03.00	33.00	05.00	37.00	06.00	087.00
D.I. Khan	01.10	01.40	04.00	24.50	02.00	38.50	20.60	92.10
Quetta	04.00	15.00	82.00	22.00	TR	07.00	TR	130.00

Source: Personnel Communication (Meteorological Office, 2011); TR: Traces

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