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Research Article

Heterosis and inbreeding depression for pod yield and its components in groundnut (*Arachis hypogaea* L.).

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Abstract

Thirty-six crosses generated in a diallel fashion excluding reciprocals using nine genotypes were evaluated to study the extent of heterosis and inbreeding depression for pod yield and yield attributing characters in groundnut. Considerable heterosis over better parent (heterobeltiosis) was observed for the number of mature pods per plant, harvest index and biological yield, while the traits like pod and kernel yield per plant showed low heterobeltiosis, and it was absent or in negative direction for the traits like days to 50% flowering, days to maturity, 100-kernel weight, shelling outturn and sound mature kernels in all the crosses. High inbreeding depression was recorded for days to maturity and 100-kernel weight, while fully matured kernels and biological yield did not show any inbreeding depression. The cross combination, TPG 41 × AK 303 exhibited significant and positive heterobeltiosis (16.4%), highest standard heterosis (123.1%) and maximum mean performance (24.2g) for pod yield per plant. Only one cross (NRCG 115 × AK 303) out of 36, showed significant and high inbreeding depression for pod yield per plant. Negative estimates of heterotic effects observed in some traits may be attributed to inter-allelic interactions. No clear-cut relationship between heterosis and inbreeding depression was observed for pod yield and related traits. Superior segregants from the cross, TPG 41 × AK 303 may be selected for further improvement in the pod yield and its contributing traits.

Key words: Groundnut, heterosis, inbreeding depression, pod yield

Introduction

Groundnut is a premier oilseed crop in India, contributing about 27% of the total area and 33% of the total production of the oilseed crops. It is a rich source of edible oil, high quality protein, fat and carbohydrates. Exploitation of hybrid vigour in crop plants for quantum jump in yield and other quantitative characters is one of the approaches in crop improvement to cope up with the ever-increasing demand for food grains and oil production. In groundnut, heterosis cannot be exploited for higher production through commercial hybrids due to cleistogamous nature of flower and poor seed recovery during hybridization. Hence, the heterosis assumes importance in breeding as heterotic crosses have the potentiality to throw out superior segregants in subsequent generations. The estimates of heterosis and inbreeding depression provide information about the nature of gene action involved in the expression of yield and related traits. The information is also essential to formulate efficient breeding programmes for the improvement of the crop. Though there are a number of reports on heterosis, information is limited in case of inbreeding depression especially for the traits like pod yield and yield components. Therefore, the present investigation was carried out to estimate the magnitude of the heterosis and inbreeding depression in 36 crosses of groundnut in F_1 and F_2 generations, respectively.

Material and Methods

The experimental material for the present study comprised nine genotype *viz*., GG 5, NRCG 115, NRCG 201, NRCG 10389, TPG 41, J 71 (JB 1138), JB HPS K 08-1, J 11 and AK 303. These genotypes were crossed in diallel mating fashion to develop 36 F_1s(excluding reciprocals) and their 36 F_2s, which were evaluated along with parents in randomized block design with three replications during summer 2010 season at the Instructional Farm, Junagadh Agricultural University, Junagadh. Each entry consisted of single row of 2 m length for each of parents and F_1s, and two rows each of F_2 progenies. Inter- and intra-row spacing adopted was 45 and 10 cm, respectively. Recommended agronomic package of practices for the region were followed to raise crop successfully. The observations were recorded on five randomly selected competitive plants in parents and F_1s and 20 plants in F_2s for 10 characters (Table 1). Heterosis over better parent (BP) as per Fonseca and Patterson (1968) was calculated, while standard heterosis (SH) using GG 6 variety as standard check was calculated as per Meredith and Bridge (1972). Inbreeding depression (ID) from F_1 to F_2 was calculated by the formula , ID(%) = [(F_1 – F_2) / F_1] x 100 where F_2 denotes the mean of F_2 population for a trait.

