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Combining Ability Analysis of Quantitative Traits in Chickpea (*Cicer arietinum* L.)

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ABSTRACT

Three lines and six testers were utilized for combining ability analysis in chickpea to generate information on nature of gene action and to identify potential general and specific combiners for important quantitative traits during *rabi* 2008. Higher estimates variance components due to *gca* for plant height and harvest index and those due to *sca* variance for number of pods were obtained. Both *gca* and *sca* components were of equal magnitude for root length, number branches, 100 seed weight, seed yield and biomass indicating the role of additive and non-additive gene action in the inheritance of various quantitative traits in chickpea. JAKI-9218, JG-74 and WR-315 were good general combiners for seed yield and other traits. Two promising crosses NBeG 1 X WR 315 and JAKI-9218 X ICC 12479 with significant *sca* effects were identified for further exploitation. To harness different gene effects, diallel selective mating or biparental mating followed by pedigree method of selection may be followed to recover desirable transgressive segregants for yield and other attributes in the breeding material studied.

Key words : Chickpea, Combining ability, Gene action, Line x Tester analysis

Chickpea is an important *rabi* pulse crop in Andhra Pradesh grown in an area of 6.47 lakh ha with a production of 8.47 lakh tonnes. The major constraint to chickpea production in Andhra Pradesh is drought as most of the chickpea area is in scarce rainfall zone comprising of Kurnool, Anantapur and Kadapa districts. A rapid increase in the chickpea area (1.10 lakhs in 1995-96 to 6.47 lakhs in 2009-10) in the state necessitated to breed varieties which can with stand drought and can be grown well under receding moisture situations. Other biotic constraints which limit chickpea productivity are *Fusarium* wilt and *Helicoverpa* pod borer. Knowledge of genetic systems governing the inheritance of the traits and combining ability of parents is a pre requisite for initiating planned breeding programmes. This helps in the selection of suitable parents for hybridization and also promising crosses for further exploitation by choosing appropriate selection technique. Therefore, the present investigation was taken up with nine chickpea genotypes to elucidate information on nature of gene action for traits of economic importance and also to work out the combing ability of parental genotypes.

MATERIAL AND METHODS

Three high yielding chickpea genotypes viz., NBeG – 1, JAKI-9218 and JG-130 were chosen as lines and crossed with six testers. The tester genotypes were Vishal, ICCC -37 (high yielding), JG-74, WR-315 (tolerant to wilt) and ICC 12478 and ICC 12479 (tolerant to *Helicoverpa* pod borer). Three lines were crossed with six testers during Rabi, 2008-09 resulting in 18 F_1 crosses. Eighteen F_1 crosses and nine parents were evaluated during *rabi* 2009-10 in a randomized block design with two replications. Each genotype was grown in a single row of four meter length by adopting a spacing of 30 cm x 10 cm. Non experimental material viz., JG-11 was grown around the experiment to avoid border effect. Recommended package of practices were followed for raising the crop. Data were recorded on eight biometrical traits viz., plant height (cm), root length (cm), number of branches per plant, number of pods per plant, 100 seed weight (g), seed yield (g/plant), biomass (g/plant) and harvest index on five randomly selected plants in each replication. Combining ability analysis was done as per modified line x tester analysis (Singh and Chaudhary, 1985).

Table 1. Analysis of variance for combining ability for eight quantitative traits in chickpea.

Source of Variation	Degrees of freedom	Plant height (cm)	Root length (cm)	Number of branches per plant	Number of pods per plant	100 seed weight (g)	Seed yield (g plant^{-1})	Biomass (g plant^{-1})	Harvest Index
Parents	8	11.80**	3.34*	13.92**	62.15**	68.64**	7.80**	74.67**	73.7
Parents vs Crosses	1	1.84	3.17	123.52**	1313.92**	246.61**	66.19**	59.85*	592.6**
Crosses	17	8.31**	5.06**	80.35**	183.46**	10.67**	12.94**	47.56**	142.1**
Lines	2	4.35	2.85	173.67	295.81	2.50	28.87	59.95	399.1*
Testers	5	17.67*	8.90	91.00	151.82	22.14*	13.63	64.46	201.9
Line X Testers	10	4.42	3.58*	56.36**	176.82**	6.57**	9.40**	36.63**	60.8
Error	52	2.61	1.25	3.52	10.58	1.13	1.17	10.33	36.2
σ^2 *gca*		1.87	1.03	28.63	47.39	2.49	4.46	11.53	58.7
σ^2 *sca*		0.91	1.17	26.42	83.12	2.72	4.12	13.15	12.3
σ^2 *gca* / σ^2 *sca*		**2.06**	**0.88**	**1.08**	**0.57**	**0.91**	**1.08**	**0.88**	**4.77**

RESULTS AND DISCUSSION

Results of analysis of variance and analysis of combining ability in 18 crosses and nine parents for eight quantitative traits were presented in Table 1. Mean squares for all the traits except harvest index were found to be significant in parental genotypes. In crosses, mean squares were significant for all the traits. This revealed that there exists substantial variability among parents as well as crosses for most of the traits. Mean squares due to parents vs. crosses were significant for number of branches, number of pods, 100 seed weight, seed yield, biomass and harvest index revealing the expression of heterosis for these attributes in F_1 hybrids.

