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HETEROSIS AND HERITABILITY STUDIES FOR SUPERIOR SEGREGANTS SELECTION IN CHICKPEA

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Abstract

Nine F_1 hybrids of chickpea and their parents were evaluated in randomized complete block design to estimate heterosis and heritability of grain yield and yield components. Significant differences among genotypes were found in grain yield and seven yield components. The magnitude of heterosis varied significantly between hybrids. Heterosis over mid parent in primary and secondary branches ranged from 12.31% to 56.82% and from 11.19% to 93.03%, respectively. Heterotic effects for 100 seed weight, grain yield per plant and biological yield per plant respectively varied from 18.78% to 32.96%, 4.05% to128.49% and 9.25% to 116.82%. Balkasar x C-235 exhibited maximum heterosis and heterobeltiosis for primary branches, secondary branches, grain yield plant^{-1} and biological yield plant^{-1}, whereas, Punjab-1xILC482 expressed maximum heterosis (103.97%) and heterobeltiosis (75.80%) for number of pods plant^{-1}. Broad sense heritability for different traits ranged from 45.23% to 85.76%. Maximum heritability was recorded for number of seed per pod and 100 seed weight. High heterosis with moderate heritability and high genetic advance obtained for number of pods plant^{-1} provide opportunity for identification of superior segregates from Punjab-1xILC482, C-235xBittal-98 and BalkasarxC-235.

Introduction

Chickpea (C*icer arietinum* L.) is the third most important food legume crop worldwide. India and Pakistan are the major countries for its area and production. It has an important role in agriculture economy of rain-fed areas of Pakistan where chickpea is planted on one million hectares approximately with fluctuating grain yield 388kg-794ha^{-1}. Chickpea is consumed as green vegetable, split and roasted grains (Wahid & Ahmed, 1999) and in confectionaries. Although it has paramount importance in our daily diet yet its production does not meet the demand of the population. The reason of its low production is the precarious weather conditions which pose a-biotic and biotic stresses on chickpea crop. Abiotic stresses are drought and low/high temperature while biotic stresses include diseases, insects and weeds. One of the effective and practical methods to cope with these stresses is to create genetic variability for identification of germplasm possessing tolerance/resistance against these stresses. In this context exploitation of hybrid vigour for tolerance/ adaptation could play a pivotal role.

Breeders have been utilizing the available genetic resources to modify the varieties to meet the ever changing requirements. In this regard the most important development in plant breeding of recent times is the extensive use of heterosis (Malik *et al.,* 1987). However in self pollinated crop the heterosis can not be exploited directly, hybrid vigor is used to identify superior hybrids as they offer more probability of developing better segregants (Sharif *et al.,* 2001 and Sagar & Chandra, 1977). In chickpea beneficial heterosis for grain filling period, seeds per plant and grain yield were reported by several research workers (Hedge *et al.,* 2002, Jena & Arora, 2002; Gupta *et al.,* 2003). The knowledge of heritability and genetic advance help to identify characters with potential improvement and to decide upon the selection pressure in breeding material (Hamid & Cheema, 1997). High genetic advance coupled with high heritability offer most effective conditions for selection in chickpea (Misra, 1991; Parshuram *et al.,* 2003; Anbessa *et al.,* 2006).

The present study was designed to estimate the degree of hybrid vigor, extent of heritability and genetic advance in F_1 hybrids. The information obtained could be used to select superior segregants from better hybrids for stress resistance, better adaptability and productivity.

Material and Methods

Nine F_1 hybrids and their parents constituted the experimental material of this study. These hybrids were developed by pulses program at NARC, Islamabad in 2003. The hybridization between pure lines was performed under field conditions following emasculation and pollination simultaneously in morning. The list of F_1 hybrid and their parents is given below:

Parents: Balkasar, Bittal -98, C-235, Dasht, Punjab-1 and ILC-482

F_1 hybrids: C-235xBalkasar, C-235xBittal-98, C235xDasht, BalkasarxC-235, Balkasarx Punjab-1, Punjab-1xBalkasar, Punjab-1xILC-482, DashtxC-235 and Bittal-98xDasht.