Results

The estimates of mean sum of squares (Table 1) due to genotypes, parents and hybrids were highly significant for all the characters studied indicating the presence of significant variation among the genotypes as well as crosses studied. Considerable genetic variation for various traits including pod yield have been reported by many workers (Golakia *et al.* 2005; John *et al.* 2006; Kadam *et al.* 2007; Khote *et al*. 2009; Korat *et al.* 2009). The mean squares for parents vs. F_1s were also found significant for all yield and its components traits, which indicated the presence of substantial amount of heterosis in cross combinations. The mean squares due to F_1s vs. F_2s revealed that the F_1s differed significantly from their F_2s for all the characters, except for days to 50% flowering and fully matured kernels suggesting the presence of considerable amount of inbreeding depression in F_2 generation for these traits.

The mean performance, various heterotic effects and inbreeding depression as well as promising crosses identified for the characters studied are presented in Table 2. The range of mean performance was wide for all the characters studied except for days to 50% flowering and shelling outturn per cent. Flowering is a complex trait and sensitive to photoperiod and temperature. However, under long day conditions, as those prevail in summer season, only negligible variation has been observed for flower initiation among various genotypes. All the crosses exhibited wider range as compared to their parents for almost all the traits. However, the various heterotic effects were high for pod yield per plant, kernel yield per plant, number of mature pods per plant, harvest index and biological yield.

Most of the crosses exhibited significant and desirable heterosis over better parent (heterobeltiosis) for number of mature pods per plant, harvest index and biological yield per plant, whereas greater magnitude of desirable standard heterosis was observed for all the characters studied except for shelling outturn per cent, fully matured kernels and days to 50% flowering. The negative heterosis observed in some of the crosses may be attributed to non-allelic interaction with the large number of decreasing alleles.

A perusal of the crosses with heterotic effects revealed that none of the crosses were superior for all the traits studied. However, the crosses, NRCG 10389 × J 11 for number of mature pods per plant; TPG 41 × AK 303 for pod yield per plant; NRCG 115 × NRCG 201 for harvest index and NRCG 115 × NRCG 10389 for biological yield showed significant and desired standard heterosis, heterobeltiosis alongwith maximum *per se* performance (Table 2). For kernel yield per plant, the cross NRCG 10389 × J 11 showed significant and positive heterobeltiosis while the cross, TPG 41 x AK 303 showed significant and positive standard heterosis with high mean *per se* performance.

None of the crosses showed significant and desired heterobeltiosis for days to 50% flowering, days to maturity, 100-kernel weight, sound mature kernels and shelling outturn. The cross, NRCG 10389 × J 11 for days o 50% flowering and days to maturity, JB HPS K 08-1 × AK 303 for 100-kernel weight, GG 5 × NRCG 10389 for fully matured kernels and NRCG 201 × J 11 for shelling out turn per cent, showed significant and positive standard heterosis respectively. High heterosis for pod yield and its contributing traits has been reported by Vyas *et al.* 2001; Manivel *et al*. 2003; Yadav *et al.* 2006; Mothilal and Muralidharan 2007; Venkateswarlu *et al.* 2007; Jivani *et al*. 2008; Sharma and Gupta 2010.

The inbreeding depression studied in the F_2s showed that only one cross, NRCG 115 × AK 303, recorded significant and positive inbreeding depression for pod yield, kernel yield and number of mature pods per plant. The crosses, JB HPS K 08-1 × AK 303 and GG 5 × AK 303 exhibited high inbreeding depression for days to 50% flowering and days to maturity. The crosses, JB HPS K 08-1 × J 11, J 71 × JB HPS K 08-1 and NRCG 10389 × AK 303 showed high inbreeding depression for 100- kernel weight, shelling outturn per cent and harvest index, respectively.

None of the crosses exhibited inbreeding depression in significant and positive direction for fully matured kernels and biological yield. This indicates that the mechanism for inbreeding depression varied among the crosses. Similar findings also cited for different traits by Rudraswamy *et al.* 1999; Jayalakshmi *et al.* 2000; Jayalakshmi and Reddy 2005; John and Vasanthi 2006 and Jivani *et al*. 2008.

