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Combining Ability and Heterosis Studies for Yield and Yield Contributing Characters in Groundnut (*Arachis hypogaea L.*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In groundnut during Rabi 2015-16 Combining ability and heterosis was studied among 9 crosses involving three diverse lines viz., KDG 128, KDG 126 and ICGV 00348 and 3 testers viz., Kadiri 7, Kadiri 6 and JCG 2141 in presence of check Dharani. On the basis of *per se* performance and General combining ability (GCA) effects together, the parents KDG 126 and Kadiri-7 were identified as better combiners for various yield and its attributing characters. These parental materials could be better utilized as valuable basic material in developing high yielding groundnut varieties. Among those, based on *per se* performance, the corresponding GCA status of parents and SCA effects for most of the yield traits *viz.,* days to 50%flowering, days to maturity, 100 kernel weight and pod yield per plant only one cross viz., KDG 126 x Kadiri 7 was considered as better one.

Keywords: Groundnut; general combining ability; specific combining ability; heterosis and yield.

1. INTRODUCTION

Groundnut (*Arachishypogaea* L.) is an important edible oil seed crop in India as well as in the world. The national average productivity of India is 1917 kg / ha, which is low compared to USA (2863 kg / ha) and China (2645 kg/ha) is mainly attributed to the lack of high yielding varieties

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suitable for rainfed condition, responsive to fertilizers and improved agronomic practices in India. Tremendous genetic variation for pod yield and its components is available in the gene pool of groundnut which can be exploited for future breeding programmes. To break this yield gap, improved groundnut varieties and agronomic management practices are highly essential. In this context, information onthe combining ability of parents and the nature of gene action of yield its components would help in understanding the inheritance of characters, selection of suitable parents for hybridization and identification of promising early generation crosses so as to design an appropriate and efficient breeding strategy for further genetic improvement of groundnut genotypes. Finally, the knowledge of the type of gene action involved in the expression of yield and yield components is essential to choose an appropriate breeding strategy to isolate desirable segregants in the later generations. An investigation was taken up in groundnut to study the general and specific combining ability and the gene action determining the yield and yield components using line x tester design.

2. MATERIALS AND METHODS

Material for this study consisting of three diverse lines viz., KDG 128, KDG 126 and ICGV 00348 and three tester's viz., Kadiri 7, Kadiri 6 and JCG 2141 were selected as parents for the study. These parents were crossed in line x tester mating design to generate 9 hybrids at Regional Agriculture Research Station, Polasa, Jagtial during *Rabi* 2015-16. The experiment was laid down in Randomized Complete Block Design with three replications. The parents and crosses were raised in five rows of 5m length with a spacing of 30cm x 10cm during *rabi* 2016-17. All the recommended package of practices was followed to grow the healthy and good crop. Fertilizer dose @ 27 kgs urea, 100 kgs single super phosphate and 33 kgs potash per acre in basal application, 10 kgs urea and 200 kgs gypsum per acre during pegging stage. A total of 9 to 10 irrigations were given throughout the crop growth period based on moisture holding capacity of the soil. Five plants data was recorded both in parents and hybrids by random selection in each replication. Relevant data was recorded for the purpose viz., days to 50 per cent flowering, plant height (cm), days to maturity, no. of pods per plant, 100 pod weight (grams), 100 kernel weight (grams), sound matured kernels, shelling% and pod yield per plant. The statistical analysis was done as per procedure given by Kempthorne [1] for combining ability analysis using line × tester mating design. The mean values thus obtained were subjected to line x tester analysis.

3. RESULTS AND DISCUSSION

3.1 Phenotypic Characterization of Parents and Hybrids (Study of Means)

Analysis of Variance revealed the significant differences among the genotypes for yield and yield components *viz.*, days to 50 per cent flowering, plant height (cm), days to maturity, Number of pods per plant, 100 pod weight (grams), 100 kernel weight (grams), sound matured kernels, shelling % and pod yield per plant (grams) clearly indicating that there was high amount of genetic variation (Table 1).

Grain is the product of its prime components *viz.,* number of pods per plant x 100 pod weight in ground nut. High amount of variability was noticed for these traits as compared to others in the present experimentation. Hence, selection of the parents was fully justified indicatingthe preponderance of the divergence among the parents that remits in production of better hybrids with varying performance. Among parents, pod yield per plant ranged from 17.7 to 28.3 g with a general mean of 20.9 g. Among the lines, KDG 126, among the testers, Kadiri 7 was top yielders with 22 g, 28.3 g per plant respectively. The grain yield among the hybrids varied from 15 g (ICGV00348 x Kadiri 6) to 23 g (KDG 126 x Kadiri 7).Only one hybrid (KDG 126 x Kadiri7) recorded significantly higher pod yield per plant over the best check Dharani (22.7 g).

