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Amit Kumar
Department of Genetics and Plant Breeding, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Mukesh Kumar
Department of Genetics and Plant Breeding, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Pooran Chand
Department of Genetics and Plant Breeding, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

SK Singh
Department of Genetics and Plant Breeding, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Puspendra Kumar
Department of Agricultural Biotechnology, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

LK Gangwar
Department of Genetics and Plant Breeding, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Corresponding Author:
Amit Kumar
Department of Genetics and Plant Breeding, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Studies on genetic variability and inter relationship among yield and related traits of parents and F_1 population in Chickpea (*Cicer arietinum* L.)

Amit Kumar, Mukesh Kumar, Pooran Chand, SK Singh, Puspendra Kumar and LK Gangwar

Abstract
In the present investigation, crosses were made between 9 lines and 4 testers during Rabi, 2017-18 and sufficient F_1 seed was obtained for all the 36 crosses. All the 13 parents and their 36 F_1 were grown during Rabi 2018-19 in randomized block design (RBD) with three replications. Analysis of variance showed highly significant differences among all ten traits for days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, number of seeds per pod, biological yield per plant, grain yield per plant, harvest index, 100 grain weight, indicating the presence of considerable variability among the all traits. The PCV values were higher than GCV values for all the characters under study indicating more influence of environmental factors. However, narrow differences observed between the PCV and GCV in certain cases indicated that these characters were less influenced by the environment. Higher genotypic coefficient of variation was found for number of pods per plant and low genotypic coefficient of variation was found for days to 50% flowering, days to maturity and harvest index. Estimate of high (>60%) heritability (broad sense) was observed for the characters namely, days to 50 per cent flowering days to maturity, plant height, number of primary branches per plant, number of pods per plant, number of seeds per pod, biological yield per plant, grain yield per plant, and 100 grain weight. The characters namely plant height, number of primary branches per plant, number of pods per plant biological yield per plant, grain yield per plant, and 100 grain weight exhibited high heritability and high genetic advance. Grain yield per plant had a highly significant positive correlation with number of primary branches per plant, number of pods per plant, biological yield per plant, harvest index and 100 grain weight at both the genotypic and phenotypic level. The results showed that biological yield per plant had maximum direct effect followed by harvest index on grain yield along with highly significant correlation in desirable direction towards grain yield per plant.

Keywords: Genetic variability, Chickpea, *Cicer arietinum* L.

Introduction
Gram or Chickpea (*Cicer arietinum* L.), also called garbanzo bean or Bengal gram, a member of family Fabaceae, is a self pollinated leguminous crop, diploid (2n=16) annual grown in different area of the world but its cultivation is mainly concentrated in semiarid environments. The leading chickpea growing countries in the world are India, Pakistan, Mexico, Turkey, Ethiopia and Myanmar (Keneni *et al.*, 2011) [13]. Chickpea is the cheapest and readily available source of protein, fats and carbohydrates (Choudhary *et al.*, 2012) [7]. Pulses are the important source of protein in our country in vegetarian diet. Pulses, have the unique ability to fix atmospheric nitrogen and thus play a vital role in sustainable agriculture. Pulses are unique crops having in-built mechanism to trap atmospheric nitrogen in their root nodules and restore soil fertility. India is largest producer and consumer of chickpea in the world. In India, the area under chickpea was 10.76 million hectares with a production of 11.16 million tones and productivity of 1037 kg/ha during Rabi 2017-18 (Annon. 2018). Unfortunately, despite its nutritional values and economic importance, chickpea production is very low per hectare in the country. This is primarily due to poor genetic makeup of the available cultivars. Genetic variability is a prerequisite for any breeding program, which provides opportunity to a plant breeder for selection of high yielding genotypes. The expected improvement in yield components primarily depends on the nature and magnitude of heritable portion of total variation. Selection based on a single character may not always be effective. On the other hand, it is very cumbersome process for a breeder to consider a large number of component characters simultaneously in selection procedure. The presence of genetic variability is of utmost importance for any breeding programme and due to this reason the plant breeders have

emphasized the evaluation of germplasm for the improvement of crop yield as well as for utilization in further breeding programmes. The study of character is also essential for ascertaining their contribution towards yield. Direct and indirect effects of yield contributing characters on yield are also important in selecting high yielding genotypes. Path coefficient analysis is used to detect characters having direct and indirect effects on yield. Therefore, this study was undertaken to study the variability, heritability, genetic advance and assess the relationship of yield and different yield contributing characters of chickpea.