Results of analysis of combining ability in Table 1 also revealed that variance due to combining ability of lines was significant for harvest index where variance due to combining ability of testers was significant for plant height and 100 seed weight. Variances due to lines x testers interaction was significant for root length, number of branches, number of pods, 100 seed weight, seed yield and biomass.

In self pollinated crops like chickpea, knowledge of relative magnitude of fixable and non fixable genetic variance will be helpful in choosing appropriate breeding technique. In the present study, a perusal of relative magnitude of components due to *gca* and *sca* variances revealed predominance of *gca* variance for plant height and harvest index indicating the role of additive gene action in the inheritance of these traits. Hence selection for these traits in early segregating generations will be effective. Number of pods per plant exhibited higher magnitude of component due to *sca* variance there by indicating that this trait is under the influence of non-additive genes. Variance components due *gca* and *sca* are of equal magnitude incase of other traits viz., root length, number of branches, 100 seed weight, seed yield and biomass. Gupta *et al.,* (2007) reported predominant additive gene effects for plant height and non additive gene effects for number of branches, number of pods, 100 seed weight, seed yield and harvest index. Where as Bharadwaj *et al.,* (2009) reported predominance of additive gene action in governing plant height, number of pods, plant biomass, harvest index, grain yield and 100 seed yield and non-additive gene action for number of branches, Hedge *et al.,* (2008) reported that *gca* variances were significant and higher in magnitude for biological yield and harvest index indicating the predominant role of additive gene action. Preeti Verma and Waldia (2010) reported that the magnitude of non additive variance was considerably higher for plant height, number of pods, 100 seed weight, biological yield and seed yield. Such differences in variation reported in different studies may be due differences in mating system, method of analysis (random vs. fixed) and / or in the parental material that was used in those studies (Singh *et al.,* 1992). In view of importance of both additive and non additive gene effects for various traits in chickpea, adoption of breeding strategies like diallel selective mating or

Table 2. General combining ability effects and *per se* performance (in parenthesis) of lines and testers for eight quantitative traits in chickpea.

Parent	Plant height (cm)	Root length (cm)	Number of branches per plant	Number of pods per plant	100 seed weight (g)	Seed yield (g plant^{-1})	Biomass (g plant^{-1})	Harvest Index
Lines								
NBeG-1	0.669	-0.161	-2.108**	-2.294**	0.517	-1.389**	-2.489*	-1.472
	(32.3)	(10.0)	(18.5)	(28.1)	(24.1)	(7.5)	(28.2)	(26.5)
JG-130	-0.497	0.547	-2.283**	-3.403**	-0.350	-0.285	1.836	-4.889*
	(33.7)	(8.5)	(19.8)	(20.7)	(24.7)	(6.9)	(20.1)	(34.0)
JAKI-9218	-0.172	-0.386	4.392**	5.697*	-0.167	1.674**	0.653	6.36**
	(34.3)	(11.4)	(14.7)	(30.2)	(23.0)	(8.5)	(28.1)	(30.5)
S Em±	0.4662	0.3226	0.5414	0.9389	0.3070	0.3117	0.9280	1.737
Testers								
Vishal	1.369	-0.536	-2.825**	-5.936**	1.083*	-0.576	-4.606**	7.19**
	(34.5)	(8.9)	(13.4)	(18.3)	(25.6)	(9.8)	(25.0)	(39.5)
JG-74	-0.964	0.214	1.425	0.364	0.750	2.657**	2.361	6.36*
	(33.9)	(7.4)	(12.1)	(25.7)	(19.5)	(9.2)	(22.6)	(40.5)
ICC 12479	0.653	2.281**	-0.358	4.514**	-0.117	0.682	1.911	-2.30
	(32.1)	(7.1)	(17.2)	(26.8)	(13.1)	(7.5)	(19.0)	(39.5)
ICCC-37	-1.747*	-0.086	-5.775**	-5.136**	2.617**	-1.710**	-3.772*	0.53
	(27.5)	(8.7)	(12.8)	(23.2)	(11.7)	(3.5)	(10.5)	(33.0)
WR315	2.369**	-0.686	5.175**	6.647**	-2.650**	-0.643	1.494	-5.13
	(32.0)	(8.5)	(14.0)	(37.4)	(13.8)	(7.1)	(15.3)	(46.5)
ICC 12478	-1.681*	-1.186*	2.358**	-0.453	-1.683**	-0.410	2.611	-6.64*
	(29.0)	(8.5)	(15.0)	(25.5)	(12.6)	(5.0)	(15.2)	(33.5)
S Em±	0.6593	0.4562	0.7656	1.3278	0.4342	0.4409	1.3124	2.45

biparental mating and then advancing the breeding material though pedigree method at later stages will help to exploit different genetic effects in the present set of breeding material. Nagaraja *et al*., (2002) and Narendra Singh (2004) observed greater genetic variability for various traits in the progeny of chickpea crosses generated through biparental mating.

