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GENETIC VARIABILITY AND INTER-RELATIONSHIP STUDIES IN ADVANCED INTERSPECIFIC DERIVATIVES OF CHICKPEA

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ABSTRACT

The present study was undertaken to assess the variations and association among yield and its contributing traits in interspecific derivatives of chickpea. One hundred thirty chickpea interspecific derivatives of four wide crosses were evaluated for various agro-morphological traits. The analysis of variance revealed the presence of sufficient variability among the recombinant lines for all the traits studied. Genotypic and phenotypic coefficients of variation were found to be higher for seed yield per plant, 100-seed weight, plant height and pods per plant. Likewise, moderate PCV and GCV were observed for biological yield per plant and harvest index. Selection will be effective for traits such as plant height, 100-seed weight, biological yield per plant, number of pods per plant, seed yield per plant and harvest index as they showed high heritability along with high genetic advance. Correlation and path coefficient analysis revealed that higher seed yield per plant can be obtained by selecting derivatives with high biological yield per plant, number of pods per plant, 100-seed weight and harvest index. Overall interspecific recombinant lines *viz*; R-31 (Cross I - PUSA 372 X ILWC 229), R-12, R-27 and R-30 (Cross II - PBG 5 X ILWC 229), R-3 (Cross III -PBG 5 X ILWC 246) and R-6 (Cross IV - BGD 72 X ILWC 246) were found superior over the best check, Him Palam Chana 1 (DKG 986).

Keywords: Chickpea, Correlation, Heritability, Interspecific Derivatives, Variability

Chickpea (*Cicer arietinum* L.) is the third most important grain legume in the world and India is the largest producer of chickpea. The chickpea most probably originated from South-eastern Turkey and adjoining Syria (Auckland and Maesen, 1980). A narrow genetic base of cultivated chickpea has hindered the realization of high yields in chickpea breeding programmes. Furthermore, various abiotic and biotic stresses are the major bottlenecks for increasing chickpea productivity globally. Due to limited genetic variability within the primary gene pool, the genetic improvement of chickpea by classical breeding involving inter-varietal crosses has met with limited success and thus, the use of interspecific hybridization was advocated to broaden the genetic base of cultivated gene pool. Utilization of exotic germplasm in breeding programmes is needed to enhance the productivity and diversity of crop varieties. Crosses involving genetically diverse parents are likely to produce high variability in segregating generations. The related wild species i.e. *Cicer reticulatum* and *C. echinospermum* are of special significance because they grow vigorously and possess acceptable plant traits including resistance to biotic (*Ascochyta* blight and *Fusarium* wilt) and tolerance to abiotic (cold and drought) stresses. Both of these wild species are cross compatible with cultivated chickpea (Ladizinsky and Adler, 1976; Pundir and van der Maesen 1983). Genetic base of cultivated chickpea can be broadened by incorporating various traits from these two wild species (Singh *et al*., 2018). In present study, advanced derivatives of interspecific crosses of *Cicer arietinum* with *C. reticulatum* and *C. echinospermum* were evaluated for yield and its important component traits. The study of correlation is important to provide knowledge about the interrelationship of seed yield with other important characters, which can be selected to increase the yield. But it does not suggest the cause and effect relationship between two characters. So, path coefficient analysis was used for partitioning the correlation coefficients into direct and indirect effects to estimate the contribution of each character to yield. Therefore, an attempt was made to gather information on genetic variability and association among yield components so as to identify promising interspecific derivatives of chickpea.

MATERIALS AND METHODS

The present investigation was carried out at CSK HPKV, Research Sub Station, Berthin, Bilaspur, Himachal Pradesh during *rabi* season 2019-20. The experimental site was located at an elevation of about 625 m above mean sea level, representing the sub-mountain, low hill, sub-tropical zone of the state. The F_6 derivatives of *Cicer arietinum* with *C. reticulatum* (ILWC

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229) and *C. echinospermum* (ILWC 246) were evaluated along with 4 checks i.e. Him Palam Chana 1 (DKG 986), Himachal Chana 1 (HC 1), GPF 2 and Himachal Chana 2 (HC 2). A set of 130 chickpea interspecific derivatives of four crosses i.e. 50 of Cross I (PUSA 372 x ILWC 229), 46 of Cross II (PBG 5 x ILWC 229), 8 of Cross III (PBG 5 x ILWC 246) and 26 of Cross IV (BGD 72 x ILWC 246) were evaluated in the augmented block design. In each block 10 lines with 4 checks of 3 m length were sown at row to row and plant to plant spacing of 30cm and 10cm, respectively. Experiment was carried out following standard agronomic management practices recommended by the university. Phenotypic data on days to 50 per cent flowering and days to 75 per cent maturity was recorded on plot basis while plant height (cm), branches per plant, inter-node length (cm), biological yield per plant (g), number of pods per plant, number of seeds per pod, 100-seed weight (g), harvest index (%) and seed yield per plant (g) were collected as average of five randomly taken plants during the growth period and at maturity.

