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Genotype-Environment Interaction and Genetic Parameters in Chickpea (*Cicer arietinum* L.) Landraces

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Abstract

In order to determine the desirable line for chickpea rainfed sowing, seven local lines (K- 6, G- 35, D- 15, F-20, B -17, H- 45 and M- 20) were selected from Syrian chickpea landraces. These lines were grown during two seasons 2006 / 2007- 2007 / 2008 at two different locations (Tal-sandal: with a mean annual precipitation of 475mm, Harran: with a mean annual precipitation of only 300 mm). Genotype-environment interaction and genetic parameter were studied for seed yield per plant /g, days to maturity and protein content.

The results showed that effect of location (L) and season (E) was highly significant ($P < 0.01$) while the interaction among Locations, Seasons and Genotypes (L x E x G) was not significant ($P > 0.05$).

The heritability for protein content varied from (0.83) to (0.93) that indicated the presence of a considerable proportion of total variability due to genetic causes. A high genetic advance (GA) (51.5 to 62.7) % was achieved for seeds yield per plant. The environmental variance (σ2e) was very low for days to maturity and protein content. The differences between genotypic (GCV) and phenotypic (PCV) coefficient of variability were very small.

The results recommended to selection line M-20 that was the desirable line for both seed yield per plant (33 to 40) g and protein content (22.17 to 24.72%) as compared to other lines.

Keywords: Chickpea, Genotype-Environment, Genetic parameters, Protein content

1. Introduction

Chickpea is the second most cultivated grain legume in the world after phaseolus bean (Rubio *et al.,* 1998; Rubio *et l.,* 2004). Chickpea is traditionally grown as a rainfed spring crop in Syria, mainly on the soil moisture conserved during winter rains in areas with seasonal precipitation of about 300mm. Winter chickpea sowing produces correspondent plants with a longer flowering period and higher yield than those sown in spring. All winter improved varieties (Ghab3- Ghab4- Ghab5) which released by international Center for Agricultural Research in the Dry Areas (ICARDA) were susceptible to the developed fierce lines of Ascochyta blight.

In recent years, Ascochyta blight has caused widespread yield losses in chickpea (Knights and Siddique, 2002), it can spread in epidemic form and results in 75 to 100% yield loss for the winter improved varieties. Chickpea farmers in Syria still keep and cultivate their own seeds generation to avoided winter sowing because of the risk of heavy crop loss.

Syria's flora includes several local cultivars and landraces of chickpea are found in diverse forms in many zone of Syria.

Chickpea landraces are potentially a useful germplasm resource of genetic variability for traits of interest such as stress resistance and tolerance and grain quality characteristics (Moulla *et al.,* 2005).

Several researchers (Ghafoor *et al.,* 2000; Malik *et al.,* 1988) have emphasized the utility of the estimates of Heritability (H2) and genetic advance (GA) in the prediction of response of quantitative characters to selection in chickpea. Heritability alone is not very useful but this statistic along with genetic advance is valuable (Johnson *et al*., 1955).

Genotype x environment interaction (G x E) is increasingly important, because breeding programs tend to be more internationally oriented. During recent decades, new improvements have been accomplished in plant physiology, agronomy, and statistics and some incorporated approaches emerged for G x E interactions evaluation (Brancourt, 1999).

Presence of genotype × environment interaction necessitates evaluation of genotypes in a wide range of environments to find desirable genotypes (Zali *et al.,* 2008).

The major goal of this work to study the genotype-environment interaction and some genetic parameter for these selected lines. Moreover, selection the favorite promise line that had good qualitative and quantitative characteristics under rainfed spring sowing.

2. Materials and Methods

2.1 Plant Material and agricultural practices

This research achieved in the General Commission for Scientific Agricultural Research (GCSAR) in Syria and International Center for Agricultural Research in the Dry Areas (ICARDA).

Seven local lines (K-6, G-35, D-15, F-20, B-17, H- 45 and M-20) have been selected from Syrian chickpea landraces (these landraces collected by GCSAR and ICARDA) (Table 1).

These lines sown in a Randomized Complete Block Design (RCBD) with three replications during two seasons / 2007 2006-2007 / 2008 in two different locations (Tal-sandal: with a mean annual precipitation of 475mm, Harran: with a mean annual precipitation of only 300 mm). Seeds were hand sown on 15 March for both 2006 / 2007 - 2007 / 2008 seasons. Each line sown in 2 rows of 5 m length, spaced 45 cm between rows and 35 cm between plants.

Plots were fertilized with 100 kg / ha super phosphate (P2O5: 46% P). The experiment was conducted under rainfed condition. Hand weeding and pesticide application..

