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Full Length Research Paper

Genetic analysis of morpho-physiological and quality traits in chickpea genotypes (*Cicer arietinum* L.)

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The present study was conducted on two different locations, (1) fields of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan and (2) the field of Chaudhary Agriculture farms, Kasur, Pakistan, during the crop season of 2010-2011. Eighty chickpea genotypes (seventy lines and ten check varieties) were evaluated for genetic variability in morpho-physiological and quality traits in chickpea. Highest values of heritability and genetic advance were found for 100-seed weight, proteins, chlorophyll contents, pods per plant, leaf area and grain yield. Correlation studies showed that leaflets per leaf, chlorophyll contents, 100-seed weight and leaf area with pods per plant; proteins with 100-seed weight, proteins and biomass per plant with grains per plant were positive and significant at both genotypic and phenotypic levels at location 1. Leaflets per leaf, chlorophyll contents and proteins with grain yield; 100-seed weight and biomass per plant with seeds per pod were positive and highly significant at genotypic and phenotypic level for location 2. The higher value of genetic variability, genotypic and phenotypic correlation coefficients indicated that these traits can be used for selecting high yielding and better quality chickpea genotypes.

Key words: *Cicer arietinum,* correlation, proteins, genetic variability, chickpea, PBG, UAF, Pakistan.

INTRODUCTION

Among the pulses, chickpea (*Cicer arietinum* L.) is the third leading grain legume in the world and first in the South Asia. 92% of the area and 89% of the production of grain are concentrated in semi-arid tropical countries (Anonymous, 1995). The range of cultivation of chickpea extends from the Mediterranean basin to the Indian sub-continent and southward of Ethiopia and the East African highlands. Two types of chickpea, one namely Kabuli is grown in temperate regions while the second type chickpea is grown in the semi-arid tropics (Muehlbauer and Singh, 1987). Chickpea is the principal Rabi pulse crop and important source of calories in Pakistan which is predominantly grown in the vast rain fed areas of the country. Pakistan ranks the second to India in terms of acreage of chickpea which is 1050 thousand hectares with an annual production of 571 thousand tonnes (Anonymous, 2009, 2010). It is rich and readily available source of protein both for human and animals. The average yield of chickpea is low as compared to other chickpea growing countries.

In Punjab about 90% gram is cultivated in rain fed areas; the major chickpea production belt is Thal including the districts of Bhakhar, Mianwali, Layyah, Khushab and parts of Jhang. Chickpea is the cheapest and readily available source of protein (19.5%), fats (1.4%), carbohydrates (57-60%), ash (4.8%) and (4.9-15.59%) moisture (Huisman and Van der Poel, 1994). It makes up the deficiency of cereal diets. It also helps with replenishment of soil fertility by fixing of atmospheric nitrogen through symbiosis coupled with deep root system. The average yield of chickpea in Pakistan is low

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Table 1. Agro ecological characteristic of each location.

Location 1 Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan			
Months	**Max. temperature (℃)**	**Min. temperature (℃)**	**Precipitation (mm)**
November	28.2	10.4	2.0
December	22.1	6.1	8.0
January	19.4	4.8	16.0
February	22.4	7.6	18.0
March	27.4	12.6	23.0
April	34.2	18.3	14.0

Location 2 Chaudhary Agriculture farms Kasur, Pakistan			
Months	**Max. temperature (℃)**	**Min. temperature (℃)**	**Precipitation (mm)**
November	28.1	10.2	2.5
December	21.8	5.9	8.6
January	19.2	4.7	15.8
February	22.1	7.4	17.9
March	27.1	12.5	23.2
April	33.9	18.1	14.3

as compared to other chickpea growing countries of the world. This is primarily due to poor genetic makeup of the cultivars, excessive vegetative growth, low tolerance to diseases and no availability of seeds of improved varieties. Grain yield is of primary importance and the most complex trait as it is dependent upon the interaction of growth, environment and genetic makeup of the plant. Apart from direct selection for grain yield, the objective of yield enhancement may in most situations be more effectively fulfilled on the basis of performance of yield and its components. These components contribute to grain production both directly. Genotypic and phenotypic correlations are of value to indicate the degree to which various quantitative traits of the plant are associated with economic productivity.

