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Studies on Combining Ability and Heterosis for Yield and its Component Traits in Groundnut (*Arachis hypogaea* L.)

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A B S T R A C T

A half diallel cross involving six parental lines and their 15 F_1 crosses (without reciprocals) were evaluated for combining ability of parents for 13 characters in groundnut. Variances due to sca were greater than that of gca indicating predominance of non-additive gene action control on all the traits except days to maturity and plant height. The genotypes TCGS-29 and K-134 were found as good general combiners for kernel yield, pod yield per plant, mature pods per plant and 100-kernel weight while K-1238 was a good general combiner for shelling percentage, harvest index and percent pod set per plant, and Faizapur local for pegs per plant and pods per plant. Further, the most heterotic crosses identified in the study, involved either one or both good general combiners. Four heterotic crosses *viz*., K-134 × TCGS-29, TCGS-29 × K-1238, K-134 × K-1238 and TPT-4 × Local Red were emerged-out as good specific combiners for kernel yield per plant, pod yield per plant, mature pods per plant, pods per plant, pegs per plant, shelling percentage, 100-kernel weight, harvest index, percent pod set per plant and primary branches per plant. The cross combination TPT-4 × Faizapur Local was earlier to flower and mature with good sca effects. An attempt of inter-mating of selected plants in the advance generations of these five crosses is suggested to obtain transgressive segregants for pod and kernel yield in groundnut.

Keywords

Groundnut, Diallel cross, Combining ability, Heterosis.

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Introduction

Groundnut (*Arachis hypogaea* L.) is an important edible oil seed crop. The big gap in the productivity levels of India (991 Kg / ha) compared to USA (2863 Kg / ha) and China (2645 Kg/ha) is due to the lack of high yielding varieties 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. To bridge this yield gap, evolving new improved groundnut varieties are very much essential. In this context, the information on the 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.

Materials and Methods

The breeding material chosen for the present study comprised of six groundnut genotypes *viz*., K-134, TPT-4, Local Red, TCGS-29, K-1238 and Faizapur Local that were selected as parents from distant clusters based on previous genetic divergence studies. Fifteen F_1s (excluding reciprocals) were produced through a diallel design involving these six parents. The evaluation of 15 F_1s along with their six parental genotypes was studied in randomized complete block design (RCBD) with three replications at the college Farm, S.V. Agricultural College, Tirupathi, Andhra Pradesh. Each cross was grown in three rows of 4.5 m length by adopting the spacing 30 × 10 cm. Observations were recorded on ten randomly selected competitive plants from each cross in each replication for 13 quantitative traits *viz*., primary branches per plant, days to 50% flowering, days to maturity, plant height, pegs per plant, mature pods per plant, per cent pod set, harvest index, shelling percentage, 100-kernel weight, pod yield per plant and kernel yield per plant. The combining ability analysis was carried out following the model I and method 2 of Griffing (1956).

Results and Discussion

Analysis of variance for combining ability revealed that the mean squares for both gca and sca were highly significant for all the characters except for plant height where mean squares for sca was non-significant. These results indicated the importance of both additive and non-additive gene effects (Table 1). The high ratio of gca: sca variances (more than unity) was recorded for days to maturity and plant height indicating that these characters were governed predominantly by additive component of heritable variance. The gca: sca ratios were less than unity for all other traits suggesting that these characters were governed predominantly by non-additive component. Similar kind of non-additive gene action was reported earlier for kernel yield per plant, pod yield per plant (Shoba *et al.*, 2010, Gor *et al.*, 2013, Prabhu *et al.*, 2014 and Waghmode *et al*., 2017), primary branches per plant, pegs per plant, pods per plant (Jivani *et al.*, 2009), mature pods per plant and 100-kernel weight (Shaik Nisar Ahmed, 1995, Ganesan *et al.*, 2010), for shelling percentage (Kuchanur *et al.*, 1997, Mothilal *et al.*, 2010) and for pod yield (Makne *et al.*, 1992, Dasaradha *et al.*, 2004, Ganesan *et al.*, 2010 and Mothilal *et al.*, 2010). Similarly the importance of additive gene action in the inheritance of days to maturity was reported by Basu *et al.*, (1987) whereas for plant height both additive and non-additive gene effects were reported by Habib *et al.*, (1985). The estimates of gca effects recorded for the genotypes TCGS-29 and K-134 were found as good general combiners for kernel yield per plant, pod yield per plant and mature pods per plant (Table 2). Similarly, the genotype K-1238 was found as good general combiner for shelling percentage, harvest index and percent pod set. Faizapur Local was identified as good combiner for pegs per plant and pods per plants while, Local Red and TCGS-29 were emerged-out as a good combiners for days to maturity, 100-kernel weight and plant height. The genotypes TPT-4 and TCGS-29 were also found to be good general combiners for early flowering and early maturity whereas K-1238 and TPT-4 for primary branches per plant.

