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Combining Ability Analysis for various Quantitative traits in Chickpea (*Cicer arietinum* L.)

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ABSTRACT
Present investigation comprised three female and five male parents were crossed to developed fifteen hybrids. These fifteen hybrids along with their parental lines and two checks namely Digvijay and BDNG 797 were grown during rabi season of 2018-19. The parental linesVijay exhibited high GCA effect for days to 50% flowering, number of primary branches per plant, number of secondary branches per plant and harvest index, JAKI-9218 for days to 50% flowering, days to maturity, number of seed per pod, plant height and 100 seed weight, SAKI-9516 for number of primary and secondary branches per plant, number of seed per pod and seed yield per plant and the tester, ICC-111 for days to maturity, number of primary branches, number of pods per plant, 100 seed weight and seed yield per plant. The cross, Vijay x ICC-111 recorded high significant and desirable SCA effect for number of primary and secondary branches per plant, number of pods per plant, number of seed per pod and seed yield per plant and the cross SAKI-9516 x ICC-101 for number of pods per plant, number of seed per pod and seed yield per plant.
Key words: hybrids, parental lines, 50% flowering, high significant and SCA effect

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INTRODUCTION

Among the pulse crops, chickpea (*Cicer arietinum* L.) also name as Bengal gram is an important annual grain legume used in human diet. Chickpea seeds are very rich source of carbohydrates (48-55 %), protein (5-6 %), fats (2-7 %) and many other essential nutritive components, which are consumed by humans. The majority of chickpea is grown under rainfed condition in India as it has a low requirement of fertilizer, irrigation and other agro chemicals. Thus the cultivation on low-input traditional production system has led to highly variable yields observed spatially over different locations. India is the major chickpea producing country and contributing over 75 per cent of total world chickpea production. The chickpea production in the country was 9.3 million tonnes with an average productivity of 974 kg/ha in 9.6 million ha area reported by Anonymous [2]. Among the chickpea growing state, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh, Karnataka, Chhattisgarh, Bihar and Jharkhand contributing more than 95 per cent to the total production. In Maharashtra chickpea was grown on 19 lakh ha area with total production 17 lakh tons with an average productivity of 891kg/ha reported by Anonymous [2]. Despite several efforts over past decades, chickpea production has been very low.

Selection of appropriate parent is the pre-requisite for sound breeding program. The combining ability analysis helps in selection of desirable parents based on their performance in hybrid combinations. The analysis also throws light on nature and magnitude of gene actions operative in the inheritance of different characters. It thus helps in deciding the appropriate selection criteria to be practiced in segregating populations. Line x Tester analysis is an extension of top cross method in which several testers are used reported by Kempthorne [10] which provides information about general and specific combining ability of parents and at the same time it is helpful in identifying best heterotic crosses.

MATERIAL AND METHODS

The current research work was investigated at the College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parabhani. Eight genetically diverse chickpea genotypes comprised of three lines *viz*., Vijay, SAKI-9516, JAKI-9218 and five testers *viz*., ICC-4958, ICC-85, ICC-101, ICC-111, BCG-79 were crossed during *rabi* season 2017-18 in line x tester fashion by using hand emasculation and pollination as described by Yermanos (19). The total 15 Chickpea hybrids along with 8 parents and two checks Digvijay and BDNG 797 were grown in Randomized Block Design with two replications during *rabi* season 2018-19 at the College of Agriculture, Latur. Observations were recorded on five randomly selected plants for all the seed yield and yield contributing trait in chickpea.All the agronomic practices were followed to raise a good crop. Data in each experiment of all entries was subjected to analysis of variance reported by Panse and Sukhatme [11] for testing the significance of treatments. Combining ability analysis and the testing of significance of different genotypes was based on the procedure given by Kampthorne [10].