Correlation study thus provides information on correlate response of important plant traits and therefore leads to a directional model for yield response. However, present study was initiated with the prime objective of observing the mutual relationships of different quantitative traits and extent of their contribution to seed yield and quality of chickpea. The studies thus clearly envisage augmenting the relatively scarce information available on these characters which may be profitably exploited in future breeding programmes of chickpea improvement.

MATERIALS AND METHODS

The present studies were conducted on two different locations, (1) fields of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad and (2) the field of Chaudhary Agriculture farms Kasur, Pakistan, during the crop season 2010-2011. Table 1 show their agro ecological characteristics, the experimental material comprised eighty chickpea genotypes (Table 2), while Table 3 shows the traits recorded for these genotypes.

Analysis of variance for all characters, were carried out using the method of Steel and Torrie (1997) and individual comparison of varietals mean was accomplished by Duncan's New Multiple Range Test. Genotypic and phenotypic correlations were calculated to observe the association between different traits (Kwon and Torrie, 1964). Heritability coupled with genotypic variation was calculated by using Mather and Jinks (1982) model of heritability. Genetic advance was calculated through methods demonstrated by Falconer (1989).

RESULTS AND DISCUSSION

Leaflets per leaf

It is persuaded from Table 4 that the mean leaflets per leaf in location 1 was 11.23±0.254; the phenotypic variance (39.451) was higher than the genotypic variance (29.652) and environmental variance (3.514). The coefficient of genotypic variance was 1.951% while the coefficient of phenotypic variance was 1.652%. The moderate type of heritability was found as 75.162% and the genetic advance 52.039%. Higher genetic advance indicated the additive variance that can help to select higher yielding chickpea genotypes (Hardwirck and Andrews, 1980). Similar findings were reported by Adhikari and Pandey (1982). The mean leaflets per leaf was 11.6±0.651, the coefficient of phenotypic variance was higher 5.314% while the other genetic parameters showed less value at location 2 (Table 5) as compared to location 1 due to environmental variations. Study of Table 6 shows that positive and highly significant genotypic correlation coefficients of leaflets per leaf were found with grains per plant and grain yield per plant while negative but significant genotypic correlation coefficient was found for seeds per pod. Similar results have been obtained by Yadav et al. (2001). A positive and significant phenotypic correlation coefficient was found for pods per plant,

Table 2. The eighty chickpea genotypes.

S/N	Genotypes	Description	S/N	Genotypes	Description
1	1002	Line	41	709	Line
2	Bittle-98	Check Variety	42	118	Line
3	1006	Line	43	868	Line
4	1288	Line	44	4009	Line
5	620	Line	45	1049	Line
6	1007	Line	46	103	Line
7	1001	Line	47	112	Line
8	Pb2000	Check Variety	48	119	Line
9	CM-98	Check Variety	49	Balkasar-2000	Check Variety
10	5006	Line	50	4047	Line
11	102	Line	51	1015	Line
12	Paidar-91	Check Variety	52	102	Line
13	1004	Line	53	1154	Line
14	115	Line	54	214	Line
15	698	Line	55	1010	Line
16	820	Line	56	62262	Line
17	818	Line	57	1003	Line
18	1005	Line	58	406	Line
19	846	Line	59	120	Line
20	2006	Line	60	635	Line
21	4025	Line	61	206	Line
22	9605	Line	62	1013	Line
23	110	Line	63	1012	Line
24	205	Line	64	108	Line
25	AUG-27	Check Variety	65	1201	Line
26	810	Line	66	1036	Line
27	161	Line	67	220	Line
28	217	Line	68	848	Line
29	1014	Line	69	2009	Line
30	Wanhar-2000	Check Variety	70	AUG-786	Check Variety
31	5008	Line	71	2008	Line
32	118	Line	72	405	Line
33	117	Line	73	107	Line
34	1205	Line	74	219	Line
35	1017	Line	75	1276	Line
36	101	Line	76	290	Line
37	106	Line	77	210	Line
38	932	Line	78	Noor-91	Check Variety
39	114	Line	79	1118	Line
40	781	Line	80	AUG-424	Check Variety

seeds per pod and grain yield per plant. The remaining correlation associations were non-significant. From Table 7 it is clear that positive and highly significant genotypic correlation coefficients of leaflets per leaf were found with chlorophyll contents, pods per plant, biomass per plant and seeds per pod. A positive and significant phenotypic correlation coefficient was found for pod per plant. The remaining correlation associations were non-significant. The results indicated that these traits were greatly influenced by the environment (Arshad et al., 2002). It is indicated from the results that selection on the basis of leaflets per leaf may be non-effective for higher yielding chickpea genotypes.