Table.1 Analysis of variance for combining ability for pod yield and its components in groundnut

Character	Mean sum of squares (MSS)			$\sigma^2 g_i$	$\sigma^2 s_{ij}$	$\sigma^2 g_i / \sigma^2 s_{ij}$
	***gca* (*df* = 5)**	***sca* (*df* = 15)**	**Error**			
Primary branches per plant	1.49**	0.81**	0.19	0.16	0.63	0.26
Days to 50 % flowering	0.46**	0.31*	0.12	0.04	0.18	0.23
Days to maturity	37.92**	2.21*	1.07	4.6	1.12	4.09
Plant height	22.66**	2.37	1.65	2.63	0.72	3.66
Pegs per plant	32.25**	37.37**	2.54	3.72	34.83	0.11
Pods per plant	19.46**	35.56**	2.36	2.14	33.21	0.06
Mature pods per plant	17.33**	29.57**	3.09	1.78	26.48	0.07
Percent pod set	44.62**	20.77**	2.53	5.26	18.24	0.29
Harvest Index	18.77**	13.22**	2.23	2.07	10.99	0.19
Shelling percentage	21.68**	10.23**	2.89	2.34	7.34	0.32
100-Kernel weight	32.10**	13.69**	1.84	3.78	11.86	0.32
Pod yield per plant	19.13**	13.73**	2.25	2.11	11.49	0.18
Kernel yield per plant	11.90**	8.44**	0.78	1.39	7.66	0.18

* Significant at $P = 0.05$ ** Significant at $P = 0.01$

Table.2 General combining ability effects of six parents of groundnut for pod yield and its components

Parents	Primary branches per plant	Days to 50% flowering	Days to maturity	Plant height (cm)	Pegs per plant	Pods per plant	Mature pods per plant	Per cent pods set	Harvest index	Shelling percentage	100-kernel weight	Pod yield per plant	Kernel yield per plant
K-134	-0.31*	0.36**	3.99**	-1.87**	2.42**	0.26	0.82	-3.46**	1.77**	-0.41	-0.71	1.08*	0.61*
TPT-4	0.32*	-0.35**	-0.93**	-0.46	0.16	-0.1	0.28	-0.85	0.19	-0.48	2.85**	-0.03	-0.25
Local Red	-0.23	-0.01	-2.10**	1.13**	-0.75	-1.33*	-1.1	-1.69**	-2.47**	-1.46*	-1.04*	-0.15	-0.57
TCGS-29	-0.53**	-0.1	-1.18**	2.73**	0.75	1.47**	2.42**	1.51**	-0.1	1.14*	1.96**	2.20**	2.07**
K-1238	0.60**	0.15	-0.64	-1.30**	-3.51**	-2.16**	-1.41*	2.33**	1.37**	2.63**	-0.57	-1.48**	-0.37
Faizapur Local	0.17	-0.06	0.86*	-0.23	0.92	1.86**	-1.01	2.16**	-0.75	-1.41*	-2.49**	-1.62**	-1.50**
SE (g_i)	0.14	0.11	0.34	0.42	0.51	0.5	0.57	0.51	0.48	0.55	0.44	0.48	0.29
***P* = 0.05**	0.28	0.23	0.68	0.84	1.04	1	1.15	1.04	0.97	1.11	0.88	0.98	0.58
***P* = 0.01**	0.38	0.3	0.91	1.12	1.39	1.34	1.53	1.39	1.3-	1.48	1.18	1.31	0.77

* Significant at *P* = 0.05 ** Significant at *P* = 0.01

Table.3 Specific combining ability effects of 15 crosses of groundnut for pod yield and its components

