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

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ABSTRACT

In order to identify a biotype (s) which could withstand drought as well as blight stress, twenty genotypes of chickpea (CMC211S, NCS 9917, CMC5 99S, CMC186M, AZC-06, SL-01-13, SL-02-23, SL-03-64, 3CC113, 3CC116, 96A4504, 96A4580, BRC-61, CH23/00, CH24/00, 01032, 01067, 93127, 98154, and Bittal-98) developed by different research institutes of Pakistan, were evaluated against the prevalent biotic and abiotic stresses at 13 different locations, for various agronomic traits. In this study, 20 different lines developed by various institutes at federal as well as provincial level were evaluated against the said abiotic and biotic stresses and then statistical tools were applied in order to assess their stability. One genotype (AZC-06) developed at Arid Zone Research Institute, Bahawalpur, and another genotype (CH23/00), from Nuclear Institute for Agricultural and Biology (NIAB), Faisalabad have shown considerable potential by producing average grain yield of 2061 and 2116 Kg ha^{-1} respectively.

Key words: Stability, genotype, drought, *Ciser arietinum.*

INTRODUCTION

Chickpea is widely cultivated as a post-monsoon winter crop in Pakistan. Pakistan ranks second to India in terms of area occupied by chickpea (FAO, 2005) and its production has increased from 7.3 to 8.4 million tonnes during last 30 years because of per hectare increase in productivity from 693 to 786 kg (Anon., 2008). According to FAO statistics (FAOSTAT, 2004), chickpea yields vary mainly due to biotic and abiotic stresses. Among all abiotic stress drought is one of the major productivity reducers which causes fluctuation in the world production of chickpea. Smithson *et al*., 1985 reported that it completes its life cycle in water stress environments coupled with high temperatures and desiccating winds. Although, chickpea is considered relatively drought-tolerant species compared to other cool-season grain legumes (Sharma *et al*., 1974), but grain yield is severely affected by drought stress during the post flowering period (Silim and Saxena, 1993).The gradual depletion of stored soil moisture and coincident increase in potential evapo-transpiration generally leads to the progressive development of drought. Terminal drought stress in chickpea is common but more critical for crops growing during the post-rainy season and relying on stored soil moisture (Subbarao *et al*., 1995). The crop often suffers from water stress during reproductive growth stage because rainfall declines and evapo-transpiration increases. Naturally plants depend on reserved soil moisture for sustaining growth and development during the critical reproductive stage (Singh and Sri Rama, 1989). Reports of large responses of chickpea grain yield to supplemental irrigation at flowering stage have been documented (Sheldrake and Saxena, 1979, Saxena *et al*., 1991), which indicated that water deficit at flowering was major constraints for achieving potential yields. Adaptive mechanisms that were related to the ability of crops to improve drought resistance could be classified as drought avoidance and drought tolerance (Levitt, 1980). Avoidance related to the maintenance of high tissue water potential and consists of mechanism that reduced water loss from plants and also maintains water uptake. Drought tolerance refers to the ability of the plants to withstand low tissue water potential. Clarke and Townley-Smith (1984) suggested that a combination of both avoidance and tolerance mechanisms was required. The best drought avoiding genotypes require tolerance because some reduction in plant water potential is unavoidable during drought. The second major production constraint is *Ascochyta* blight disease (Nene 1980, 1982). This disease is not of major concern at the present but is potentially dangerous.

The assessment of yield stability under the stressed environments can be approached in two ways: 1. 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; 2. Eberhart and Russell (1966) defined a stable variety as one with a regression coefficient (b=1) and a minimum deviation from regression line ($S^2d_i=0$). Therefore, a variety with high mean yield over the environments, regression coefficient and deviation from regression line as small as possible i.e. ($S^2d_i=0$) will be a better choice for a stable variety.

MATERIALS AND METHODS

National Uniform Yield Trial -Desi was conducted during 2007-08 at 13 different locations throughout the country (Table-2). The trial comprised of 20 entries (Table-1) including one check. The candidate lines were planted in Randomized Complete Block Design with three replications at 13 different locations. Each replication contained six rows (4m long) of each entry. The row spacing and plant spacing were maintained as 30 cm and 10 cm, respectively. The sowing dates were different at different locations. The data recorded included: Days to flowering, Plant height, Dry matter yield, Grain yield which statistically analyzed using Statistical Package “Mstat 4 C“.

Appendix 1. Temperature and rainfall data for the reporting year 2007-08 at NARC, Islamabad.

Month	Maximum Temperature (C^0)	Minimum Temperature (C^0)	Rainfall (mm)
Nov. 2007	25.23	7.20	13.35
Dec. 2007	18.93	2.58	Nil
Jan.2008	14.5	1.8	122.06
Feb.2008	19.34	4.51	45.37
March 2008	28.08	11.2	24.35
April, 2008	28.83	14.26	80.88
May, 2008	35.74	19.3	10.14
Total	-	-	296.15

Source: Land and Water Programme, NARC, Islamabad

Table 1. Parameters of Chickpea National Uniform Yield Trial (Desi) 07-08 (National Agricultural Research Centre, Islamabad).

