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Combining ability analysis for seed yield and other yield contributing trait in kabuli chickpea (*Cicer areitinum* L.)

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Abstract
The Line x Tester fashion four lines were crossed with six testers to elucidate the information to select the parents with good GCA and crosses with good SCA effects. The resultant 24 hybrids were evaluated along with 10 parents with three standard checks during Rabi season 2017-18 at Pulses Research Unit Dr. PDKV, Akola. The analysis of variances for combining ability revealed highly significant differences for all the characters among all the crosses. Among the lines PKV Kabuli-2 and BDNGK-807 and among the testers Shubhra were found to be promising general combiners for seed yield and other yield contributing characters. Based on highest significant positive SCA effects only two crosses PKV Kabuli-2 x Shubhra (3.33) and Kripa x Phule G-0739 (2.08) were identified as promising for seed yield and other yield contributing characters.

Keywords: General and specific combining ability, line x tester, chickpea

Introduction
Among the pulses, Chickpea is one of the most important food legumes in the world. It plays an important role in human nutrition as a source of protein, energy, fiber, vitamins, and minerals for large population sectors in the developing world and is considered as a healthy food in many developed countries (Jodha and Subbarao, 1987) [3].
India is the largest producer of this crop; its productivity is low when compared to other countries like Italy, Turkey, Iran, Sudan etc. The important genetic factors like, photo and thermo sensitivity, low harvest index, flower drop, poor stability of present cultivar, susceptibility to disease and pest, management factors like predominantly cultivated on receding soil moisture and marginal land, inadequate plant protection. About 85% of the total chickpea production in the world is of *desi* type. *Kabuli* type though much in demand. Therefore there is need to developed *kabuli* chickpeas for attaining stable yields under receding soil moisture conditions.
To break the yield platue hybrid breeding is the one of the alternatives. But commercial hybrid seed production is not possible due to cleistogamous flower and unavailability of sterility gene in chickpea. Therefore, there was need to develop new high yielding varieties through hybridization using diverse parents. The study of combining ability helps in isolating useful parental lines and desirable specific cross combinations which could be further exploited in development of improved varieties. Accordingly, the present investigation was undertaken to have the knowledge on nature of combining ability and heterosis for yield and yield attributes. It helps in the selection of suitable parent for incorporation in hybridization programme. The parents are selected on the basis of their performance in a series of crosses.

Material and Method
Four lines *viz.*, PKV Kabuli-2, BDNGK-807, Chanoli, Kripa, and six testers *viz.*, Virat, BDNGK-798, Phule G-12310, Shubhra, Phule G-0739, MNK-1 were planted during 2016-17 at Pulses Research Unit Dr. PDKV, Akola and crossing was performed in Line x Tester fashion it produced 24 hybrids. During Rabi 2017-18, 24 crosses along with their parents and 3 standard checks Virat, PKV Kabuli-2, PKV Kabuli-4 were evaluated in Randomized Block design along with two replications. Observations were recorded on five randomly selected plants in each cross combination per replication for 10 quantitative characters. Data obtained were subjected to Line x Tester analysis Kemthorn (1957).

To estimated general and specific combining ability effects and their respective variances. The result of analysis presented blow.

Result and Discussion

The analysis of variances revealed significant differences for all the characters indicating the sufficient diversity and wider genetic differences among the parents and crosses (Table 1). Pertaining crosses into lines, testers and line x tester revealed that variances due to lines were significant for all the characters excepted number of primary branches per plant and number of empty pods per plant. Where has for testers studied in a Line x Tester analysis of 24 crosses obtained by crossing four lines with six testers was carried out and the total variance due to crosses was partitioned into portions attributable to females (lines), males (testers), interactions; female x male (line x tester) and error sources. The variance due to crosses was significant for all the characters. The mean squares due to lines (females) were for days to maturity, plant height, number of pods per plant and seed yield were found significant, indicates wide variability existing among the genotypes. The interactions due to lines x testers were significant for all the traits studied except plant height, suggesting that significant contribution of SCA effect towards the variation among the crosses The estimates of general combining ability effects of female and male parents are presented (Table 2). In chickpea positive GCA effects are desirable for all the characters studied except days to 50% flowering, days to maturity, and number of empty pods per plant for which negative GCA effects are desirable. Most of the male and female parents showed the significant differences for all the characters.