4. COMBINING ABILITY ANALYSIS

4.1 Analysis of Variance for Combining Ability

The material comprising of 16 genotypes (3 lines, 3 testers, 9 hybrids and one check) was evaluated during *Rabi 2016-17* in dry system of cultivation to carryout line x tester analysis (Table 3). Analysis of variance revealed the presence of significant differences among the crosses for all the characters studied except for plant height and pod yield per plant. Portioning of crosses into lines, testers and line x tester revealed that lines and testers exhibited significant differences for sound mature kernels.

Mean Sum of Squares due to line x tester showed that the variances were significant for days to 50% flowering, days to maturity, 100 pod weight, 100 kernel weight and shelling percentage. This indicated the existence of sufficient amount of variability in the material under study and there is a better scope for identifying promising parents and hybrid combinations.

4.2 Combining Ability Variances and Gene Action

The estimates of general combing ability (GCA) and specific combining ability (SCA) variances have been presented in Tables 4 and 5. GCA is associated with additive gene action, while SCA is due to dominance and epistasis. In the present investigation, SCA variances were higher than GCA variances for all the characters indicating the predominance of non-additive gene action for all characters. Similar kind of non-additive gene action was reported earlier for kernel yield per plant, pod yield per plant [2-8].

4.2.1 General combining ability (GCA)

The lines, KDG 126 recorded the significant positive GCA effects and mentioned as a good general combiner for grain yield per plant. Among the 3 testers studied, Kadiri -7 manifested non-significant positive GCA effects, for grain yield per plant. On the basis of *per se* performance and GCA effects together, the parents KDG 126 and Khadiri-7 were identified as better combiners for various yield and its attributing characters. These parental materials could be better utilized as valuable basic material in developing high yielding ground nut varieties.

4.2.2 Specific combining ability (SCA)

Pod yield is the ultimate objective in hybrids development, generally hybrids with 20-25 per cent yield improvement would be considered as promising hybrids for commercial cultivation. For pod yield per plant three hybrids *viz.,* KDG 128 x Kadiri 6, KDG 126 x Kadiri 7 and ICGV00348 x JCG-2141 exhibited non-significant positive SCA effects with higher mean estimates.

Based on *per se* performance, SCA effects and the corresponding GCA status of parents, only one crosses *viz.,* KDG 126 x Kadiri 7 was considered as better one.

In the present study, the hybrid, KDG 126 x Kadiri 7 recorded desirable SCA effects for most of the yield traits *viz.,* Days to 50%flowering, days to maturity, 100 kernel weight and pod yield per plant.

5. STUDY OF HETEROSIS

Standard heterosisis is the superior performance of the hybrid over the commercial check (Dharani). It was estimated in 9 hybrids for ten characters (*viz*., days to 50% flowering, plant height, days to maturity, number of pods per plant, 100 pod weight, 100 kernel weight, sound matured kernel, shelling percent and pod yield per plant) is presented in Table 6. The negative heterosis for days to 50% flowering and plant height indicates earliness and short stature respectively which are desirable, while for other characters positive heterosis values were considered as desirable.

Only one hybrid KDG 126 X Kadiri 7 registered highly significant positive standard heterosis over standard check Dharani, that proved its performance in 100 pod weight, 100 kernel weight and pod yield per plant.Similar results were obtained by Jayalaxmi et al. [9], Vindhiyavarman and Raveendran [10], Gor et al. [6] and Manoharan [11].

This experiment results proposing the preponderance of non-additive gene action for the characters studied have supporting evidences from the earlier research works viz., Savitramma et al. [12] for number of pods per plant and 100 kernel weight, John et al. [13] for chlorophyll content, Mohan et al. [14] for sound mature kernel percent and Padmaja et al. [15] for shelling percentage.

Table 1. Analysis of variance (Mean Squares) for yield and yield components in groundnut

Source of variation	Degrees of Freedom	Days to 50 per cent flowering	Pant Height (cm)	Duration of Maturity (Days)	Number of pods per plant	100 pod weight (g)	100 kernel weight (g)	Sound matured kernels	Shelling %	Pod yield per plant (g)
Replicates	2	4.77	5.02	6.93	42.52	18.06	4.08	12.89	8.31	0.56
Genotypes	15	8.46**	53.46**	123.22**	106.29**	389.52**	26.44**	33.64**	32.82**	26.61**
Error	30	1.54	7.13	3.89	21.03	11.59	3.32	8.45	6.00	8.09
Total	47	3.89	21.82	42.10	49.15	132.48	10.73	16.68	14.66	13.68

Table 2. Mean values of 6 parents and 9 F_1s for yield and yield contributing characters in groundnut