RESULTS AND DISCUSSION

The knowledge of combining ability helps in identifying superior parents and specific cross combinations which can be exploited for different breeding purposes. Such studies are essential in choosing the appropriate breeding and selection methodologies for further improvement of crop.All genotypes showed differences with respect to the traits studied in the analysis of variance for line x tester crosses presented in Table 1. This situation indicated that there was a significant variation among lines, testers and crosses; therefore, it is possible to compute the general and specific combining abilities in the parents and crosses, respectively.

Among all the parents, none of the parent evinced good GCA for all traits (Table 2). The estimates of general combining ability effects revealed that among parent, SAKI-9516 had good general combining ability for seed yield and its attributing traits like number of primary branches per plant, number of secondary branches per plant, number of pods per plant and number of seeds per pod. Similarly, ICC-111 also had good general combining ability for seed yield, number of pods per plant and 100 seed weight. Parents, JAKI-9218 and ICC-101 showed high GCA effects for 100 seed weight. Parents, Vijay, ICC-101, ICC-85 and ICC-4958 were good general combiner for harvest index. For days to 50 per cent flowering and days to maturity, JAKI-9218 was found to be good negative combiner for earliness. Hence, it is suggested that these parents can be used in hybridization programme for improving respective trait in chickpea. These results are in agreement with Patil [13] for secondary branches per plant, harvest index, 100 seed weight, number of pods per plant and days to maturity; Verma and Waldia [18] for 100 seed weight, seed yield, number of pods per plant, seed yield and harvest index; Chauhan *et al*. [3] and Gadekar and Dodia [5] for seed yield and its attributing trait; Parameshwarappa *et al.* [12] for seed yield per plant, number of pods per plant, 100 seed weight and days to 50 per cent flowering and Reddy *et al.* [15] for number of pods per plant and number of branches per plant, who had reported positive and significant GCA effect for seed yield and its attributing trait and negatively significant GCA effect for days to 50 per cent flowering and days to maturity.

According to Sprague and Tatum [17] the SCA is controlled by non-additive gene action. The SCA effect is an important criterion for identification of crosses. In the present investigation, result indicated that none of the cross was showed specific combining ability for all studied traits (Table 3). The cross, Vijay x ICC-111 was best specific combiner for seed yield per plant and its attributing trait like number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, plant height and 100 seed weight followed by the SAKI-9516 x ICC-85 for seed yield, number of secondary branches per plant and 100 seed weight and negative SCA effect for days to maturity and days to 50 per cent flowering. The cross combinations, JAKI-9218 x ICC-4918 and SAKI-9516 x ICC-101 were good specific combiner for seed yield and number of pods per plant. The crosses, Vijay x ICC-111, SAKI-9516 x ICC-111, JAKI-9218 x BCG-79 and Vijay x ICC-4958 were also good specific combiner for harvest index. Significant positive SCA effects earlier were reported by Gaidhani *et al.* [6] for seed yield per plant, number of pods per plant, 100 seed weight and harvest index; Sarode and Nagargoje [16] and Rathod *et al.* [14] for seed yield per plant and number of pods per plant; Verma and Waldia [18] and Dudhe and Kumar [4] for seed yield and 100 seed weight; Gautam and Gupta [7], Chauhan *et al.* [3], Parameshwarappa *et al.* [12] and Jagdish and Jayalakshmi [8] for seed yield. Negative SCA effects for days to maturity and days to 50 per cent flowering were reported by Gadekar and Dodiya [5] and Reddy *et al.* [15].

Table 1: Analysis of variance of Line x Tester crosses for different quantitative characters in chickpea