The seeds of parents and F_1 progenies were sown in 1.5 m long single rows using randomized complete block design (RCBD) with three replications. Rows were spaced 30 cm apart and plant to plant distance was maintained at 10 cm. Five plants from parents and F_1 hybrids were randomly selected from each replication to record data on number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, plant height, 100-seed weight, seed yield plant^{-1} and biological yield plant^{-1}. The data were statistically analyzed (Steel & Torrie 1980) to determine the significance of difference between genotypes for parameters under consideration. Heterosis was calculated by following formulae:

$$\text{Heterosis} = \frac{F_1\text{-mid parent value}}{\text{Mid parent value}} \text{ X } 100$$

$$\text{Heterobeltiosis} = \frac{F_1\text{-better parent value}}{\text{Better parent value}} \text{ X } 100$$

Heritability and genetic advance were computed by following formulae:

Heritability (Broad sense) = $h^2 = Vg/Vp$
Genetic Advance= h^2. $\delta p.k$
h^2 = heritability estimate
δp = standard deviation of phenotypic variance
k = selection differential (20%=1.40)

Results and Discussion

Heterosis studies: The hybrid with high heterotic effects may offer better chances of identification of desirable pure lines in the following advance generations as compared to hybrid with low heterosis. The results of present study revealed significant differences among various hybrids and their parents (Table 1). The mean values indicated in the table showed that the primary branches plant^{-1} in parental genotypes ranged from 3.94-6.05 as compared to3.81-6.75 in hybrids. The number of secondary branches plant^{-1} in parents and hybrids varied from 12.55-22.48 and 15.51-29.66 respectively. The number of pods plant^{-1} in parental genotypes varied from 72.73 to 128.90 and in hybrids from 106.80 to 244.0. Maximum primary branches plant^{-1} (6.72) and secondary branches plant^{-1} (29.66) were produced by Balkasar x C-235. Maximum pods plant^{-1} in parental genotypes were observed in C-235 (145.30) and among hybrids maximum pods plant^{-1}were produced by C-235 x Bittal-98 (244). Number of seed pod^{-1} ranged from 1.77 to 1.92. Hundred seed weight differed significantly both among parents and hybrids. C-235 exhibited 12.75g as compared to 31.26g in Bittal-98. Similarly, 100-seed weight in hybrids ranged from 14.75 to 28.83. The grain yield plant^{-1} in parental genotypes varied from 27.24g (Punjab-1) to 46.53g (Bittal -98) on the other hand the grain yield plant^{-1} in hybrids ranged from 37.06 to 75.54g. The total biological yield differed from 75g in C-235xBittal-98 to 139.20g in Balkasar x C-235 hybrids.

The heterosis and heterobeltiosis estimates (Table 2) indicated both negative and positive heterosis for all the traits in different cross combination. The heterotic effects in Table 2 indicated that seven out of nine F_1 hybrids showed increase in number of primary branches plant^{-1} over their mid parental values and their positive heterosis ranged from 3.61% (C-235xBalkasar) to 56.82% (BalkasarxC-235). As for as heterobeltiosis was concerned 5 out of 9 F_1 hybrids exhibited positive values ranging from 11.84% (Bittal-98xDasht) to 47.10% (Punjab-1xBalkasar). Positive heterosis for primary branches plant^{-1} has already been reported in chickpea by Singh *et al*., (1973) and Jeena & Arora (2000). The cross BalkasarxC-235 showed 93.04% positive heterosis for the number of secondary branches plant^{-1}. Another hybrid Punjab-1xBalkasar exhibited 68.97% increase over mid parental value for this character. Negative heterosis for this trait was observed in C-235xBittal-98. Maximum heterobeltiosis was shown by cross BalkasarxC-235 (63.24%) while minimum by Bittal-98xDasht (0.24%). These results are in confirmation with the results of Kamatar *et al*., (1996). Heterotic effects for number of pods plant^{-1} over their respective mid and better parents are presented in Table 2. All the hybrids exhibited positive heterosis ranging from 8.33% (C-235xDasht) to 103.97% (Punjab-1xILC-482). Heterobeltiosis estimates for this trait varied from 14.54% (Punjab-1xBalkasar) to 75.80% (Punjab-1xILC-482). Two crosses C-235xBalkasar and C-235xDasht showed negative heterobeltiosis. A perusal of Table 2 indicated that the positive heterotic effects for number of seed plant^{-1} were not much pronounced. Maximum increase of 23.64% was shown by the cross Punjab-1xILC-482 and minimum of 2.60 % by the cross Punjab-1xBalkasar. Most of the hybrids showed heterobeltiosis and it ranged from 0.59% to 8.47%. Manifestation of heterosis over mid parental value was observed in 4 out of 9 crosses for plant height. Only one cross Bittal-98xDasht excelled the better parent value by 2.06%. Similar results were reported by Ghafoor *et al*., (1990) and Jha *et al*., (1996) in mungbean and chickpea. Two hybrids BalkasarxC-235 (16.07%) and BittalxDasht (18.78%) exhibited positive heterosis in 100seed weight. All the crosses showed negative heterobeltiosis for this trait. The similar findings in chickpea were reported by Ghafoor *et al*., (1990) and Sharif *et al*., (2001).