Materials and Methods

In the present investigation, crosses were made between 9 lines and 4 testers during Rabi, 2017-18 and sufficient F_1 seed was obtained for all the 36 crosses. All the 13 parents and their 36 F_1 were grown during Rabi 2018-19 in randomized block design (RBD) with three replications. Each 36 F_1s were planted in two meter long 2 row the parents were sown in three row. The rows were spaced 30cm apart and plant to plant was retained 10cm. Five competitive plants from each plot were randomly selected for recording observations for plant height (cm), number of primary branches per plant, number of pods per plant, number of seeds per pod, biological yield per plant (g), grain yield per plant (g), harvest index (%), 100 grain weight (g) except days to 50 per cent flowering and days to maturity, which were recorded on plot basis. Average data from the selected plants of each plot in respect of different characters were used for various statistical analyses. Analysis of variance for randomized block design (RBD) was done as per Panse and Sukhatme (1985) [3], phenotypic co-efficient of variation and genotypic co-efficient of variation was calculated as per the formula suggested by Burton (1952) [6] and heritability and genetic advance was estimated using the formula suggested by Allard (1960) [2]. Correlation coefficients were calculated as per the methods suggested by Searle, 1961 and path coefficient were worked out as per the method of Dewey and Lu (1959) [8].

Result and Discussion

Analysis of variance showed highly significant differences among all ten traits for days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of pods per plant, number of seeds per pod, biological yield per plant (g), grain yield per plant (g), harvest index (%), 100 grain weight (g), indicating the presence of considerable variability among the all traits (Table 1). The PCV values were higher than GCV values for all the characters under study indicating more influence of environmental factors (Table-2). However, narrow differences observed between the PCV and GCV in certain cases indicated that these characters were less influenced by the environment. Similar results were obtained by Saki *et al.*, (2009) and Shiv Kumar *et al.,* (2013) for seed yield and its components in chickpea. These findings, suggested that selection can be effective on the basis of phenotype along with equal probability of genotypic levels. Coefficients of variation of agronomic traits have been widely used to determine the variations available in the population. Moreover, the values of genotypic and phenotypic coefficient of variations, >20%, 10 to 20% and <10% are considered to be higher, intermediate and lower respectively (Getachew *et al*., 2015) [9]. The effectiveness of selection in any crop depends on the extent and nature of phenotypic and genotypic variability present in different agronomic traits found in the population (Arora, 1991; Keneni *et al.*, 2011) [13]. In this study, a higher genotypic coefficient of variation (22.75) was found for number of pods per plant and low genotypic coefficient of variation (2.37- 4.97) was found for days to 50% flowering, days to maturity and harvest index. High genotypic coefficient of variation indicated the availability of high genetic variation for selection and improvement; while the lower value indicated that selection is not effective for particular character because of the narrow genetic variability (Mullualem *et al.,* 2017; Shiferaw *et al.,* 2017) [17, 24].

Genotypic coefficient of variation gives an idea of the quantum of genetic variability in given traits and provides a means to compare the variability in different quantitative characters. But, the same time it is not possible to estimate heritable variation with the help of genetic coefficient of variation alone. That is why (Burton 1952) [6], advocated that the genetic coefficient of variation together with heritability estimate give a better picture of the amount of advance to be expected by selection. Thus, the knowledge of heritability of a character helps the plant breeders in predicting the genetic advance for any quantitative characters and aids in exercising necessary selection procedure. Estimate of high (>60%) heritability (broad sense) was observed for the characters namely, days to 50 per cent flowering (76.31) days to maturity (90.42), plant height (93.98), number of primary branches per plant (90.13), number of pods per plant (95.72), number of seeds per pod (78.23), biological yield per plant (87.40), grain yield per plant (80.17), and 100 grain weight (87.26) indicated that these characters would respond positively to selection because of their high heritability. Similar observations were also reported by Joshi and Bapu (2008) [12], Muhammad *et al.* (2013) [16], Singh *et al*. (2018) [26].

High (>20%) estimates of genetic advance expressed as per cent of mean have been recorded for plant height (21.45), number of primary branches per plant (33.40), number of pods per plant (44.45), biological yield per plant (23.99), grain yield per plant (27.40), and 100 grain weight (32.11) its, suggested that good response for selection based on per se performance. Where finding supported by similar noting of Vaghela *et al.* (2009) [9], Shweta *et al*. (2014) [25], Husssain *et al.* (2016) [11], and Manikanteswara *et al*. (2019) [15].

The characters namely plant height, number of primary branches per plant, number of pods per plant, biological yield per plant, grain yield per plant, and 100 grain weight exhibited high heritability and high genetic advance so it is considered under control of additive genes, which highlights the usefulness of plant selection based on phenotypic performance thus mass selection, will be most suitable for improvement of these traits. Moderate heritability accompanied with low genetic advance as percentage of mean observed for harvest index indicated that non-additive gene effect was important and mass selection on phenotypic value may not be much effective to improve this trait.

