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Combining Ability Analysis of Yield and Yield Attributes in *Kabuli* Chickpea (*Cicer arietinum* L.)

N Jagadish, V Jayalakshmi, B Narendra and P Umamaheshwari
Department of Genetics and Plant Breeding, Agricultural Colelge, Mahanandi, Andhra Pradesh

ABSTRACT

An investigation with six diverse *kabuli* genotypes and their 15 half diallel F1 hybrids was taken up during *rabi* 2012-13 to elucidate information on the gene action involved in the inheritance of yield and yield attributes and also to identify promising parents and cross combinations for evolving high yielding large seeded or extra large seeded *kabuli* chickpea. Both additive and non additive gene actions were found to be involved in the genetic control of yield and yield attributes with a predominance of additive gene action for plant height, number of pods per plant, shoot biomass per plant, harvest index, seed yield and 100 seed weight and non additive gene action for number of branches plant. Hence, breeding methods like biparental mating in F_2 or recurrent selection or modified pedigree methods were suggested for exploiting both the types of gene actions for evolving high yielding purelines. Parental genotypes with superior general combing ability effects *viz.,* Vihar, and NBeG 72 for seed yield; KAK 2 and ICCV 95333 for harvest index and Phule G 05107 and MNK 1 for plant height and 100 seed weight and promising crosses *viz.,* KAK 2 and Vihar and MNK 1 x NBeG 72 can be exploited for breeding high yielding large seeded or extra large seeded *kabuli* chickpea.

Key words : Combining ability, Yield.

Chickpea is the third most important grain legume in the world after dry beans and dry peas. In India, it is grown in 8.32 m ha area with an annual production of 7.58 million tonnes. But, the productivity of chickpea is low (912 kg ha^{-1}) compared to the expected potential (5000 kg ha^{-1}). Though India is worlds' largest producer of chickpea, the production is not enough to meet the domestic demand. Thus, India has to import large quantities of chickpea every year. On an average, India has spent US$ 115 m annually on chickpea import during 2007 to 2011. Out of this import, major share is of extra large seeded or lage seeded *kabuli* chickpea. In chickpea two distinct types are available *viz., desi* and *kabuli*. Among them *kabuli* chickpea has good demand in the international market as compared to *desi* chickpea, However, the yield potential of *kabuli* chickpea is comparatively low and hence there is a need to improve the yield levels in *kabuli* chickpea through systematic breeding programmes. Development of large seeded (or) extra large seeded *kabuli* chickpea (> 40-50g/100 seed weight) varieties insulated with resistance to *Fusarium wilt* and other major stresses will help in enhancing the productivity of crop in India. The choice of breeding method depends on the gene action involved in the inheritance of the characters. The techniques developed by Jinks and Haymans (1953) and Griffing (1956) evaluate the varieties in terms of their genetic makeup and provide information on the nature and magnitude of genetic parameters and general and specific combining ability of parents and their crosses respectively. Therefore, an attempt was made to assess the nature of gene effects for yield and yield attributes in *kabuli* chickpea for deciding efficient breeding methodology and also to identify promising parents and potential crosses for evolving high yielding and bold seeded *kabuli* chickpea.

MATERIAL AND METHODS

Six diverse *kabuli* genotypes *viz.,* Vihar, ICCV 95333, KAK 2, MNK 1, Phule G 05107 and NBeG 72 were chosen for evolving half diallel set of fifteen crosses excluding reciprocals .The experimental material consist of twenty one genotypes (six parents and 15 F_1s) were sown in a randomized block design with three replications with 45 and 10 cm spacing during *rabi* 2012-13 at

Regional Agricultural Research Station, Nandyal, respectively. Five random plants were selected from each genotype in each replication and observations were recorded for number of branches per plant, plant height (cm), number of pods per plant, shoot biomass per plant (g), harvest index (%), seed yield (g) and 100 seed weight (g). The combining ability analysis was made following Griffing's model I and method II (1956).

RESULTS AND DISCUSSION

Analysis of variance for seven characters (table 1) revealed significant difference among the genotypes for all the characters indicating appreciable amount of variability for traits under investigation. Combining ability analysis (table 2) revealed that general combining ability (*gca*) and specific combining ability (*sca*) variances were significant for all the characters studied, indicating the importance of both additive and non-additive genetic components of variation in the inheritance or expression of these attributes. The importance of both types of gene effects has been observed earlier in chickpea for seed yield and related attributes (Bhardwaj *et al.* 2009 and Karami 2011). However, the component due to GCA was considerably higher than the SCA variance for all characters except number of branches per plant indicating the preponderance of additive genetic effects in the inheritance of the characters. Non-additive genetic control for number of branches per plant was reported by (Gupta *et al.* 2007 and Naveed *et al.* 2012). However, others (Bhardwaj and Sandu 2009 and Bhardwaj *et al.* 2009) reported additive gene effects for other characters which are more prominent. Such disparities in the observations may arise from differences in the genetic constitution of the parental materials studied, variation in the environment, the techniques used in analyzing the data and the precision of the experiment (Singh *et a,* 1992). In order to recover higher frequency of desirable recombinants with high yield potential, biparental mating in F_2 or recurrent selection or modified pedigree methods can be employed to harness both additive and non additive gene actions (Joshi 1979, Nagaraj *et al.* 2002).