Table 1. Mean values and mean squares from analysis of variance of six parents and nine F_1 hybrids for yield and yield components in chickpea.

Parents and crosses	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	Plant height (cm)	100-seed weight (g)	Seed yield plant^{-1} (g)	Biological yield plant^{-1} (g)
Balkasar	3.94	12.55	72.73	1.77	74.30	28.50	33.13	65.40
Bittal-98	4.07	16.75	121.50	1.23	70.54	31.26	46.53	102.30
C-235	4.63	18.18	145.30	1.76	56.63	12.75	32.99	63.00
Dasht	4.01	13.73	78.82	1.77	77.18	28.20	38.24	82.52
Punjab-1	4.14	16.72	93.28	1.69	59.38	17.28	27.24	68.92
ILC-482	6.05	22.48	128.90	1.06	70.49	30.92	40.93	81.44
C-235xBalkasar	4.44	21.39	130.20	1.88	58.61	17.92	44.96	91.28
C-235xBittal-98	3.81	15.51	244.00	1.76	54.17	14.75	60.43	75.00
C-235xDasht	4.25	19.78	121.40	1.92	55.11	16.06	37.06	79.28
BalkasarxC-235	6.72	29.66	181.40	1.70	72.92	23.94	75.54	139.20
BalkasarxPunjab-1	4.88	21.23	123.60	1.85	69.75	21.78	49.88	111.40
Punjab-1xBalkasar	6.08	24.73	106.80	1.77	69.93	22.54	42.70	107.60
Punjab-1xILC-482	5.69	26.30	226.60	1.70	64.88	19.08	73.63	124.90
DashtxC-235	5.79	24.65	176.40	1.76	66.00	18.47	49.08	119.90
Bittal-98xDasht	4.63	16.79	162.60	1.56	71.82	28.83	72.31	104.40
MS (V)	2.660*	72.125*	7415.527**	0.165**	169.668**	113.537**	716.922**	1643.795**
MS (R)	0.068	22.528	4194.342	0.014	55.958	8.988	157.819	197.126
MS (E)	0.765	18.545	2092.491	0.011	24.715	5.955	175.564	383.748

* and ** = Significant at 0.05 and 0.01 percent probability level, respectively.

Table 2. Estimates of heterosis and heterobeltiosis of nine F_1 hybrids for various quantitative traits in chickpea.

Crosses	Number of primary branches $plant^{-1}$		Number of secondary branches $plant^{-1}$		Number of pods $plant^{-1}$		Number of seeds pod^{-1}	
	Heterosis % age	Hetero-beltiosis % age	Heterosis % age	Hetero-beltiosis % age	Heterosis % age	Hetero-beltiosis % age	Heterosis % age	Hetero-beltiosis % age
C-235xBalkasar	+3.61	-4.10	+39.21	+17.72	+19.43	-10.38	+9.62	+6.21
C-235xBittal-98	-12.31	-17.71	-11.19	-14.94	+82.90	+68.01	+21.37	0.00
C-235xDasht	-1.51	-8.20	+23.97	+8.86	+8.33	-16.43	+11.63	+8.47
BalkasarxC-235	+56.82	+45.14	+93.04	+63.24	+66.39	+24.88	-0.87	-3.95
BalkasarxPunjab-1	+20.69	+17.87	+45.06	+26.97	+48.90	+32.53	+6.6	+4.52
Punjab-1xBalkasar	+50.68	+47.10	+68.97	+47.90	+28.66	+14.54	+2.60	0.00
Punjab-1xILC-482	+11.70	-5.95	+34.18	+16.99	+103.97	+75.80	+23.64	+0.59
DashtxC-235	+34.18	+20.05	+54.49	+35.66	+57.41	+21.42	+1.74	-0.56
Bittal-98xDasht	+12.82	+11.84	+0.33	+0.24	+51.41	+33.78	+6.85	-11.86

Table 2. (Cont'd.).

