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EVALUATION AND UTILIZATION OF HIGH YIELDING HYBRIDS OF CHICKPEA

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ABSTRACT

Twenty five chickpea (*Cicer arietinum*) hybrids, derived from crosses of five lines and five testers, along with their F_2 and parents were used to estimate heterosis, inbreeding depression and combining ability. Based on per se performance, results of the top five high yielding hybrids have been highlighted. Manifestation of heterosis was maximum for seed yield and minimum for 100-seed weight. High heterosis for a trait was generally accompanied by significant inbreeding depression. The sca variance estimates were greater than those for gca for yield and its components, except 100-seed weight, where contribution of gca was greater. Poor combiners also could give rise to heterotic hybrids in our material. Based on these results, it is suggested that heterotic response, level of inbreeding depression and gca effects of the parents, considered together, can help in identifying the crosses that are ultimately likely to yield better performing pure lines by applying appropriate breeding methods.

Key words: *Cicer arietinum*, chickpea, inbreeding depression, combining ability.

In autogamous crops like chickpea, recombination breeding has been extensively used to create new reservoirs of genotypic variations which serve as building blocks for exploitation in a breeding programme. A dynamic breeding programme involving parents with diverse genetic backgrounds requires thorough evaluation of the material so as to identify the potentially productive crosses. Many reports have appeared on heterosis for yield and its components in chickpea [1]. However, in order to identify potential crosses for further exploitation it is imperative to have prior information about heterosis and inbreeding depression, and the nicking ability of the parents involved. The present study is an attempt in this direction.

MATERIALS AND METHODS

Five dwarf lines of chickpea (Pusa 212, Pusa 408, GG 588, P 436–2 and P 4353–1), selected on the basis of desirable agronomic characters, were crossed with five tall male parents (BG 257, Pusa 261, BG 268, BG 274 and BG 276) derived from crosses between Indian and Russian cultivars. Ten parents and 25 each of F_1

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and F_2 were raised in completely randomised blocks with three replications, each with one row of each parent and F_1 and eight rows of each F_2. The row length was 4 m with row-to-row and plant-to-plant distance of 60 cm and 20 cm, respectively. Five competitive plants per plot in each parent and F_1 and 20 plants in each F_2 were scored for seeds/pod, pods/plant, 100-seed weight (g) and seed yield/plant (g).

Heterosis was calculated as percentage deviation from mean value of F_1 over midparent (MP) and better parent (BP) values. Inbreeding depression was calculated as per cent depression from F_1 mean to F_2 means.

RESULTS

As seen from the range of midparent (MP) and better parent (BP) heterosis, the magnitude of positive heterosis was always higher than negative heterosis for all the characters studied (Table 1). Average heterosis was maximum for seed yield and minimum for 100-seed weight. The highest (16) and the lowest (8) numbers of crosses showing higher than the average BP heterosis were observed for 100-seed weight and seeds/pod, respectively.

Table 1. Heterotic response for yield and its components in twenty-five chickpea hybrids

Heterotic response	Characters			
	seeds/pod	pods/plant	100-seed weight	yield/plant
MP : range	−10.1−25.3	−32.1−76.9	−16.9−6.4	−22.0−85.3
mean	5.7	14.9	−0.9	21.8
BP : range	−11.6−20.5	−42.0−50.6	−33.9−(−6.4)	−26.2−56.5
mean	−1.4	−0.8	−14.1	10.2
No. of crosses with MP heterosis above average	13	12	12	8
No. of crosses with BP heterosis above average	8	13	16	11

Table 2 shows the per se performance of the five top yielding hybrids in respect of yield and its components. Hybrid P 436-2 × BG 274 was the highest yielder, followed by Pusa 408 × BG 274, Pusa 212 × BG 276, Pusa 408 × Pusa 261, and P 436–2 × BG 257. The yield of these five hybrids ranged from 85.3% to 15.9% higher than the MP values and the increases were statistically significant in three hybrids (Table 3).

