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Namrata P Malge
M.Sc. Student, Department of Genetics and Plant Breeding, Faculty of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dhaneshwari N Pachkhande
M.Sc. Student, Department of Genetics and Plant Breeding, Faculty of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dadas ND
M.Sc. Student, Department of Genetics and Plant Breeding, Faculty of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dr. Lande SS
Assistant Professor of Genetics and Plant Breeding, Pulses Research Unit, Dr. PDKV Akola

Dr. Archana W Thorat
Senior Research Scientist, Pulses Research Unit, Dr. PDKV, Akola, Maharashtra, India

Corresponding Author:
Namrata P Malge
M.Sc. Student, Department of Genetics and Plant Breeding, Faculty of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Combining ability analysis for yield and it's components in chickpea (*Cicer arietinum* L.)

Namrata P Malge, Dhaneshwari N Pachkhande, Dadas ND, Dr. Lande SS and Dr. Archana W Thorat

Abstract
Combining ability studies were carried out through a line x tester design cross for eleven important quantitative traits. Variance due to general combining ability and specific combining ability were significant for all the characters. Phule Vikram, PDKV Kanchan, AKG -1303 among the lines and JCP-101 among the testers were found to possess significant GCA effects for most of the yield contributing characters. A cross PDKV Kanchan × GJG-0814 showed high significant SCA effects for days to 50% flowering, days to maturity, plant height, no. of primary branches per plant, 100 seed weight and no. of seed per pod. This cross may be exploited by heterosis breeding.

Keywords: Chickpea, *Cicer arietinum*, quantitative traits

Introduction
Yield being a complex character and also due to high degree of environment interaction, its improvement is difficult. It can only be improved if component characters can be improved. For improving any quantitative traits, the choice of suitable parents in a breeding programme is of upmost importance in achieving desired improvement in the crops. The information regarding combining ability of parents and F_1's for yield and component become very important to the plant breeder in the context of deciding efficient breeding methodology. Combining ability also helps in proper understanding of inheritance of characters, which in turn helps in selection of suitable parents, for hybridization. The present study was undertaken to investigate the relative importance of general and specific combining ability for yield and its importance through line x tester analysis.

Method and Materials
Present research was conducted at Pulses Research Unit, Dr. PDKV, Akola. The parent material for the study consisted of four lines *viz*., PDKV Kanchan, Phule Vikram, AKG-1303, Chanoli and six tester *viz*., GAU-1107, GJC-3, WR-315, JCP-101, C-1821 and GJG-0814. Crossing work was done in *rabi* 2018-19 and evaluation was done in *rabi* 2019-20, resultant 24 crosses ten parents and checks JAKI-9218 were sown in RBD design with two replications for evaluation. Each entry was sown in one row of 3 m length in each replication with inter and intra-row spacing was 45 cm and 10 cm, respectively. All the standard agronomic and plant protection measures were used.
The data was recorded on plant basis and plot basis, from each genotype in each replication on 5 randomly selected plants and their average value was computed for ten quantitative traits *viz*., Plant stand, days to 50% flowering, days to maturity, plant height (cm), number of primary branches, number of secondary branches, number of pods per plant, 100 seed weight (g), seed yield per plant (g), number of seeds per pod, number of empty pods per plant, growth habit, loddging resistance. The combining ability analysis was done by according to kempthorne's line x tester analysis.

Results and discussion
The analysis of variance for the combining ability revealed that mean square due to general combining ability (GCA) and specific combining ability (SCA) were highly significant for all the character under study (Table 1). Estimation of GCA effects of parents and SCA effects of the crosses for different characters is given in table 2 and 3.
Phule Vikram, PDKV Kanchan, JCP-101, and AKG-13103 were a good combiner for yield and yield contributing characters. Phule Vikram identified as best combiner for number of seeds per pod, 100 seed weight and seed yield per plant, PDKV Kanchan recorded negative

(desirable) significant gca effect for days to 50% flowering. JCP-101 recorded significant gca effect for plant stand, days to early flowering and maturity, number of secondary branches per plant, 100 seed weight, number of seeds per pod, lowest number of empty pods per plant. Hence, these parents should be exploited in hybridization programme to improve seed yield. It will be ideal to combine Phule Vikram and JCP-101 so that more favourable gene recombination could be obtained for all the important economic traits. In present investigation, it is also observed none of the parents was found to general combiner for all the traits. Therefore, it would be desired to have multiple crosses involving all these parents and make selection in advance generations as reported by Panwar *et al.* (1985) [2].

