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Full Length Research Paper

Combining ability analysis and heterosis in a diallel cross of okra (*Abelmoschus esculentus* L. Moench)

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The genetic basis of yield and its components were studied using a 9 × 9 diallel cross techniques according to Griffing's Method 2, Model 1 in 2007. The 36 F_1's and the 9 parents were evaluated in 2 locations; Mubi and Yola in Adamawa State, Nigeria, in 2008 wet season in a randomized complete block design (RCBD) replicated 3 times. The result showed significant entries, parents and crosses mean squares for all traits in the pooled analysis, suggesting that the okra population was highly variable for all the traits and therefore, would most likely respond to selection. Significant GCA (general combining ability) and SCA (Specific combining ability) variances were also obtained in all the traits, implying that both the additive and non-additive gene effects operated in the genetic expression of the traits. The non-additive gene effect was however greater in magnitude as shown by the GCA and SCA ratios which were all less than unity. Combining ability analysis of parent also revealed that Mothol-AE2, Mothol-AE3, Gerio-AE1 and Mothol-AE1 gave consistently high general combining ability effects for most of the traits, indicating that their cross combinations will produce desirable segregates for the improvement of yield. Both mean performance of crosses and SCA effect identified Mothol-AE2 x Mothol-AE3, Mothol-AE1 × Mothol-AE3, Mothol-AE2 × Gerio-AE1 and Mothol-AE2 × Mothol-AE1 as the best crosses. Therefore, the mean performance of parents and crosses can be used to predict high general combining ability of parents as well as high SCA effects and heterotic effects of the crosses. The hybrid Mothol-AE2 × Mothol-AE3 exhibited heterosis of up to 23.3% in yield per plant over the higher yielding parent. This showed high performance of the hybrid over the best parent.

Key words: Okra cultivars, genetic components, diallel cross, additive, non additive.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop in the tropical and subtropical region of the world. Okra cultivation was introduced into Africa several millennia ago, evidenced by document dating back to ancient Egypt. The total world production was put at 4.1 million metric tones out of which the developing countries produced about 3.4 million metric tones (Delannoy, 2001). It is grown mainly for its leaves and young pods which are frequently eaten as green vegetable. It is beneficial as anti ulcer, comparable to a standard drug misoprotol with good results. It's alkaline pH could also contribute to its effect in gastro- intestinal ulcers by neutralizing the digestive acids (Wammanda, 2007).

General combining ability measures the average performance of a parent in hybrid combination. Adeniji (2003) in his studies of 8 accessions of West African okra, observed accession 3 and 6 as the high general combiners. Ahmad (2002) also observed varieties B13 and B34 as the best general combiner out of the 6 varieties due to its high positive GCA recorded in almost all the characters study in the varieties of okra. Specific combining ability (SCA) refers to those instance in which the performance of a hybrid is relatively better or worse than would be expected on the basis of the average performance of the parents involved. Heterosis is said to

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be a function of increasing genetic diversity. Heterosis is thought to result from the combined action and interaction of allelic and non allelic factors and is usually closely and positively correlated with heterozygosity (Falconer, 1989). Ahmad (2002) reported that a substantial heterosis of 26 and 19.2% in pod length and yield per plant could be exploited by producing F_2. Similarly, Wammanda (2007) reported heterosis of 17.2, 15.4 and 10.6% in plant height, number of pods per plant and pod length, respectively in okra.

Unfortunately, Okra like many local vegetables had hitherto not received as much research attention in Nigeria as most arable crops (Ogunlela et al., 1989). Researches on okra have been conducted at National Horticultural Research Institute (NIHORT) Ibadan and Institute for Agricultural Research (IAR), Ahmadu Bello University (ABU), Samaru Zaria with much emphasis on agronomy and physiology. Genetic Improvement program has made little progress due to the fact that okra continues to be regarded as marginal crop. In tropical Africa there is a wide variety of cultivars adopted to various environments and selected for various uses in West Africa (Ado et al., 1987).

Ariyo et al. (1990) reported that very few local cultivars have been receiving attention at IAR, Samaru Zaria on the genetic Improvement. Some few accessions of West Africa okra were evaluated at University of Agriculture, Abeokuta in the South Western part of Nigeria to study the mode of inheritance and genetic control of some important characters (Kehinde and Adeniji, 2003). The study was limited to those cultivars found in those areas. Genetic investigation of transmission of various important characters has remained far from fully explored. This is due to the facts that there is insufficient genetic information on various species and cultivars of okra in Nigeria, which could help in the genetic improvement of this vital vegetable. For this reason this research study was conducted with the following objectives in mind: (1) To estimate the general combining ability (GCA) and specific combining ability (SCA) variances in the okra population; this would indicate the nature of gene action governing the different characters under study; (2) To determine the GCA and SCA of parents and crosses respectively, that will identify superior parent and cross-combinations and (3) To determine the level of heterosis in the F_1's if any.