The general combining ability *i.e.,* the average performance of a strain or genotype in a cross is the most important criteria for selecting promising parents in self pollinated crops, as phenotypically promising parents do not always produce superior offspring in the segregating generation (Allard 1960). A study of general combining ability effects of parents (table 3) indicated that Vihar is a good general combiner for number of branches per plant, number of pods per plant, shoot biomass per plant and seed yield per plant. KAK 2 showed high *gca* effects for number of pods per plant and harvest index. MNK 1 and Phule G 05107 exhibited high *gca* effects for 100 seed weight and plant height. ICCV 95333 is a good combiner for harvest index.NBeG 72 was superior general combiner for number of pods per plant and seed yield per plant. After comparing the performance of parental lines for general combining ability revealed that the Vihar was superior over the rest of the chickpea parental lines for yield and yield components. The *per se* performance of parents also highly correlated to high *gca* effects. Thus these promising parents could be selected and extensively used for hybridization programme for evolving high yielding and bold seeded *kabuli* chickpeas.

Sprague and Tatum (1942) attributed specific combining ability of crosses to dominant deviation and epistatic interaction and in self pollinated crops like chickpea high *sca* effects of a particular cross combination will be useful if it is accompained by high *gca* effects of the respective parents. A study of estimate of *sca* effects (table 4) revealed that only one cross Vihar x KAK 2 displayed positive and significant *sca* effect for seed yield per plant. This promising cross also had positive and significant *sca* effects for other yield components *viz.,* number of branches per plant, number of pods per plants, shoot biomass per plant and 100 seed weight. This cross exhibited superiority for various attributes due to additive x dominance gene effects as supported by *gca* effects of respective parents involved in the crosses.

Vihar x MNK 1 had showed positive significant *sca* effects for number of branches per plant and number of pods per plant. Other promising crosses *viz.,* Phule G 05107 x NBeG 72 for plant height; MNK 1 x NBeG 72 for 100 seed weight showed positive significant *sca* effects. The superior its of these crosses can be attributed to

Table 1. Analysis of variance for seven characters in chickpea.

Source	D.F	Mean Squares						
		Plant height (cm)	Number of branches per plant	Number of pods per plant	Shoot biomass per plant (g)	Harvest index (%)	Seed yield per plant (g)	100 Seed weight (g)
Replications	2	5.88	8.26	2.34	1.27	9.40	0.18	1.53
Treatments	20	24.73**	23.36**	255.73**	37.94**	49.58**	8.06**	157.48**
Error	40	4.27	4.32	4.84	7.48	12.32	2.06	4.25

* Significant at 5 % level ** Significant at 1% level

Table 2. Analysis of variance for combining ability for seven characters in chickpea.

Source	D.F	Plant height (cm)	Number of branches per plant	Number of pods per plant	Shoot biomass per plant (g)	Harvest index (%)	Seed yield per plant (g)	100 Seed weight (g)
Mean sum of squares (*gca*)	5	22.88*	14.52*	290.07*	39.35*	41.36*	7.15*	163.86*
Mean sum of squares (*sca*)	15	3.36*	5.54*	16.96*	3.74	8.25*	1.19	15.37*
Error	40	1.42	1.44	1.61	2.49	4.10	0.68	1.41
σ^2 *gca*		2.68	1.63	36.05	4.60	4.65	0.80	20.30
σ^2 *sca*		1.93	4.10	15.35	1.25	4.14	0.51	13.95

* Significant at 5 % level ** Significant at 1% level

Table 3. Estimates of general combining ability effects and the mean performance (in parentheses) of parents for seven characters in chickpea.