Table 1: Analysis of variance for various traits in line x tester analysis of chickpea

Sources	d.f.	Plant stand	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 seed weight per plant (g)	Seed yield per plant (g)	No. of Seeds per pod	No. of empty pods per plant
		1	2	3	4	5	6	7	8	9	10	11
Replications	1	0.941	6.485	2.485	11.97	0.640	22.36	3.907	0.058	1.951	0.00	0.024
Treatments	33	28.09**	34.53**	8.690**	56.52**	0.738**	18.58*	90.89**	57.77**	67.67**	0.014**	2.19**
Parents	9	0.472	13.88	12.22**	52.89**	0.312	3.944	106.07**	34.20**	39.58**	0.018**	3.11**
Parents vs Crosses	1	720.88**	38.24	67.81**	1.067	9.531**	11.96	390.72**	52.38**	6.504	0.008	20.31**
Crosses	23	8.781**	42.45**	4.735*	60.35**	0.522**	24.59**	71.92**	67.23**	81.31**	0.013*	1.04
Error	33	0.729	13.72	2.515	9.873	0.177	9.464	28.76	2.497	4.951	0.006	0.700

Table 2: General combining ability effects of parents in chickpea

Parents	Plant Stand	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 Seed weight (g)	Seed yield per plant (g)	No. of seeds per pod	No. of empty pods per plant
Line (Female)											
PDKV Kanchan	0.146	-2.146**	-0.458**	3.740*	0.225**	0.556	2.204	1.856**	3.562**	0.006**	-0.273**
Phule Vikram	0.729**	-1.146**	-0.208**	2.623	-0.150**	0.84	1.604	4.081**	3.900**	0.048**	-0.040**
AKG-1303	0.646**	-1.229**	-0.292**	2.300	-0.283**	0.498	-1.204**	3.223**	2.288*	-0.027**	0.685**
Chanoli	-1.521**	4.521	0.958*	-8.663**	0.208**	-1.894**	-2.604**	-9.160**	-9.750**	-0.027**	-0.373**
SE(gi)	0.246	1.067	0.457	0.907	0.121	0.888	1.548	0.456	0.642	0.022	0.241
CDat5%	0.509	2.212	0.947	1.876	0.251	1.837	3.203	0.943	1.328	0.046	0.499
CDat1%	0.692	3.002	1.285	2.546	0.341	2.493	4.346	1.28	1.803	0.063	0.678
Testers (Male)											
GAU-1107	0.729**	-0.021**	-0.292**	0.168	0.058	-0.248**	-2.046**	-1.519**	-1.746**	-0.023**	0.273
GJC-3	0.146	-0.396**	0.708	-0.357	0.008	-1.073**	0.042	-0.131**	0.183	0.015**	0.585*
WR-315	-0.104**	1.229	-0.417**	0.734	0.146*	-3.560**	-1.296**	-0.606**	-0.411**	-0.010**	-0.177**
JCP-101	1.396**	-1.521**	-0.417**	1.185	0.083	3.640**	-0.508**	1.406*	1.124	0.027**	-0.577**
C-1821	0.146	0.729	0.583	-0.435**	0.033	1.09	1.267	0.456	0.516	0.002	-0.215**
GJG-0814	-0.854**	-0.021**	-0.167**	-1.295**	-0.329**	0.152	2.542	0.394	0.335	-0.010**	0.11
SE(gi)	0.301	1.3099	0.56	1.11	0.149	1.087	1.896	0.558	0.786	0.027	0.295
CDat5%	0.624	2.709	1.16	2.298	0.308	2.25	3.922	1.155	1.627	0.056	0.612
CDat1%	0.847	3.677	1.574	3.118	0.418	3.053	5.323	1.568	2.208	0.077	0.83