However, BP heterosis for yield was significant only in two of the hybrids, viz. P 436–2 × BG 274 and Pusa 408 × BG 274, which also exhibited significant positive inbreeding depression. In these two hybrids, heterotic for yield, significant and positive MP heterosis as well as inbreeding depression were also noted for pods/plant. In the third heterotic cross for yield (Pusa 212 × BG 276), depression

Table 2. Per se performance of top high yielding hybrids for yield and its components

Cross	Character values			
	seeds/pod	pods/plant	100-seed weight (g)	yield/plant (g)
P 436-2 × BG 274	1.59	253.0	18.14	64.5
Pusa 408 × BG 274	1.48	274.7	15.37	62.9
Pusa 212 × BG 276	1.65	198.7	17.96	61.0
Pusa 408 × Pusa 261	1.71	238.7	13.51	55.6
P 436-2 × BG 257	1.49	232.7	16.40	53.4

from F_1 mean to F_2 mean was nonsignificant. For 100-seed weight, none of the five top yielding hybrids displayed significant heterosis as compared to both the parents, though significant inbreeding depression was observed in crosses Pusa 408 × BG 274 and Pusa 212 × BG 276. Two crosses, P 436–2 × BG 274 and Pusa 408 × Pusa 261, showing significant positive MP heterosis for seeds per pod, exhibited nonsignificant inbreeding depression.

The analysis of combining ability showed that mean squares due to lines and testers were significant only for 100-seed weight (Table 4). Mean squares due to line × tester interactions were significant for seeds/pod, 100-seed weight and yield. None of the lines or testers showed significant gca effects for yield and pods/plant. For 100-seed weight, line P 436–2 and testers BG 274 and BG 276 showed significant positive gca effects.

DISCUSSION

The data presented in this paper provide information on the evaluation of chickpea hybrids and their parents through the estimates of heterosis and inbreeding depression and combining ability analysis. Twenty-five hybrids originating from crosses between five lines and five testers were analysed for yield and its components. However, exploitation of heterosis for extracting high yielding pure lines is considered meaningless unless per se performance of hybrids is also taken into account. Accordingly, detailed analysis of the five top yielding hybrids is presented to obtain an insight into the nature of heterosis, inbreeding depression and gene action.

Heterosis was observed for yield and all its components studied. Though 33–66% of the hybrids had mean values higher than the average BP heterosis for any one trait, the differences between character means of the hybrids and better parents were significant only in a few cases. Only three of the five top yielding hybrids showed significant positive MP heterosis for grain yield and two of these crosses (P 436–2 × BG 274 and Pusa 408 × BG 274) were significantly superior to the better parents also. Further, the heterotic hybrids for grain yield did not show significant heterosis for all yield components. In fact, appreciable heterosis for one or two components was sufficient to register heterosis for grain yield.

Table 3. Heterosis (%) over midparent (MP), better parent (BP), inbreeding depression (ID), and parental gca combinations (P) for yield and its components in five top yielding hybrids

Character		Values in different crosses				
		P 436-2 × BG 274	Pusa 408 × BG 274	Pusa 212 × BG 276	Pusa 408 × Pusa 261	P 436-2 × BG 257
Seeds/pod:	MP	25.3**	8.0	9.3	14.8**	0.7
	BP	20.4**	−3.3	−4.1	11.8	−8.6
	ID	5.7	−6.1	10.4*	8.2	0.0
	P	Low × low	Low × low	Low × low	Low × low	Low × low
Pods/plant:	MP	76.9**	43.2*	22.1	10.7	27.3
	BP	50.6*	3.0	5.9	−10.5	17.7
	ID	37.6**	26.2**	−11.1	3.4	17.6
	P	Low × low	Low × low	Low × low	Low × low	Low × low
100-seed weight:	MP	−7.9	−1.4	4.2	4.6	−3.8
	BP	−10.5	−24.1	−16.3	−8.2	−14.2
	ID	−3.3	22.1**	16.4**	3.5	−7.6
	P	High × high	Low × high	Low × high	Low × low	High × low
Yield/plant:	MP	85.3**	78.3**	67.3**	43.1	15.9
	BP	52.7*	45.7*	43.3	28.6	7.1
	ID	32.9*	39.0**	15.4	18.5	5.7
	P	Low × low	Low × low	Low × low	Low × low	Low × low

*, **Significant at 5% and 1% levels, respectively.

