INTERRELATIONSHIPS AMONG YIELD AND YIELD CONTRIBUTING TRAITS IN CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

Twenty chickpea genotypes including four varieties were evaluated for the existence of genetic variability and to know the interrelationship among yield traits under study during 2013-2014, at University of Agriculture, Faisalabad. The experiment was carried out in a randomized complete block (RCB) design with three replications. Data were recorded on number of days taken to flowering, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, plant height, number of days taken to maturity, number of pods $plant^{-1}$, numbers of seed $pods^{-1}$, total plant weight, Number of grains $plant^{-1}$, 100- seed weight and grain yield $plant^{-1}$. The obtained data were analyzed for genetic variability parameters, correlation and path coefficient analysis. The height broad sense heritability estimates were obtained for 100-seed weight (0.977), plant height (0.971), total plant weight (0.971) and number of primary branches $plant^{-1}$. Genetic advance was higher for plant height (9.054), total plant weight (9.054), number of pods $plant^{-1}$ (6.414) and 100-seed weight (2.941). The phenotypic coefficient of variation (PCV) was invariably slightly higher than their corresponding genetic coefficient of variation (GCV) due to influence of environment on character expression. Heritability estimates were higher for all characters except number of days taken to maturity and number of grains per plant, which exhibited moderate heritability. Hundred seed weight, plant height, total plant weight and primary branches per plant would be the suitable selection criteria to accomplish better grain yield in chickpea.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) commonly known as gram belongs to the family leguminosae is a major pulse crop that contributes about 12 % of the world pulse production (Khan *et al*., 2011). It has the ability to fix the atmospheric nitrogen and improve soil fertility that ultimate lower the cost of production (Ali *et al.,* 2008). It is the third most important pulse crop after dry bean and peas with a wide distribution across the tropics, sub tropics and temperate regions (Singh, 1997). It is an important source of dietary protein of the pre-dominant population of Indian sub-continent (Viveros *et al*., 2001). The Asian region contributes 70% to the total world's chickpea production (Malik *et al*., 2010). In Pakistan, it is cultivated on 0.98 million hectares with production of 0.67 million tons (Anonymous, 2012-13).

For any breeding program the genetic variability play an important role as it provide opportunity to plant breeder for selection of high yielding genotypes. Meanwhile, the information of yield and its association with yield contributing parameter provide the basis for the effective selection of improved varieties (Saleem *et al.*, 2005). Information of the genetic variation with the help of suitable parameters such as genetic advance, heritability estimate and genetic coefficient of variation are the prime requirements of an effective breeding program. The concept of heritability determines the difference observed among the characters is due to environmental influence or a result of genetic makeup. Genetic advance gives an idea of possible improvement of new population through selection, when compared to the parent population. The genetic advance depends upon the amount of genetic variability and magnitude of the epistasis effect of the environment (Gul *et al*., 2013).

Some of the attributes are significantly associated among themselves and with grain yield. The analysis of relationships among these characters and their associations with grain yield is essential to establish selection criteria (Atta *et al*., 2008). Progress in any breeding program depends upon the nature and magnitude of variability present in the parent population. Assessment of the extent of genetic variability within chickpea is fundamental for chickpea breeding (Qureshi *et al*., 2004).

During chickpea breeding, the main consideration must be heritability along with genetic advance as alone is not a good indicator of the amount of desirable genetic variability (Noor *et al*., 2003). The information regarding genetic variability, heritability and association of various characters provide a basis to the plant breeders to breed the chickpea genotypes possessing higher yield potential. Selection based on grain yield a polygenic character, is usually not very efficient, but selection based on its component characters could be more efficient.

Grain yield is the main consideration and the most complex trait for breeder point of view as it dependent upon the interaction of genetic makeup of plant and environment. Apart from direct selection for grain yield, the objective of enhanced yield may, in most situations, be more effectively fulfilled on the basis of performance of yield and its components. These components may contribute directly or indirectly to the overall yield (Zeeshan *et al.,* 2013). . Path coefficient analysis is one of the reliable statistical techniques to quantify the interrelationships of different yield components (Mushtaq and Saleem, 2013). The present study was initiated with the prime objective of estimating mutual relationships among different quantitative traits and the type and extent of their contribution to ultimate seed yield.