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

Table 3: Specific combining ability effects in chickpea

Sr. No.	Crosses	Plant Stand	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 Seed weight (g)	Seed yield per plant (g)	No. of seeds per pod	No. of empty pods per plant
		1	2	3	4	5	6	7	8	9	10	11
1	PDKVKanchanxGAU-1107	0.479	-6.979*	0.708	0.376	-0.225	-4.394	-3.604	-3.906**	-4.012*	-0.044	-0.09
2	PDKVKanchanxGJC-3	-0.896	5.896*	-1.792	-0.304	0.575	-2.219	-4.542	-0.194	-1.591	-0.081	-0.502
3	PDKVKanchanxWR-315	-1.646*	-0.229	0.833	-2.72	0.338	-0.931	-0.954	-1.369	0.253	-0.056	-0.34
4	PDKVKanchanxC-1821	3.354**	5.521*	0.333	0.379	0	0.069	4.758	-1.819	2.318	0.106	0.66
5	PDKVKanchanxJCP-101	-1.396*	-0.729	1.333	1.434	-0.25	3.119	-5.367	0.019	-1.975	0.031	-0.202
6	PDKVKanchanxGJG-0814	0.14	-3.479	-1.417	0.834	-0.438	4.356	9.708*	3.631**	5.007**	0.044	0.473
7	PhuleVikramxGAU-1107	-0.604	4.021	-2.542*	-0.762	0.6	0.723	0.546	-0.081	0.6	0.065	-0.423
8	PhuleVikramxGJC-3	3.021**	-8.104**	1.958	0.913	-0.6	0.898	6.708	0.981	3.141	0.127*	0.265
9	PhuleVikramxWR-315	-1.729**	3.771	-0.917	-2.783	-0.188	-1.215	2.146	0.756	0.595	-0.098	0.577
10	PhuleVikramxC-1821	-2.229**	-0.479	-1.917	0.926	0.425	3.085	7.258	1.194	2.73	0.015	0.277
11	PhuleVikramxJCP-101	3.021**	-2.229	1.083	1.936	-0.225	-3.865	-6.717	-0.356*	-4.213*	-0.11	-0.035
12	PhuleVikramxGJG-0814	-1.479*	3.021	2.333*	0.229	-0.012	0.373	-9.942*	-0.494	-2.852	0.002	-0.66
13	AKG-1303xGAU-1107	-1.021	0.104	0.542	1.326	0.483	-0.085	-3.196	2.377*	0.862	-0.01	0.702
14	AKG-1303xGJC-3	-1.396*	-0.021	0.042	-0.594	-0.267	1.34	-3.433	-0.71	-0.917	0.002	-0.46
15	AKG-1303xWR-315	2.854**	1.854	1.167	3.42	0.346	-0.073	-1.196	0.515	-0.663	-0.023	0.302
16	AKG-1303xC-1821	0.854	-2.896	0.667	1.004	-0.292	1.427	-2.883	-1.748	-2.958	-0.06	-0.798
17	AKG-1303xJCP-101	-1.896**	1.854	-0.833	-4.431	-0.342	-0.873	8.242*	2.002	4.800**	0.115*	0.24
18	AKG-1303xGJG-0814	0.604	-0.896	-1.583	-0.726	0.071	-1.735	2.467	-2.435*	-1.124	-0.023	0.015

19	ChanolixGAU-1107	1.146	2.854	1.292	-0.941	-0.858**	3.756	6.254	1.61	2.55	-0.01	-0.19
20	ChanolixGJC-3	-0.729	2.229	-0.208	-0.016	0.292	-0.019	1.267	-0.077	-0.633	-0.048	0.698
21	ChanolixWR-315	0.521	-5.396	-1.083	2.083	-0.496	2.219	0.004	0.098	-0.185	-0.177**	-0.54
22	ChanolixC-1821	-1.979**	-2.146	0.917	-2.309	-0.133	-4.581*	-9.133*	-1.265	-2.09	-0.06	-0.14
23	ChanolixJCP-101	0.271	1.104	-1.583	1.061	0.817*	1.619	3.842	0.335	1.388	-0.035	-0.002
24	ChanolixGJG-0814	0.771	1.354	0.667	0.121	0.379	-2.994	-2.233	-0.702	-1.031	-0.023	0.173
	SE(m)±	0.603	2.619	1.121	2.221	0.298	2.175	3.792	1.117	1.573	0.055	0.591
	CD(0.05%)	1.249	5.419	2.32	4.596	0.616	4.5	7.845	2.311	3.254	0.113	1.224
	CD(0.01%)	1.695	7.354	3.148	6.237	0.837	6.107	10.647	3.137	4.417	0.154	1.661

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

SCA effects of crosses revealed that none of the crosses had significant SCA effect for all the traits. PDKV Kanchan × GJG-0814, AKG-1303 × JCP -101, Phule Vikram × GJC-3, Phule Vikram × GAU-1107, AKG-1303 × GAU-1107 and Chanoli × JCP-101were six promising crosses for green pod yield considering SCA effects. These crosses involve only four good general combiners. Therefore, they may be exploited for isolating transgressive segregates in $F_{2,}$ if the additive genetic system present in good combiner and complementary epistatic effect in the F_1 acted in the direction to maximise the desirable plant attributes.

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