After maturity, ten plants were apart harvested from each plot. Data were recorded on seeds yield per plant (gm) and days to maturity. Protein content was estimated according to Kjeldahl method.

2.2 Genetic Parameters Estimates

Heritability in broad sense (H^2 or h^2) was estimated according (Falconer, 1989) as equation (1):

$$h^2 = \frac{\sigma^2_g}{\sigma^2_p} \quad (1)$$

h^2: Heritability; $\sigma^2 g$: genotypic variance and $\sigma^2 p$: phenotypic variance. Genotypic ($\sigma^2 g$), Phenotypic ($\sigma^2 p$) and Environmental Variances ($\sigma 2e$) were obtained from the analysis of variance table according (Comstock and Robinson, 1952) as equations (2):

$$\sigma^2 g = (MS2-MS3)/r;\ \sigma^2 p = MS2/r \text{ and } \sigma 2e = MS3. \quad (2)$$

(Where r: replication, MS2: Mean square for cultivar, MS3: Mean square for error).

Coefficient of Variability (CV %); Genotypic Coefficient of Variability (GCV%); Environmental Coefficient of Variability (ECV%) and Phenotypic Coefficient of Variability (PCV%) were calculated as suggested by Burton (1952) as equations (3):

$$CV = \sigma ph / X * 100;\ G.C.V = \sigma^2 g / X * 100;\ PCV = \sigma^2 p / X * 100 \text{ and } \sigma 2e = \sigma^2 g / X * 100.$$

X: Grand Mean. (3)

Genetic advance (GA) was calculated with the method suggested by (Singh and Chaudhary 1979; Allard, 1960) as equations (4):

$$GA = k.\sigma ph.h^2 \quad (4)$$

Where: σph : Standard deviation; K:(constant = 2.06 at 5%selection intensity) and GA%: genetic advance in percentage mean.

Analysis of variance (ANOVA), Genotype-environment interaction (L x E x G), Standard Error (SE ±) and Least Significant Difference L.S.D at P ≤ 1%, 5% performed using a computer software (Genstat 7th edition and SPSS 15).

3. Results and discussion

We will demonstrate the results in the locations and seasons for each studied characteristic and genetic parameters separately follow as:

3.1 Mean of Seeds Yield per Plant: (SY/P)

The maximum seeds yield per plant (SY/P) was recorded for line M- 20 in both locations and seasons. The line M- 20 had (40) g in Tal Sandal and (36) g in Harran location for 2006/2007, also M- 20 had (37) g, (33) g in Tal Sandal and Harran respectively in 2007 / 2008 seasons.

The effect of location (L) and season (E) was significant (P < 0.01) while the interaction (L x Ex G) was not significant **(** P > 0.05) **(**Table 2).

3.2 Mean of Days to Maturity: (DM)

Days to maturity (DM) in 2006 / 2007 varied from (65.33) for Fo-20 in Harran to (80.67) days for D-15 in Tal-Sandal while varied from (64.67) days for Fo-20 in Harran to (77.33) days for D-15 in Tal-Sandal at 2007 /2008 season. The Analysis of Variance (ANOVA) showed significant differences for day to maturity (P < 0.01) in both locations and seasons.

The interaction of location (L), season (E) and (Lx G) was significant at (0.01) level of probability. The interaction (L x E x G) was not significant (P > 0.05).(table 3).

3.3 Mean of Protein Content %: (PC)%

The Analysis of Variance (ANOVA) showed significant differences for protein content (PC) % in both locations and seasons (P < 0.01). The effect of location (L), season (E) and line (G x L) interaction was significant at (0.01) level of probability while the interaction (E x G), (L x E) and (L x G x E) was not significant P > 0.05 (Table 4).

3.4 Heritability and genetic parameters

Estimates of heritability for seeds yield per plant varied from (0.96) to (0.99) whereas days to maturity gave the highest estimate of heritability (0.99) in both locations and seasons, which indicated that total variability was due to genetic causes.

A high estimate of heritability for protein content varied from (0.83) to (0.93) reflected that selection could be effective for improving the trait and the environmental influence for protein content was very low.

The genetic advance (GA) % was the highest for seeds yield per plant (varied from 51.50% to 62.7%).

The environmental variance **(**σ2e) was very low for days to maturity and protein content compared to environmental variance **(**σ2e) for seeds yield per plant.

The differences between genotypic coefficient (GCV) and phenotypic coefficient (PCV) of variability were very small for all studied characteristics indicating negligible role of environment (table 5).

