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STUDY OF HETEROSIS USING DIALLEL ANALYSIS FOR YIELD AND ITS COMPONENT TRAITS IN CHICKPEA

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ABSTRACT

Forty five hybrids of chickpea along with their ten parental lines in diallel fashion excluding reciprocal were studied to assess the extent of heterobeltiosis and standard heterosis over standard check i.e. GJG-3 for yield and its component traits. Heterosis in grain yield per plant was reflected through heterosis in number of branches per plant, number of pods per plant, number of seeds per pod and 100-seed weight. The hybrid IC-269269 X IC-269272 expressed the highest heterobeltiosis for grain yield per plant followed by IC-269277 X Dahod yellow and IC-269273 X GG-1. Similarly, heterosis over standard parent (GJG-3) was manifested by two crosses IC-269269 X IC-269272 and IC-269277 X Dahod yellow for grain yield per plant. Based on *per se* performance, heterosis and diallel analysis,the cross combinations IC-269269 X IC-269272, Dahod yellow X GJG-3, IC-269273 X GG-1, IC-269273 X IC-269310 and IC-269277 X Dahod yellow were found promising for their utilization in chickpea breeding.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most important food legume crop worldwide,covering 73.7 lakh hectares with a total production of 58.9 lakh tonnes and productivity of 799.19 kg/ha (FAOSTAT, 2012). It is a good source of essential amino acids, but is limited in the sulfur containing amino acids methionine (1.3-1.6 %) and cysteine (2.5-3.0 %). Chickpeas complement cereals, which are deficient in the amino acid lysine, thus providing balanced nutrition when the two are consumed together (Woods *et al*., 2007). Now a day, because of yield potential of improved varieties is not sufficient to attract the farmers as well as consumers due to smaller grain size, low yield potential and susceptibility to various biotic stresses, plant breeders have to hit out the superior crosses by utilization of heterosis (Srivastava and Singh, 2013). It is vital to measure the extent of genetic dissimilarity among the parental lines involved in hybridization programmes for exploitation of heterotic vigour because high genetic dissimilarity among parents exhibits utmost heterotic response (Moll and Stuber, 1976).

The heterosis phenomenon gets immense value due to vigorous performance of F1 hybrids over its parents and standard check variety (Kumar et al., 2013). In many cross pollinated species like maize, cotton, onion, alfalfa and some vegetables, heterosis has been successfully commercially exploited (Singh et al., 2010). It has been mandatory to exploit heterosis in self pollinated crops like pulses for enhancing productivity. In pulses, a number of researchers has reported and exploited heterosis appreciably for various characters including yield contributing traits (Gupta *et al.*, 2003; Hedge *et al.,* 2007 and Adeyanju, 2009). The main objective of heterosis in the present study was to know the genetic make-up of parents and to create variability through segregation and recombination in advanced generations of the crosses. Heterosis for yield related traits was reported in many legumes (Singh, 1993). In practical plant breeding, the heterosis measured over better parent and standard parent or popular cultivar is more realistic and is of more practical importance.

MATERIALS AND METHODS

The experiment was conducted at Center of Excellance for Research on Pulses (CERP) Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during rabi season 2012-13. Ten genotypes (IC-269268,IC-269269, IC-269272, IC-269273, IC-269277, IC269295, IC269310, Dahod yellow, GG-1 and GJG-3) of chickpea were chosen. Such genotypes were crossed in 10 x 10 half diallel mating design excluding reciprocals. The choice of the genotypes was based on their differences for many agronomic characters.

The complete set of 55 genotypes comprising ten parental genotypes and 45 F_1's were evaluated in Randomized Block Design with three replication during rabi season, 2013-14. Each plot consists of double row of three meter length. The inter row and intra row spacing was 45 and 10 cm, respectively. The observations were recorded from randomly selected five competitive individual plants *viz.,* plant height (cm), number of branches per plant, number of pods per plant, number of seeds per pod, grain yield per plant (g), 100-seed weight (g), harvest index (%) and protein content (%). The heterosis over better parent was estimated following Fonseca and Patterson (1968).