Source of Variation	Df	Days to 50% flowering	Days to maturity	No. of primary branches / plant	No. of secondary branches / plant	No. of pods / plant	No. of seeds / Pod	Plant height (cm)	Harvest index (%)	100 seed weight (g)	Seed yield / plant (g)
Replications	1	2.17	0.34	0.16	0.77	305.00	0.00	0.49	11.50	6.71	11.82
Treatments	22	62.53**	62.22**	0.90**	90.37**	4297.72**	0.05**	44.11**	121.66**	69.94**	354.17**
Parents	7	35.57**	105.20**	0.67**	33.32**	2091.35**	0.03**	69.92**	179.53**	104.43**	87.80**
Crosses	14	75.05**	43.77**	0.58**	60.97**	3737.57**	0.05**	32.53**	32.02**	42.47**	262.51**
Parents vs. Crosses	1	76.06**	19.60*	7.09**	901.37**	27584.37**	0.08**	25.59**	971.46**	213.04**	3502.16**
Line Effect	2	172.90*	265.03**	0.77	357.32**	10371.58	0.16*	39.22	43.83	209.86**	566.72
Tester Effect	4	104.95	9.47	0.91	12.05	2274.93	0.02	48.36	47.76	19.90	221.99
Line x Tester Effect	8	35.65**	5.62	0.36**	11.35**	2810.40	0.04**	22.95**	21.21*	11.92**	206.718**
Error	14	0.673	2.57	0.04	1.22	129.34	0.00	0.55	4.36	1.76	10.85
Total	29	30.95	31.68	0.46	44.80	2171.12	0.022	21.84	61.87	35.20	178.72

*** and ** indicated significance at 5 % and 1 % level, respectively.**

Table 2: Estimates of general combining ability effects (GCA) of parents for quantitative characters in chickpea.

Sr. No.	Parents	Days to 50% flowering	Days to maturity	No. of primary branches per plant	No. of secondary branches per plant	No. of pods / plant	No. of seeds / pod	Plant height (cm)	Harvest index (%)	100 Seed weight (g)	Seed yield / plant (g)
Lines											
1	Vijay	-0.80**	1.63*	0.043**	4.99**	-5.25**	-0.13**	-1.15**	2.42*	-3.49**	-1.52**
2	SAKI-9516	4.50**	4.13**	0.25**	1.62**	34.61	0.02**	2.28**	-1.16**	-1.69**	8.17*
3	JAKI-9218	-3.70**	-5.76**	-0.29**	-6.62**	-29.08**	0.12**	-1.13**	-1.25**	5.18**	-6.65**
Testers											
4	ICC-4958	2.80**	-0.23**	0.53**	2.018**	-21.49**	-0.06**	-2.09**	1.29	-0.34**	-6.29**
5	ICC-85	1.13*	-1.56**	-0.41**	0.493	-10.30**	0.08**	4.74**	2.21	-2.24**	-0.24**
6	ICC-101	1.13*	1.10	-0.19**	-0.04**	-1.03**	0.04**	-1.86**	2.17	2.31*	1.86
7	ICC-111	2.30**	-0.73**	0.27**	-1.81**	30.70	-0.05**	-1.29**	-1.33**	1.31	9.18*
8	BCG-79	-7.36**	1.43	-0.19**	-0.64**	2.13	-0.014**	0.51*	-4.33**	-1.04**	-4.52**

*** and ** indicated significance at 5 % and 1 % level, respectively.**

Table 3: Estimates of specific combining ability (SCA) for quantitative characters in chickpea.