The interaction (L x E x G) for all studied characteristics was not significant, probably due to high adaptation for these landraces with climatic conditions under many zones (locations) along years (seasons), for thousands of year's chickpea landraces have evolved under the influence of natural and artificial selection as performed by many generations of farmers.

Abdel *et al.,* (2005) found no significant interaction detected between seasons; the main source of yield variation in the Mediterranean region is variation in rainfall.

Tuba *et al.,* (2004) Reported that Irrigation (E) X Cultivars (G) interaction was significant for some characterictes in some cultivares, this revealed the different response of these cultivares under rainfed and irrigation conditions.

Zvereny *et al.,* (2006) found that heritability for most Characters and Genotype x Year interaction Variance (GYV) were small (heritability ranged from 5.47% to 51.66%) due to larger phenotypic variances, indicating environmental influence.

These results are in agreement with Jahagirdar *et al.* (1994) who found high heritability together with high genetic advance for 100 seed weight and seeds yield per plant.

Arshad *et al.* (2004) found high rang for seeds yield per plant (11.7) for twenty-four candidate varieties of chickpea.

High heritability estimates were reported by Tripathi (1998); Kumar *et al*. (1999) and Saleem *et al.,* (2002) for 100-seed weight (93.6%).

The results are in contrast with Kumar and Krishna (1998) who found that grain yield per plant had poor heritability estimates.

4. Conclusions

The available information's from our study will be helpful to devise an efficient selection criterion to select the most desirable lines under rainfed conditions in Syria.

The results suggested that improvement for seeds yield per plant can be efficient through selection the line M-20 that had highest seed yield per plant (33 to 40)g and high protein content (22.17 to 24.72%) as compared to other lines.

We concluded there is significant differences among studied lines, also the effect of location (L) and season (E) was significant ($P< 0.01$) suggested that lines behaved differentially in each location and season. The interaction (L x E x G) was no significant for all characteristics ($P > 0.05$).

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Table 1. List of (7) chickpea accessions used in study

Entry No.	Line Name	Source
1	K- 6	Gene Bank of GCSAR, Syria
2	G- 35	Gene Bank of GCSAR, Syria
3	D- 15	Gene Bank of GCSAR, Syria
4	F-20	Gene Bank of GCSAR, Syria
5	B -17	Gene Bank of ICARDA, Syria
6	H- 45	Gene Bank of GCSAR, Syria
7	M- 20	Gene Bank of GCSAR, Syria

Table 2. ANOVA and Interaction for seeds yield per plant in (7) chickpea selected lines grown during two seasons 2006 / 2007- 2007 / 2008 at tow locations Tal-Sandal and Harran

Locations (L) / Lines (G)		Seasons (E)			
		2006 / 2007		2007 / 2008	
		Tal-Sandal (SY/P)	Harran (SY/P)	Tal-Sandal (SY/P)	Harran (SY/P)
K- 6		35.00	30.00	29.00	27.00
G- 35		29.00	25.00	24.33	22.33
D- 15		20.00	16.33	17.67	13.67
F-20		23.00	21.00	20.00	19.00
B -17		21.67	16.67	19.33	14.67
H- 45		33.00	30.00	30.00	28.00
M- 20		40.00	36.00	37.33	33.00
Grand Mean (X)		28.81	25.00	25.38	22.50
ANOVA	Mean Square	171.762	165.778	151.714	156.206
	F- Value	32.205	39.116	33.894	99.404
	P -Value	0.000**	0.000**	0.000**	0.003**
$LSD_{0.01}$		5.613	5.004	5.142	3.047
$LSD_{0.05}$		4.0444	3.605	3.705	4.044
SE ±		1.622	1.584	1.522	1.50
CV%		25.8	29.04	27.50	30.70
Interaction	G	0.000 < 0.01**			
	L	0.000 < 0.01**			
	E	0.001 < 0.01**			
	L x G	0.387 > 0.05 n.s			
	E x G	0.719 > 0.05 n.s			
	L x E	0.389 > 0.05 n.s			
	L x E x G	0.916 > 0.05 n.s			

, * Significant at 0.05 and 0.01 percent probability level, respectively. n.s: not Significant.

