Short Communications

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Generation mean analysis and genetic parameters for yield and contributing traits in chickpea (*Cicer arietinum*)*

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The productivity of chickpea (*Cicer arietinum* L.) is apparently low in most of its growing areas mainly because it is cultivated in marginal and neglected areas with less care, crop itself is less input responsive and is highly sensitive to biotic and abiotic stresses. These challenges can be effectively answered by developing new and superior varieties with high yield and quality suitable for diverse environmental conditions. Since, yield and contributing traits are highly influenced by environment, the effects of genotypic factors on yield and related traits in plant breeding research need to be examined. To formulate a proficient breeding programme and for developing high-yielding varieties, it is essential to understand the genetics of the yield and related traits. Genetic parameters, viz mode and magnitude of gene effects, heritability, genetic advance under selection helps the researchers in adopting the suitable breeding procedure and appropriate time (early generation or advance generation) to apply the selection for the improvement of different traits related to yield. Yield is a dependent trait, several independent and inter-dependant contributing traits with different degree and direction are associated with it. The correlation studies between yield and contributing traits will be helpful in sorting out most associated contributing traits to yield. The objective of present investigation was genetic analysis of yield and related traits using generation mean analysis, narrow sense heritability and genetic advance under selection as per cent of mean. To find out the most yield-contributing traits correlation coefficient studies were also carried out for some metric traits.

The investigation was carried out at CCSHAU, Hisar during *rabi* (winter) season of 2004–05, 2005–06 and 2006–07. The experimental material was developed during 2004–05 and 2005–06. In the first year crosses were attempted between HC 5 × H 00 256, HC 5 × HC 3 and HC 1 × H 00 256. These F_1's along with the four parents were again raised during *rabi* 2005–06, to obtain F_2 generation and simultaneously these F_1's were back crossed also with their parents to get backcross generations. The experimental material comprises six generations, viz P_1, P_2, F_1, F_2, B_1 and B_2 for each cross was raised in a randomized block design with three replications during *rabi* 2006–07. The parents, F_1s, and backcrosses were sown in single rows with 30 × 10 cm^2 spacing in three meter long rows, while the F_2s were sown in five rows. The recommended agronomic package of practice was followed to raise the crop. The observations were recorded on seven metric traits, viz (i) primary branches/plant, (ii) secondary branches/plant, (iii) effective pods/plant, (iv) plant height (cm), (v) grains/pod, (vi) grain yield/plant and (vii) 100 grain weight (g). Replication-wise 20 plants from non-segregating generations (parents and F_1s), 70 plants from F_2 were randomly selected for data recording, whereas in both backcross generations observations were recorded from all the plants.

Generations mean analysis for metric traits and yield was performed following Mather and Jink 1971 and joint scaling test following Cavalli 1952. Standard procedures were followed to work out correlations, heritability and genetic advance.

A considerable extent of variation was exhibited in the mean values among parents and their different generations for various traits depicting sufficient genetic variation in the material. The parents significantly differed for all the traits. The F_1s of all the crosses showed intermediate expression for primary branches/plant, grains/pod, 100- grain weight and plant height indicating presence of both additive and non-additive gene effects.

The F_1s showed over dominance for pods/plant and

*Short note

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grain yield/plant (all crosses) and for secondary branches/plant (cross HC 5 × HC 3 and HC 1 × H 00 256). Inbreeding depression was noticed in all the crosses for secondary branches/plant, number of pods/plant, grain yield /plant and for primary branches/plant in cross HC 5 × HC 3. Over dominance and inbreeding depression are indicative of non-additive type of gene effects. On the contrary, the mean F_2 value for plant height was higher over F_1 mean for all the crosses; however there was considerable variation in the height of F_2 populations of all the crosses. The over performance of F_2 may be due to transgressive segregants.

The three parameter joint scaling test of Cavalli (1952) revealed a good fit of non-epistatic (additive-dominance) model (Table 1) for primary branches/plant (HC 5 × H 00 256), secondary branches per plant (HC 1 × H 00 256), effective pods/plant (HC 5 × HC 3) and grains/pod (HC 5 × H 00 256 and HC 5 × HC 3). It is obvious from these results that additive effect is significant except for secondary branches/plant (HC 1 × H 00 256) and these traits can be improved through simple selection.

The additive gene effects were significant for all the traits irrespective of the crosses except for secondary branches/plant and plant height (HC 1 × H 00 256), where it was insignificant. Similarly, the dominance gene effects were also significant for most of the traits in all the three crosses except for primary branches/plant (HC 5 × H 00 256) and grain yield/plant (HC 5 × H 00 256 and HC 5 × HC 3). The additive × additive (i) type of epistatis was also significant for most of the traits in all the crosses. Similarly (j) and (l) type of interaction effects were significant for primary branches/plant [(l) type, HC 1× H 00 256], grain yield/plant [both (j) and (l) type in HC 5 × H 00 256), (l) type in HC 1 × H 00 256], 100 grain weight (both type in all the crosses) and plant height [(j) type in HC 1 × H 00 256, (l) type (all the crosses)]. Farshadfar *et al.* (2008) and Girase and Deshmokh (2000) also reported the additive and non-additive effects for different traits they studied in chickpea. In our study the magnitude of dominance component was higher than the