Sr. No.	Name of Crosses	Days to 50% flowering	Days to maturity	No. of primary branches / plant	No. of econdary branches / plant	No. of pods / plant	No. of seeds / Pod	Plant height (cm)	Harvest index (%)	100 seed weight (g)	Seed yield / plant (g)
1	Vijay x ICC-4958	0.80	1.03	0.12	-1.59	9.85	-0.05**	-1.94**	1.92	0.01	-1.94
2	Vijay x ICC-85	2.46**	-1.13	-0.02	-2.17*	-30.23**	-0.01	-4.88**	-0.34	1.06	-11.63***
3	Vijay x ICC-101	-0.03	-0.30	0.25	0.96	-32.80**	-0.07**	1.72**	3.15	-1.04	-6.59*
4	Vijay x ICC-111	2.30**	0.03	0.19	2.03*	46.15**	0.05**	1.35*	-1.26	1.31	11.67**
5	Vijay x BCG-79	-5.53**	0.36	-0.54**	0.76	7.02	0.09	3.75**	-3.47*	-1.34	8.48**
6	SAKI-9516 x ICC-4958	-1.50*	0.03	-0.08	3.77**	-40.77**	-0.04**	-0.78	-4.14*	0.81	-7.49**
7	SAKI-9516 x ICC-85	-1.33*	-2.13	-0.48**	0.82	7.31	0.01	0.88	-0.25	2.56*	6.97**
8	SAKI-9516 x ICC-101	-2.33**	1.20	0.04	-1.95*	34.16**	0.21**	-0.82	1.14	-2.14*	8.15**
9	SAKI-9516 x ICC-111	-3.00**	0.53	0.28	-2.39**	-24.67**	-0.16**	1.21*	2.47	-2.14*	-1.38
10	SAKI-9516 x BCG-79	8.16***	0.36	0.24	-0.25	23.99**	-0.02**	-0.48	0.78	0.91	-6.24*
11	JAKI-9218 x ICC-4958	0.70	-1.06	-0.03	-2.17*	30.91**	0.09**	2.73**	2.22	-0.82	9.43**
12	JAKI-9218 x ICC-85	-1.13	3.26*	0.51**	1.34	22.92*	-0.002	4.00**	0.59	-3.62**	4.66
13	JAKI-9218 x ICC-101	2.36**	-0.90	-0.30*	0.98	-1.34	-0.14**	-0.90	-4.29*	3.18**	-1.55
14	JAKI-9218 x ICC-111	0.70	-0.56	-0.47**	0.35	-21.48*	0.12**	-2.56**	-1.21	0.83	-10.29**
15	JAKI-9218 x BCG-79	-2.63**	-0.73	0.29*	-0.51	-31.02**	-0.07**	-3.26**	2.69	0.43	-2.25

*** and ** indicated significance at 5 % and 1 % level, respectively.**

The cross combination, Vijay x ICC-111 for seed yield per plant, number of secondary branches per plant and primary branches per plant; SAKI9516 x ICC-101 for seed yield per plant and number of seeds per pod; SAKI-9516 x ICC-85 for seed yield per plant; JAKI-9218 x ICC-101 for 100 seed weight; JAKI-9218 x BCG-79 and JAKI-9218 x ICC-111 for days to 50 per cent flowering, days to maturity and plant height exhibited high *per se*, high significant SCA in desirable direction with high x high or high x low GCA effects suggesting additive x additive or additive x dominance type of gene interaction in this crosses. Thus these crosses are likely to throw transgressive segregants which need to be exhibited for the importance of chickpea. Other crosses, Vijay x BCG-79 for seed yield; SAKI-9516 x ICC101 for harvest index and number of pods per plant and Vijay x ICC-111 and SAKI-9516 x BCG-79 for number of pods per plant recorded high *per se*, high significant SCA in desirable direction with low x low GCA effects due to dominant x dominant type of epistasis. These crosses exhibited significant SCA effect due to complimentary type of gene action or involvement of non-allelic interaction of fixable and non-fixable genetic variance. These could be because of correlation of undesirable effects in such combinations to obtain better segregation selection may be postponed to latter generation to developed high yielding varieties.The results are agreement with Patil *et al.* [13] for plant height, secondary branches per plant, number of pods per plant, 100 seed weight, seed yield per plant and harvest index; Jayalakshmi *et al*. [9] for seed yield per plant, number of pods per plant and 100 seed weight; Reddy *et al.* [15] for seed yield, number of branches per plant and number of pods per plant and Amadabade *et al*. (1) for number of pods per plant, number of seeds per plant and grain yield.

CONCLUSION

On the basis of magnitude of GCA effects for yield and its components, the parents, SAKI-9516, ICC-101 and ICC-111 could be used in heterosis breeding.The crosses, Vijay x ICC-111, SAKI-9516 x ICC-101, SAKI-9516 x ICC-85 and Vijay x BCG-79 exhibited high *per se* and significant SCA effects for yield and yield contributing traits. Thus, these could be selfed to obtained transgressive segregates from advanced generations.

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