Improvement in a complex attribute like pod yield may be convenient if breeding programme will be made through attributing agro economical characters. The comparison of three crosses with high heterobeltiosis for pod yield with other yield attributing traits (Table 3) revealed that manifestation of heterosis for pod yield by TPG 41 × AK 303, also showed heterotic effect for kernel yield per plant and number of mature pods per plant. The crosses that showed higher estimates of heterosis in general did not show high inbreeding depression.

The results revealed that both additive and non-additive gene effects are main genetical components which control pod yield and its contributing traits. Therefore, the breeding methods will have to be modified in respect to capitalize the genetic variance due to fixable and non-fixable gene interactions. The efforts can be made to develop multiple crosses among desirable F_1s, following some sort of inter mating, which will considerably increase the frequency of potential and desirable trangressive segregants in the segregating generations. This segregating generations are to be subjected to intensive objective oriented selection for crop improvement.

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Table 1 Analysis of variance (mean sum of squares) for the experimental design for 10 characters in groundnut

Source	d. f.	Days to 50% flowering	Days to maturity	Number of mature pods per plant	100-kernel weight (g)	Sound mature kernels (%)	Shelling outturn (%)	Pod yield per plant (g)	Kernel yield per plant (g)	Harvest index (%)	Biological yield (g)
Replications	2	1.25	1.60	0.04	1.38	17.30	0.80	0.08	0.18	9.09	24.47
Genotypes	80	9.65**	52.77**	6.96**	359.68**	127.27**	21.94**	49.27**	20.19**	119.58**	841.38**
Parents	8	17.83**	115.18**	3.55**	782.39**	277.20**	21.02**	60.59**	23.21**	54.58**	1421.01**
F_1s	35	4.63**	34.46**	7.06**	306.82**	103.65**	20.07**	44.86**	18.45**	80.29**	519.18**
F_2s	35	13.05**	57.07**	6.62**	336.32**	122.03**	24.39**	53.05**	22.07**	115.03**	949.95**
Parents vs crosses	1	9.34**	5.01*	8.46**	3.56*	43.99**	20.35**	20.07**	7.11**	2058.89**	3586.98**
F_1s vs F_2s	1	1.52	91.82**	41.22**	2.50*	21.31	10.42**	9.79**	4.09**	234.85**	935.89**
Error	160	1.11	1.07	0.47	0.64	6.33	0.87	1.23	0.59	10.53	19.76

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

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Table 2 Range of *per se* performance, heterobeltiosis (BP), standard heterosis (SH), inbreeding depression (ID), along with most heterotic crosses and inbreeding depression for 10 characters in groundnut

Characters	Range						Better parents based on *per se* performance	Number of hybrids with significant heterosis and inbreeding depression						Best hybrid based on mean performance		
	Per se performance			Heterosis		ID (%)		Over better parent		Over standard parent		ID		Heterosis effect over		ID over
	Parents	Crosses F_1	F_2	BP (%)	SH (%)			+ve	-ve	+ve	-ve	+ve	-ve	BP	SC	
Days o 50% flowering	34.00 to 41.00	35.00 to 40.33	35.00 to 42.33	-2.56 to 14.71	-9.48 to 4.31	-6.72 to 5.26	J 11 (34.00) NRCG 10389 (35.33)	21	0	0	4	0	2	-	NRCG 10389 × J 11 (35.00)	JB HPS K 08-1 × AK 303 (42.33)
Days to maturity	100.67 to 118.33	102.67 to 116.33	101.67 to 117.67	0.00 to 9.60	-4.94 to 7.72	-4.70 to 3.32	J 11 (100.67) NRCG 10389 (102.00)	29	0	10	18	3	18	-	NRCG 10389 × J 11 (102.67)	GG 5 × AK 303 (111.33)
Number of mature pods/plant	7.53 to 10.40	7.13 to 13.33	8.42 to 13.55	-26.32 to 28.21	-11.57 to 65.29	-38.32 to 16.77	J 11 (10.40) NRCG 10389 (10.27)	9	8	21	0	2	17	NRCG 10389 x J 11 (13.33)	NRCG 10389 × J 11 (13.33)	NRCG 115 × AK 303 (8.77)
100-kernel weight (g)	32.92 to 72.24	32.65 to 68.10	32.03 to 69.67	-32.39 to 0.28	-16.40 to 74.37	-9.52 to 8.73	AK 303 (72.24) JB HPS K08-1 (67.09)	0	31	22	11	12	16	-	JB HPS K 08-1 × AK 303 (68.10)	JB HPS K 08-1 × J 11 (53.55)
Fully matured kernel (%)	64.03 to 91.68	64.19 to 91.36	66.76 to 90.20	-14.46 to -0.15	-23.65 to 8.65	-11.75 to 11.33	GG 5 (91.68) NRCG 10389 (90.40)	0	18	3	13	0	0	-	GG 5 × NRCG 10389 (91.36)	-

