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Heterosis for Quantitative Traits in Wide Crosses of Chickpea (*Cicer arietinum* L.)

Noor E Mujjassim[1*], S. D. Nehru[2] and Jayarame Gowda[2]

[1]UAS, GKVK, Bengaluru, [2]AICRP on Sunflower, UAS, GKVK, Bengaluru

*Corresponding Author E-mail: mujjassim28@gmail.com

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ABSTRACT

Nine chickpea (Cicer arietinum L.) hybrids developed from Line X Tester mating design along with their 6 parents (3 lines and 3 testers) for generating information on heterosis and gene action in respect of seed yield and its attributing traits and it has been carried out at the experimental plots of Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences, Bengaluru. Highly significant differences in mean sum of squares was observed among the parents (lines + testers) and crosses for some of the yield and its attributing traits. Mean performance of crosses is studied among nine hybrids the crosses A-1 × HC 5 and JG 11 × HC 5 (34.5 days) were earliest to flower followed by JG 11 × JG 315 and JG 11 × JG 24 (36.0 days) which are on par with one another. Significant standard heterosis was noticed in all the characters namely days to 50 percent flowering, plant height, number of primary branches, number of pods per plant, seed yield per plant, 100 seed weight, and days to maturity. Most of the hybrids showed significant heterosis over standard check, which indicates selected productivity traits in case of JG 11 was lower than majority of experimental hybrids.

Key words: *Cicer arietinum, Chickpea, Heterosis.*

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a self-pollinated, annual, diploid (2x = 2n= 16), cool season food legume and it is the third most important pulse crop after common bean and pea and it is valued as source of protein to the largely vegetarian population of India. In India Chickpea covers an area of 9.54m ha with annual production of 9.08m tonnes and productivity 951 kg/ha. Chickpea is an important legume in India, Africa, and Central and South America. The seeds are high in fibre and protein and are a good source of iron, phosphorus, and folic acid. An ancient crop, is important in both developed and developing nations. It originated in south-eastern Turkey and the adjoining northern regions of Syria.

Chickpea is a highly self-pollinated crop and the scope for exploitation of hybrid vigour is considered to be one of the outstanding achievements of plant breeding.

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In case of self-pollinated crops including chickpea, heterosis *per se* cannot be exploited by way of heterotic hybrids due to biological infeasibility. Utility of heterosis *per se* may not be much useful in chickpea, but cross combinations showing heterotic vigour can be utilised as the source populations for deriving superior progenies. To know the potential of hybrids in a crop, the study on magnitude and direction of heterosis is of paramount important. Heterotic response being dependent upon the degree of genetic divergence among the parents involved and it would be of great interest to know the extent of heterosis among divergent types in chickpea. Breeders have been utilizing the available genetic resources to modify the varieties to meet the ever changing requirements. However, in self-pollinated crop, the heterosis cannot be exploited directly, hybrid vigour identify superior hybrids as they offer more probability of throwing better segregants[1]. In chickpea beneficial heterosis for grain filling period, seeds per plant and grain yield was reported by Ahmed Bakhsh *et al*.[2].

MATERIAL AND METHODS

The material for the present study consists of three genotypes, A-1, JG 11, and JAKI 9218 designated as females and three genotypes, JG 315, HC 5, JG 24, designated as males. The characteristics of these genotypes were presented in the table 1. The genotypes were procured from AICRP on Chickpea, GKVK, Bengaluru. These lines and testers were crossed in a line × tester mating design to synthesize nine crosses. During Rabi-Summer 2014-15 crosses were effected in Line X Tester mating design.

During early kharif 2015 synthesized F_1`s (9 hybrids) along with their 6 parents (three lines and three testers) and a standard check (JG 11) were evaluated for quantitative traits in RCBD design with two replications. Each genotype (Parents, Hybrids and a Check) was grown in two rows of 3 m length consisting of 30 plants per row with a spacing of 10 cm between plants within a row and 30 cm between rows at experimental plots of Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, Gandhi Krishi Vignana Kendra (GKVK), Bengaluru. All the recommended package of practices was followed to raise a healthy crop.

Observations were taken on five representative plants in each genotype (hybrids, parents and checks) by tagging at random from each replication. Total observations were recorded on the quantitative traits like Days to 50 *per cent* flowering, Plant height, Number of primary branches, Number of pods plant^{-1}, Seed yield plant^{-1} , 100 - seed weight and Days to maturity. Heterosis over mid parent and better parent was calculated as per the standard statistical formulae.