MATERIALS AND METHODS

Nine cultivars of okra (Mothol-AE2, Pella-AE1, Mothol-AE5, Mothol-AE1, Pella-AE2, Mothol-AE4, Mothol-AE3, Gerio-AE1 and Gerio-AE2) were collected from local farmers in Hong (latitude10° 03'N and longitude 13° 07'E) and Yola (latitude 9° 14'N and longitude 12° 32'E) local Government Areas of Adamawa State Nigeria, based on diversity such as fruit length, fruit diameter, fruit colour, ridged or unridged fruit, pricky hairy fruit, smooth hairy fruit and other morphological characteristics that prominently distinguish one cultivar from another.

A crossing nursery plot was established in 2007 wet season at the Teaching and Research Farm of Federal University of Technology Yola, Adamawa State. At anthesis, hybridization was made among the 9 cultivars according to diallel mating design of Method 2 of Griffing (1956b). For each cross, an average of 3 flowers were emasculated on the female plot and pollinated with the desired male pollens, there by generating a 9 × 9 hybrids seeds. The cultivars were stagger planted to achieve nicking, that is, simultaneous flowering in cultivars with different flowering dates.

Field evaluation of the parents and the F_1's generation were conducted in 2008 wet season at 2 locations namely, Teaching and Research Farm, Federal University of Technology Yola and College of Agriculture, Mubi, Adamawa State.

The experimental layout was a randomized complete block design with 3 replications. 2 seeds were planted per hill and later thinned to one plant per stand. Each plot consisted of 15 plants per plot and spaced 60 by 45 cm between and within rows, respectively. The plots received N.P.K 15:15:15 fertilizer applied at the rate of 50 kg ha^{-1} in 2 split doses, at 3 weeks after sowing and at flowering. All other agronomic practices were carried out as recommended. Data collection was made on 10 plants sampled at random in each plot and the mean of the sampled plants was used as plot means for analysis. Data collected were subjected to analysis of variance. Similarly, the GCA and SCA variance were also estimated according to Griffin (1956b) Method 2 model 1. The mathematical model for the combining ability analysis was assumed to be:

$$X_{ijk} = \mu + r_k + g_i + g_j + s_{ij} + \frac{i}{bckk} \sum \sum e_{ijkl}$$

i, j = 1,2,3,--------------9, P
k = 1, 2, and 3, b
l = 1,2, 3,------------10, c

Where,
μ = population mean
P = number of parent
b = number of replicates
c = number of observations per plot
g_i, g_j = the general combining ability, (GCA) effect for the i^{th} and j^{th} parent
r_k = The replication effect
s_{ij} = The specific combining ability (SCA) effect for the cross between the i^{th} and j^{th} parents such that $s_{ij} = s_{ji}$ and
e_{ijkl} = the environmental effects associated with the $ijkl^{th}$ individual observation.

RESULTS AND DISCUSSION

The mean squares from the analysis of variance combined across locations for all the traits are presented in Table 1. Similarly, the variances for both GCA and SCA were also highly significant for all the traits, indicating that the additive and non additive genetic make up of the genotypes were also highly variable. The mean squares for parent x crosses was not significant.

The interactions, location × entries, location × parents, locations × crosses and location × parents × crosses, showed significant differences for all the traits under

Table 1. Mean square analysis of variance combined across locations for all traits.