S. No.	Genotypes	Plant Height (cm)	Days to Flowering	Bio.Yield (kg/ha)	Grain Yield (kg/ha)	Harvest Index (%)
1	CMC211S	47	133	4583	2166	46
2	NCS 9917	46	136	694	274	39
3	CMC5 99S	43	135	3703	1754	47
4	CMC186M	50	134	3935	1834	45
5	AZC-06	47	133	5925*	2898**	48*
6	SL-01-13	48	136	4861	2142	43
7	SL-02-23	47	137*	4537	2097	46
8	SL-03-64	48	133	6388**	2722	42
9	3CC113	49	135	5092	2444	49
10	3CC116	51	133	5092	2180	43
11	96A4504	45	135	4490	2342	52
12	96A4580	48	132	3935	1833	46
13	BRC-61	47	132	4074	1828	44
14	CH23/00	45	134	5324	2518	46
15	CH24/00	45	133	5555	2587	46
16	01032	44	133	5000	2217	44
17	01067	51*	133	6018*	2754*	45
18	93127	45	134	5324	2661	49
19	98154	50	135	5092	2405	47
20	Bittal-98	50	132	5231	2362	44
	Mean squares	10.394	2.218	318659.2	117764.3	39.87
	$LSD_{0.05}$	5.51	2.54	964.7	586.5	10.79

RESULTS AND DISSUSIONS

Twenty genotypes (Table 1) were tested against biotic and abiotic stresses in comparison with improved check (Bittlal-98) during growth season 2007-08. During the season, the rainfall (296.15 mm) was normal with even distribution through all important growth stages of plant up to anthesis. But at maturity stage, the crop had to experience terminal drought. Under these drought conditions, several genotypes shattered the seed. There was no incidence of fungal diseases because of dry climate (see temperature & rainfall distribution in appendix 1). Genotype # 5 (AZC-06) from AZRI, Bahawalpur and # 8 (SL-03-64) AZS from Karak were little earlier in flowering and maturity at NARC (Table 1). Genotype 5 (AZRI, Bahawalpur) produced significantly ($P<0.05$) more grain yield (2898 kg ha^{-1}) than the check, Bittal-98 (2361kg ha^{-1}) at NARC location (Table 1) as well as at other thirteen locations (2060 kg ha^{-1}) (Table 5) and is judged as the most stable one for both stress and stress free environment (Table 3). Another genotype 17 (AARI, Faisalabad) was also outyielded 2754 kg ha^{-1} as compared to check Bittal-98 (2361kg ha^{-1}) at NARC location (Table 1) but across the locations, it did not perform well (Table 5). Genotype 14 (CH23/00) from NIAB, Faisalabad proved significantly out yielded (2116Kg ha^{-1}) than check 1842Kg ha^{-1}) at all locations (Table 5). One of the main reasons for growing genotypes in a wide range of environments is to estimate their stability; Wricke (1962) considered ecovalence, that it is the contribution of a genotype to the GE interaction sum of squares. Shukla (1972a) also partitioned the GE interaction sum of squares into components for each genotype separately by considering the stability variance of the specific genotype.

Table 2. Locations of Pakistan where genotypes were tested.

S/No.	**Locations**	**Research Institutes**
1.	Northern Punjab	National Agricultural Research Centre, Islamabad
2.	Northern Punjab	Ayub Agricultural Research Institute, Faisalabad.
3.	Southern Punjab	Gram Research Station, Kaloor Kot
4.	Southern Punjab	Regional Agricultural Research Institute, Bahawalpur
5.	Southern Punjab	Arid Zone Research Institute, Bahawalpur
6.	Southern Punjab	Arid Zone Research Institute, Bahakar
7.	Upper Sindh	Quaid- Awan Agricultural Research Institute, Larkana.
8.	Northern Punjab	Barani Agricultural Research Station, Fateh Jang
9.	Plains of NWFP	Nuclear Institute for Food and Agriculture, Peshawer.
10.	Northern Punjab	Barani Agricultural Research Institute, Kohat.
11.	Northern Punjab	Barani Agricultural Research Institute, Chakwal.
12.	Southern Punjab	Agricultural Research Institute, Dera Ismail Khan.
13.	Northern Punjab	Nuclear Institute for Agricultural and Biology, Faisalabad

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

Genotypes	MS	bi	Means
1	792084	0.467	1702
2	784695	-0.273	749
3	986669	0.188	1271
4	537214	0.497	1557
5	846130	1.106	2060*
6	698587	2.291	1610
7	609983	0.747	1621
8	614592	-0.272	1649
9	850058	-0.195	1764
10	677613	1.801	1713
11	826989	1.297	1648
12	1020801	0.208	1705
13	714558	1.737	1449
14	939780	1.241	2116*
15	1091335	0.620	1994
16	337500	1.470	1923
17	690736	-0.106	1874
18	584646	1.726	1715
19	404453	3.222	2039
20	821475	1.227	1842

Table 4. Pooled Analysis of Variance for grain yield.