Table 1 Estimation of gene effects of generation means on six parameter model for yield-related traits in chickpea

Cross	Genetic parameter						Epistatis	Jst χ^2 Value
	m	(d)	(h)	(i)	(j)	(l)		(3 parameter)
Primary branches/plant								
HC 5 × H 00 256	2.54*	0.69*	0.88					9.69
HC 5 × HC 3	2.31*	0.76*	3.78*	2.97*	1.90	–3.31		19.17*
HC 1 × H 00 256	3.02*	0.87*	3.32*	3.14*	1.07	–4.06*	D	24.61*
Secondary branches/plant								
HC 5 × H 00 256	5.54*	1.86*	10.81*	8.75*	–0.60	–7.81		26.98*
HC 5 × HC 3	4.91*	1.38*	13.13*	10.10*	–1.23	–11.27		34.97*
HC 1 × H 00 256	7.24*	0.05	3.33*					7.13
Effective pods/plant								
HC 5 × H 00 256	23.67*	12.68*	39.92*	23.47*	–20.04	–20.34		15.69*
HC 5 × HC 3	16.13*	6.25*	24.71*					7.0
HC 1 × H 00 256	21.48*	8.55*	45.69*	34.94*	–1.04	–45.78		13.03*
Grains/pods								
HC 5 × H 00 256	1.19*	0.97*	–0.04					0.73
HC 5 × HC 3	1.15*	0.73*	–0.02					1.16
HC 1 × H 00 256	1.13*	0.51*	0.66*	0.59*	–0.19	–0.27		31.52*
Yield /plant(g)								
HC 5 × H 00 256	3.31*	4.47*	6.21*	3.21	–6.97*	–4.12*	D	20.41*
HC 5 × HC 3	2.58*	1.58*	4.10*	2.19*	–1.76	–1.67		13.85*
HC 1 × H 00 256	3.19*	1.97*	8.31*	7.72*	–1.47	–15.01*	D	13.07*
100-grain weight(g)								
HC 5 × H 00 256	14.87*	2.05*	–6.95*	–2.24	7.68*	12.41*	D	75.02*
HC 5 × HC 3	17.31*	2.02*	–20.28*	–15.68*	11.41*	46.62*	D	303.94*
HC 1 × H 00 256	14.38*	1.32*	–9.74*	–7.90*	6.79*	19.58*	D	52.7*
Plant height(cm)								
HC 5 × H 00 256	58.24*	–0.76*	–65.33*	–64.50*	–0.93	119.03*	D	171.70*
HC 5 × HC 3	57.06*	–0.03	–5.08*	–6.53*	–4.20	8.70*	D	14.22*
HC 1 × H 00 256	50.32*	–2.22*	–42.07*	–36.84*	14.98*	58.41*	D	90.63*

where m, (d), (h) are mean, additive and dominance effects, while (i), (j) and (l) are additive × additive, additive × dominance and dominance × dominance effects respectively. Jst = joint scaling test additive, indicated that selection would be more effective if it might be practised in later generations.

Duplicate type of epistasis was noticed for 100- grain weight (all the crosses), plant height (all the crosses), grain yield/plant (HC 5 × H 00 256 and HC 1 × H 00 256) and for primary branches/plant (HC 1 × H 00 256). Farshadfar *et al.* (2008) also reported duplicate type of epistasis for number of pods/plant and number of grains/plant. This type of epistasis, which is unpredictable in nature, complicates selection programmes aimed for genetic improvement of a character because under such situation it would be difficult for the breeder to identify promising segregants. Growing large populations in segregating generations and adopting biparental matings in the early segregating generation to get transgressive segregants would be a right approach to exploit the non-additive genetic variation present in the genetic material.

The narrow sense heritability is the ratio of additive genetic variance to the total phenotypic variance. As it is indicative of the fixable component of total genetic variation, its higher values would be a sign of the improvement of the traits through simple selection. Primary branches/plant (15.44%) in cross HC 5 × H 00 256, grains/pod (17.86%) in cross HC 5 × HC 3, grain yield/plant (19.85%) in cross HC 1 × H 00 256 and 100- grain weight (17.29%) in cross HC 5 × HC 3 expressed low (<20%) narrow sense heritability. The rest of the traits indicated moderate narrow sense heritability (20–50%). Similarly Muhammad Arshad *et al.* (2003) Cobos *et al.* (2007) (grain yield), Derya *et al.* (2006) (grain yield, primary branches, secondary branches and pods/plant) and Farshadfar *et al.* 2008 (pods/plant) also observed low heritability while on contrary Gumber *et al.* 2003 reported high heritability. In our experiment the low and moderate values of heritability indicated that the non-additive and environmental effects were more prominent in the expression of traits and selection should be delayed for some generations, when the additive component of genetic variation get increased at the cost of non-additive components of genetic variations.