Chlorophyll contents (mg g^{-1} fr.wt.)

It can be observed from Table 4, that the mean

Table 3. Traits recorded for the genotypes.

Traits	Method of measurement
Leaflets per leaf	Simple counting of leaflets each leaf contain
Chlorophyll contents (mg g^{-1} fr.wt.)	Chlorophyll meter
Leaf area (cm^2)	Leaf area meter
Pods per plant	Simple counting
seeds per pod	Simple counting
grain per plant	Simple counting
biomass per plant (grams)	electronic balance (OHAUS-GT4000, USA)
100-seed weight (grams)	electronic balance (OHAUS-GT4000, USA)
grain yield per plant (grams)	electronic balance (OHAUS-GT4000, USA)
Carbohydrates (%)	Association of Official Analytical Chemists (AOAC, 1990)
Proteins (%)	Association of Official Analytical Chemists (AOAC, 1990)

chlorophyll contents in location 1 were 1.625±1.953; the phenotypic variance (17.421) was higher than the genotypic variance (15.237) and environmental variance (2.362). The coefficient of genotypic variance was 0.942% while the coefficient of phenotypic variance was 0.842%. The higher value of heritability was found as 87.463% and the genetic advance 26.741%. Similar findings were reported by Raval and Dobariya (2003) and Kidambi et al. (2006). The mean chlorophyll contents (in location 2) were 1.973±1.451 higher than the location 1 as the higher rainfall was recorded there, the genotypic and phenotypic variances were higher 135.41 and 135.547, respectively, and the higher value of heritability was found as 99.80% and the genetic advance 36.606% was also greater than the location 1. The other genetic parameters showed less value at location 2 (Table 5) as compared to location 1. Table 6 and 7 persuaded that positive and highly significant genotypic correlation coefficients of chlorophyll contents were found with grains yield per plant and leaflets per leaf, pods per plant and grains per plant, respectively. Negative but significant phenotypic correlation coefficients of chlorophyll contents were found with carbohydrates and 100-seed weight. The remaining correlation associations were non-significant. The higher values of heritability indicated that selection on the basis of chlorophyll contents may be effective for higher yielding chickpea genotypes.

Leaf area (cm^2)

It can be observed from Table 4, that the mean leaf area in location 1 was 0.197±0.624; the phenotypic variance (21.421) was higher than the genotypic variance (19.453) and environmental variance (2.714). The coefficient of genotypic variance was 1.122% while the coefficient of phenotypic variance was 9.284%. The higher value of heritability was found as 90.812% and the genetic advance as 34.139%. Similar findings were reported by Chavan et al. (1994) and Ali et al. (2010).

The mean leaf area was 0.186±0.564 higher than the location 1, the genotypic and phenotypic variances were higher 28.251 and 33.201, respectively, and the coefficient of genotypic variance was 18.623% while the coefficient of phenotypic variance was 20.188%. The higher value of heritability was found as 85.10% and the genetic advance 49.586% was greater than the location 1. Table 6 persuaded that positive and highly significant genotypic correlation coefficients of leaf area were found with proteins, 100-seed weight and seeds per pods. Negative but significant phenotypic correlation was found for proteins, biomass per plant and seeds per pod. The remaining Correlation associations were non-significant. From Table 7 it is cleared that positive and highly significant genotypic and phenotypic correlation coefficients of leaf area were found with proteins, 100-seed, pods per plant, carbohydrates and grains per plant. The higher values of heritability and genetic advance indicated that selection on the basis of leaf area leaf may be effective for higher yielding chickpea genotypes. Similar results have been obtained by Raval and Dobariya (2003) and Obaidullah et al. (2006).