RESULTS AND DISCUSSION

Analysis of variance showing highly significant differences among the parents (lines + testers) as evident from ANOVA (Table 2) for four characters *viz*., days to 50 *per cent* flowering, plant height, 100 seed weight and days to maturity, justify the selection of parents for the study. The crosses also differed significantly for most of the yield attributing traits either due to one of the parent or both the parents. Significant differences among the crosses could be due to differences among both the parents. It is also noticed there is a significant variance due to lines × testers suggested involvement of non-allelic gene action in the inheritance of 100 seed weight. Significance of variance due to line × tester interaction in chickpea for yield and yield attributing traits was reported by Bahl and Kumar[3].

Mean performance of crosses is studied (Table. 3) among nine hybrids the crosses A-1 × HC 5 and JG 11 × HC 5 (34.5 days) were earliest to flower followed by JG 11 × JG 315 and JG 11 × JG 24 (36.0 days) which are on par with one another. Contrary to this, JAKI 9218 × JG 24 (38.0 days), took maximum number of days for 50 *per cent* flowering. Maximum plant height of 42.40 cm was recorded by the cross A-1 × HC 5 which differed significantly from all other crosses. Among 9 hybrids evaluated the cross JG 11 ×

JG 24 recorded highest seed yield plant^{-1} (24.3 g) which differed significantly from all other crosses. On the other hand, lowest seed yield plant^{-1} of (10.8 g) was observed in the cross JG 11 × JG 315. Maximum 100 seed weight (28.9 g) was exhibited by the cross JG 11 × JG 24 which differed significantly from all other crosses while lowest 100 seed weight (19.5 g) was noticed in the hybrid JG 11 × JG 315, followed by A-1 × JG 315 (20.3 g) and A-1 × HC 5 (21.1 g) which are on par with each other.

Studies on mid parent and standard heterosis suggested there is a significant average heterosis for all the attributes indicating the possibility of obtaining elite lines in the Segregating generations for the genetic improvement of chickpea. There is a possibility to sort out the recombinants possessing most of the desirable yield and its contributing traits. For a character, when significant heterosis over mid parent is observed in majority of the crosses, it indicates non additive gene action for that character. Assuming that epistasis is absent, the cause of heterosis can be attributed to dominance gene action. Heterosis for different characters, are presented below, based on this assumption.

The standard heterosis over check JG 11 and heterosis over midparent for yield and yield attributing characters are presented in the Table 4, for days to 50 *per cent* flowering out of nine hybrids, five hybrids showed significant heterosis for days to 50 *per cent* flowering over mid parent and two hybrids exhibited significant positive heterosis over standard check JG 11, indicating that dominance type of gene action is prevalent for this character. The range of heterosis over mid parent was -16.38 to 4.23. The hybrid JAKI 9218 × HC 5 exhibited highest mid parent negative heterosis (16.38 *per cent*) in desirable direction. Similar observations were made by Bahl and Kumar[3], Gadekar and N.S. Dodiya[6], and Bhardwaj *et al.*[4], depicted desirable significant negative mid parent heterosis for both the maturity related traits indicating that the genes with negative effects were dominant. For plant height out of nine hybrids, three hybrids expressed significant negative heterosis for plant height. The cross combination JAKI 9218 × JG 315 expressed higher negative heterosis over standard check JG 11. None of the crosses were found significant positive relative heterosis for plant height indicated that none of the genes with positive dominant effects for this trait. The result obtained in present investigation was contradictory with those of Gadekar and Dodiya[6]. Six hybrids showed significant negative mid parent heterosis for plant height. Here significant heterosis over mid parent is observed in majority of the crosses, indicating presence of non-additive gene action for plant height. These results are in agreement with Bhardwaj *et al.*[4]. For number of primary branches five crosses out of nine, manifested significant positive heterosis over standard check JG 11 for number of primary branches. The highest significant heterosis was found to be expressed by A-1 × HC 5 for number of primary branches followed by JAKI 9218 × JG 24. These results are in conformity with Chauhan *et al.*[7], and Deshmukh *et al.*[8]. Four hybrids showed significant positive mid parent heterosis for number of primary branches. The highest significant mid parent heterosis was found to be expressed by JG 11 × JG 24 for number of primary branches followed by JAKI 9218 × JG 24. The result obtained in present investigation was contradictory with those of Mandal and Bahl[10], Ahmed Bakhsh *et al.*[2], and Reddy Yamini *et al.*[11].