Sources	**df**	**M.S.**
Total	259	732472.562
Environments	12	1074627.125
Varieties	19	146401.687
Var.x Env.	228	763303.750
Env.+ Var.x Env.	240	778869.875
Env. (Lin.)	1	12895496.000
Var.x Env.(Lin)	19	573908.625
Pooled Dev.	220	741495.500
Pooled error	494	107840.883

: 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

According to 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 shall necessarily show b value of less than one. According to stability table 3, varieties no 5 and 14 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 5 (AZC-06) from AZRI, Bahawalpur along with genotype 14 (CH23/00) from NIAB, Faisalabad performed as per our goals in terms of drought, cold (Fig 1) Considering the three parameters of stability in (Table 3) the genotypes 5 (AZC-06) from AZRI, Bahawalpur and genotype 14 (CH23/00) 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 5 and 14 with special reference to *Ascochyta* blight needs to be looked into because during the reporting year, this stress did not occur in nature at the test sites. Pooled analysis of variance showed highly significant difference among the genotypes and environments for grain yield.

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

Entry No.	Entry name	Source	NARC	AARI F.abad	GBRS K.Kot	BARI B.Pur	AZRI B.Pur	AZRI Bhakkar	QAARI Larkana	BARS F.Jang	NIFA Pesh.	BARS Kohat	BARI Chakwal	ARI DIK	NIAB F.abad	MEAN
1	CMC211S	NARC	2170	2169	3241	1333	1616	1267	1703*a	1392	1052	1569*a	1972	2048	588	1702
2	NCS-9917	NARC	274	238	879	850	167	338	500	979	1957*a	208	1139	1819	383	749
3	CMC59S	NARC	1757	1060	2268	317	316	1110	1102	1643	1433	764	2367	2217	168	1271
4	CMC186M	NARC	1834	1713	2593	1483	690	1161	1296	1444	1530	1000	3100	2056	342	1557
5	AZC-06	AZRI, BPUR	2901*a	1972	3333*a b	2167*ab	2472	1414	1611*a	1731	1893*ab	1000	3383	2435	483	2061
6	SL01-13	ARS KARAK	2142	1607	3010	1433	1516	1190	1176	1865*ab	226	1076	2883	1717	1091*ab	1610
7	SL02-23	ARS KARAK	2096	1032	2639	733	2023	1218	1055	1518	1523	1347	3311	2199	375	1621
8	SL03-64	ARS KARAK	2725	1681	2593	667	1449	1716*ab	1129	1310	1105	757	3430	2331	542	1649
9	3CC113	BARI, Chk	2450	1968	2963	1067	1690	1333	1620	1522	1395	1069	3450	1909	492	1764
10	3CC116	BARI, Chk	2180	1481	2685	1717	1648	1442	1629	1349	190	1194	3339	3018*ab	399	1713
11	96A4504	AZRI, Bhak	2348	1303	2847	1233	883	1361	1286	1808	1318	646	3428	2574	393	1648
12	96A4580	AZRI, Bhak	1830	1843	2222	1900	1065	1053	1370	1556	1194	958	3567	2939	662	1705
13	BRC-61	BARI, Bpur	1833	1412	2129	1567	1333	908	1232	1467	937	556	3511	1659	289	1449
14	CH23/00	NIAB	2520	2676*a	3379*a	1450	2281	1316	1287	1389	1765*ab	1507*a b	3872	3146*a	917	2116
15	CH24/00	NIAB	2592	2296	3009	1883	1944	1110	1777*a	1521	1667	1417	3744	2435	533	1994
16	01032	AARI	2217	1643	3055	1783	1505	1558	1187	1595	1030	1687*a	3694	2609	1437*a	1923
17	01067	AARI	2758*a	2463*ab	3541*a	1290	1014	1261	1407	1674	953	1326	4017	2068	586	1874
18	93127	AARI	2661	1322	3010	917	935	1941*a	1389	2086*a	880	667	3739	2146	602	1715
19	98154	AARI	2405	2181	3333	2317*a	2273	1190	1666	1412	1908*a	1146	3767	2367	542	2039
20	BITTAL-98	Check	2362	2289	2917	1183	1861	1696	1629	1397	1378	694	3233	2418	884	1842
	Co. Var.%	-	15.6	16.9	6.86	13.2	34.9	15.9	8.3	26.3	10.5	47.2	4.5	24.9	39.8	-
	LSD (0.05)	-	570	480	315	296	827	338	185	668	226	803	242	949	384	-

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