High heritability coupled with high genetic advance for these characters have also been reported earlier by Sharanappa *et al.* (2014) [22], Thakur *et al*. (2018) [29], Honnappa *et al*. (2018) [10], Mohan and Thiyagarajan (2019) and Pithiya and Javia (2019) [20].

Yield is a complex trait and controlled by polygene and very often influenced by environment. Therefore, phenotypic selection based only on yield is not effective. Correlation and path co-efficient helps the way to select plant for breeding purpose by the plant breeders. Genotypic and phenotypic correlation coefficients among ten characters are presented in

Table 3. The genotypic correlations were higher than phenotypic correlations for the studied traits. Grain yield per plant had a highly significant positive correlation with number of primary branches per plant, number of pods per plant, biological yield per plant, harvest index and 100 grain weight at both the genotypic and phenotypic level suggests the high degree of association between these traits and determine the component characters on which selection can be used for genetic improvement in yield. Such positive correlation seed yield and these attributes have also been reported in chickpea by Singh and Shiva Nath (2012) [14], Singh *et al.* (2014) [28], Shedge *et al.* (2019) [23] and Manikanteswara *et al*. (2019) [15].
The direct and indirect effects of yield contributing traits on seed yield were analyzed by path analysis. Seed yield per plant was considered as effect (dependent variable) while remaining traits were treated as causes (independent variables) and shown in Table 4. The results showed that biological yield per plant had maximum direct effect followed by harvest index on grain yield along with highly significant correlation in desirable direction towards grain yield per plant. Hance, obtained true and prefect relationship between grain yield. However, these characters indicated direct selection based in selecting the high yielding genotypes of chickpea. These results were also supported earlier by Padmavathi *et al.* (2013) [18], Bala *et al*. (2015) [5], Kumar *et al*. (2018) [14] and Manikanteswara *et al*. (2019) [19, 15].
The contribution of residual effects that influenced grain yield per plant was very low at both genetic and phenotypic levels, reflected that the traits in study were sufficient enough to account the variability in the dependent characters. These results were in agreement with the earlier findings of Joshi and Bapu (2008) [12], Akansha *et al.* (2016), Singh *et al.* (2018) [26] and Pithiya and Javia (2019) [20].

Table 1: Mean sum squares for parents and hybrids

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Plant Height (cm)	N/O primary branches per plant	N/O Pods per plant	n/o seeds per pod	Biological yield per plant (gm)	Seed yield per plant (gm)	Harvest index (%)	100 seeds weight (gm)
Replication	2	2.46	13.80	5.43	0.52	11.87	0.010	2.91	9.91	59.59	5.40
Treatment	48	16.56**	56.50**	86.57**	1.54**	245.69**	0.125**	96.91**	30.36**	26.49**	49.86**
Error	96	1.55	1.93	1.81	0.05	3.61	0.011	4.44	2.31	10.74	2.32

*, ** significant at 5% and 1% level, respectively

Table 2: Phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance as % of mean in Chickpea

Characters	Heritability (%)	Genetic Advance	GA as % means	GCV (%)	PCV (%)
Days to 50% flowering	76.31	4.03	4.27	2.37	2.72
Days to maturity	90.42	8.35	5.75	2.94	3.09
Plant Height (cm)	93.98	10.62	21.45	10.74	11.08
No primary branches per plant	90.13	1.38	33.40	17.08	17.99
No Pods per plant	95.72	18.10	44.85	22.25	22.75
No seeds per pod	78.23	0.36	19.23	10.55	11.93
Biological yield per plant (g)	87.40	10.69	23.99	12.46	13.33
Seed yield per plant (g)	80.17	5.64	27.40	14.86	16.59
Harvest index (%)	32.85	2.71	5.87	4.97	8.67
100 seeds weight (g)	87.26	7.66	32.11	16.69	17.86

Table 3: Estimates genotypic and phenotypic correlation coefficients for different characters in Chickpea

