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GENETIC DIVERGENCE AND INTER-RELATIONSHIP STUDIES IN CHICKPEA (*Cicer arietinum* L.)

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Genetic variability, heritability and interrelationships for seed yield and its components (days taken to 50% flowering, plant height, number of pods per plant, days taken to 90% maturity, 100-seed weight) were estimated in 20 advance genotypes of chickpea collected from various sources along with one check variety (Pb-2000). Highly significant differences existed among the genotypes tested for all the traits. Genotype BRC-61 recorded highest seed yield of 2396 kg ha^{-1} where as check variety Bunjab-2000 yielded only 2068 kg ha^{-1}. Genotype BRC-61 was the earliest in maturity and had highest weight of 100 seeds. Significant and positive correlations were found between yield and 100-seed weight, number of pods per plant and plant height. Broad sense heritability ranged from 89.61 (seed yield) to 99.99% (100-seed weight). Heritabilities for 100-seed weight and number of pods per plant were the greatest compared to other traits. Phenotypic coefficient of variation (PCV) for days taken to flowering, days taken to maturity, plant height and seed yield were higher than genotypic coefficient of variations (GCV) which means that the expression of these traits is more influenced by environmental effects. It is, therefore, suggested that the grain yield could be improved by using the 100-seed weight and number of pods per plant as selection criterion in chickpea.
Keywords: *Cicer arietinum*, genetic variability, heritability, correlation, seed yield

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a winter grain legume crop and plays a vital role in the economy of the farming communities of the rainfed areas. Chickpea is grown on an area of 1.081 m ha with a production of 0.741 m tons in Pakistan (Anonymous, 2009). The decline in productivity of chickpea is primarily because of low yielding chickpea cultivars. The availability of good quality and pure seed of improved varieties is another limiting factor. The development of new cultivars with high yield potential and inbuilt resistance to biotic and abiotic stresses is the only remedy to attain self sufficiency in chickpea production. Presence of variation among various traits is very important for breeding new desirable plant types (Saleem *et al*., 2002b). Information of the genetic variability, heritability and association of various characters provides a basis to the plant breeders to breed the chickpea genotypes possessing higher yield potential.

A positive and highly significant correlation between days to flowering, number of pods plant, plant height, 100-seed weight and grain yield was reported by Arshad *et al*. (2002, 2003), Arshad and Bakhsh (2004), Akhtar *et al*. (2003a,b), Güler *et al*. (2001), Arora and Jeena (2001), Jeena and Arora (2000), Kumar *et al*. (2001), Nimbalkar (2000), Narayana and Reddy (2002), Saleem *et al*. (2002a,b), Jeena *et al*. (2005) and Rao and Rao (2005). They suggested that these characters may be given more importance while making selection for higher yield potential in chickpea.

Similarly Sial *et al*. (2003) and Burli *et al*. (2004) also observed the highest heritability estimates for days to maturity followed by 100-grain weight, days to 50% flowering and plant height and suggested that selection for these three characters would be more effective in improving chickpea grain yield. Yücel *et al*. (2006) suggested that seed yield per plant can be improved by indirect selection for number of pods per plant. Patil and Phandis (1997) reported the greatest genetic variations in number of pods per plant and 100-seed weight while greater phenotypic variations were reported for number of days taken to 50% flowering by Adhikari and Pandey (1982). Number of pods per plant had great phenotypic variation (Khorgade *et al*,. 1985).

The aim of the present study was to determine genetic variability, heritability and correlations among important traits to establish a selection criterion for development of high yielding genotypes of chickpea.

MATERIALS AND METHODS

The experiment consisted of 20 chickpea genotypes of diverse origin developed by various research institutes/stations (Table 1) within the country including approved variety (Pb-2000) as check. The trial was laid out following Randomized Complete Block Design with four replications keeping plot size of 7.2 m^2 at Regional Agricultural Research Institute, Bahawalpur during crop season 2006-07. Each genotype was grown in six rows keeping row to row distance of 30 cm and plant to plant distance of 10 cm. Uniform agronomic practices were applied to all entries throughout the growth period. Data regarding yield and yield components (days taken to 50% flowering, plant height, number of pods per plant, days taken to 90% maturity and 100-seed weight) were recorded. The data were subjected to analysis of variance using MSTATC statistical package. Correlations, genotypic variance, phenotypic variance, genotypic coefficient of variation and phenotypic coefficient of variation were computed by using the Minitab statistical programme. Broad sense heritability was calculated as described by Blum and Lehrer (1973) and Corleto (1976).