For number of pods plant^{-1}, only three crosses manifested significant positive heterosis over commercial check JG 11. The cross JG 11 × HC 5 expressed the higher heterosis followed by A-1 × JG 24. The result obtained in present investigation was contradictory with those of Gadekar and Dodiya[6] and Chauhan *et al.*[7]. While only one cross manifested significant positive mid parent heterosis for number of pods per plant. The results suggest limited variability among the parents and their ability to produce heterotic hybrids. This calls for involvement of diverse parents to develop heterotic hybrids.

These results are in agreement with Mandal and Bahl[10], Ahmed Bakhsh *et al*.[2], and Reddy Yamini *et al*.[11].

For seed yield plant^{-1}, six crosses manifested significant positive heterosis over commercial check JG 11. The cross JG 11 × JG 24 expressed the higher heterosis followed by JG 11 × HC 5. The result obtained in the present investigation was contradictory with those of Gadekar and Dodiya[6], Deshmukh and Bhapkar[8] and Chauhan *et al*.[7]. Four hybrids showed significant positive mid parent heterosis for seed yield per plant. The highest significant mid parent heterosis was found to be expressed by JG 11 × HC 5 for seed yield plant^{-1} followed by JG 11 × JG 24. These results are in agreement with Bahl and Kumar[4], Mandal and Bahl[10] and Ahmed Bakhsh *et al*.[2].

For 100 seed weight only two crosses, JAKI 9218 × HC 5, JAKI 9218 × JG 315 exhibited significant positive mid parent heterosis for 100 seed weight. The result obtained in present investigation was contradictory with those of Bhardwaj *et al*.[4], and Jayalakshmi *et al*.[9]. Five crosses manifested significant negative heterosis over commercial check JG 11. These results are in agreement with Bahl and Kumar[3] who reported negative non-significant standard heterosis. For days to maturity all the nine crosses manifested significant negative mid parent heterosis. The cross A-1 × JG 24 expressed the higher mid parent heterosis followed by A-1 × HC 5. The result obtained in the present investigation was contradictory with those of Bhardwaj *et al*.[4]. Also, all the nine crosses showed significant positive standard heterosis for days to maturity. These results are in conformity with Gadekar and Dodiya[6] and Chauhan *et al*.[7].

Significant standard heterosis was noticed in all the characters namely, days to 50 *per cent* flowering, plant height, number of primary branches, number of pods per plant, seed yield per plant, 100 seed weight, and days to maturity. Most of the hybrids showed significant heterosis over standard check, which indicates selected productivity traits in case of JG 11 was lower than majority of experimental hybrids. The crosses showing non additive type of gene action as revealed by their substantial heterosis over their mid parents also are likely to throughout desirable segregants, but those can be stabilized only if additive × additive type of epistasis is the major component.

Table 1a. Details of the lines used and their salient features

Parents	Source	Salient Features
A-1	AICRP on Chickpea, GKVK, Bengaluru	Highly adopted local variety
JAKI-9218	AICRP on Chickpea, GKVK, Bengaluru	Resistance to wilt, root rot, collar rot
JG-11	AICRP on Chickpea, GKVK, Bengaluru	Early, bold seeded, resistant to wilt and highly adopted

Table 1b. The details of the testers used and their salient features

Parents	Source	Characteristics
JG-24	AICRP on Chickpea, GKVK, Bengaluru	High yield and moderately resistance to wilt
JG – 315	AICRP on Chickpea, GKVK, Bengaluru	Tall and erect type, wilt resistant
HC-5	AICRP on Chickpea, GKVK, Bengaluru	Tall and erect type.

Table 2: Analysis of variance for seed yield and its attributing traits in parents and crosses of chickpea (*Cicer arietinum* L.)

Source of variations	df	Mean sum of squares						
		Days to 50% flowering	Plant height (cm)	Number of primary branches	Number of pods plant^{-1}	Seed yield/ plant (g)	100 Seed weight (g)	Days to maturity
Replication	1	0.83	1.83	6.68	2887.39	325.64	1.58	0.53
Treatments	14	21.77**	61.57**	11.5*	498.01	44.36**	45.8**	31.39**
Parents	5	45.283**	61.03**	1.42	286.25	8.37	91.57**	32.00**
Crosses	8	3.0*	11.10	5.37	363.68	38.29*	21.55**	23.55**
Parent vs Crosses	1	54.45**	467.97**	110.95**	2631.46**	272.86**	10.90*	91.02**
Error	14	0.83	9.43	3.48	252.72	11.22	1.36	4.81

*Significant @ P = 0.05 **Significant @ P = 0.01

Table 3. Mean performance of chickpea hybrids in respect of grain yield and its attributing traits