Parental line/Cross	Days to 50 per cent flowering	Pant Height (cm)	Duration of Maturity (Days)	Number of pods per plant	100 pod weight (g)	100 kernel weight (g)	Sound matured kernels	Shelling %	Pod yield per plant (g)
Lines									
KDG 128	28.7	32.7	103	35.7	79.7	40	82	61.7	20.7
KDG 126	28.3	30.7	106	34.7	73.7	38.7	88	66	22
ICGV00348	31.7	24.3	115	34	53	38.3	80.3	67.3	18.7
Testers									
KADIRI-7	33	31	122	24	102	49	86.7	59	28.3
KADIRI-6	28.3	43	105	23	83.7	40.3	90	64.7	22
JCG-2141	28.7	28.3	100	25	82	40.3	86.7	67.3	23.3
Crosses									
KDG 128 X Kadiri 7	30.7	33.7	118	36.3	91	41.3	86	67.3	21.3
KDG 128 X Kadiri 6	29.3	35.7	107	41.7	86	42	92	70	19.7
KDG 128 X JCG-2141	30	29.3	109	35.3	82.7	40.7	86.7	65.7	21
KDG 126 X Kadiri 7	30	32.7	118	37	89.3	44.7	80.7	61.7	23
KDG 126 X Kadiri 6	27.3	29.7	107	42.7	85	38.3	83.3	59.3	17.7
KDG 126 X JCG-2141	28	32.3	111	35.7	82.7	42	87.7	62.3	21
ICGV00348 X Kadiri 7	33	26.3	120	30.7	66.3	36.7	82.3	66	19.7
ICGV00348 X Kadiri 6	29	32	112	33	69	41.3	82.3	69.7	15
ICGV00348 X JCG-2141	29	30.7	109	30	72	39.3	87.3	64	18
Dharani (Check)	29.3	35	110	25.7	82.7	37.7	85.7	64	22.7
Experimental Mean	29.6	31.7	111	32.8	80.1	40.7	85.5	64.8	20.9
SE±	0.28	0.67	0.93	1.01	1.66	0.47	0.58	0.55	0.53
C.D (5%)	2.07	4.45	3.29	7.64	5.67	3.04	4.84	4.08	4.74
C.V (%)	4.19	8.42	1.78	13.99	4.25	4.48	3.40	3.78	13.63

Table 3. Analysis of variance of combining ability for yield and yield contributing characters in groundnut

Source of variation	DF	Days to 50 per cent flowering	Pant Height (cm)	Duration of Maturity (Days)	Number of pods per plant	100 pod weight (g)	100 kernel weight (g)	Sound matured kernels	Shelling %	Pod yield per plant (g)
Replicates	2	7.37	3.37	6.25	76.92	5.44	0.14	5.59	6.33	2.33
Crosses	8	8.09**	82.39	163.34**	128.09**	535.41**	29.75**	38.75**	33.08**	23.08
Line Effect	2	0.59	58.25	27.81	472.48**	1119.44*	40.25	62.70*	37.33	48.11
Tester Effect	2	10.48	187.70	180.25	6.48	766.77	35.14	83.81**	52.11	16.44
Line x Tester effect	4	10.64**	41.81	222.64**	16.70	127.72**	21.81**	4.25	21.44*	13.88
Error	16	1.24	8.62	4.09	26.59	15.02	3.23	6.34	6.33	9.20
Total	26	3.82	30.91	53.25	61.69	174.41	11.15	16.25	14.56	12.94

** significant at p= 0.05, ** significant at p= 0.01*

Table 4. General combining ability of parents for yield and yield contributing characters in groundnut

Lines	Days to 50 per cent flowering	Pant Height (cm)	Duration of Maturity (Days)	Number of pods per plant	100 pod weight (g)	100 kernel weight (g)	Sound matured kernels	Shelling %	Pod yield per plant (g)
KDG 128	-0.29	-2.85**	-1.51*	2.59	-12.77**	-2.18**	3.03**	-0.44	-1.44
KDG 126	0.14	2.03*	-0.40	-8.18**	7.77**	2.03**	1.29	-1.77*	2.66*
ICGV00348	0.14	0.81	1.92**	5.59**	5.00**	0.14	1.74	2.22*	-1.22
Testers									
KADIRI-7	0.92*	0.37	5.03**	-0.18	9.44**	2.25**	-1.59	-2.77**	1.55
KADIRI-6	-1.18*	4.37**	-3.51**	0.92	-0.44	-0.85	3.51	1.44	-0.66
JCG-2141	0.25	-4.74**	-1.51*	-0.74	-	-1.40*	-1.92	1.33	-0.88
CD 95% GCA(L&T)	0.91	1.93	1.39	3.31	2.45	1.29	2.03	1.76	2.05