Among female parents, PKV Kabuli-2 recorded significant GCA effect for maximum five characters such as days to 50% flowering, days to maturity, plant height, number of pods per plant, 100 seed weight and seed yield per plant. Other female parent Chanoli was found to highest GCA effect for number of secondary branches, number of pods per plant, number of seeds per pod and empty pods per plant. Also female BDNGK-807 was found highest GCA effect for Days to 50% flowering and days to maturity and female line Kripa posses highest GCA for 100 seed weight.

The male parent, Shubhra recorded significant GCA effect for maximum characters *viz*, plant height, secondary branches, number of pods and seed yield per plant. The male parent Phule G-12310 recorded highest significant GCA effect for days to 50% flowering, 100 seed weight, number of empty pods per plant. The male BDNGK-798 posses significant GCA effect for primary branches, number of pods per plant and seeds per pod. The male parent MNK-1 posses significant GCA effect for 100 seed weight, and number of seeds per pod. By recording significant positive GCA effects hence, among the lines PKV Kabuli-2, Chanoli and BDNGK-807 and among the testers Shubhra and Phule G-1230 were proved to be good combiners for seed yield and most of the related characters and need to be exploited in future breeding programmed. The parents which are good generals combiner for yield possessed GCA effects in the desired direction for yield components was also reported earlier by Verma and Waldia (2010) [6], Jeena and Arora (2001) [2].

Only two crosses were identified good specific combination for seed yield per plant among these crosses the positive SCA effects for seed yield also exhibited significant positive SCA effects for other contributing traits. The cross combination PKV Kabuli-2 x Shubhra showed significant positive SCA effects for seed yield per plant along with number of secondary branches and number of pods per plant. Other cross Chanoli x Phule G-12310 showed significant positive SCA effects for seed yield per plant along with Days to 50% flowering, days to maturity, number of primary branches, number of secondary branches and empty pods per plant indicating its suitability for higher yield and early maturing genotypes. Similar finding were observed in present studied were also reported by Shinde and Deshmukh (1990), Malhotra *et al*. (1983) [4] and Gowda and Bahl (1978) [1].

Table 1: Analysis of Variance for Combining Ability

Sources of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of Primary branches per plant	No. of secondary branches per plant	No. of pods per plant	100 seeds weight (g)	No. of seeds per pod	No. of empty pods per plant	Seed yield per plant (g)
		1	2	3	4	5	6	7	8	9	10
Replications	1	4.08	1.69	0.52	0.59	0.40	47.80	0.02	0.001	0.00	3.12.
Crosses	23	43.82**	33.39**	39.83*	0.83**	22.98**	217.30**	277.30**	0.021**	1.35**	37.63**
Females (lines)	3	127.69**	60.47**	111.93**	0.35	66.47*	575.10**	1948.97**	0.072**	1.63	187.96**
Males (testers)	5	57.68	87.77**	86.04**	1.04	22.87	433.48**	40.39	0.019	2.17	36.36**
Females Vs Males	15	22.43**	9.85*	10.01	0.86**	14.31*	73.68**	21.94**	0.011*	1.03**	7.99*
Error	23	5.91	4.60	15.63	0.25	2.41	14.85	0.88	0.005	0.06	1.28

Note:
* Significant at 5% level of significance.
** Significant at 1% level of significance

Table 2: Estimation of general combining ability effects of parents for yield and other yield contributing traits

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches/plant	No. of secondary branches/plant
Line (Female)					
PKV Kabuli-2	-2.208**	-1.854**	3.246**	0.177	-0.163
BDNGK-807	-3.042**	-2.021**	0.929	-0.181	-1.613**
Chanoli	4.042**	2.146**	-4.071**	0.110	3.379**
Kripa	1.208	1.729**	-0.104	-0.106	-1.604**
SE(gi)	0.643	0.552	0.985	0.151	0.429
CD at 5%	1.331	1.143	2.037	0.313	0.888