MATERIALS AND METHODS

Twenty chickpea genotypes including four varieties obtained from different national institutions were planted in the randomized complete block design (RCBD) with three replications, in the experimental field of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, during 2013-14. Each genotype was planted in a separate plot which was consisted of three rows of four meter length, with a plant-to-plant and row-to-row distance of 10 and 30 cm, respectively. The plots were separated by a distance of 60 cm. Recommended cultural practices were carried out to maintain healthy crop growth (Reference??). Number of days to flowering at the time when at least 50% flowering was recorded for yield and its various yield contributing traits including, number of primary branches[-1], number of secondary branches[-1], plant height, number of days taken to maturity, number of pods plant [-1], total numbers of grain per

pods, total plant weight, Number of grains plant[-1], 100- seed weight and grain yield plant[-1]. The data were subjected to analysis of variance to test the level of significance among the genotypes for different characters under study (Steel and Torrie, 1980). Genetic parameters, genetic correlation coefficients were computed according to the methods followed by Singh and Chaudhary (1985). The significance of genotypic correlation coefficients was tested with the help of standard errors as suggested by Reeve and Rao (1981) whereas path coefficient analysis was conducted according to Dewey and Lu (1959).

RESULTS AND DISCUSSION

Genotypes differed for all the characters recorded, indicating a considerable range of genetic variability (Table 1). The maximum grain yield was recorded in the variety PB-2008, while the lowest yield was obtained from the genotype 3019. The phenotypic coefficient of variation (PCV) was invariably slightly higher than their corresponding genetic coefficients of variations (GCV) due to influence of environment on character expression (Table 2). Uddin *et al*. (1990), Noor *et al*. (2003), Arshad *et al*. (2004), Ozcelikand and Bozoglu (2004) and Idrees *et al*. (2006) have reported similar results in chickpea. Estimates of broad sense heritability varied from 0.945 in number of primary branches plant[-1] to 0.977 for 100 seed weight.

The genetic advance (5% selection intensity) was the highest for total plant weight (9.054), plant height (9.054), number of pods plant[-1] (6.414), 100 grain weight (2.941) and grain yield plant[-1] (2.908), while it was the lowest for number of grains plant[-1] (0.046) and number of secondary branches plant[-1] (0.211). It indicated that improvement could be achieved through simple selection from total plant weight, plant height and number of pods plant[-1]. Heritability alone is not useful but this statistic along with genetic advance is valuable (Yadav *et al*., 2003). For number of primary branches plant[-1], number of grains pods[-1] and number of secondary branches plant[-1], high heritability was associated with low genetic advance, indicating the influence of dominant and epistatic genes for these characters. High genetic advance of total plant weight and plant height coupled with high heritability, indicated that additive genes effect were important in determining these characters.

Table 1. Analysis of variance parameters for 20 genotypes of chickpea (*Cicer arietinum* L.)

Character	Mean ±SE	Range	CV (%)	h (%)	G.A.[*]
Number of days taken to flowering	111.62±9.71	113.3-124.7	1.53	76.12	2.232
Number of primary branches plant[-1]	2.894±0.045	3.384-2.299	7.35	94.45	0.694
Number of secondary branches plant[-1]	5.915±0.0535	5.43-640	3.90	65.82	0.211
Plant height (cm)	70.185±3.84	58.63-81.74	2.82	97.12	9.050
Number of days taken to maturity	154.891±2.75	160.72-166.01	1.04	49.0	0.922
Number of pods plant[-1]	5.915±9.740	50.50-69.60	5.10	88.02	6.414
Number of seed pods[-1]	1.631±0.007	1.527-1.727	5.21	48.50	0.047
Total plant weight (g)	69.808±3.841	39.14-57.70	2.81	97.11	9.054
Number of grain plant[-1]	112.040±36.5	91.90-123.1	5.39	86.19	0.047
100-grain weight (g)	19.691±0.313	16.87-25.13	2.83	97.74	2.941
Grain yield plant[-1] (g)	21.295±2.70	17.20-26.72	7.71	84.96	2.9080

Mean ±SE= Mean± Standard Error; CV (%) = coefficient of variability; h (%) = heritability in Broad sense; G.A.[*] = Genetic Advance (5% selection intensity)

Correlation coefficient and path analysis

The genotypic and phenotypic correlation coefficients revealed that the genotypic correlations were greater than phenotypic for most of the characters (Table 3). Grain yield plant[-1] was positive and significantly correlated with total plant weight, number of pods plant[-1], number of grains plant[-1] and 100 grain weight but it was negatively correlated with number of grains plant[-1]. The days taken to maturity show negative and highly significant correlation with grain yield plant[-1].