Cross combination	Primary branches per plant	Days to 50% flowering	Days to maturity	Plant height (cm)	Pegs per plant	Pods per plant	Mature pods per plant	Per cent pods set	Harvest index	Shelling percentage	100-kernel weight	Pod yield per plant	Kernel yield per plant
K-134 × TPT-4	-0.31	0.35	1.02	2.44*	5.59**	5.15**	3.11*	1.87	-4.39**	-1.73	-2.04*	1.91	0.62
K-134 × Local Red	0.76*	-0.32	0.86	-1.28	4.17**	1.58	-0.54	-2.58*	-0.74	-2.12	0.17	-2.30*	-2.16**
K-134 × TCGS-29	0.23	0.1	1.61*	1.72	11.20**	10.41**	10.77**	2.32	1.49	-0.93	-0.79	6.58**	5.90**
K-134 × K-1238	0.21	0.18	1.40	-1.85	0.26	0.61	-1.97	0.39	5.43**	-1.41	2.57*	1.09	0.27
K-134 × Faizapur Local	0.03	0.39	-0.43	-2.45*	-3.09*	-4.14**	-0.57	-2.90*	-0.69	1.66	4.33**	0.97	0.93
TPT-4 × Local Red	1.58**	-0.27	-0.23	-2.09*	3.69**	1.07	0.6	-3.66**	-0.35	-2.05	4.82**	3.55**	2.07**
TPT-4 × TCGS-29	1.08**	0.14	-0.14	1.44	5.86**	8.86**	9.00**	6.54**	-3.15**	-3.39**	-1.51	-0.74	-1.81**
TPT-4 × K-1238	0.02	-0.77**	0.32	-0.06	-0.68	-1.1	-1.96	-0.85	-1.65	-1.54	-1.98	-1.66	-1.57*
TPT-4 × Faizapur Local	0.08	-0.23	-2.85**	1.27	1.03	2.88*	-0.50	4.16**	0.10	1.90	-2.49*	1.28	1.33*
Local Red_× TCGS-29	-0.77*	0.48	1.02	0.33	-3.07*	-3.77**	-0.91	-2.51*	5.37**	0.45	2.20*	3.11**	1.85**
Local Red_× K-1238	-0.44	0.56*	-0.52	0.76	7.90**	5.27**	7.09**	-3.14*	3.57**	1.07	1.40	1.46	1.35*
Local Red_× Faizapur Local	-0.11	0.10	-1.02	0.55	-1.36	3.78**	-0.85	9.33**	0.12	2.41	-2.28*	2.57*	2.32**
TCGS-29 × K-1238	0.50	-0.69**	0.57	-0.55	-0.97	1.80	0.13	6.27**	1.67	6.10**	8.37**	3.94**	4.51**
TCGS-29 × Faizapur Local	1.23**	-1.15**	-0.60	-0.78	1.24	0.44	1.22	-1.33	-4.85**	0.47	-0.34	-2.55**	-1.32*
K-1238_× Faizapur Local	0.77*	-0.07	1.52	0.78	2.43*	0.81	1.79	-3.02 *	-0.35	-0.91	-2.58*	-1.74	-1.48*
SE (S_{ij})	0.32	0.25	0.76	0.94	1.17	1.12	1.29	1.16	1.09	1.24	0.99	1.10	0.65
P = 0.05	0.64	0.51	1.54	1.89	2.36	2.27	2.60	2.35	2.21	2.52	2.00	2.22	1.31
P = 0.01	0.86	0.69	2.06	2.54	3.15	3.04	3.40	3.15	2.96	3.37	2.68	2.97	1.75

* Significant at *P* = 0.05 ** Significant at *P* = 0.01

Table.4 List of best parents, best hybrids (on *per se* performance *sca* effects) and high heterotic crosses (over standard check)