Crosses	Plant height (cm)		100-seed weight (g)		Seed yield $plant^{-1}$ (g)		Biological yield $plant^{-1}$ (g)	
	Heterosis % age	Hetero-beltiosis % age	Heterosis % age	Hetero-beltiosis % age	Heterosis % age	Hetero-beltiosis % age	Heterosis % age	Hetero-beltiosis % age
C-235xBalkasar	-10.47	-21.11	-13.11	-37.12	+35.99	+35.70	+42.18	+39.57
C-235xBittal-98	-14.80	-23.21	-32.96	-52.81	+51.96	+29.87	-9.25	-26.69
C-235xDasht	-17.63	-28.60	-21.56	-43.05	+4.05	-1.52	+10.48	-1.54
BalkasarxC-235	+11.38	-1.86	+16.07	-16.00	+128.49	+128.01	+116.82	+112.92
BalkasarxPunjab-1	+4.35	-6.12	-4.84	-23.58	+65.24	+50.56	+65.87	+61.64
Punjab-1xBalkasar	+4.62	-5.88	-1.53	-20.91	+41.46	+43.98	+60.21	+56.08
Punjab-1xILC-482	-0.08	-7.96	-20.82	-38.29	+116.02	+79.89	+66.13	+53.42
DashtxC-235	-1.35	-14.48	-9.79	-34.50	+37.80	+28.35	+67.08	+48.93
Bittal-98xDasht	+10.56	+2.16	+18.78	-7.77	+96.01	+55.40	+21.94	+2.00

Table 3. Estimates of heritability and genetic advance for eight yield traits in chickpea.

Parameters	h^2 (B.S) %age	G.A
Number of primary branches plant^{-1}	45.23	0.75
Number of secondary branches plant^{-1}	49.06	4.14
Number of pods plant^{-1}	45.89	39.95
Number of seeds pod^{-1}	82.35	0.29
Plant height (cm)	66.16	7.92
100-seed weight (g)	85.76	7.76
Seed yield plant^{-1} (g)	50.69	13.39
Biological yield plant^{-1} (g)	52.26	20.74

The estimates of percent heterosis and heterobeltiosis for grain yield plant^{-1} revealed that all the hybrids showed hybrid vigour over mid parental values and 8 out of 9 hybrids surpassed their respective better parental value. Maximum positive heterosis and heterobeltiosis was observed in cross Balkasarx C-235 (128.49% and 128.01% respectively). In case of biological yield plant^{-1} the percentage increase over mid parental values ranged from 10.48% (C-235xDasht) to 116.82% (BalkasarxC-235). Out of 9 F_1 hybrids 7 showed higher biological yield than their respective better parents and it ranged from 2.0% (Bittal-98xDasht) to 112.92% (Balkasarx C-235). Heterosis in chickpea for grain yield and biological yield has already been reported by Sharif *et al*., (2001), Kamatar *et al*., (1996), Hedge *et al*., (2002), Gupta *et al*., (2003) and Singh *et al*., (2000).

Sagar & Chandra (1977) suggested that the manifestation of heterosis in legumes may be utilized for the selection of potential crosses for their genetic improvement. This is because of high probability of having efficient segregants from better combinations than that from poor hybrids. The results of present study revealed that hybrids involving Balkasar, ILC-482 and Punjab-1 as one of the parents performed better in the cross combinations. The F_1 hybrids Balkasarx C-235, Punjab-1xILC-482, Punjab-1xBalkasar and Balkasarx Punjab-1 showed promising heterotic effects for number of secondary branches plant^{-1}, number of pods plant^{-1} grain yield plant^{-1} and biological yield plant^{-1}. Therefore chances of having good segregants from these hybrids are higher. The same four hybrids may be advanced and utilized for single plant selection. Generally, the trend of heterosis recorded in the present study is in agreement with those reported previously (Hedge *et al*., 2002, Jena & Arora, 2002 and Gupta *et al*., 2003).

Heritability studies: Estimates of heritability and genetic advance presented in Table 3 indicated low genetic advance for all the traits except for number of pods per plant. Broad sense heritability varied from 45% in primary branches to 85% in 100-seed weight. Number of seed pod^{-1} also exhibited high heritability coupled with low genetic advance indicating non additive type of gene effects of this trait. Seed yield and biological yield had moderate heritability estimates with corresponding genetic advance. Low heritability with high genetic advance was observed in number of pods plant^{-1} whereas primary and secondary branches plant^{-1} showed low heritability with low genetic advance, indicating greater environmental influence on these traits leading to limited scope of improvement for them.

Since heritability is a portion of variability that is heritable, simultaneous consideration of heterosis and heritability may provide clue for the utilization of current hybrids for selection of superior segregants for yield improvement (Parshuram *et al*., 2003; Anbessa *et al*., 2006).

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