Hybrids	Days to 50% flowering	Plant height (cm)	Number of primary branches	Number of pods plant^{-1}	Seed yield/ plant (g)	100 seed weight (g)	Days to maturity
A-1 × HC -5	34.50	42.40	11.00	69.50	15.55	21.15	92.00
A-1× JG- 315	37.00	40.60	7.80	76.20	17.56	20.30	92.00
A-1 × JG -24	37.50	39.60	10.30	77.50	18.19	27.35	92.00
JAKI × HC -5	37.00	37.60	7.90	65.90	18.28	23.00	96.00
JAKI × JG-315	36.50	35.73	6.90	55.00	13.29	24.00	96.00
JAKI ×JG -24	38.00	37.07	10.83	54.93	18.39	26.750	96.000
JG-11 × HC -5	34.50	42.17	9.90	88.40	23.82	24.90	96.00
JG-11 × JG -315	36.00	39.77	7.55	44.58	10.89	19.55	103.00
JG-11 × JG -24	36.00	41.50	10.70	68.60	24.36	28.90	96.00
S.Em.$_{\pm}$	0.64	2.12	1.27	10.89	2.31	0.85	1.97
C.D @ P= 0.05	1.94	6.41	3.84	5.60	6.97	2.58	5.94
C.V.%	2.4	6.9	3.8	16.2	14.7	5.1	2.8

Table 4. Estimates of mid parent heterosis and standard heterosis (over check JG 11) for seed yield and its attributing traits in chickpea (*Cicer arietinum* L.)

Crosses	Days to 50% flowering		Plant height		Number of primary branches		Number of pods/ plant		Seed yield / plant		100 seed weight	
	MP	SC	MP	SC	MP	SC	MP	SC	MP	SC	MP	SC
A-1 × HC -5	-12.10**	-2.82	-8.82	-7.83	80.33*	175.00*	23.12	112.54	26.27	88.03	3.55	-21.38**
A-1× JG- 315	4.23	4.23	-2.87	-11.74	34.48	95.00	24.92	133.03*	31.14	112.33*	5.18	-24.54**
A-1 × JG -24	0.00	5.63*	-16.10*	-13.91	74.58	157.50*	51.66	137.00*	31.38	119.95*	-3.10	1.67
JAKI × HC -5	-16.38**	4.23	-27.48**	-18.26*	49.06	97.50	47.10	101.53	89.53	121.04*	24.66*	-14.50*
JAKI × JG-315	-9.88**	2.82	-24.21**	-22.32**	38.00	72.50	11.45	68.20	24.00	60.74	38.53*	-10.78*
JAKI ×JG -24	-10.59**	7.04*	-29.46**	-19.42*	112.35*	170.75*	39.25	67.99	64.53*	122.33*	1.90	-0.56
JG-11 × HC -5	-12.11**	-2.82	-13.33*	-8.33	100.00*	147.50*	108.49*	170.34*	128.82*	188.03*	9.57	-7.43
JG-11 × JG -315	1.41	1.41	-9.50	-13.53	62.37	88.75	-5.06	36.31	-5.18	31.68	-9.49	-27.32**
JG-11 × JG -24	-4.00	1.41	-15.91*	-9.78	125.26*	167.50*	85.16	109.79	104.02**	194.56*	-5.32	7.43
S.Em.$_{\pm}$	0.73	0.84	2.45	2.83	1.91	2.21	13.91	16.07	3.00	3.46	1.07	1.23
C.D @ P= 0.05	1.69	1.95	5.67	6.54	4.42	5.10	32.09	37.06	6.92	7.99	2.46	2.85
C.D @ P= 0.01	2.46	2.85	8.25	9.52	6.43	7.42	46.70	53.92	10.07	11.62	3.59	4.14

*Significant @ P = 0.05 **Significant @ P = 0.01

CONCLUSION

Chickpea is a highly self-pollinated crop and the scope for exploitation of hybrid vigour is considered to be one of the outstanding achievements of plant breeding and the heterosis breeding was effectively utilized in self-pollinated crops primarily due to presence of high magnitude of non-additive type of gene effects coupled with additive effects for yield and its components. In present study, both additive and non-additive type of gene actions were important in governing all traits studied resulting in high heterosis in selected cross combinations for yield per plant and associated traits. Most of the hybrids showed significant heterosis over standard check, which indicates selected productivity traits in case of JG 11 was lower than majority of experimental hybrids. Most of the best performing crosses for majority of the characters involved at least one high general combining parent. The variation in the performance of hybrids was large due to the effect of tester followed by moderate contribution from lines and lower contribution from line × tester. Importance of non-additive gene action reflected in the predominance of contributions of line × tester interaction for the traits *viz*., number of pods per plant.

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