CD at 1%	1.806	1.551	2.765	0.425	1.205
Testers (Male)					
Virat	1.292	-1.47*	-0.887	0.040	1.121*
BDNGK-798	4.29**	5.646**	1.463	0.627**	1.083*
Phule G-12310	-3.583**	-2.979**	0.812	-0.185	-0.029
Shubhra	0.417	-0.729	5.263**	0.090	1.846**
Phule G-0739	-1.083	-2.604**	-2.888*	-0.123	-1.57**
MNK-1	-1.333	2.146**	-3.763**	-0.448*	-2.442**
SE(gi)	0.788	0.6768	1.2065	0.185	0.525
CD at 5%	1.630	1.400	2.495	0.383	1.087
CD at 1%	2.212	1.900	3.387	0.520	1.476
Parents	**No. of pods per plants**	**100 seed weight (g)**	**No. of seeds per pod**	**No. of empty pods per plant**	**Seed yield per plant (g)**
Line (Female)					
PKV Kabuli-2	2.781*	7.048**	-0.064**	0.438**	3.967**
BDNGK-807	-1.635	4.390**	-0.041*	0.129	1.386**
Chanoli	7.573**	-19.002**	0.110**	-0.421**	-5.415**
Kripa	-8.719**	7.565**	-0.005	-0.146	0.061
SE(gi)	1.070	0.259	0.017	0.089	0.360
CD at 5%	2.214	0.536	0.037	0.184	0.746
CD at 1%	3.004	0.727	0.050	0.250	1.013
Testers (Male)					
Virat	3.490*	-1.573**	0.001	0.371**	0.826
BDNGK-798	3.190*	-0.323	0.057*	0.633**	0.904
Phule G-12310	-0.423	1.365**	-0.047*	-0.254*	-0.336
Shubhra	9.30**	-2.135**	-0.008	-0.379**	3.171**
Phule G-0739	-3.260*	-1.185**	-0.058*	0.333**	-1.721**
MNK-1	-12.29**	3.852**	0.055*	-0.704**	-2.845**
SE(gi)	1.310	0.317	0.021	0.109	0.442
CD at 5%	2.711	0.656	0.045	0.226	0.914
CD at 1%	3.680	0.891	0.0615	0.307	1.240

Note
* Significant at 5% level of significance.
** Significant at 1% level of significance

Table 3: Estimation of specific combining ability effects of crosses for yield and other yield contributing traits

Sr. No.	Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pods per plant	100 seed weight (g)	No. of seeds per pod	Empty pods per plant	Seed yield per plant (g)
		1	2	3	4	5	6	7	8	9	10
1	PKV Kabuli-2 x Virat	4.458**	1.729	-1.196	0.485	-0.212	-6.356*	0.140	-0.007	-0.613*	-2.002*
2	PKV Kabuli-2 x BDNGK-798	-1.042	0.604	3.054	-0.202	2.375*	5.544*	-2.86**	-0.044	0.475*	1.800
3	PKV Kabuli-2 x Phule G-12310	-1.167	-1.771	1.204	-0.090	-1.363	-2.844	0.452	0.060	0.413	-0.960
4	PKV Kabuli-2 x Shubhra	-1.667	0.979	0.254	0.285	2.563*	10.13**	-0.048	0.001	1.138**	3.333**
5	PKV Kabuli-2 x Phule G-0739	-0.167	0.354	-2.296	0.048	0.188	0.494	0.202	0.051	-0.275	0.595
6	PKV Kabuli-2 x MNK-1	-0.417	-1.896	-1.021	-0.527	-3.550**	-6.96*	2.115**	-0.061	-1.138**	-2.766**
7	BDNGK-807 x Virat	-2.208	1.896	1.121	-0.156	-0.063	-0.340	1.298	0.045	0.296	0.419
8	BDNGK-807 x BDNGK-798	0.792	-0.729	-0.429	0.856*	0.575	-4.240	-1.702*	-0.036	-0.167	-1.989*
9	BDNGK-807 x Phule G-12310	1.667	0.396	-3.879	-0.731	-1.713	0.073	1.110	0.018	0.721**	1.721
10	BDNGK-807 x Shubhra	-0.833	1.146	3.571	-0.506	-2.588*	-1.352	-2.890**	0.029	-0.554*	-1.236
11	BDNGK-807 x Phule G-0739	-0.833	-0.979	-1.279	0.506	0.638	-0.590	3.060**	0.029	0.333	-0.194
12	BDNGK-807 x MNK-1	1.417	-1.729	0.896	0.031	3.150**	6.44*	-0.877	-0.084	-0.629**	1.280
13	Chanoli x Virat	-4.292*	0.729	-0.379	-0.898*	-2.754*	-2.548	3.440**	-0.022	0.146	0.130
14	Chanoli x BDNGK-798	2.208	1.604	-2.329	0.365	-1.617	4.252	3.190**	0.162**	-0.417	1.533
15	Chanoli x Phule G-12310	-5.917**	-4.354**	1.621	0.877*	3.796**	5.415	-0.998	-0.059	-0.729**	0.023
16	Chanoli x Shubhra	3.083	-1.021	-1.329	-0.398	1.221	-7.51**	4.002**	-0.023	-0.204	-0.835
17	Chanoli x Phule G-0739	2.583	-0.146	2.421	-0.085	1.646	-2.398	-4.948**	-0.073	0.083	-2.482**
18	Chanoli x MNK-1	2.333	1.104	-0.004	0.140	-2.292*	2.790	-4.68**	0.015	1.121**	1.631
19	Kripa x Virat	2.042	-2.271	0.454	0.569	3.029**	9.24**	-4.877**	-0.016	0.171	1.454
20	Kripa x BDNGK-798	-1.958	-1.479	-0.296	-1.019*	-1.333	-5.55*	1.373*	-0.082	0.108	-1.344
21	Kripa x Phule G-12310	5.417**	3.646*	1.054	-0.056	-0.721	-2.644	-0.565	-0.018	-0.404	-0.784
22	Kripa x Shubhra	-0.583	-1.104	-2.496	0.619	-1.196	-1.269	-1.065	-0.007	-0.379	-1.261
23	Kripa x Phule G-0739	-1.583	0.771	1.154	-0.469	-2.471*	2.494	1.685*	-0.007	-0.142	2.081*
24	Kripa x MNK-1	-3.333*	2.521	0.129	0.356	2.692*	-2.269	3.448**	0.130**	0.646**	-0.145
	SE(D)±	1.576	1.353	2.413	0.370	1.038	2.621	0.634	0.043	0.218	0.884
	CD 5%	3.260	2.800	4.991	0.767	2.147	5.423	1.313	0.090	0.452	1.828
	CD 1%	4.424	3.800	6.774	1.041	2.914	7.360	1.781	0.123	0.614	2.481