Pods per plant

It is persuaded from Table 1a that the mean pods per plant in location 1 was 55.897±1.725; the phenotypic variance (63.451) was higher than the genotypic variance (59.451) and environmental variance (18.341). The coefficient of genotypic variance was 2.091% while the coefficient of phenotypic variance was 16.522%. The higher heritability was found as 93.696% and the genetic advance 104.336%. Similar findings were reported by Adhikari and Pandey (1982) and Dasgupta et al. (1992). The mean pod per plant was higher (57.713±1.452) than the location 1, the coefficient of genotypic variance was 40.642% while the coefficient of phenotypic variance was 42.435%. The higher heritability was found as 96.29% and the genetic advance was less than the location 1 as

Table 4. Estimates of genetic components in chickpea genotypes (Department of Plant Breeding and Genetics, UAF, Pakistan).

Quantitative traits	GV	PV	EV	GCV (%)	PCV (%)	ECV (%)	Broad-sense Heritability (h^2)%	Genetic Advance %	Means± S.E
leaflet per leaf	29.652	39.451	3.514	1.951	1.652	0.491	75.162	52.039	11.23±0.254
Chlorophyll contents	15.237	17.421	2.362	0.942	0.842	0.823	87.463	26.741	1.625±1.953
Leaf Area	19.453	21.421	2.714	1.122	9.284	4.012	90.812	34.139	0.197±0.624
Carbohydrates	6.231	6.694	0.639	0.612	4.453	3.123	93.083	10.935	58.682±0.123
Proteins	28.254	29.321	0.151	1.493	1.263	5.426	96.361	49.586	17.98±1.421
Biomass per plant	10.546	19.214	7.941	1.144	4.921	3.728	54.887	18.508	45.834±1.145
Pods per plant	59.451	63.451	18.341	2.091	16.522	8.925	93.696	104.336	55.897±1.725
Seeds per pod	20.610	24.341	10.431	1.095	0.955	0.914	84.672	36.171	1.652±2.255
100-seed weight	21.791	21.951	13.470	3.692	0.984	4.526	99.271	38.243	1.985±1.161
Grain yield per plant	34.312	36.341	1.214	0.647	5.692	3.615	94.417	60.218	28.531±1.242
Grains per plant	22.437	37.439	5.741	5.383	6.781	0.742	59.929	39.377	57.012±1.124

GV = Genotypic variance, PV = phenotypic variance, GCV = genotypic coefficient of variance, PCV = phenotypic coefficient of variance, EV = environmental variance, ECV = environmental coefficient of variance.

Table 5. Estimates of genetic components in chickpea genotypes (Chaudhary Agriculture farms Kasur, Pakistan).

Quantitative traits	GV	PV	EV	GCV (%)	PCV (%)	ECV (%)	Broad-sense heritability (h^2)%	Genetic advance %	Means± S.E
leaflet per leaf	6.551	4.451	0.354	1.426	5.314	0.491	57.652	45.035	11.6±0.651
Chlorophyll contents	135.41	135.547	1.1564	0.208	0.209	0.71	99.80	36.606	1.973±1.451
Leaf Area	28.251	33.201	2.8369	18.623	20.188	3.53	85.10	49.586	0.186±0.564
Carbohydrates	0.565	0.62	0.0058	2.0204	2.309	3.01	91.10	99.126	58.598±0.257
Proteins	82.483	87.688	5.204	19.168	19.763	4.815	94.06	144.751	18.12±1.341
Biomass per plant	1.248	1.751	8.2708	34.29	40.612	3.40	71.30	21.910	47.651±1.256
Pods per plant	41.792	43.403	17.0445	40.642	42.435	8.45	96.29	73.35	57.713±1.452
Seeds per pod	0.023	0.025	0.002	10.119	10.603	2.999	91.10	0.297	1.714±2.143
100-seed weight	245.867	270.16	24.301	18.933	19.933	5.971	91.00	30.812	1.941±1.132
Grain yield per plant	9.98	10.110	0.121	11.295	11.363	1.243	98.80	6.471	29.481±1.212
Grains per plant	15.377	17.512	2.135	17.369	18.536	6.472	87.80	7.569	57.112±1.314

GV = Genotypic variance, PV = phenotypic variance, GCV = genotypic coefficient of variance, PCV = phenotypic coefficient of variance, EV = environmental variance, ECV = environmental coefficient of variance.

73.35%. The other parameters showed less value at location 2 (Table 5) as compared to location 1. Study of Table 6 shows that positive and highly significant genotypic correlation coefficients of pods per plant were found with proteins, biomass per plant and seeds per pod. Similar results have been obtained by Yadav et al. (2001). The remaining correlation associations were non-significant.