RESULTS AND DISCUSSION

Heterosis, a fundamental tool, used for the improvement of

Table 1: ANOVA for yield and its ten component traits in Chickpea

Source	d. f.	Days to flowering	Daysto maturity	Plant height	Number of Branches	Number of Podsper plant	Number of seeds per pod	Grain yield per plant	100-seed weight	Harvest index	Protein content
Replications	2	27.87	17.47	13.55	0.11	701.50	0.014	5.56	0.45	7.76	0.11
Genotypes	54	118.68**	236.54**	119.16**	2.51**	20729.27**	0.61**	285.41**	39.81**	557.92**	4.58**
Parents	9	188.31**	1001.51**	99.12**	5.19**	19929.16**	0.33**	430.40**	101.05**	297.70**	10.90**
Hybrids	44	87.66**	2360.34**	74.08**	2.02**	12383.84**	0.68**	261.59**	26.84**	579.25**	3.32**
P vs. H	1	856.57**	1104.28**	2283.10**	0.01	395132**	0.48**	28.21**	59.59**	1961.43**	3.318**
Error	108	9.64	7.87	9.94	0.06	1054.79	0.03	2.41	1.36	3.08	0.037

*, ** Significant at P = 0.05 and 0.01 per cent levels, respectively

Table 2: *Per se* performance of five superior hybrids based on grain yield per plant

Source	Days to flowering	Daysto maturity	Plant height(cm)	Number of branches per plant	Number of pods per plant	Number of seeds per pod	Grain yieldper plant (g)	100-seed weight(g)	Harvest index(%)	Protein content(%)
IC-269269 X IC-269272	69.00	125.00	53.33	8.10	322.33	2.00	65.40	12.93	48.67	20.82
Dahod yellow X GJG-3	67.67	114.67	47.33	7.53	171.67	2.60	52.60	17.70	58.67	19.76
IC- 269273 X GG-1	63.67	123.33	50.67	6.37	156.00	1.70	45.80	13.53	59.00	19.60
IC-269273 X IC-269310	67.67	124.67	48.67	6.40	192.67	1.50	45.20	13.53	48.33	19.20
IC-269277 X Dahod yellow	64.00	119.33	51.67	6.00	281.67	2.57	38.80	13.40	32.00	20.42
General mean	67.00	119.52	54.24	5.58	246.09	1.79	34.44	9.47	43.11	20.45
S.Em. ±	1.79	1.62	1.82	0.15	18.75	0.092	0.89	0.67	1.01	0.11

*, ** Significant at P = 0.05 and 0.01 per cent levels, respectively

Table 3: Heterosis percentage in F_1 hybrid over better parents [BP] and standard parent [SP] for characters plant height (cm) and number of branches per plant