Genetic advance which refers to the improvement in the mean genotypic value of selected individuals over the parental population is influenced by genetic variability, heritability and selection intensity. The genetic advance as per cent of mean was moderate (14–40%) for all the traits in cross HC 1 × H 00 256. Since heritability was also moderate for this cross and the rate of genetic advance is connected with heritability, direct selection would be effective, but if it is delayed for one or two generations that would be much better option because non-additive and environmental components of variation are still higher at this stage. Primary branches/plant (24.74% and 33.45% respectively in cross

Table 2 Estimates of correlation coefficients between grain yield/plant and contributing traits in chickpea

Trait	1	2	3	4	5	6	7
HC 5 × H 00 256							
Primary branches	1	0.19*	0.29*	0.28*	0.62*	–0.11*	0.18*
Secondary branches		1	0.19*	–0.09	0.56*	0.89*	0.26*
Pods/plant			1	0.09	0.04	–0.04	0.48*
Grains/pod				1	–0.02	–0.11	0.38*
100-grain weight					1	0.12*	0.14*
Plant height						1	–0.04
Grain yield/plant							1
HC 5 × HC 3							
Primary branches	1	0.44*	0.15*	0.22*	–0.23*	–0.17*	0.16*
Secondary branches		1	0.65*	0.10	–0.20*	0.05	0.30*
Pods/plant			1	-0.04	–0.13*	0.24*	0.34*
Grains/pod				1	–0.12*	0.09	0.09
100-grain weight					1	0.14*	0.25*
Plant height						1	-0.10
Grain yield/plant							1
HC 1 × H 00 256							
Primary branches	1	0.12	0.33*	0.17*	0.12*	–0.18*	0.32*
Secondary branches		1	0.43*	–0.48*	0.59*	0.97*	0.43*
Pods/plant			1	0.09	–0.20*	0.06	0.35*
Grains/pod				1	–0.11*	–0.53*	–0.14*
100-grain weight					1	0.38*	–0.19*
Plant height						1	0.19*
Grain yield/plant							1

*Significant at 5%

HC 5 × H 00 256 and HC 5 × HC 3) and secondary branches/ plant (25.44% and 25.07% respectively in cross HC 5 × H 00 256 and HC 5 × HC 3), grains/pod (22.41%, 18.58% and 20.93% respectively in crosses HC 5 × H 00 256, HC 5 × HC 3 and HC 1 × H 00 256) and grain yield/plant (18.69%, 15.19% and 17.72% respectively in crosses HC 5 × H 00 256, HC 5 × HC 3 and HC 1 × H 00 256) expressed moderate genetic advance. Findings of Farshadfar *et al.* (2008) for grain yield/plant were also in confirmatory to our result. The least genetic advance was observed for 100- grain weight (9.19%) and for plant height (9.57%) in cross HC 5 × HC 3. The genetic advance as percent of mean, for effective pods/ plant (11.0%), 100 grain weight (12.3%) and plant height (12.4%) was low in cross HC 5 × H 00 256. So it would be a better option to practice the selection for these traits in advance generations (F_3/F_4).

The primary branches, secondary branches and pods/ plant expressed significant positive relation with yield (all crosses). Several workers studied the correlation coefficients between yield and contributing traits in chickpea, most of them observed positive and significant correlation between grain yield/plant and pods/plant (Derya *et al.* 2006, Sagir *et al.* 2004) grain yield and plant height (Derya *et al.* 2006), grain yield and secondary branches (Derya *et al.* 2006,) and grain yield and 100- grain weight (Derya *et al.* 2006, Muhammad Arshad *et al*. 2003). We also found the similar results (Table 2) with few exceptions and slight cross to cross deviations, viz insignificant correlation of yield with plant height (HC 5 × H 00 256 and HC 5 × HC 3), grains/pod (HC 5 × HC 3) and negative correlations with yield of grains/pod and 100-grain weight. Since most of associations between grain yield and contributing traits are significant, indirect selection for yield can be done in early segregating generations.

SUMMARY

The genetics of yield and related traits in three chickpea crosses HC 5 × H 00 256, HC 5 × HC 3 and HC 1 × H 00 256 were studied using generation mean analysis. Over dominance was observed for pods and grain yield/plant (all crosses) and secondary branches/plant (HC 5 × HC 3 and HC 1 × H 00 256). Inbreeding depression was noticed in all the crosses for secondary branches/plant, number of pods/ plant and grain yield /plant. Both additive and dominance gene effects were significant for most of the traits, but the magnitude of later was high. The additive × additive interaction effects for most of the traits in all the crosses were also significant. Duplicate type of epistasis was noticed for 100- grain weight and plant height (all the crosses), grain yield/plant (HC 5 × H 00 256 and HC 1 × H 00 256) and primary branches/plant (HC 1 × H 00 256). The narrow sense heritability was low (<20%) to moderate (20–50%). Genetic advance as percent of mean was moderate (15–40%) for most of the traits except pods/plant (HC 5 × H 00 256), 100- grain weight and plant height (HC 5 × H 00 256 and HC 5 × HC 3), where it was low (<15%). Correlation between yield and primary branches, secondary branches and pods/plant was positive and significant, irrespective of the crosses.

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