Table 2. Genetic parameters for various quantitative characters in 20 chickpea lines

Genotypes	DF	DM	PH	PB	SB	WP	PP	SP	GP	HGW	GY
Noor-2009	121.76	166.01	81.74	3.833	6.16	58.63	68.60	1.550	104.3	16.87	21.32
290	121.40	164.50	66.67	3.065	5.43	67.23	59.63	1.650	115.1	19.60	20.92
1276	120.16	164.34	72.03	2.631	5.80	62.90	57.10	1.727	123.1	18.30	18.26
6001	120.00	164.23	58.63	3.701	5.76	81.73	61.90	1.713	122.1	18.87	22.04
1017	119.16	164.00	67.24	2.963	6.10	68.67	69.60	1.653	115.4	18.13	21.96
PB-2000	118.83	163.80	67.47	2.765	5.83	72.03	61.53	1.633	114.3	21.00	21.95
210	118.73	163.83	65.23	3.232	5.80	67.47	56.07	1.623	112.3	20.50	19.83
1286	117.83	163.60	66.83	2.334	6.06	67.47	66.10	1.537	99.50	21.56	24.43
1288	117.66	163.50	78.50	3.232	6.40	76.57	65.93	1.607	109.0	19.97	23.47
3019	117.50	163.50	68.66	3.834	6.30	75.53	50.50	1.653	115.9	18.60	17.20
6060	117.43	163.33	69.01	2.400	5.53	65.23	64.23	1.690	120.6	17.60	19.34
CH-7	116.40	163.21	67.13	2.299	6.10	69.00	67.73	1.553	105.5	20.87	23.03
6009	116.26	162.71	80.74	2.400	5.61	60.87	57.30	1.550	99.97	18.83	19.96
220	116.00	162.30	60.87	3.466	5.56	78.87	61.70	1.710	91.90	17.00	21.40
214	115.83	162.15	65.72	2.503	6.13	66.83	61.30	1.650	121.4	18.27	21.32
114	115.83	161.60	76.59	2.431	5.60	80.74	54.47	1.713	115.0	17.80	17.27
1031	115.40	161.50	78.85	3.202	6.40	65.73	63.73	1.527	122.6	23.83	24.71
1159	115.33	161.30	65.85	2.931	6.23	53.80	53.80	1.640	97.23	20.63	19.48
7020	115.26	161.19	75.53	2.400	5.66	66.67	63.70	1.537	114.4	20.46	21.29
PB-2008	113.33	160.72	62.90	2.365	5.83	78.50	62.93	1.710	121.2	25.13	26.72
MS (V)	13.4 **	5.36 **	133.1 **	0.83 **	0.16 **	133.0 **	81.29 **	0.014 **	264.1 **	13.9 **	18.0 **
MS (R)	8.149	0.118	0.097	0.007	0.061	0.097	16.117	0.008	24.745	0.165	0.892
MS (E)	9.71	2.749	3.841	0.045	0.054	3.841	9.740	0.007	36.482	0.313	2.697

* = significance at 0.05 and ** = significant at 0.01 probability level, respectively.
DF= days to flowering; DM= days to maturity; PH= plant height; PB= primary branches; SB= secondary branches; WP= weight of plant; PP= pods plant[-1]; SP= seed plant[-1]; GP= grains plant[-1]; HGW= 100 grain weight; GY= grain yield plant[-1]

The estimation of contribution by the individual character in the grain yield, which showed that number of grains pods[-1] had maximum positive direct effect on grain yield plant[-1] followed by 100 grain weight, number of grain plant[-1], number of secondary branches, number of days taken to maturity, number of primary branches, number of days taken to flowering while characters like plant height and total plant weight had negative direct effects on grain yield.

An overall appraisal of the correlation matrix and path coefficient analysis reveals that number of grains plant[-1] and number of pods plant[-1] exerted great influence both directly and indirectly on grain yield. Correlation between numbers of grains plant[-1] and grain yield was greatly reduced owing to the indirect negative influence of number of pods plant[-1]. If maximum grain yield is to be obtained, a compromise is made during selection for these two traits and other traits have to give consideration. Suitable recombination might be obtained through biparental mating, mutation breeding or diallal selective mating to break undesirable linkage (Ghafoor *et al.*, 1990).