Genotype	Plant height (cm)	Number of branches per plant	Number of pods per plant	Shoot biomass per plant (g)	Harvest index (%)	Seed yield per plant (g)	100 Seed weight (g)
Vihar	0.09	2.72**	9.52**	4.04**	-2.86**	1.19**	-3.26**
	(41.6)	(18)	(48.4)	(27.3)	(42.6)	(12.1)	(36.3)
ICCV 95333	0.06	-0.62	-1.12*	-0.00	1.48*	0.23	-0.56
	(41.3)	(12.9)	(29.7)	(21.1)	(54.2)	(11.9)	(42.3)
KAK 2	-3.18**	-0.25	2.95**	-1.01	3.04**	0.06	-5.02**
	(34.7)	(12.8)	(37.4)	(17.1)	(58.7)	(10.6)	(31.1)
MNK 1	1.36*	-0.44	-5.94**	-1.62*	-2.32**	-1.26**	4.82**
	(46.3)	(14.1)	(15.6)	(17.2)	(43.6)	(7.9)	(57.8)
Phule G 05107	1.50*	-0.84*	-6.61**	-2.04**	-0.20	-0.93*	6.18**
	(45.8)	(14.6)	(17.0)	(18.0)	(50.4)	(9.8)	(60.3)
NBeG 72	0.16	-0.55	1.20*	0.63	0.85	0.71*	-2.15**
	(40.5)	(13.2)	(38.5)	(22.7)	(56.6)	(13.7)	(34.0)
SE (gi)	0.38	0.38	0.41	0.50	0.65	0.26	0.38
SE (gi-gi)	0.59	0.60	0.63	0.78	1.01	0.41	0.59

* Significant at 5 % level ** Significant at 1% level

Table 4. Estimates of specific combining ability effects for seven characters in chickpea.

Cross	Plant height (cm)	Number of branches per plant	Number of pods per plant	Shoot biomass per plant (g)	Harvest index (%)	Seed yield per plant (g)	100 Seed weight (g)
Vihar x ICCV 95333	1.39	-1.913*	-6.942**	-0.694	-2.019	-0.864	2.161*
Vihar x KAK 2	1.403	4.749**	5.738**	4.729**	-1.518	2.463**	3.866*
Vihar x MNK 1	-2.547*	3.402**	6.239**	1.072	2.415	0.761	-5.603**
Vihar x Phule G 05107	1.182	-1.993*	-0.359	-1.17	2.085	-0.013	-3.181**
Vihar x NBeG 72	0.924	0.779	-1.645	0.618	0.864	0.447	1.596
ICCV 95333 x KAK 2	1.703	2.158**	-1.412	1.042	-1.63	0.306	1.703
ICCV 95333 x MNK 1	1.086	-1.457	2.156	-0.748	3.346*	0.267	-3.03**
ICCV 95333 x Phule G 05107	-2.851*	1.148	5.758**	1.077	0.193	0.706	-4.093**
ICCV 95333 x NBeG 72	1.357	1.954*	-1.829	0.125	-3.822	-1.071	1.59
KAK 2 x MNK 1	0.132	-3.221**	0.077	0.928	0.22	0.451	-2.565*
KAK 2 x Phule G 05107	0.728	-0.699	-4.548**	-2.877*	-0.483	-1.666*	-0.419
KAK 2 x NBeG 72	-1.064	0.491	-1.141	0.875	-3.271	-0.373	-0.522
MNK 1 x Phule G 05107	-1.889	1.037	2.18	1.996	-1.823	0.484	-4.385**
MNK 1 x NBeG 72	1.186	0.309	-3.974**	-1.156	-2.038	-0.552	3.616**
Phule G 05107 x NBeG 72	2.282*	-2.042*	-1.828	-0.257	-2.961	-0.666	1.422
S.E of Sii-Sjj	1.194	1.201	1.271	1.580	2.027	0.829	1.191
S.E of Sij-Sik	1.580	1.588	1.682	2.090	2.681	1.097	1.576
S.E of Sij-Skl	1.463	1.470	1.557	1.935	2.483	1.016	1.459

* Significant at 5 % level ** Significant at 1% level

additive x dominance type of gene action. Some of the superior crosses had both the parents with poor combining abilities (ICCV 95333 x KAK 2 for number of branches per plant; ICCV 95333 x Phule G 05107 for number of pods per plant and Vihar x KAK 2 for 100 seed weight).This may be due to complementary type of gene action or involvement of non allelic interaction of non fixable genetic variance (Sharma and Mani, 2001).

Promising crosses with high mean and favourable *sca* effects consisting of atleast one parent with high *gca* effect (Vihar x KAK 2 for yield and yield components, Phule G 05107 x NBeG 72 for plant height; Vihar x KAK 2 and Vihar x MNK 1 for number of branches per plant; Vihar x KAK 2 for shoot biomass per plant; MNK 1 x NBeG 72 for 100 seed weight) would throw trangressive and stable performing segregants for respective traits.

Farmers of Maharashtra, Karnataka and Andhra Pradesh are showing great interest in cultivation of extra large seeded and by duration *kabuli* types. Therefore, bold seeded *kabuli* varieties *viz.,* Phule G 05107 and MNK 1 which had significant *gca* effects apart from high *per se* performance along with the cross, MNK 1 x NBeG 72 with significant *sca* effects can be utilized for evolving extra large seeded *kabuli* chickpea genotypes with suitable crop duration.

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