Sr.No.	Hybrids	Grain yield per plant (g)		Number of branches per plant	
		BP	SP	BP	SP
1.		-50.16**	-13.70**	-37.44**	-45.77
2.	IC-269268 X IC-269269	-11.71**	4.16**	-24.63**	-34.62
3.	IC-269268 X IC-269272	-8.62**	1.79	-21.18**	-31.67
4.	IC-269268 X IC-269273	-40.41**	-15.48**	-34.48**	-43.21
5.	IC-269268 X IC-269277	-29.59**	-13.70**	-24.14**	-34.23
6.	IC-269268 X IC-269295	-37.81**	-12.50**	-29.28**	-32.95
7.	IC-269268 X IC-269310	-16.59**	-15.48**	-20.20**	-30.77
8.	IC-269268 X Dahod yellow	-18.94**	1.79	-18.72**	-29.49
9.	IC-269268 X GG-1	-15.21**	-10.13**	-21.79**	-21.79
10.	IC-269268 X GJG-3	75.49**	-4.77	38.86**	3.85
11.	IC-269269 X IC-269272	9.71*	-7.73	0.65	-33.33
12.	IC-269269 X IC-269273	26.82**	-4.77	8.39*	-28.21
13.	IC-269269 X IC-269277	3.64	-17.27**	-1.29	-34.62
14.	IC-269269 X IC-269295	-72.11**	-10.71*	-45.95**	-48.72
15.	IC-269269 X IC-269310	-9.83*	-15.48**	-11.61**	-41.41
16.	IC-269269 X Dahod yellow	-5.73	-11.91**	-4.94	-34.23
17.	IC-269269 X GG-1	-50.22**	-2.38	-30.77**	-30.77
18.	IC-269269 X GJG-3	-30.05**	7.14	-12.00**	-34.23
19.	IC-269272 X IC-269273	-8.94**	4.16	-6.86	-30.38
20.	IC-269272 X IC-269277	-23.97**	3.57	-12.57**	-34.62
21.	IC-269272 X IC-269295	-34.24**	14.29**	-24.32**	-28.21
22.	IC-269272 X IC-269310	-44.72**	8.93*	-29.71**	-47.44
23.	IC-269272 X Dahod yellow	12.16**	11.91**	4.57	-21.79
24.	IC-269272 X GG-1	-14.41**	8.93*	-16.67**	-16.67
25.	IC-269272 X GJG-3	24.66**	-4.16	14.71**	-33.33
26.	IC-269273 X IC-269277	29.83**	-12.50**	17.48**	-28.21
27.	IC-269273 X IC-269295	-12.00**	-13.09**	-13.51**	-17.95
28.	IC-269273 X IC-269310	17.39**	-5.95	29.37**	-30.38
29.	IC-269273 X Dahod yellow	43.13**	-9.51*	17.90**	-18.33
30.	IC-269273 X GG-1	-10.45**	-24.41**	-6.84*	-6.79
31.	IC-269273 X GJG-3	18.64**	4.76	11.19*	-32.05
32.	IC-269277 X IC-269295	-25.94**	-7.14	-21.62**	-25.64
33.	IC-269277 X IC-269310	57.72**	-7.73	32.35**	-23.07

Table 3: Cont.....

Sr.No.	Hybrids	Grain yield per plant (g)		Number of branches per plant	
		BP	SP	BP	SP
34.	IC-269277 X Dahod yellow	-5.21	-5.35	0.62	-30.38
35.	IC-269277 X GG-1	-17.50**	-1.19	-17.95**	-17.94
36.	IC-269277 X GJG-3	-29.05**	-2.37	-31.08**	-34.61
37.	IC-269295 X IC-269310	33.56**	-5.35	18.18**	-27.82
38.	IC-269295 X Dahod yellow	28.44**	-7.14	14.81**	-20.51
39.	IC-269295 X GG-1	-20.78**	-15.48**	-15.81**	-15.76
40.	IC-269295 X GJG-3	-49.48**	-8.92*	-30.18**	-33.71
41.	IC-269310 X Dahod yellow	-44.62**	-9.51**	-30.63**	-34.23
42.	IC-269310 X GG-1	-36.36**	-13.70**	-32.48**	-32.43
43.	IC-269310 X GJG-3	29.90**	-9.51**	12.96**	-21.79
44.	Dahod yellow X GG-1	-2.41	-15.49**	-3.42	-3.46
45.	Dahod yellow X GJG-3	-39.08**	-19.05**	-28.21**	-28.20
S.Em. ±		1.27	1.27	0.20	0.20
Significant heterosis		41	41	38	0
No. of +^{ve} significant		13	13	11	0
No. of -^{ve} significant		28	28	27	0

MP = Mid Parent; BP = Better Parent; SP = Standard Parent; * and** indicates significant at P = 0.05 and P = 0.01 levels, respectively

Table 4: Heterosis percentage in F_1 hybrid over better parents [BP] and standard parent [SP] for characters number of pods per plant and number of seeds per pod