Table 1. Origin of selected chickpea genotypes

S. No.	Contributing Research Institutes/Stations	No. of genotypes
1	Arid Zone Research Institute (AZRI), Bhakkar	3
2	Arid Zone Research Institute (AZRI), Bahawalpur	1
3	Regional Agricultural Research Institute (RARI), Bahawalpur	1
4	National Agricultural Research Centre (NARC), Islamabad	5
5	Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad	3
6	Pulses research Institute (PRI), Faisalabad	4
7	Barani Agricultural Research Institute (BARI), Chakwal	2
8	Check (Punjab-2000)	1
	Total	20

RESULTS AND DISCUSSION

The data were subjected to statistical analysis. The mean sum of squares for grain yields, days taken to 50% flowering, days taken to 90% maturity, 100-seed weight, plant height and number of pods per plant differed significantly ($P<0.01$) indicating the presence of adequate genetic variability among all the tested genotypes (Table 2). Jeena *et al*. (2005) reported high amount of genetic variability for number of pods per plant, 100-seed weight and seed yield. Out of 20 entries, genotype BRC-61gave maximum grain yield of 2396 kg ha^{-1} while CMC211S was at second place in term of grain yield (2318 kg ha^{-1}). The check variety produced 2068 kg ha^{-1} (Table 3).

The results revealed that number of days taken to 50% flowering ranged from 75.5 (BRC-61) to 87.5 (AZC06 and 96A001). Number of days taken to 90% maturity ranged from 131.5 (BRC-61) to 149.5 (CH24/00), 100-seed weight ranged from 15.2 to 27.7 g, plant height from 62.9 to 72.6 cm and number of pod per plant from 24.5 to 69.0.

The genotype BRC-61 took minimum period (75.5 days) for 50% flowering compared to other genotypes. It also matured earlier than all the other genotypes. It is a bold seeded genotype having 100-seed weight of 27.7 g compared to 22.4 g of the approved chickpea variety (Pb-2000). It produced maximum number of pods (69.0). The other better performing genotypes were CMC211S, 90261 and NCS9917. However, the genotypes AZC-06, 93127, 96A4580 and 3CC113 had high 100-seed weight compared to check and the other genotypes.

Analysis of correlation coefficients between yield and yield components revealed that grain yield had significant and positive correlations with plant height, 100-seed weight and number of pods per plant (Table 4). The results are in line with Saleem *et al*. (2002b), Arshad and Bakhsh (2004) and Jeena *et al*. (2005) who reported similar results. Güler *et al*. (2001) and Yücel *et al*. (2006) reported compatible results in terms of plant height and number of pods per plant. Akhtar *et al*. (2003a,b) reported significant and positive correlations between seed yield and 100-seed weight.

Number of days taken to 90% maturity had positive correlation with plant height and 100-seed weight while negative correlation with number of pods per plant (Table 4). These findings are in agreement with Akhtar *et al*. (2003a). 100-seed weight was negatively correlated with plant height while it had positive correlation with number of pods per plant (Table 4). These results are compatible with those of Akhtar *et al*. (2003a).

Negative and non-significant correlation was found between number of days taken to 50% flowering, number of days taken to 90% maturity and 100-seed weight while number of days taken to 50% flowering was positively correlated with plant height and number of pods per plant (Table 4). The results are supported by the findings of Akhtar *et al*. (2003a).

Table 2. Summary of analysis of variance (mean squares) of various traits of 20 chickpea genotypes during 2006-07

SOV	DF	DTF	DTM	SW	PH	NPP	SY
Replications	3	24.45	0.130	0.005	1.52	15.60	629151
Genotypes	19	51.69**	30.910	38.54**	214.83**	605.25**	1209016**
Error	57	4.713	1.186	0.004	2.980	3.570	125614
Probability Value		0.000	0.000	0.000	0.000	0.000	0.000

DF=Degree of freedom, DTF=Days taken to 50% flowering, DTM=Days taken to 90% maturity, SW=100-seed weight, PH=Plant height, NPP=Number of pods per plant, SY=Seed Yield ** = significant at both 5% and 1%