Table 6. Genotypic and phenotypic correlation of various quantitative traits (Department of Plant Breeding and Genetics, UAF, Pakistan).

Traits	r	Chl. C	LA	NPP	Carbohydrates	Proteins	BMP	100-SW	NSPP	NGP	GY
LL	G	0.1576	0.1012	0.0765	0.0524	-0.1234	-0.0234	0.1124	-0.9542**	0.5723*	0.7921*
	P	0.1205	0.1033	0.4121*	-0.0424	-0.1943	-0.0423	0.1124	-0.4156*	0.2134	0.3749*
Chl. C	G		-0.0233	0.2135	-0.2995*	0.1853	-0.1672	-0.4289*	-0.2125	-0.2103	0.9522**
	P		0.0234	-0.0124	-0.2123	0.1093	-0.0223	-0.1954	-0.1125	-0.2101	0.4951*
LA	G			0.0134	0.0234	0.6793**	-0.1224	0.3789*	0.4956*	0.1124	-0.0363
	P			0.0423	0.0312	-0.3986*	-0.6821*	-0.1324	-0.2976*	-0.1134	-0.0442
NPP	G				-0.1234	0.5995**	0.2962*	-0.2145	0.3986*	-0.1135	0.0895
	P				-0.0146	0.1368	0.1915	-0.1521	-0.0545	0.0129	0.0942
Carbohydrates	G					0.1124	0.1122	-0.2131	0.4971*	0.3626**	-0.7834**
	P					0.0572	0.0210	-0.1325	0.2798*	0.3624*	-0.5706*
Proteins	G						-0.0223	0.4787**	0.3985*	0.6534*	0.4952*
	P						-0.1142	-0.0398	-0.2879*	-0.2945*	-0.2986*
BMP	G							-0.0894	0.7798*	0.3983**	0.3496**
	P							-0.1034	-0.2134	0.4987**	0.0893
100-SW	G								0.4969**	-0.0912	-0.4932**
	P								0.2769*	-0.2532*	-0.2343**
NSPP	G									0.4548*	0.3441*
	P									0.1521	-0.2138*
NGP	G										0.14367
	P										-0.31445*

*=Significant at 5% probability level, ** = highly significant at 1% probability level, = leaflets per leaf, NPP= pod per plant, Chl. C =chlorophyll contents, NSPP=number of seeds per pod, LA= leaf area, BMP =biomass per plant, GYP = grain yield per plant, NGP =number of grains per plant.

From Table 7 it is cleared that positive and highly significant genotypic correlation coefficients of pods per plant were found with leaflets, chlorophyll contents, leaf area, proteins, biomass per plant, 100-seed weight and grains per plant. A negative but significant phenotypic correlation coefficient was found for proteins and biomass per plant. The remaining correlation associations were non-significant. Similar results have been obtained by Wadud and Yaqoob (1989), Bhaduoria et al. (2003) and Obaidullah et al. (2006). The higher values of heritability and genetic advance indicated that selection on the basis of pods per plant may be effective for higher yielding chickpea genotypes.

Seeds per pod

It is persuaded from Table 1a that the mean seed per pod in location 1 was 1.652±2.255; the phenotypic variance (24.341) was higher than the genotypic variance (20.610) and environmental variance (10.431). The coefficient of genotypic variance was 1.095% while the coefficient of phenotypic variance was 0.955%. The higher value of heritability was found as 84.672% and the genetic advance 36.171%. Similar findings were reported by Bicer (2005) and Ali et al. (2011). The mean seeds per pod were greater 1.714±2.143 than the location 1; the higher heritability was found as 91.10% and the genetic advance was smaller than the location 1 as 0.297%. The coefficient of genotypic variance was 10.119% while the coefficient of phenotypic variance was 10.603%. The other parameters showed lower values at location 2 (Table 5) as compared to location 1. Study of Table 6 indicated that positive and highly significant genotypic correlation

Table 7. Genotypic and phenotypic correlation of various quantitative traits (Chaudhary Agriculture farms Kasur, Pakistan).