Source of variation	DF.	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Internode distance (cm)	Fruit length (cm)	Fruit diametre (cm)	Number of fruit per plant	Yield per plant (g)
Location	1	27.12**	35.50**	180.55**	3.29^{NS}	9.47**	14.71**	3.00^{NS}	3.86^{NS}
Rep/Location	4	3.50**	3.47*	2.60*	0.97^{NS}	6.79**	1.82^{NS}	7.41**	3.49**
Entries	44	34.11**	15.69**	7.53.**	1.52*	43.71**	8.16**	13.68**	25.27**
Parents	8	94.57**	31.98**	9.94**	2.03*	133.63**	8.73**	48.48**	42.07**
Crosses	35	21.11**	12.38**	6.94**	1.52*	22.83**	8.22**	5.14**	20.94**
Parent × crosses	1	5.33*	3.96*	5.64*	0.30^{NS}	55.24**	3.73*	34.04**	42.25**
Location × entries	44	1.04^{NS}	5.38**	2.89**	1.52*	2.10**	1.71*	1.61*	1.76*
Location × parents	8	2.05*	2.89**	8.80**	2.37*	2.98**	3.97**	2.08*	2.97**
Location × crosses	35	1.59*	6.96**	8.32**	1.62*	2.15**	1.62*	1.56*	1.60*
Location × parent × crosses	44	34.11**	15.69**	7.53**	1.52*	43.71**	8.16**	13.68**	25.27**
GCA	8	97.70**	46.34**	22.41**	2.61*	173.81**	23.80**	41.25**	49.69**
SCA	36	28.78**	11.24**	6.47**	1.06^{NS}	27.20**	6.51**	10.71**	23.49**
GCA × location	8	1.98^{NS}	6.42**	13.45**	0.79^{NS}	2.09*	2.52*	2.38*	2.65*
SCA × location	36	0.98^{NS}	5.29**	8.32**	1.07^{NS}	2.11**	1.70*	2.56**	3.75**
Pooled Error	176	5.63	9.48	2.11	10.25	2.02	0.05	1.53	11.12
Ration δ^2gca/δ^2sca		0.32	0.40	0.36	0.32	0.60	0.37	0.38	0.20
Heritability (N_S)		0.72	0.59	0.42	0.17	0.84	0.69	0.71	0.55

*= Significant at (p = 0.05), ** = Significant at (p = 0.01), NS = Not Significant, N_s = Narrow sense heritability;DF;degree of freedom.

observation except for days to 50% flowering for location × entries interaction which showed no significant difference. GCA × location and SCA × location interactions were significant for all the traits except for days to 50% flowering and internode distance.These genetic variation suggest that all the cultivars under study were amenable to selection procedures.The significant GCA and SCA variances for all the traits, signify the importance of both gene effects. However, the magnitude of the GCA variance appeared more preponderant indicating that the additive gene effect was important in the control and inheritance of the traits. Similar result was reported by Ahmad (2003) in West African okra.

Model 1 was invoked in the estimation of variance components, which were subsequently used to estimate the GCA and SCA ratios. It was apparent that the non-additive gene action was discovered to be more important than the additive gene effect as all the ratios where less than unity. Similar result was reported for yield and yields components in West Africa okra by Ariyo (1993). The reason for such a result was due to the fact that the parental materials used for this study were selected for divergence for most of the traits.

This investigation therefore revealed that both the additive and non-additive gene effects were important in the genetic control of all the traits. Under such a situation, a breeding procedure that would take cognizance of the 2 gene effects simultaneously would be most desirable. In view of this, Ahmad et al. (1997) suggested that a breeding approach which can mop up the fixable additive gene action and at the same time maintain considerable heterozygosity for exploiting the dominance gene action may prove most beneficial in improving this vegetable.

Narrow sense heritability were high for all the traits (Table 1) except for number of branches per plant and internode distance which showed moderate and low narrow sense heritability, respectively. The high heritability estimates for plant height, fruit length, fruit diameter and number of branches per plant in this study agrees with

Table 2. Best performing parents and crosses on the basis of *per se* performance and general and specfic combining ability effects.

Characters	Parent (*per se*)	Crosses (*per se*)	General combiners	Specific combiners
Days to50% flowering	Gerio- AE2	Mothol –AE5 x Gerio – AE2	Gerio –AE1	Pella -AE2 x Mothol –AE4
Plant height(cm)	Gerio –AE1	Pella –AE1 x Mothol –AE4	Pella –AE1	Mothol-AE2x Mothol-AE4
No. of branch per plant	Gerio –AE1	Mothol –AE4 x Gerio –AE2	Pella –AE2	Mothol–AE2 x Gerio–AE1
Internode distance (cm)	Gerio –AE1	Mothol -AE1 x Gerio –AE1	Gerio –AE1	Mothol–AE5 x Gerio–AE1
Fruit length (cm)	Mothol –AE2	Mothol –AE2 x Mothol –AE3	Mothol –AE2	Mothol-AE2x Mothol-AE3
Fruit diametre(cm)	Gerio –AE1	Pella –AE1 x Pella –AE2	Mothol –AE3	Mothol–AE1 x Gerio–AE1
No. of fruit per plant	Gerio –AE1	Mothol –AE2 x Gerio –AE1	Mothol –AE1	Mothol–AE1 x Gerio–AE1
Yield per plant (g)	Mothol –AE2	Mothol –AE2 x Mothol –AE3	Mothol –AE2	Mothol-AE2x Mothol-AE3