Characters		Days to 50% flowering	Days to maturity	Plant Height (cm)	No primary branches per plant	No of Pods per plant	No seeds per pod	Biological yield per plant (g)	Seed yield per plant (g)	Harvest index (%)	100 seeds weight (g)
Days to 50% flowering	G	1.000	0.691**	-0.003	-0.427**	-0.382**	-0.339**	-0.467**	-0.406**	-0.096	-0.041
	p	1.000	0.677**	0.006	-0.328**	-0.314**	-0.277**	-0.396**	-0.298**	0.001	-0.030
Days to maturity	G		1.000	-0.001	-0.333**	-0.204*	-0.503**	-0.245**	-0.292**	-0.294**	0.144
	p		1.0000	0.000	-0.297**	-0.189*	-0.435**	-0.240**	-0.241**	-0.118	0.144
Plant Height (cm)	G			1.000	-0.140	0.270**	-0.084	0.097	0.029	-0.125	-0.159
	p			1.0000	-0.118	0.276**	-0.040	0.110	0.056	-0.047	-0.144
No primary branches per plant	G				1.000	0.639**	0.099	0.734**	0.692**	0.260**	0.174*
	p				1.000	0.628**	0.114	0.680**	0.642**	0.196*	0.152
No Pods per plant	G					1.000	0.057	0.866**	0.834**	0.372**	0.264**
	p					1.000	0.077	0.821**	0.760**	0.217**	0.234**
No seeds per pod	G						1.000	0.039	0.133	0.341**	-0.017
	p						1.000	0.088	0.174*	0.212**	-0.041
Biological yield per plant (g)	G							1.000	0.945**	0.348**	0.366**
	p							1.000	0.844**	0.099	0.281**
Seed yield per plant (g)	G								1.00	0.632**	0.242**
	p								1.000	0.613**	0.191*
Harvest index (%)	G									1.000	-0.149
	p									1.000	-0.043
100 seeds weight (g)	G										1.000
	p										1.000

*, ** significant at 5% and 1% level, respectively

Table 4: Estimates of direct and indirect effect of different characters on grain yield per plant in Chickpea

Characters		Days to 50% flowering	Days to maturity	Plant Height (cm)	No primary branches per plant	No of Pods per plant	No seeds per pod	Biological yield per plant (g)	Harvest index (%)	100 seeds weight (g)	R with Seed yield per plant (g)
Days to 50% flowering	G	0.0153	0.0007	0.0000	0.0048	0.0128	0.0034	-0.4107	-0.0330	0.0008	-0.406**
	p	0.0135	0.0034	0.0000	-0.0001	0.0042	0.0014	-0.3216	0.0007	0.0004	-0.298**
Days to maturity	G	0.0106	0.0011	0.0000	0.0037	0.0068	0.0050	-0.2154	-0.1007	-0.0028	-0.292**
	p	0.0091	0.0050	0.0000	-0.0001	0.0025	0.0022	-0.1949	-0.0635	-0.0018	-0.241**
Plant Height (cm)	G	-0.0001	0.0000	-0.0098	0.0016	-0.0091	0.0008	0.0856	-0.0426	0.0031	0.029
	p	0.0001	0.0000	-0.0063	0.0000	-0.0037	0.0002	0.0893	-0.0251	0.0018	0.056
No primary branches per plant	G	-0.0065	-0.0004	0.0014	-0.0111	-0.0214	-0.0010	0.6457	0.0890	-0.0034	0.692**
	p	-0.0044	-0.0015	0.0007	0.0002	-0.0083	-0.0006	0.5527	0.1052	-0.0019	0.642**
No Pods per plant	G	-0.0059	-0.0002	-0.0027	-0.0071	-0.0335	-0.0006	0.7616	0.1274	-0.0051	0.834**
	p	-0.0042	-0.0010	-0.0017	0.0002	-0.0132	-0.0004	0.6668	0.1163	-0.0030	0.760**
No seeds per pod	G	-0.0052	-0.0005	0.0008	-0.0011	-0.0019	-0.0100	0.0339	0.1168	0.0003	0.133
	p	-0.0037	-0.0022	0.0003	0.0000	-0.0010	-0.0051	0.0713	0.1137	0.0005	0.174*
Biological yield per plant (g)	G	-0.0072	-0.0003	-0.0010	-0.0082	-0.0291	-0.0004	0.8794	0.1190	-0.0071	0.945**
	p	-0.0053	-0.0012	-0.0007	0.0002	-0.0109	-0.0005	0.8126	0.0530	-0.0036	0.844**
Harvest index (%)	G	-0.0015	-0.0003	0.0012	-0.0029	-0.0125	-0.0034	0.3057	0.3424	0.0029	0.632**
	p	0.0000	-0.0006	0.0003	0.0001	-0.0029	-0.0011	0.0803	0.5367	0.0005	0.613**
100 seeds weight (g)	G	-0.0006	0.0002	0.0016	-0.0019	-0.0089	0.0002	0.3218	-0.0512	-0.0193	0.242**
	p	-0.0004	0.0007	0.0009	0.0000	-0.0031	0.0002	0.2285	-0.0229	-0.0126	0.191*

*, ** significant at 5% and 1% level, respectively
Residual effects =0.00097 and 0.00401

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