The knowledge of combining ability is useful to assess the mating ability of parents in self pollinated crops (Baker, 1978). General combining ability in conjunction with *per se* performance helps to identify potential parental genotypes. General combining ability estimates of parental genotypes and their *per se* performance for eight quantitative traits are presented in table 2. None of the parental genotypes was found to be promising for all the traits. Among lines JAKI – 9218 was note worthy on account of its positive and significant *gca* effects for number of branches (4.392**), number of pods (5.697*), seed yield (1.674**) and harvest index (6.36**). This line also had comparatively higher mean value for number of branches, number of pods, and seed yield. Among testers, Vishal for 100 seed weight (1.083*) and harvest index (7.19**); JG-74 for seed yield (2.657**) and harvest index (6.36*); ICC 12479 for root length (2.281**) and number of pods (4.514**); ICCC 37 for 100 seed weight (2.617**); WR 315 for plant height (2.369**), number of branches (5.175**) and number of pods (6.647**) and ICC 12478 for number of branches (2.358**) recorded positive and significant *gca* effects. High *gca* effects are due to fixable additive and additive x

Table 3. Specific combining ability effects, *per se* performance and gca status of parental lines of promising crosses in chickpea.

Character	Superior crosses with significant *sca* effects	*Sca* effects	*Per se* performance	*Gca* status of parents
Root length (cm)	JG-130 X JG-74	2.153*	12.2	Low X Low
Number of Branches	NBeG -1 x ICCC-37	4.708**	15.3	Low X Low
	JG-130 X JG-74	5.733**	23.4	Low X Low
	JAKI-9218XICC 12479	3.342*	25.9	High X Low
	JAKI- 9218 X WR -315	9.108**	37.2	High X High
Number of Pods	NBeG-1 X WR-315	5.728*	46.8	Low X High
	JG-130 X JG-74	14.269**	47.9	Low X Low
	JAKI-9218XICC 12479	12.519**	59.4	High X High
	JAKI- 9218 X WR -315	5.236*	54.3	High X High
100 Seed weight (g)	NBeG-1 X WR-315	3.083**	24.2	Low X Low
	JAKI-9218XICC 12479	2.333**	25.3	Low X Low
Seed yield (g plant^{-1})	NBeG-1 X WR-315	3.339**	10.9	Low X Low
	JAKI-9218XICC 12479	2.501**	14.4	High X Low
Biomass (g plant^{-1})	NBeG-1X WR-315	7.106**	28.8	Low X Low

additive gene action and therefore parental genotypes used in the present study registering high *gca* effects hold promise in breeding superior chickpeas.

In chickpea owing to its autogamous genetic architecture, specific combining ability effects are not readily useful. However, if *sca* is due to additive x additive gene action, it is fixable in later generations and therefore superior transgressive segregants can be isolated from such crosses. Crosses with significant *sca* effects, their mean performance and the *gca* status of parental genotypes involved in crosses with high *sca* effects for various traits are presented in table 3. Significant *sca* effects were not recorded in any of the crosses for plant height and harvest index. JG-130 X JG 74 recorded significant *sca* effects for root length (2.153*), number of branches (5.733**) and number of pods (14.269**). This cross recorded high mean values for root length and number of pods. However, the parents involved in this cross were found to be low general combiners for all the three traits. Significant *sca* effects in this cross might be due to dominant epitasis which may be due to genetic diversity and interaction of heterozygous loci for specific traits.

Other promising crosses on the basis of *sca* effects were NBeG 1 X WR 315 and JAKI-9218 X ICC 12479. These crosses also recorded higher mean values for some of the traits. NBeG1 X WR 315 was superior with respect to number of pods (low x high), 100 seed weight (low x low), seed yield (low x low) and biomass (low x low). JAKI-9218 X ICC 12479 recorded significant *sca* effects for number of branches (high x low), number of pods (high x high), 100 seed weight (low x low) and seed yield (high x low). JAKI 9218 X WR – 315 is another cross involving high X high general combiners, registered positive and significant *sca* effects for number of branches and number of pods per plant. High *sca* effects in this cross are readily fixable as its superior performance is due to interaction of desirable high *gca* effects of both parental genotypes involved where as crosses with significant *sca* effects involving high x low general combining ability are likely to throw transgressive segregants if additive genetic system present in the good combiner and complementary epistatic effects in the F_1 work in the same direction to maximise the desirable plant attributes (Langham, 1961). .

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