* Significant at 5% level of significance ** Significant at 1% level of significance

Table 4: GCA effects of promising parents on desirable direction for seed yield and other yield contributing traits

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pods per plant	100 seed weight (g)	No. of seeds per pod	Empty pods per plant	Seed yield per plant (g)
	1	2	3	4	5	6	7	8	9	10
Lines (Females)										
PKV Kabuli-2	-2.20**	-1.85**	3.24**	-	-	2.78*	7.04**	-	-	3.96**
BDNGK-807	-3.04**	-2.02**	-	-	-	-	4.39**	-	-	1.38**
Chanoli	-	-	-	-	3.37**	7.57**	-	0.11**	-0.42**	-
Kripa	-	-	-	-	-	-	7.56**	-	-	-
Testers (Males)										
Shubhra	-	-	5.26**	-	1.84**	9.30**	-	-	-0.37**	3.17**
BDNGK-798	-	-	-	0.62**	1.08*	3.19*	-	0.057*	-	-
Phule G-12310	-3.58**	-2.97**	-	-	-	-	1.36**	-	-0.25**	-
MNK-1	-	-	-	-	-	-	3.85**	0.05*	-0.70*	-

Table 5: SCA effects of promising crosses in desirable direction for yield and other yield contributing traits

Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of secondary branches	No. of pods per plant	100 seed weight (g)	No. of seeds per pod	Empty pods per plant	Seed yield per plant (g)
	1	2	3	4	5	6	7	8	9	10
PKV Kabuli-2 x Shubhra	-	-	-	-	2.56**	10.13**	-	-	-	3.33**
Chanoli x Phule G-12310	-5.91**	-4.35**	-	0.87*	3.79**	-	-	-	-0.72**	-
Kripa x MNK-1	-3.33*	-	-	-	2.69*	-	3.44**	0.13**	-	-
Kripa x Phule G-0739	-	-	-	-	-	-	1.68*	-	-	2.08*
PKV Kabuli-2 x BDNGK-798	-	-	-	-	2.37*	5.54*	-	-	-	-
Chanoli x Virat	-4.29*	-	-	-	-	-	3.44**	-	-	-
Chanoli x Shubhra	-	-	-	-	-	-	4.00**	-	-	-

*: Significant at 5% level of significance
**: Significant at 1% level of significance

Conclusion

Among parents, PKV Kabuli-2, BDNGK-807, Shubhra and Phule G-12310 recorded highest significant GCA effect hence, these genotypes were recognized as the best parental material among the available genotypes and can be used as parents in hybridization programmed. The crosses PKV Kabuli-2 x Shubhra and PKV Kabuli-2 x BDNGK-798 were found promising. On the basis of *per se* performance of GCA and SCA effects. These crosses may be employed to exploit non-additive component response. However, the performances of this cross have to be evaluated in large scale trials.

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