Table 3. Mean values of various traits of 20 chickpea genotypes during 2006-07

Genotypes	Source	DTF	DTM	SW (g)	PH (cm)	NPP	SY (kg ha^{-1})
AZC-06	AZRI, BAHAWALPUR	87.5^{a}	144.8^{b}	22.2^{f}	72.6^{ef}	42.3^{h}	1583^{defg}
3CC-116	BARI, CHAKWAL	80.0^{cd}	142.0^{cdef}	15.2^{q}	87.1^{b}	58.9^{de}	1271^{fghi}
96A001	AZRI, BHAKKAR	87.5^{a}	143.5^{bc}	19.3^{j}	62.9^{i}	58.1^{e}	495^{j}
NCS0506	NARC, ISLAMABAD	79.8^{cde}	144.8^{b}	19.6^{h}	80.2^{c}	30.7^{j}	1104^{ghi}
93127	PRI, FAISALABAD	80.0^{cd}	141.3^{defg}	22.3^{e}	76.5^{d}	52.1^{f}	1161^{ghi}
NCS0605	NARC, ISLAMABAD	77.0^{def}	141.0^{defg}	17.1^{n}	74.1^{de}	31.3^{j}	922^{ij}
CH23/00	NIAB, FAISALABAD	86.0^{a}	141.3^{defg}	18.4^{l}	72.9^{ef}	47.1^{g}	1750^{cdef}
96A4580	AZRI, BHAKKAR	76.5^{f}	142.5^{cd}	23.2^{c}	72.2^{ef}	43.3^{h}	1333^{fghi}
NCS0601	NARC, ISLAMABAD	76.8^{ef}	142.0^{cdef}	21.6^{g}	86.9^{b}	64.0^{b}	974^{hij}
3CC113	BARI, CHAKWAL	77.0^{def}	142.0^{cdef}	23.3^{b}	68.6^{gh}	24.5^{k}	974^{hij}
98004	PRI, FAISALABAD	76.3^{f}	145.0^{b}	16.1^{p}	75.8^{d}	61.2^{cd}	1443^{efgh}
96A4504	AZRI, BHAKKAR	82.3^{bc}	140.5^{fg}	17.6^{m}	73.3^{e}	47.0^{g}	964^{hij}
BRC-61	RARI, BAHAWALPUR	75.5^{f}	131.5^{h}	27.7^{a}	72.1^{ef}	69.0^{a}	2396^{a}
NCS9917	NARC, ISLAMABAD	80.0^{cd}	142.0^{cdef}	19.0^{k}	82.2^{c}	51.8^{f}	2031^{abcd}
90261	PRI, FAISALABAD	77.0^{def}	142.3^{cde}	19.0^{k}	90.6^{a}	46.0^{g}	2240^{abc}
CMC211S	NARC, ISLAMABAD	76.5^{f}	140.3^{g}	16.4^{o}	81.5^{c}	38.7^{i}	2318^{ab}
CH24/00	NIAB, FAISALABAD	85.0^{ab}	149.5^{a}	19.4^{i}	68.7^{gh}	47.9^{g}	1245^{ghi}
98154	PRI, FAISALABAD	77.0^{def}	140.8^{efg}	18.4^{l}	81.2^{c}	31.1^{j}	1839^{bcde}
CH58/99	NIAB, FAISALABAD	81.0^{c}	144.8^{b}	16.4^{o}	66.9^{h}	62.1^{bc}	1052^{hi}
PB-2000	CHECK	76.0^{f}	140.5^{fg}	22.4^{d}	70.5^{fg}	51.9^{f}	2068^{abcd}
CV (%)		2.730	0.770	0.960	2.300	3.980	25.46
LSD (5%)		3.074	1.542	0.089	2.444	2.675	501.84

DTF = Days taken to 50% flowering, DTM = Days taken to 90% maturity, SW = 100-seed weight, PH = Plant height, NPP = Number of pods per plant, SY = Seed Yield

Table 4. Correlation coefficients among various traits of 20 chickpea genotypes during 2006-07