Traits	r	Chl. C	LA	NPP	Carbohydrates	Proteins	BMP	100-SW	NSPP	NGP	GY
LL	G	0.4523*	0.3727	0.6982**	-0.2436	0.3996	0.4781*	0.0422	0.4841*	-0.5085*	0.2765
	P	0.3118	0.3093	0.6178**	-0.1857	0.3552	0.4370	-0.0020	0.4349	-0.4382	0.2676
Chl. C	G		-0.0213	0.7313*	0.0562	-0.0172	-0.0562	0.0231	0.0636	0.4849*	0.0237
	P		0.0235	0.3119*	0.0345	-0.2651	-0.1236	0.0364	-0.0023	0.0564	0.2454
LA	G			0.9181**	0.2455*	0.5921**	0.6360**	0.4685*	0.0614	0.2654*	0.2011
	P			0.4525*	0.5646**	0.2665*	0.5530*	0.4381*	0.0816	0.2137*	0.1681
NPP	G				0.1243	0.3963*	0.3653**	0.33892*	0.1047	0.4912*	0.2252
	P				0.1145	0.7897**	0.4462*	0.2635	0.0862	0.2010	0.1452
Carbohydrates	G					0.5956*	-0.9628**	-0.7426**	-0.1595	-0.8964**	0.0362
	P					0.4977*	-0.7625**	-0.5526*	-0.1061	-0.6383**	0.0281
Proteins	G						0.4531**	0.7531**	0.1579	0.8701**	-0.1161
	P						0.2351*	0.7149**	0.1584	0.8373**	-0.1150
BMP	G							-0.0897	0.7798*	0.3983**	0.3496**
	P							-0.1032	-0.2324	0.4986**	0.0891
100-SW	G								0.4681**	-0.1569	-0.4642**
	P								0.2569*	-0.6431*	-0.2223**
NSPP	G									0.4228*	0.3405*
	P									0.1523	-0.2648*
NGP	G										-0.1327
	P										-0.2177*

*= Significant at 5% probability level, **=highly significant at 1% probability level, LL=leaflets per leaf, NPP=pod per plant, Chl. C=chlorophyll contents, NSPP=number of seeds per pod, LA=leaf Area, BMP=biomass per plant, GYP=grain yield per plant, NGP=number of grains per plant.

coefficients of seeds per pod were found with proteins, grains per plant, carbohydrates and grain yield per plant. The remaining correlation associations were non-significant. Similar results have been obtained by Singh et al. (1997), Ozcelik et al. (2004) and Ali et al. (2010) and Ali and Ahsan (2011). Negative but significant correlation was found for leaflets per leaf and pods per plant. From Table 7 it is cleared that positive and highly significant genotypic correlation coefficients of seeds per pod were found with leaflets per leaf, 100-seed weight, grains per plant and grain yield per plant. Similar results have been obtained by Jeena and Arora (2001) and Ali et al. (2011). The higher values of heritability and genetic advance indicated that selection on the basis of seeds per pod may be effective for higher yielding chickpea genotypes.

Grains per plant

It is persuaded from Table 4 that the mean grains per plant in location 1 was 57.012±1.124; the phenotypic variance (37.439) was higher than the genotypic variance (22.437) and environmental variance (5.741). The coefficient of genotypic variance was 5.383% while the coefficient of phenotypic variance was 6.781%. The moderate heritability was found as 59.929% and the genetic advance 39.373%. Similar findings were reported by Bicer (2005) and Ali et al. (2011). The mean grains per plant were greater 57.112±1.314 than the location 1; the higher heritability was found as 87.80% and the genetic advance was smaller than the location 1 as 7.569%. The coefficient of genotypic variance was 17.369%, while the coefficient of phenotypic variance was 18.536%. The other parameters showed lower values at

location 2 (Table 5) as compared to location 1. Study of Table 6 indicated that positive and highly significant genotypic correlation coefficients of grains per plant were found with leaflets per leaf, proteins, seeds per pod, carbohydrates and 100-seed weight.

The remaining correlation associations were non-significant. Similar results have been obtained by Singh et al. (1997) and Ali et al. (2010). From Table 7 it is cleared that positive and highly significant genotypic correlation coefficients of grains per plant were found with chlorophyll contents, proteins, 100-seed weight, carbohydrates, pods per plant and biomass per plant. Similar results have been obtained by Ali et al. (2011). The higher values of heritability and genetic advance indicated that selection on the basis of grains per plant may be effective for higher yielding chickpea genotypes.