Sr.No.	Hybrids	100-seed weight (g)		Number of seeds per pod	
		BP	SP	BP	SP
1.	IC-269268 X IC-269269	0.95	-64.89**	-8.33	13.08
2.	IC-269268 X IC-269272	2.14	-41.49**	-25.40**	20.77
3.	IC-269268 X IC-269273	6.18	-38.23**	-31.67**	5.38
4.	IC-269268 X IC-269277	17.10*	-62.06**	-36.36**	7.69
5.	IC-269268 X IC-269295	8.08	-52.70**	22.92**	51.54
6.	IC-269268 X IC-269310	-11.11*	-65.25**	-13.46	15.38
7.	IC-269268 X Dahod yellow	-33.38**	-37.02**	-18.75*	0.00
8.	IC-269268 X GG-1	-49.72**	-22.41**	7.55	46.15
9.	IC-269268 X GJG-3	-4.20	-37.30**	54.17**	90.00
10.	IC-269269 X IC-269272	-2.96	-31.42**	-4.76	53.85
11.	IC-269269 X IC-269273	-0.25	-32.84**	-8.33	40.77
12.	IC-269269 X IC-269277	-6.91	-58.23**	27.27**	115.38
13.	IC-269269 X IC-269295	-7.16	-59.08**	33.33**	43.85
14.	IC-269269 X IC-269310	-34.02**	-51.63**	-15.38*	13.08
15.	IC-269269 X Dahod yellow	-37.28**	-57.45**	-7.14	1.10
16.	IC-269269 X GG-1	-58.27**	-37.45**	-6.34	36.15
17.	IC-269269 X GJG-3	7.12	-58.16**	104.76**	120.77
18.	IC-269272 X IC-269273	-4.73	-18.30**	-34.92**	5.38
19.	IC-269272 X IC-269277	3.29	-49.64**	-9.09	53.85
20.	IC-269272 X IC-269295	2.54	-42.34**	-17.46**	33.08
21.	IC-269272 X IC-269310	-31.62**	-44.11**	-30.16**	13.08
22.	IC-269272 X Dahod yellow	-38.01**	-50.43**	-38.10**	2.10
23.	IC-269272 X GG-1	-54.56**	-57.52**	-9.52	46.15
24.	IC-269272 X GJG-3	1.21	-37.87**	9.52	76.92
25.	IC-269273 X IC-269277	12.66	-53.62**	28.79**	117.69
26.	IC-269273 X IC-269295	3.31	-62.98**	-35.00**	12.14
27.	IC-269273 X IC-269310	-31.79**	-59.01**	-25.00**	15.38
28.	IC-269273 X Dahod yellow	-41.91**	-65.67**	-35.00**	11.20
29.	IC-269273 X GG-1	-54.56**	-66.80**	-15.00*	30.76
30.	IC-269273 X GJG-3	2.21	-79.71**	15.00*	76.92
31.	IC-269277 X IC-269295	-1.74	-51.63**	-9.09	53.84
32.	IC-269277 X IC-269310	-26.32**	-59.36**	-33.33**	13.07
33.	IC-269277 X Dahod yellow	-53.61**	-40.07**	16.67**	97.69
34.	IC-269277 X GG-1	-47.92**	-51.63**	19.70**	102.30
35.	IC-269277 X GJG-3	14.68*	-63.83**	-3.03	63.84
36.	IC-269295 X IC-269310	-11.62*	-66.52**	-32.69**	-10.00
37.	IC-269295 X Dahod yellow	-25.43**	-64.75**	4.88	10.00
38.	IC-269295 X GG-1	-55.12**	-49.71**	-9.43	23.07

Table 4: Cont.....