Heterosis in F_1 and inbreeding depression in F_2 considered together can give some idea about the genetic control of a character, and thus help in isolating high yielding pure lines from the promising crosses.

High heterosis for grain yield and pods/plant coupled with significant inbreeding depression, observed in crosses P 436–2 × BG 274 and Pusa 408 × BG 274, may be largely due to dominance and epistatic interactions involving dominance. Isolation of true breeding lines as good as or better than heterotic hybrid may be a difficult proposition in such crosses unless special breeding methods like recurrent selection, diallel selective mating etc. are employed. Parallel relationship between heterosis and inbreeding depression [2–4] suggests the importance of nonadditive gene action in this crop. Midparent heterosis without inbreeding depression for grain yield and a fair amount of heterosis for pods/plant (though nonsignificant) in cross Pusa 212 × BG 276 imply that mostly additive and additive × additive interactions may be

Table 4. ANOVA of combining ability (mean squares) for yield and its components in chickpea

Source	d.f.	Characters			
		seeds per pod	pods per plant	100-seed weight	yield per plant
Lines	4	0.022	1880	30.8**	156.3
Testers	4	0.022	3190	35.9**	158.5
Lines × testers	16	0.024*	4940	2.3**	285.3**
Error	48	0.014	3560	0.9	184.0

*, **Significant at 5% and 1% levels, respectively.

involved in this case. Such crosses have the potential to throw desirable transgressants in the segregating generations which the breeder can handle through pedigree breeding method. In the crosses Pusa 408 × Pusa 261 and P 436–2 × BG 257, F_1 values did not deviate significantly from both the parents for any of the characters except seeds/pod in the former cross where MP heterosis was observed. Also, no depression from F_1 to F_2 generation was noticed. Lack of both heterosis and inbreeding depression in these crosses which were selected on the basis of high mean performance, suggests the presence of favourable genes with additive effects. Breeding procedures that lead to the development of homozygous varieties should prove productive in such cases.

The unusual situation of nonsignificant heterosis coupled with significant inbreeding depression in a few cases could have arisen due to sampling error.

Estimates of sca variances were higher than the corresponding estimates of gca for seed yield and its components, except for 100-seed weight where additive component was greater. Depending on the gca effects of parents for a particular character, they are categorised as high (good) or low (poor) combiners, and their hybrids classified into three possible combinations of gca effects, i.e., high × high, high × low or low × high, and low × low. Interestingly, all the top five high yielding hybrids belong to low × low combination in respect of seeds/pod, pods/plant and seed yield. Evidently, low × low combination was not a barrier for recovering heterotic crosses. Such heterotic hybrids arising from poor combining parents in chickpea are not unusual [4, 5]. In case of 100-seed weight, three hybrids with high × low or low × high combinations were observed, which indicates that recovery of desirable transgressive segregates is a practical possibility if additive effects of one parent complement the epistatic effects of the other.

REFERENCES

1. A. K. Mandal and P. N. Bahl. 1983. Exploitation of heterosis in chickpea. Problems and potential—a review. Agric. Rev., 4: 29–33.

2. B. A. Kunadia and D. P. Singh. 1981. Combining ability in *kabuli* gram (*Cicer arietinum* L.). Intern. Chickpea Newsl., **4:** 6–7.

3. R. B. Deshmukh and D. G. Bhapkar. 1982. Heterosis and inbreeding depression in chickpea. Indian J. Genet., **42:** 208–212.

4. M. A. K. Mian. 1985. Heterosis, Inbreeding Depression and Combining Ability Analysis in Chickpea (*Cicer arietinum* L.). Ph.D. Thesis. I.A.R.I., New Delhi.

5. P. M. Salimath and P. N. Bahl. 1985. Heterosis and combining ability for earliness in chickpea. Indian J. Genet., **45:** 97–100.