** significant at p= 0.05, ** significant at p= 0.01*

Table 5. Specific combining ability of crosses for yield and yield contributing characters in groundnut

Cross	Days to 50 per cent flowering	Pant Height (cm)	Duration of Maturity (Days)	Number of pods per plant	100 pod weight (g)	100 kernel weight (g)	Sound matured kernels	Shelling %	Pod yield per plant (g)
KDG 128 X Kadiri 7	-1.81*	3.07	-10.03**	1.07	1.44	-1.25	0.14	-0.55	-1.33
KDG 128 X Kadiri 6	-0.03	-2.92	1.85	-1.03	5.33*	0.51	1.03	-0.44	2.22
KDG 128 X JCG-2141	1.85*	-0.14	8.18**	-0.03	-6.77**	0.74	-1.18	1.00	-0.88
KDG 126 X Kadiri 7	2.07*	-3.48*	8.18**	0.18	3.55	3.51**	0.48	-1.88	2.22
KDG 126 X Kadiri 6	-0.48	4.51*	-0.92	-1.92	-5.22*	-2.03	-1.29	-0.44	-1.88
KDG 126 X JCG-2141	-1.59*	-1.03	-7.25**	1.74	1.66	-1.48	0.81	2.33	-0.33
ICGV00348 X Kadiri 7	-0.25	0.40	1.85	-1.25	-5.00*	-2.25*	-0.63	2.44	-0.88
ICGV00348 X Kadiri 6	0.51	-1.59	-0.92	2.96	-0.11	1.51	0.25	0.88	-0.33
ICGV00348 X JCG-2141	-0.25	1.18	-0.92	-1.70	5.11*	0.74	0.37	-3.33*	1.22
CD 95% SCA	1.57	3.34	2.41	5.73	4.24	2.24	3.52	3.05	3.56

Table 6. Estimates of standard heterosis (H) for yield and yield contributing characters in groundnut

Cross	Days to 50 per cent flowering	Pant Height (cm)	Duration of Maturity (Days)	Number of pods per plant	100 pod weight (g)	100 kernel weight (g)	Sound matured kernels	Shelling %	Pod yield per plant (g)
IVK15-21 X K7	-2.27	-6.67	-6.08**	38.96*	-3.63	6.19	-4.28	-3.65	-8.82
IVK15-21 X K6	-3.41	-12.38	-3.04	35.06*	-10.89**	2.65	2.72	3.13	-2.94
IVK15-21 X JCG-2141	7.95*	-30.48**	4.56**	32.47*	-35.89**	1.77	-6.23*	5.21	-17.65
IVK14-21 X K7	12.50**	-11.43	11.55**	-6.49	23.79**	30.09**	1.17	-7.81*	25.00*
IVK14-21 X K6	-3.41	22.86**	-4.56**	-1039	1.21	7.08	5.06	1.04	-2.94
IVK14-21 X JCG-2141	-2.27	-19.05**	-8.51**	-2.60	-0.81	7.08	1.17	5.21	2.94
ICGV00348 X K7	4.55	-3.81	7.90**	41.56*	10.08**	9.73*	0.39	5.21	-5.88
ICGV00348 X K6	0.00	1.90	-2.43	62.34**	4.03	11.50*	7.39*	9.38**	-13.24
ICGV00348 X JCG-2141	2.27	-16.19*	-0.61	37.66*	0.00	7.96	1.17	2.60	-7.35
SE ±	1.05	2.23	1.61	3.82	2.83	1.49	2.35	2.04	2.37

** significant at p= 0.05, ** significant at p= 0.01*

6. SUMMARY AND CONCLUSION

Based on the overall study, it was concluded that the among the three lines and three testers KDG 126, K7 recorded good *per se* mean and GCA effect respectively in terms of yield and its attributing traits. These parental materials could be better utilized as valuable basic material in developing high yielding ground nut varieties. Among the nine hybrids only one hybrid *viz.,* KDG 126 x K7 expressed high SCA effect and significant standard heterosis over the check, Dharani.

In general, the crosses showing desirable SCA effects for dry pod yield/ plant also had high SCA effects for yield contributing characters viz. plant height (cm), number of pods/ plant, 100 kernel weight (g), shelling (%). Most of the crosses exhibiting desirable SCA effects involved parents with high and low GCA effects indicating the influence of non-additive gene interaction in these crosses. Hence parents of these crosses can be utilized for bi-parental mating or reciprocal recurrent selection programme for developing superior varieties with high yield. Whereas crosses with higher SCA and having both parents with good GCA effects could be exploited by pedigree method to yield transgressive segregants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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