Statistical analysis for augmented block design was done as per Federer (1955). The genotypic and phenotypic coefficients of variation and heritability (broad sense) were calculated as suggested by Burton and Devane (1953). Correlation coefficient analysis was calculated as per Fisher and Yates (1963). Path analysis was done by following methods given by Al-Jibouri *et al.* (1958) and Dewey and Lu (1959).

RESULTS AND DISCUSSION

Genetic variability assessment

The analysis of variance revealed that mean sum of square due to block while ignoring the treatments was significant for all the traits except seeds per pod whereas when the treatments were eliminated the mean sum of squares was significant for inter-node length, pods per plant and harvest index (Table 1). The mean sum of square due to checks was significant for days to 50 per cent flowering, plant height and 100-seed weight. The mean sum of squares due to varieties/derivatives was significant for nine traits, except for number of branches per plant and seeds per pod; suggesting prevalence of wide range of genetic variability and adequate scope of selection. The mean sum of squares due to check v/s varieties was significant for majority of traits, except for harvest index which indicates that there was presence of significant variability between checks and lines. The mean sum of squares due to treatment (ignoring blocks) was significant for most of the traits, except for seeds per pod whereas sum of squares due to treatment (eliminating blocks) was significant for all the traits, except for number of branches per plant and seeds per pod. Genetic variability is prerequisite for a plant

Table 1. Analysis of variance for various characters in chickpea derivatives

Source of variation	d.f.	Days to 50 per cent flowering	Days to 75 per cent maturity	Plant height (cm)	Branches per plant	Inter-node length (cm)	Pods per plant	Seeds per pod	100-seed weight (g)	Seed yield per plant(g)	Biological yield per plant(g)	Harvest index(%)
Block (ignoring treatments)	12	38.82**	28.29**	521.36**	0.25*	1.12**	81.96**	0.06	15.52**	19.17**	27.58**	52.45**
Block (eliminating treatments)	12	1.25	3.29	3.74	0.08	1.05**	7.50**	0.04	9.95	1.29	3.46	9.94**
Treatment (ignoring blocks)	133	59.33**	36.38**	116.05**	0.15*	0.26**	46.77**	0.05	1.76*	14.61**	37.61**	17.04**
Treatment (eliminating blocks)	133	55.94**	34.13**	69.34**	0.14	0.26**	40.05**	0.05	16.29**	12.99**	35.44**	13.20**
Checks	3	16.28**	0.27	66.58**	0.06	0.10	5.22	0.05	3.22*	0.77	7.17	0.50
Varieties/derivatives	129	41.68**	26.48**	103.40**	0.13	0.22**	47.54**	0.05	1.80*	14.44**	36.00**	17.52**
Check v/s varieties	1	2464.70**	1422.40**	1895.70**	2.84**	6.29**	72.70**	0.25*	9.57**	78.10**	337.07**	4.84
Error	36	1.30	3.40	4.50	0.09	0.10	2.62	0.04	0.98	0.76	3.02	2.01

* Significant at $P \leq 0.05$ **Significant at $P \leq 0.01$

Table 2. Mean, range and variability parameters in chickpea derivatives

Trait	Mean	Range	PCV (%)	GCV (%)	h^2bs (%)	GA (% of mean)
Days to 50 per cent flowering	105.59	96.75-119.75	6.11	6.01	96.85	12.21
Days to 75 per cent maturity	158.93	149.94-171.44	3.23	3.02	87.15	5.82
Plant height (cm)	48.20	30.13-71.94	21.09	20.63	95.64	41.62
Branches per plant	3.02	1.98-4.29	12.28	6.59	28.79	7.29
Inter-node length (cm)	3.73	1.94-5.50	12.75	9.51	55.69	14.65
Pods per plant	33.68	25.10-55.10	20.46	19.89	94.46	39.89
Seeds per pod	1.66	1.14-2.14	13.99	7.47	28.50	8.22
100-seed weight (g)	18.19	11.08-31.25	23.35	22.71	94.57	45.57
Seed yield per plant (g)	13.62	9.18-25.50	27.89	27.14	94.70	54.49
Biological yield per plant (g)	35.86	27.82-56.62	16.72	16.01	91.60	31.61
Harvest index (%)	37.43	29.45 – 46.03	11.18	10.51	88.48	20.41