Sr.No.	Hybrids	100-seed weight (g)		Number of seeds per pod	
		BP	SP	BP	SP
39.	IC-269295 X GJG-3	-17.09**	-50.92**	58.54**	66.92
40.	IC-269310 X Dahod yellow	-25.43**	-58.44**	-17.31*	10.00
41.	IC-269310 X GG-1	-15.97**	-66.17**	-3.77	30.76
42.	IC-269310 X GJG-3	-24.13**	-38.08**	-23.08**	2.30
43.	Dahod yellow X GG-1	-40.27**	-76.59**	1.89	38.46
44.	Dahod yellow X GJG-3	-5.85	-63.47**	90.24**	100
45.	Hybrids	0.95	-67.87**	16.98*	59.23
S.Em. ±		25	25	0.13	0.13
Significant heterosis		1	1	29	0
No. of +^{ve} significant		24	24	11	0
No. of -^{ve} significant		100-seed weight (g)	100-seed weight (g)	18	0

MP = Mid Parent; BP = Better Parent; SP = Standard Parent;* and** indicates significant at P = 0.05 and P = 0.01 levels, respectively

Table 5: Heterosis percentage in F_1 hybrid over better parents [BP] and standard parent [SP] for characters harvest index (%) and protein content (%)

Sr.No.	Hybrids	Harvest index (%)		Protein content (%)	
		BP	SP	BP	SP
1.	IC-269268 X IC-269269	-37.36**	-39.45**	-13.24**	13.01
2.	IC-269268 X IC-269272	17.95**	2.22	-14.00**	12.02
3.	IC-269268 X IC-269273	19.75**	7.78	-16.55**	10.87
4.	IC-269268 X IC-269277	-61.54**	-66.67**	-14.35**	11.56
5.	IC-269268 X IC-269295	-26.92**	-36.67**	-14.96**	10.75
6.	IC-269268 X IC-269310	28.74**	24.45**	-17.72**	7.17
7.	IC-269268 X Dahod yellow	25.64**	8.88*	-16.32**	8.96
8.	IC-269268 X GG-1	26.92**	10.00*	-13.09**	13.18
9.	IC-269268 X GJG-3	-26.77**	-19.45**	-16.04**	9.36
10.	IC-269269 X IC-269272	-16.09**	-18.88**	-7.23**	20.35
11.	IC-269269 X IC-269273	-44.25**	-46.12**	-7.44**	22.95
12.	IC-269269 X IC-269277	-33.91**	-36.12**	-1.91**	23.58
13.	IC-269269 X IC-269295	-24.14**	-26.67**	5.99**	29.48*
14.	IC-269269 X IC-269310	-74.71**	-75.55**	-3.33**	18.09
15.	IC-269269 X Dahod yellow	-33.91**	-36.12**	-2.67**	18.90
16.	IC-269269 X GG-1	-50.57**	-52.22**	-16.33**	2.20
17.	IC-269269 X GJG-3	-22.73**	-15.**	-1.10	20.81
18.	IC-269272 X IC-269273	-51.23**	-56.12**	-11.37**	17.75
19.	IC-269272 X IC-269277	-20.53**	-33.33**	-12.18**	13.93
20.	IC-269272 X IC-269295	-35.10**	-45.55**	-8.98**	18.09
21.	IC-269272 X IC-269310	-60.34**	-61.67**	-3.19**	25.61
22.	IC-269272 X Dahod yellow	-45.03**	-53.88**	-7.81**	19.60
23.	IC-269272 X GG-1	-42.43**	-51.38**	-4.01**	24.57
24.	IC-269272 X GJG-3	-32.83**	-26.12**	-11.73**	14.51
25.	IC-269273 X IC-269277	-42.59**	-48.33**	-11.78**	17.23
26.	IC-269273 X IC-269295	1.85	-8.33	-6.50**	24.22
27.	IC-269273 X IC-269310	-16.67**	-19.45**	-16.45**	10.98
28.	IC-269273 X Dahod yellow	8.64**	-2.22	-10.83**	18.44
29.	IC-269273 X GG-1	9.26**	-1.66	-14.74**	13.29
30.	IC-269273 X GJG-3	-26.87**	-19.55**	-9.75**	19.88
31.	IC-269277 X IC-269295	-4.55	-30.00**	-8.94**	14.73
32.	IC-269277 X IC-269310	-24.14**	-26.66**	-3.47**	21.61
33.	IC-269277 X Dahod yellow	-20.66**	-46.66**	-6.33**	18.03
34.	IC-269277 X GG-1	-42.11**	-51.11**	-1.30	24.39
35.	IC-269277 X GJG-3	-43.43**	-37.78**	-5.69**	18.84
36.	IC-269295 X IC-269310	-37.13**	-39.21**	4.52**	26.47
37.	IC-269295 X Dahod yellow	-32.58**	-50.55**	6.51**	28.84*
38.	IC-269295 X GG-1	6.58*	-10*	3.89**	25.66
39.	IC-269295 X GJG-3	-36.87**	-30.55**	0.03	21.04
40.	IC-269310 X Dahod yellow	-60.34**	-61.66**	1.92*	19.71
41.	IC-269310 X GG-1	-36.78**	-38.88**	5.54**	23.98
42.	IC-269310 X GJG-3	-49.49**	-44.45**	5.17**	23.52
43.	Dahod yellow X GG-1	-2.63	-17.78**	0.56	17.34
44.	Dahod yellow X GJG-3	-11.11**	-2.21	-2.11**	14.21
45.	GG-1 X GJG-3	-61.11**	-57.21**	9.45**	13.35
S.Em. ±	1.43	1.43	0.16	0.16	
Significant heterosis	42	39	41	1	
No. of +^{ve} significant	8	3	6	1	
No. of -^{ve} significant	34	36	35	0	