Table 2. Continued

Characters	Range						Better parents based on *per se* performance	Number of hybrids with significant heterosis and inbreeding depression						Best hybrid based on mean performance		
	Per se performance			Heterosis		ID (%)		Over better parent		Over standard parent		ID		Heterosis effect over		ID over
	Parents	Crosses F_1	Crosses F_2	BP (%)	SH (%)			+ve	-ve	+ve	-ve	+ve	-ve	BP	SC	
Shelling outturn (%)	64.13 to 72.64	63.58 to 72.85	62.52 to 73.29	-11.58 to 0.29	-9.97 to 3.17	-5.84 to 5.47	J 11 (72.64) NRCG 10389 (72.25)	0	23	3	17	5	12	-	NRCG 201 × J 11 (72.85)	J 71 × JB HPS K 08-1 (63.65)
Pod yield per plant (g)	10.19 to 21.56	9.31 to 24.20	9.23 to 27.11	-25.26 to 16.42	-14.14 to 123.08	-25.68 to 19.84	JB HPS K08-1 (21.56) AK 303 (20.78)	3	18	27	0	1	3	TPG 41 × AK 303 (24.20)	TPG 41 × AK 303 (24.20)	NRCG 115 × AK 303 (14.37)
Kernel yield per plant (g)	7.36 to 14.42	6.66 to 16.54	6.55 to 18.49	-24.92 to 16.38	-13.21 to 115.65	-29.95 to 21.60	AK 303 (14.42) JB HPS K08-1 (13.87)	5	14	27	0	5	5	NRCG 10389 × J 11 (9.31)	TPG 41 × AK 303 (16.54)	NRCG 115 × AK 303 (9.52)
Harvest index (%)	20.89 to 32.29	22.89 to 44.64	22.27 to 46.32	6.55 to 44.70	-22.05 to 71.48	-21.13 to 30.14	NRCG 10389 (32.29) GG 5 (31.19)	20	0	29	1	2	0	NRCG 115 × NRCG 201 (44.64)	NRCG 115 × NRCG 201 (44.64)	NRCG 10389 × AK 303 (26.32)
Biological yield (g)	23.95 to 77.87	11.65 to 59.93	13.14 to 78.26	-51.35 to 68.51	-62.50 to 92.89	-82.65 to 30.86	NRCG 115 (77.87) NRCG 10389 (75.94)	4	14	8	15	0	0	NRCG 115 × NRCG 10389 (11.65)	NRCG 115 × NRCG 10389 (11.65)	-

Table 3 Comparative study of three heterobeltiotic crosses for pod yield with other yield components in groundnut

Name of cross	Percent heterosis over better parent (heterobeltiosis)										
	Pod yield per plant(g)	Days to 50% flowering	Days to maturity	Number of mature pods per plant	100 kernel weight (g)	Sound mature kernel (%)	Shelling Outturn (%)	Kernel yield per plant (g)	Harvest index (%)	Biological yield (g)	Average pod yield per plant (g)
TPG 41 × AK 303	16.42 **	-2.50	2.05 **	21.26 **	-6.66 **	-2.89	-4.26 **	14.73 **	15.27	5.97	24.20
GG 5 × J 71	12.56 *	3.60	1.60 *	-2.61	0.28	-5.55 *	-2.34 *	13.19 *	17.56	-7.72	14.63
NRCG 201 × J 71	12.37 *	4.46	0.64	5.92	-6.19 *	-0.15	0.15	10.04	35.96 **	-28.18 **	13.93