breeder to execute useful selection. The present studies revealed that sufficient genotypic differences existed for traits under study among the 130 chickpea derivatives. High amount of genetic variability for many traits including seed yield per plant has also been showed by various workers. Akhtar *et al.* (2011) observed significant differences among chickpea genotypes for all the traits under study. Zali *et al.* (2011) reported that by selecting an ideotype having higher number of pods per plant, number of seeds per plant and 100-seed weight, seed yield in chickpea can be increased. Nihal and Sait (2012) reported that traits such as plant height, biological yield per plant and pods per plant can be considered as important yield components in chickpea improvement.

The number of days to 50 per cent flowering of the lines ranged from 96.75 to 119.75 days with a general mean value 105.59 days (Table 2). About eighty nine lines had early flowering than the best check Him Palam Chana 1 (112.46 days). The number of days to 75 per cent maturity ranged from 149.94-171.44 days with a mean value 158.93 days. About ninety lines were early maturing than the best checks Him Palam Chana 1 (164.84 days) and HC 1 (164.84 days). The plant height varied from 30.13-71.94 cm with a mean value of 48.20 cm. The branches per plant varied from 1.98 to 4.29 with a mean value of 3.02. The inter-node length lies between 1.94-5.50 cm with a mean value 3.73 cm. Total numbers of pods per plant ranged from 25.10 to 55.10 with a mean value of 33.68. The 100-seed weight varied from 11.08-31.25 g with a mean value 18.19 g. Total seed yield per plant ranged from 9.18 g to 25.50 g with a mean value 13.62 g. Thirty six lines were found to have higher seed yield per plant than the best check Him Palam Chana 1 (12.41 g). The harvest index ranged from 29.45 to 46.03 with a mean value 37.43. The coefficients of phenotypic variability were higher in magnitude than the genotypic variability for all the characters assessed (Table 2). High phenotypic and genotypic coefficients of variation (PCV and GCV) were observed for plant height (21.09; 20.63), 100-seed weight (23.35; 22.71) and seed yield per plant (27.89; 27.14) indicating selection for these traits will be beneficial because of additive gene action. Moderate PCV and GCV were observed for biological yield per plant (16.72; 16.01) and harvest index (11.18; 10.51). Low PCV and GCV were observed for days to 50 per cent flowering (6.11; 6.01) and days to 75 per cent maturity (3.23; 3.02). High heritability coupled with high genetic advance was observed for plant height, 100-seed weight, biological yield per plant, number of pods per plant, seed yield per plant and harvest index indicating the presence of additive gene action and selection of these traits would be more effective. Moderate heritability and genetic advance were observed for inter-node length. Low heritability and genetic advance were observed for number of branches per plant and seeds per pod indicating the presence of non-additive gene action. Similar types of findings were also reported by Akhtar *et al*. (2011), Swetha and Lavanya (2019) and Kumar *et al.* (2020).

Mean performance of traits revealed that R-20 (19.20 g), R-25(18.40 g), R-31(17.60 g), R-43 (16.77 g) and R-7 (16.36 g) lines of cross I; R-36 (25.50 g), R-5 (24.73 g), R-27 (24.10 g), R-30 (22.59 g) and R-22(21.75 g) lines of cross II; R-3 (21.68g) and R-8 (19.33g) lines of cross III; and R-10 (22.36 g), R-26 (21.81g), R-6 (22.28 g), R-24 (19.49g) and R-1 (18.52 g) of cross IV showed highest seed yield per plant (Table 3). Two lines (R-20 and R-31) of cross I, eight lines (R-12, R-13, R-22, R-23, R-27, R-30, R-44 and R-45) of cross II, one line (R-3) of cross III and two lines (R-6 and R-26) of cross IV were found superior for most of the important traits i.e. days to 50 per cent flowering, days to 75 per cent maturity, pods per plant, 100-seed weight, biological yield per plant and seed yield per

Table 3. Promising derivatives on the basis of mean performance for yield and its contributing traits in chickpea