Biomass per plant (g)

It is persuaded from Table 4, that the mean biomass per plant was in location 1 45.834±1.145; the phenotypic variance (19.214) was higher than the genotypic variance (10.546) and environmental variance (7.941). The coefficient of genotypic variance was 1.144% while the coefficient of phenotypic variance was 4.921%. The moderate heritability was found as 54.887% and the genetic advance 18.508%. Similar findings were reported by Yadav et al. (2001) and Ali et al. (2011). The mean biomass per plant was higher 47.651±1.256 than the location 1; the higher heritability was found as 71.30% and the genetic advance was greater than the location 1 as 21.910%. The coefficient of genotypic variance was 34.29% while the coefficient of phenotypic variance was 40.612%. The other parameters showed lower values at location 2 (Table 5) as compared to location 1. Study of Table 6 indicated that positive and highly significant genotypic correlation coefficients of biomass per plant were found with seeds per pod, grains per plant and grain yield per plant.

The remaining correlation associations were non-significant. Similar results have been obtained by Singh et al. (1997), Ozcelik et al. (2004) and Ali et al. (2011). From Table 7 it is cleared that positive and highly signify-cant genotypic correlation coefficients of biomass per plant were found with leaf area, chlorophyll contents, carbohydrates, pods per plant, seeds per pod, grains per plant and grain yield per plant. Similar results have been obtained by Jeena and Arora (2001), Arshad et al. (2002), Noor et al. (2003) and Ali et al. (2011). The higher values of heritability and genetic advance indicated that selection on the basis of biomass per plant may be effective for higher yielding chickpea genotypes.

100-Seed weight (g)

It is persuaded from Table 4, that the mean 100-seed weight in location 1 was 1.985±1.161; the phenotypic variance (21.951) was higher than the genotypic variance (21.791) and environmental variance (13.470). The coefficient of genotypic variance was 3.692% while the coefficient of phenotypic variance was 0.984%. The moderate heritability was found as 99.271% and the genetic advance 38.243%. Similar findings were reported by Ozcelik et al. (2004), Bicer (2005) and Ali et al. (2011). The mean 100-seed weight was lower 1.941±1.132 than the location 1 as the most of the reserved food material was used for vegetative reproduction to increase biomass per plant; the higher heritability was found as 91.00% and the genetic advance was smaller than the location 1 as 30.812%. The other parameters showed greater values at location 2 (Table 5) as compared to location 1. Study of Table 6 indicated that positive and highly significant genotypic correlation coefficients of 100-seed weight were found with proteins, seeds per pod and grain yield per plant.

The remaining correlation associations were non-significant. Similar results have been obtained by Singh et al. (1997), Ozcelik et al. (2004) and Ali et al. (2011). Negative but significant correlation was found for seeds per pod, leaf area, grains per plant and grain yield. The remaining correlation associations were non-significant. From Table 7 it is cleared that positive and highly significant genotypic correlation coefficients of 100-seed weight were found with leaf area, chlorophyll contents, carbohydrates, pods per plant, seeds per pod, grains per plant and grain yield per plant. Similar results have been obtained by Jeena and Arora (2001), Arshad et al. (2002) and Ali et al. (2011). The higher values of heritability and genetic advance indicated that selection on the basis of 100-seed weight may be effective for higher yielding chickpea genotypes.

Grain yield per plant

It is persuaded from Table 1a, that the mean grain yield per plant in location 1 was 28.531±1.242; the phenotypic variance (36.341) was higher than the genotypic variance (34.312) and environmental variance (1.214). The coefficient of genotypic variance was 0.647% while the coefficient of phenotypic variance was 5.692%. The higher heritability value was found as 94.417% and the genetic advance 60.218%. Similar findings were reported by Ali et al. (2010, 2011). The mean grain yield per plant was greater 29.481±1.212 than the location 1; the higher heritability was found as 98.80% and the genetic advance was smaller than the location 1 as 6.471%. The coefficient of genotypic variance was 11.295% while the coefficient of phenotypic variance was 11.363%. The other parameters showed lower values at location 2 (Table 5) as compared to location 1. Study of Table 6 indicated that positive and highly significant genotypic correlation coefficients of grain yield per plant were found with leaflets per leaf, proteins, seeds per pod,

carbohydrates, biomass per plant, chlorophyll contents and 100-seed weight.