Table 3. Estimates of Genotypic (r_g) and Phenotypic (r_p) correlation coefficients of various character combinations

Character		NPB	NSB	PH	NDM	NPP	NSP	TPW	NGP	HGW	GYP
NDF	G	0.4868*	0.3283*	-0.3730	0.0995*	0.1731*	0.1344*	-0.3021	0.2020	-0.6019	-0.2720
	P	0.3277*	0.2902*	-0.2282	0.0812	0.1436	0.1052	-0.2714*	0.0228	-0.5099**	-0.2658*
NPB	G	-0.1674		0.4605	-0.0333	-0.0751	-0.1047	0.3265*	0.3136	0.1056	0.1024
	P	-0.1175		0.3440**	-0.0258	-0.0829	-0.0963	0.2981*	0.2364	0.0928	0.1012
NSB	G			-0.1672	0.3246*	0.0233	0.1104	0.5086*	-0.0834	0.4591*	0.3438
	P			-0.1082	0.2912*	0.0485	0.1016	0.3573**	-0.1044	0.3750**	0.2886*
PH	G				0.6960*	0.1141*	0.1185*	-0.3300	-0.1750	-0.1571	-0.1448
	P				0.4551**	0.0925	0.0930	-0.3181*	-0.1275	-0.1579	-0.1315
NDM	G					-0.0131	-0.1836	-0.8430	-1.0995	-0.6318**	-0.6188
	P					0.0125	-0.0601	-0.5451**	-0.5929**	-0.4515**	-0.3405**
NPP	G						0.9999*	0.1680*	-0.1792	0.1059*	0.7068*
	P						0.9762**	0.1929	-0.0774	0.1043	0.6859
NSP	G							0.2788*	-0.1117	0.1613*	0.7344*
	P							0.3073*	-0.0193	0.1541	0.7223**
TPW	G								0.8335*	0.5298*	0.55705*
	P								0.5179**	0.4939**	0.5640**
NGP	G									0.1371	-0.0318
	P									0.0712	0.0068
HGW	G										0.8075*
	P										0.7342**

*Significant (0.05 probability level); **Highly significant (0.01 probability level)
NDF= Number of Days to Flowering, NPB= Number of Primary Branches, NSB= Number of Secondary Branches, PH= Plant Height (cm), NDM= Number of days to maturity, NPP= Number of Pods plant[-1], NSP= Number of Seed pod[-1], TPW= Total Plant Weight (g), NGP= Number of Grains plant[-1], HGW=100-Grain Weight, GYP= Grain Yield plant[-1](g)

Table 4. Direct (bold) and indirect (not bold) effect of yield components in chickpea

Character	DF	DM	PH	PB	SB	WP	PP	SP	GP	100GW	GY
DF	**-0.0195**	0.0095	0.0794	0.0064	-0.0079	0.0059	0.0034	0.0039	0.0027	-0.0117	-0.2916
DM	0.0369	**-0.0759**	0.0528	-0.0127	-0.0127	-0.064	-0.0009	-0.0834	-0.0139	-0.0479	-0.6947
PH	-0.0204	-0.1428	**-0.2051**	0.0069	-0.0666	-0.068	-0.2341	0.0358	-0.0243	0.3223	0.0784
PB	0.01583	-0.008	-0.0016	**-0.0483**	0.0222	0.0158	-0.0036	0.0152	-0.005	0.005	0.0542
SB	-0.0318	-0.0142	0.0276	0.0392	**-0.0852**	0.0433	0.019	-0.0071	0.0094	0.039	0.2587
WP	0.02993	0.0836	0.0327	-0.0324	-0.0504	**-0.099**	-0.0167	-0.8257	-0.2762	-0.0525	0.6814
PP	0.07081	-0.0054	0.0467	-0.0308	0.0092	0.0687	**-0.0409**	-0.0732	0.409	0.0434	0.1042
SP	0.01784	-0.0971	-0.0155	0.0277	-0.0074	0.0737	-0.0159	**-0.8832**	-0.0099	0.0121	0.0519
GP	0.03686	-0.0503	0.0325	-0.0287	0.0303	0.0765	0.2743	-0.0606	**-0.2743**	0.0443	0.2256
100GW	-0.4476	-0.4698	-0.1169	0.0785	0.3414	0.3934	0.7878	0.0102	0.1199	**-0.7436**	0.744

DF= Days to Flowering; DM= Days to Maturity; PH= Plant Height; PB=Primary Branches; SB= Secondary Branches; WP= Weight of Plant; PP= Pods Plant[-1];
SP= Seed Plant[-1]; GP= Grains Plant[-1]; 100GW= 100 Grain Weight; GY= Grain Yield Plant[-1]

The results obtained from the above discussion suggested that plant height, total plant weight, primary branches plant^{-1} and 100- seed weight gave more yield when selection was based on these characters. Genetic potential of genotypes revealed highly significant differences for all the studied traits. Genotype 4009 and 1288 had maximum total plant weight. Genotype 1017 and variety Noor-2009 had maximum pods plant^{-1}. Genotype 1115, 210 and Variety PB-2008 had maximum 100-grains weight. These genotypes can safely be used in future chickpea breeding programs for further exploitation of their genetic variability.

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