	DTF	DTM	SW	PH	NPP
DTM	-0.183^{ns} (0.105)				
SW	-0.219^{ns} (0.051)	+0.109^{ns} (0.334)			
PH	+0.353** (0.001)	+0.006^{ns} (0.956)	-0.252* (0.024)		
NPP	+0.148^{ns} (0.191)	-0.100^{ns} (0.375)	+0.103^{ns} (0.362)	+0.079^{ns} (0.486)	
SY	-0.354** (0.001)	-0.117^{ns} (0.300)	+0.715* (0.011)	+0.347** (0.002)	+0.736** (0.001)

DTF = Days taken to 50% flowering, DTM = Days taken to 90% maturity, SW = 100-seed weight, PH = Plant height, NPP = Number of pods per plant, SY = Seed Yield

* = Significant at 5%, ** = Significant at 1% (The Values in bracket are Probability values)

Table 5. Genetic parameters of various traits of 20 chickpea genotypes during 2006-07

Genetic Parameters	Traits					
	DTF	DTM	SW	PH	NPP	SY
G. Mean ±SE	79.48±0.46	142.10±0.32	19.74±0.34	75.84±0.82	47.43±1.36	1445.30±71.2
GV	11.7423	7.42975	9.63475	52.9625	150.42	270851
PV	12.9205	7.72625	9.63575	53.7075	151.313	302254
EV	1.178	0.298	0.001	0.748	0.893	31403.5
GCV (%)	4.31167	1.91820	15.7276	9.59565	25.8583	36.0086
PCV (%)	4.52282	1.95610	15.7284	9.66290	25.9349	38.0389
BSH (%)	90.8808	96.1624	99.9896	98.6129	99.4102	89.6102

DTF = Days taken to 50% flowering, DTM = Days taken to 90% maturity, SW = 100-seed weight, PH = Plant height, NPP = Number of pods per plant, SY = Seed Yield, GV = Genotypic variance, PV = Phenotypic variance, EV = Error variance, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, BSH = Broad sense heritability

Seed yield had the highest genotypic variance (270851) followed by number of pods per plant (150.42). Phenotypic variance for number of days taken to 50% flowering, number of days taken to 90% maturity, plant height and seed yield were higher than genotypic variance than other traits indicating the influence of environmental factors. Phenotypic coefficients of variation were higher than genotypic coefficient of variation for all the traits (Table 5). Higher values of phenotypic coefficients of variation and genotypic coefficients of variation were found in seed yield, number of pods per plant and 100-seed weight. Variation between phenotypic and genotypic coefficients of variation values were very low for number of days taken to 50% flowering, number of days taken to 90% maturity, 100-seed weight and plant height. The highest genotypic variance computed for seed yield offers wide scope for selection of 100-seed weight. These results get support from the findings of Burli *et al*. (2004) and Adhikari and Pandey (1982).

The highest heritability value (Table 5) was observed for 100-seed weight (99.99%) followed by number of pods per plant (99.41%), plant height (98.61%) and number of days taken to 90% maturity (96.16%). The results get support from the findings of Burli *et al*. (2004) and Arshad *et al*. (2003). Sial *et al*. (2003), Saleem *et al*. (2002a) and Yücel *et al*. (2006) who reported high heritability for 100-seed weight and number of days taken to 90% maturity.

It is very clear from the data (Table 3) that a wide range of genetic variability existed among the genotypes tested indicating the possibility of improvement in early maturity, seed weight, number of pods per plant and hence boosting up the seed yield which is an ultimate goal of the chickpea breeders (Akhtar *et al*., 2003 a,b). Yücel *et al*. (2006) concluded that the yield and yield components are multigenic traits and are strongly influenced by the environment. Therefore, the emphasis should be given to the development of chickpea genotypes with higher number of pods per plant and number of seeds per plant to improve yield.

On the basis of the results i.e. the higher positive correlation of 100-seed weight and number of pods per plant with seed yield, it is suggested that these two traits are the major and direct contributors towards yield. Saleem *et al*. (2002b) and Noor *et al*. (2003) concluded that more number of pods would produce more number of seeds and 100-seed weight is an index of seed size. Furthermore, the production of more and heavier seeds will result in higher grain yield.

CONCLUSION

The traits like 100-seed weight and number of pods per plant may be given due emphasis as a selection criterion while developing new chickpea varieties for higher yield. Furthermore, the use of genotype BRC-61 and others in future breeding program may result in the evolution of improved varieties of chickpea.

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