MP = Mid Parent; BP = Better Parent; SP = Standard Parent;* and** indicates significant at P = 0.05 and P = 0.01 levels, respectively.

crops in the form of F1 and F2 populations by improving the various yield contributing characters. The magnitude of heterosis was reported among the crosses, demonstrating potential of hybrid combinations of ten diverse parents for various traits enhancement in the present research. Table 1 illustrated the analysis of variance (ANOVA) for yield and its ten component traits among forty five F1 hybrids and their ten parents.

The analysis of variance for grain yield per plant and its attributing traits revealed highly significant differences for all the characters studied. Partitioning of genotypic variance showed that parental genotypes differed significantly for all the traits. The significant differences were also observed among 45 hybrids for all the characters. This result indicated that parental genotypes were diverse and appropriate for study of heterosis. Significant variances for parents vs. hybrids for grain yield and most other traits indicated presence of heterosis in the population of the hybrids. The degree of heterosis was varied from cross to cross for all the characters.

Out of 45 crosses 13 manifested heterobeltiosis for grain yield per plant. The range of heterobeltiosis for grain yield was wide 9.71 percent to 75.49 percent. The hybrids IC 269269 x IC 269272 recorded highest heterobeltiosis (75.49%) followed by cross IC-269277 x dahod yellow (57.72%),Table 3. Heterobeltiosis for yield and components traits have been reported in chickpea by Bakhsh, *et al*. (2007), Parameshwarappa, *et al*. (2013). For yield components traits highest heterobeltiosis were recorded *viz.,* number of branches per plant (38.86 %), for number of seeds per pod per plant (104.76 %), 100-seed weight (17.10%), harvest index (26.92%) and protein content (29.48%) similar result is also recorded by Kulkarni *et al*. (2004).

A comparative study of most heterotic crosses for grain yield per plant with their per se performances (Table 2) revealed that the hybrid IC-269269 x IC-269272 expressed the highest heterobeltiosis also maintained significant positive heterobeltiosis for number of branches per plant followed by the hybrid Dahod yellow x GJG-3 expressed the high heterobeltiosis for grain yield per plant along with yield contributing characters like number of branches per plant, number of seeds per pod and harvest index. The hybrids IC-269269 X IC-269272, Dahod yellow X GJG-3, IC- 269273 X GG-1, recorded maximum grain yield per plant.

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