Character	Promising derivatives derived from different crosses				Total
	I	II	III	IV	
Days to 50 per cent flowering	R-13, R-17, R-4, R-18 and R-25	R-33, R-18, R-13, R-9 and R-30	R-8, R-4, R-7, R-1 and R-3	R-24, R-15, R-3, R-23 and R-1	89
Days to 75 per cent maturity	R-4, R-13, R-20, R-25 and R-31	R-27, R-9, R-14, R-18 and R-23	R-4, R- 8, R-7, R-3 and R-1	R-24, R-15, R-23, R-3 and R-1	90
Plant height (cm)	R-18, R-36, R-19, R-31 and R-39	R-20, R-44, R-45, R-31 and R-26	R-2, R-3 and R-8	R-3, R-4, R-1, R-6 and R-2	73
Branches per plant	-	-	-	R-16	1
Inter-node length (cm)	R-10 and R-1	-	-	-	2
Pods per plants	R-7, R-20, R-6 and R-31	R-5, R-27, R-36, R-22 and R-30	R-3	R-10, R-6, R-26, R-15 and R-11	26
Seeds per pod	R-20, R-31 and R-36	R-22, R-23, R-27, R-30 and R-12	R-3	R-23 and R-26	15
100-seed weight (g)	R-20, R-25 and R-31	R-36, R-27, R-5, R-30 and R-22	R-3 and R-8	R-10, R-6, R-26, R-24 and R-11	27
Seed yield per plant (g)	R-20, R-25, R-31, R-43 and R-7	R-36, R-5, R-27, R-30 and R-22	R-3 and R-8	R-10, R-26, R-6, R-24 and R-1	36
Biological yield per plant (g)	R-25, R-20, R-7, R-31 and R-43	R-36, R-5, R-27, R-30 and R-13	R-3 and R-8	R-6, R-10, R-26, R-24 and R-3	35
Harvest index (%)	R-20, R-43, R-23, R-25 and R-36	R-5, R-29, R-22, R-27 and R-30	R-3 and R-8	R-10, R-26, R-24, R-1 and R-6	27

Table 4. Estimates of correlation coefficients among different traits of chickpea derivatives

Trait	Inter-node length (cm)	Days to 50 per cent flowering	Days to 75 per cent maturity	Branches per plant	Plant height (cm)	Seeds per pod	Harvest index (%)	Pods per plant	100-seed weight (g)	Seed yield per plant (g)
Days to 50 per cent flowering	0.13									
Days to 75 per cent maturity	0.09	0.97**								
Branches per plant	-0.05	0.10	0.11							
Plant height (cm)	-0.20*	0.01	0.02	0.30**						
Seeds per pod	-0.08	-0.06	-0.06	0.01	0.05					
Harvest index (%)	-0.04	-0.11	-0.11	-0.01	-0.04	0.49**				
Pods per plant	-0.02	-0.15*	-0.15*	0.03	0.09	0.67**	0.73**			
100-seed weight (g)	-0.07	-0.17*	-0.16*	0.03	0.01	0.56**	0.86**	0.84**		
Seed yield per plant (g)	-0.09	-0.20*	-0.19*	0.01	0.01	0.53**	0.88**	0.85**	0.96**	
Biological yield per plant (g)	-0.10	-0.23**	-0.21*	0.01	0.02	0.52**	0.78**	0.84**	0.93**	0.98**

* Significant at P≤0.05 **Significant at P≤0.01

plant over the best checks (Him Palam Chana 1 and HC 1). These chickpea derivatives will be evaluated in multi location trials for identification of best line for possible release as a variety in the state.

Correlation and path analysis

Correlation studies indicated that seed yield per plant had shown positive and significant association with biological yield per plant (0.98**), seeds per pod

Table 5. Estimates of direct (diagonal) and indirect effects on seed yield of chickpea derivatives