The remaining correlation associations were non-significant. Similar results have been obtained by Singh et al. (1997), Arshad et al. (2002), Ozcelik et al. (2004) and Ali et al. (2010, 2011). From Table 7 it is cleared that positive and highly significant genotypic correlation coefficients of grain yield per plant were found with 100-seed weight, seeds per pods and biomass per plant. Similar results have been obtained by Ali et al. (2011). The higher values of heritability and genetic advance indicated that selection on the basis of grain yield per plant may be effective for higher yielding chickpea genotypes.

Carbohydrates (%)

It is persuaded from Table 1a, that the mean carbohydrates in location 1 were 58.682±0.123; the phenotypic variance (6.694) was higher than the genotypic variance (6.231) and environmental variance (0.639). The coefficient of genotypic variance was 3.123% while the coefficient of phenotypic variance was 4.453%. The higher heritability was found as 93.083% and the genetic advance 10.935%. Similar findings were reported by Ali et al. (2011). The mean carbohydrates were higher 58.598±0.257 than the location 1; the higher heritability was found as 91.10% and the genetic advance was greater than the location 1 as 99.126%. The other parameters showed less value at location 2 (Table 5) as compared to location 1. Study of Table 6 indicated that positive and highly significant genotypic correlation coefficients of carbohydrates were found with seeds per pod, grains per plant and grain yield per plant. Similar results have been obtained by Ali et al. (2011). The remaining correlation associations were non-significant. From Table 7 it is cleared that positive and highly signify-cant genotypic correlation coefficients of carbohydrates were found with leaf area, proteins, biomass per plant, 100-seed weight and grains per plant. A negative but significant phenotypic correlation coefficient was found for 100-seed weight and biomass per plant. A positive and significant phenotypic correlation coefficient was found for proteins and grains per plant. The remaining correlation associations were non-significant. Similar results have been obtained by Bhaduoria et al. (2003), Ozcelik et al. (2004) and Obaidullah et al. (2006). The higher values of heritability and genetic advance indicated that selection on the basis of carbohydrates may be effective for higher yielding chickpea genotypes.

Proteins (%)

It is persuaded from Table 4, that the mean proteins in location 1 were 17.98±1.421; the phenotypic variance (29.321) was higher than the genotypic variance (28.254) and environmental variance (0.151). The coefficient of genotypic variance was 1.493% while the coefficient of phenotypic variance was 1.263%. The higher heritability was found as 96.361% and the genetic advance 49.586%. Similar findings were reported by Ali et al. (2011). The mean proteins were higher 18.12±1.341 than the location 1; the higher heritability was found as 94.06% and the genetic advance was greater than the location 1 as 144.751%. The other parameters showed higher values at location 2 (Table 5) as compared to location 1. Study of Table 6 indicated that positive and highly significant genotypic correlation coefficients of proteins were found with 100-seed weight, leaf area, pods per plant, seeds per pod, grains per plant and grain yield per plant. Similar results have been obtained by Ali et al. (2011). Negative but significant correlation was found for seeds per pod, leaf area, grains per plant and grain yield. The remaining correlation associations were non-significant. From Table 7 it is cleared that positive and highly significant genotypic correlation coefficients of proteins were found with leaf area, carbohydrates, pods per plant, biomass per plant, 100-seed weight and grains per plant. The remaining correlation associations were non-significant. Similar results have been obtained by Ali et al. (2011). The higher values of heritability and genetic advance indicated that selection on the basis of proteins may be effective for higher yielding chickpea genotypes.

Conclusions

Highest values of heritability and genetic advance were found for 100-seed weight, proteins, chlorophyll contents, pods per plant, leaf area and grain yield. Correlation studies showed that leaflets per leaf, chlorophyll con-tents, 100-seed weight and leaf area with pods per plant; proteins with 100-seed weight, proteins and biomass per plant with grains per plant were positive and significant at both genotypic and phenotypic levels at location 1. Leaflets per leaf, chlorophyll contents and proteins with grain yield; 100-seed weight and biomass per plant with seeds per pod were positive and highly significant at genotypic and phenotypic level for location 2. The higher value of genetic variability, genotypic and phenotypic correlation coefficients indicated that these traits can be used for selecting high yielding and batter quality chickpea genotypes.

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