Character	Best parents (*per se*)	Best hybrids (*per se*)	High heterotic crosses (over Standard check)	Best general combiners (*gca*)	Best specific crosses (*sca*)
Primary branches per plant	K-1238, TPT-4	TPT-4 × Local Red, K-1238 × Faizapur Local	TPT × Local Red, K-1238 × Faizapur Local	K-1238 TPT-4	TPT-4 × Local Red, TCG-29 × Faizapur Local
Days to 50% flowering	Local Red, TPT-4	TCGS-29 × Faizapur Local, TPT-4 × K-1238	TCGS-29× Faizapur Local, TPT-4 × K-1238	TPT-4 TCGS-29	TCGS-29 × Faizapur Local, TPT-4 × K-1238
Days to maturity	Local Red, TCGS-29	TPT-4 × Local Red, Local Red × K-1238	Local Red × K-1238	Local Red, TCGS-29	TPT-4 × Faizapur Local, Local Red × Faizapur Local
Plant height (cm)	TCGS-29, Local Red	Local Red × TCGS-29, TPT-4 × TCGS-29	Local Red × TCGS-29, TPT-4 × TCGS-29	TCGS-29, Local Red	K-134 × TPT-4, K-134 × TCGS-29
Pegs per plant	Faizapur Local, K-134	K-134 × TCGS-29, K-134 × TPT-4	K-134 × TCGS-29, K-134 × TPT-4	K-134, Faizapur Local	K-134 × TCGS-29, Local Red × K-1238
Pods per plant	Faizapur Local, TCGS-29	K-134 × TCGS-29, TPT-4 × TCGS-29	K-134 × TCGS-29, TPT-4 × TCGS-29	Faizapur Local, TCGS-29	K-134 × TCGS-29, TPT-4 × TCGS-29
Mature pods per plant	Faizapur Local, K-134	K-134 × TCGS-29, TPT-4 × TCGS-29	K-134 × TCGS-29, TPT-4 × TCGS-29	TCGS-29, K-134	K-134 × TCGS-29, TPT-4 × TCGS-29
Per cent pod set	K-1238, Faizapur Local	TCGS-29 × K-1238, Local Red × Faizapur Local	TCGS-29 × K-1238, Local Red × Faizapur Local	K-1238, Faizapur Local	Local Red × Faizapur Local, TPT-4 × TCGS-29
Harvest index (%)	TPT-4, K-134	K-134 × K-1238, K-134 × TCGS-29	K-134 × K-1238, K-134 × TCGS-29	K-134, K-1238	K-134 × K-1238, Local Red × TCGS-29
Shelling percentage	K-1238, K-134	TCGS-29 × K-1238, Local Red × K-1238	TCGS-29 × K-1238, Local Red × K-1238	K-1238, TCGS-29	TCGS-29 × K-1238, Local Red × Faizapur Local
100-kernel weight	TPT-4, TCGS-29	TCGS-29 × K-1238, TPT-4 × Local Red	TCGS-29 × K-1238, TPT-4 × Local Red	TPT-4, TCGS-29	TCGS-29 × K-1238, TPT-4 × Local Red
Pod yield per plant	TCGS-29, K-134	K-134 × TCGS-29, Local Red × TCGS-29	K-143 × TCGS-29, Local Red × TCGS-29	TCGS-29, K-134	K-134 × TCGS-29, TCGS-29 × K-1238
Kernel yield per plant	TCGS-29, TPT-4	K-134 × TCGS-29, TCGS-29 × K-1238	K-134 × TCGS-29, TCGS-29 × K-1238	TCGS-29, K-134	K-134 × TCGS-29, TCGS-29 × K-1238

The F_1 hybrids with significant sca effects for various traits are presented in Table 3. The cross K-134 × TCGS-29 showed significant sca effects for mature pods per plant, pod yield per plant and kernel yield per plant. The other best specific crosses identified were TCGS-29 × K-1238 for harvest index, TPT-4 × Faizapur Local for days to maturity, TCGS-29 × Faizapur Local for days to 50% flowering, TPT-4 × Local Red for primary branches per plant and K-134 × TPT-4 for plant height.

The best parents, and crosses (*per se*) good general combiners, specific combiners and heterotic crosses were furnished for pod yield and its components in Table 4. Among traits, in general, the highest significant standard heterosis estimates were observed for the characters kernel yield per plant, pod yield per plant, pegs per plant, pods per plant and mature pods per plant. The highest standard heterosis was expressed by the cross TCGS-29 × K-1238 for shelling percentage and 100-kernel weight by TCGS-29 × K-1238, for days to maturity by the cross TPT-4 × Faizapur Local, for primary branches per plant by the cross TPT-4 × Local Red and for plant height by the cross Local Red × TCGS-29. The results obtained were similar to the findings of John *et al.,* (2012) for primary branches; Jayalakshmi *et al.,* (2000) for kernel yield per plant; Vindhiya Varman and Raveendran (1997), Gor *et al.,* (2012) for pod yield per plant, mature pods per plant (Gor *et al.,* 2012) and primary branches per plant and Manoharan (2002) for plant height and primary branches per plant.

Estimates of gca and sca effects showed that it was difficult to pick up a good general combiner for all the traits together. It is evident that the crosses which exhibited desirable sca effects involved parents with good, average and poor gca effects indicating the influence of non-additive gene actions in these crosses. Hence, the utility of bi-parental mating or inter-mating among selects in advanced generations is advocated for obtaining transgressive segregants for various economic traits. The F_1 hybrids with higher sca involving parents with good gca, can be further advanced through pedigree method of breeding for isolation of high yielding pure lines of groundnut.

Based on *per se* performance, sca effects and magnitude of standard heterosis, it is to concluded that five cross combinations *viz*., K-134 × TCGS-29, TCGS-29 × K-1238, TPT-4 × Local Red, Local Red × TCGS-29 and TPT-4 × TCGS-29 were identified as best specific crosses for isolating superior groundnut genotypes for good yield and its component characters.

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