Trait	Days to 50 per cent flowering	Days to 75 per cent maturity	Plant height (cm)	Branch-es/ plant	Inter-node length (cm)	Pods/ plant	Seeds/ pod	100-seed weight (g)	Biologi-cal yield/ plant (g)	Harvest index (%)	Correlation with seed yield/ plant (g)
Days to 50 per cent flowering	**0.0849**	-0.0803	0.0000	0.0001	-0.0011	-0.0024	0.0012	-0.0171	-0.1568	-0.0285	-0.2*
Days to 75 per cent maturity	0.0824	**-0.0827**	0.0001	0.0001	-0.0008	-0.0024	0.0012	-0.0161	-0.1431	-0.0285	-0.19*
Plant height (cm)	0.0008	-0.0017	**0.0040**	0.0004	0.0017	0.0015	-0.0010	0.0010	0.0136	-0.0104	0.01
Branches per plant	0.0085	-0.0091	0.0012	**0.0013**	0.0004	0.0005	0.0000	0.0030	0.0068	-0.0026	0.01
Inter-node length (cm)	0.0110	-0.0074	-0.0008	-0.0001	**-0.0084**	-0.0003	0.0016	-0.0071	-0.0682	-0.0104	-0.09
Pods per plant	-0.0127	0.0124	0.0004	0.0000	0.0002	**0.0163**	-0.0132	0.0847	0.5726	0.1894	0.85**
Seeds per pod	-0.0051	0.0050	0.0002	0.0000	0.0007	0.0109	**-0.0197**	0.0565	0.3545	0.1271	0.53**
100.seed weight (g)	-0.0144	0.0132	0.0000	0.0000	0.0006	0.0137	-0.0110	**0.1008**	0.6339	0.2231	0.96**
Biological yield per plant (g)	-0.0195	0.0174	0.0001	0.0000	0.0008	0.0137	-0.0102	0.0938	**0.6817**	0.2024	0.98**
Harvest index (%)	-0.0093	0.0091	-0.0002	0.0000	0.0003	0.0119	-0.0097	0.0867	0.5317	**0.2794**	0.89**

Residual effect: 0.0039

(0.53**), number of pods per plant (0.85**), 100-seed weight (0.96**) and harvest index (0.88**) (Table 4). However, it had negative and significant association with days to 50 per cent flowering (-0.20*) and days to 75 per cent maturity (-0.19*). This indicated that higher seed yield per plant can be obtained by selecting lines with high biological yield per plant, seeds per pod, number of pods per plant, 100-seed weight and harvest index. Srivastava *et al*. (2017) also revealed significant and positive correlation of seed yield per plant with biological yield per plant and harvest index. Similarly, Varshini *et al.* (2019) observed highly significant and positive correlation of number of pods per plant and seed yield per plant and significant positive correlation of field emergence and number of branches per plant with seed yield per plot indicating that improvement of any of these traits could lead to an increase in seed yield.

Path coefficient analysis revealed that the highest direct positive effect on seed yield per plant was exerted by biological yield per plant (0.6817) and also its indirect effects on seed yield per plant were positive through harvest index (0.2024), 100-seed weight (0.0938), days to 75 per cent maturity (0.0174) and pods per plant (0.0137) (Table 5). The biological yield showed strong direct effect because of its strong positive correlation with seed yield (0.98). The second highest direct effect on seed yield was shown by harvest index (0.2794) and it also showed positive indirect effects through biological yield per plant (0.5317), 100-seed weight (0.0867), pods per plant (0.0119) and days to 75 per cent maturity (0.0091). After biological yield per plant and harvest index, the positive direct effects on seed yield were shown by 100-seed weight (0.1008) and days to 50 per cent flowering (0.0849). The highest direct negative effect was contributed by days to 75 per cent maturity (-0.0827), number of seeds per pod (-0.0197) and inter-node length (-0.0084). Magnitude of residual effect (0.0039) is found to be low indicating that the unexplained variance and measurement error is negligible that means the variability has been explained properly on the basis of traits studied in the present study. Bhanu *et al.* (2017) revealed that seed yield was positively and significantly associated with the number of primary branches, secondary branches and pods per plant. Both correlation and path analysis revealed that pods per plant and number of secondary branches were the major direct contributors towards seed yield. Gaur *et al.* (2014) revealed that the maximum direct effect on seed yield was showed by number of branches per plant and 100-seed weight. Nitesh *et al.* (2018) reported that seed yield per plant showed significant positive correlation with plant height, number of secondary branches, number of pods per plant, biomass yield and 100-seed weight. Path analysis indicated that highest positive direct effect was shown by number of pods per plant followed by 100-seed weight, biomass yield and number of seeds per pod.

To conclude, prevalence of wide range of genetic variability for all the traits except seeds per pod was observed suggesting adequate scope of selection. Based on high heritability coupled with high genetic advance and path analysis, the traits like plant height, pods per plant, 100-seed weight, seed yield per plant, branches per plant, biological yield per plant and harvest index should be considered during selection. Promising identified chickpea derivatives for all traits further will be evaluated in multi location trials for identification of best line for possible release as a variety in the state.

Authors' contribution

Conceptualization and designing of the research work (GK, VKS); Execution of field/lab experiments and data collection (AKB, MS, GK); Analysis of data and interpretation (AKB, GK, VKS); Preparation of manuscript (AKB, GK, VKS, MS).

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