Table 3. ANOVA and Interaction for days to maturity in (7) chickpea selected lines grown during two seasons 2006 / 2007- 2007 / 2008 at tow locations Tal-Sandal and Harran

Locations (L) / Lines (G)		Seasons (E)			
		2006 / 2007		2007 / 2008	
		Tal-Sandal (DM)	Harran (DM)	Tal-Sandal (DM)	Harran (DM)
K- 6		70.33	67.33	69.33	65.67
G- 35		69.33	66.67	68.33	65.67
D- 15		80.67	77.33	77.33	76.33
F-20		70.00	65.33	69.00	64.67
B -17		71.67	68.67	70.33	67.00
H- 45		73.00	69.33	71.33	68.33
M- 20		75.33	70.67	73.67	69.67
Grand Mean (X)		72.90	69.33	71.33	68.19
ANOVA	Mean square	47.746	46.667	30.444	166.389
	F- Value	125.333	140.0	71.037	47.54
	P- Value	0.000**	0.000**	0.000**	0.000**
$LSD_{0.01}$		1.500	1.403	1.591	1.299
$LSD_{0.05}$		1.081	1.011	1.146	0.936
SE ±		0.830	0.823	0.670	0.830
CV%		5.60	5.44	4.31	5.58
Interaction	G	0.000 < 0.01**			
	L	0.000 < 0.01**			
	E	0.001 < 0.01**			
	L x G	0.001 < 0.01**			
	E x G	0.128 > 0.05 n.s			
	L x E	0.246> 0.05 n.s			
	L x E x G	0.049 < 0.05 *			

Table 4. ANOVA and Interaction for protein content in (7) chickpea selected lines grown during two seasons 2006 / 2007- 2007 / 2008 at tow locations Tal-Sandal and Harran

Locations (L) / Lines (G)		Seasons (E)			
		2006 / 2007		2007 / 2008	
		Tal-Sandal (PC)%	Harran (PC)%	Tal-Sandal (PC)%	Harran (PC)%
K- 6		22.07	21.45	21.40	20.93
G- 35		22.79	23.02	22.10	22.20
D- 15		23.08	21.49	22.43	21.00
F-20		21.15	21.09	20.63	20.40
B -17		21.19	20.54	20.63	20.00
H- 45		21.17	21.62	20.53	21.03
M- 20		24.72	22.58	23.87	22.17
Grand Mean (X)		22.31	21.69	21.66	21.10
ANOVA	Mean square	5.299	2.169	4.553	2.045
	F- Value	13.618	5.872	9.22	6.065
	P	0.000**	0.003**	0.000**	0.003**
$LSD_{0.01}$		1.516	1.477	1.708	1.411
$_{0.05}$		1.092	1.064	1.231	1.017
SE ±		0.298	0.208	0.286	0.200
CV%		6.1	4.4	6.0	4.4
Interaction	G	0.000 < 0.01**			
	L	0.000 < 0.01**			
	E	0.000 < 0.01**			
	L x G	0.000 < 0.01**			
	E x G	0.946 > 0.05 $^{n.s}$			
	L x E	0.369 > 0.05 $^{n.s}$			
	L x E x G	0.677 > 0.05 $^{n.s}$			

Table 5. Genetic parameters for some characteristics in (7) chickpea selected lines grown during two seasons 2006 / 2007- 2007 / 2008 at tow locations Tal-Sandal and Harran

Trait	Season (E)	Location (L)	σ2g	GCV	σ2e	ECV	σ2p	PCV	H2	GA	GA%
SY/P	2006 / 2007	Tal - sandal	55.48	192.5	1.78	6.170	57.25	198.7	0.96	14.84	51.50
		Harran	53.85	215.3	4.24	16.95	55.26	221.0	0.97	14.57	58.29
	2007 / 2008	Tal - sandal	49.08	193.4	4.48	17.64	50.57	199.3	0.97	13.94	54.94
		Harran	51.5	228.8	1.57	6.97	52.1	231.2	0.99	14.12	62.70
DM	2006 / 2007	Tal - sandal	15.79	21.66	0.381	0.523	15.92	21.83	0.99	7.81	10.71
		Harran	15.44	22.28	0.333	0.480	15.56	22.44	0.99	7.72	11.13
	2007 / 2008	Tal - sandal	10.01	14.03	0.429	0.601	10.15	14.23	0.99	6.24	8.75
		Harran	15.75	23.10	0.286	0.419	15.85	23.24	0.99	7.79	11.42
PC%	2006 / 2007	Tal - sandal	1.64	7.34	0.39	1.74	1.77	7.92	0.93	2.60	11.67
		Harran	0.60	2.8	0.37	1.70	0.72	3.3	0.83	1.63	7.52
	2007 / 2008	Tal - sandal	1.35	6.25	0.49	2.28	1.52	7.01	0.89	2.40	11.09
		Harran	0.57	2.70	0.34	1.60	0.68	3.23	0.84	1.59	7.51