Adeniji and Kehinde (2003), in West African okra (*A. caillei*). Ariyo (1990) reported similar high narrow sense heritability for fruit length and fruit diameter in *A. esculentus* and concluded that selection in the F_2 generation would lead to substantial genetic improvement in fresh fruit yield. The result in this study also showed that selection in the F_2 generation for those traits will be highly effective in selecting suitable genetic base for improvement of fresh fruit yield in okra (*A. esculentus*).

The performance of the parents and the hybrids on the basis of per se performance and their combining abilities for certain traits are presented in Table 2. For best performing parents and crosses on the basis of *per se* performance and for general and specific combining ability effects, good potential existed for cultivars such as Mothol - AE2, Gerio – AE1, Mothol – AE3 and Mothol – AE4 which were significantly higher than the rest of the cultivars in terms of fresh fruit yield per plant. Gerio -AE 1 especially showed overwhelming superiority over the other cultivars for the other important yield components such as number of fruits per plant, fruit diameter, numbers of branches per plant, internodes distances and plant height. Similarly, superior high yielding crosses such as Mothol-AE2 × Mothol-AE3, Mothol-AE1 × Mothol-AE3, Mothol-AE2 × Gerio-AE1, Mothol– AE2 × Mothol – AE1 and Mothol – AE1 × Gerio – AE1 were identified and could be used for further selection to obtain high yielding varieties. Depending on the breeding objectives, there is a wide range of cultivars and crosses to choose from. If for instance the objective is to produce an early maturing variety with long pods, then hybridization between Mothol– AE2 and Gerio – AE2 could bring about the desired goal. Alternatively, if the objective is to produce high number of fruits per plant with wide pods, then Gerio – AE1 and Gerio – AE2 are good choices for hybridization.

The estimates of general combining ability effects (GCA) pooled over locations for all the traits are presented in Table 3. Estimate of general combining ability effects pooled over location; this is because they showed a relatively high positive GCA effects for most of the traits. Comparatively, Mothol-AE2 was considered the overall best general combiner because it showed positive GCA effect for 5 traits viz: days to 50% flowering, plant height, fruit length, fruit diameter and yield per plant. Gerio-AE1 and Mothol-AE3 were also considered the second and third best general combiners, respectively.

The high general combiners for yield and yield components identified in this study will produce desirable segregates for selection when crossed together. Ariyo (1993) reported that the parental varieties that showed good general combining ability may be used in a multiple crossing programme for isolating high yielding varieties in West Africa okra *A. caillei* stevels. Ahmad (2002) in his conclusion stated that selected lines from such multiple crosses could be released as conventional varieties or used as improved parents for F_1's hybrid production.

The specific combining ability, effects of the crosses for yield and yield component for the 36 crosses are presented in Table 4. Estimate of combining ability effects of crosses pooled over locations for their traits. It is important to note that each of these crosses involved at least one or both high general combiners in the parental crosses. Specific combining ability effects are usually used to identify the best cross-combinations for hybrid production. It was observed that the best cross combination in terms of SCA effects always involved one or both high general combiners as parents. For instance, most crosses with high SCA effects involved at least one of the 4 high general combining parents namely; Mothol – AE2, Mothol – AE3, Gerio – AE1 and pella – AE1. However, poor general combiner such as Gerio – AE2, Pella – AE2, and Mothol – AE5, sometimes gave good cross combinations when they were crossed with high general combiners. Ahmad et al. (1997) suggested that when parent with high GCA cross another with low GCA effects, the poor parent could throw up desirable transgressive segregates giving rise to desirable population. This is only possible if the additive genetic system present in the good general combiner and the complementary espistasis effects present in the crosses act in a complementary fashion to maximize desirable

Table 3. Estimates of general combining ability effects pooled over locations.

Genotypes	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Internode distance (cm)	Fruit length (cm)	Fruit diameter (cm)	Number of fruits per plant	Yield per plant (g)
Mothol – AE2	8.10	47.19	-1.07	-5.68	46.80	1.40	-16.99	35.74
Pella – AE1	30.72	75.66	3.50	-0.33	-6.69	-0.40	0.04	-24.36
Mothol – AE5	-1.62	-49.67	-0.07	-10.04	0.69	0.25	-0.14	-15.19
Mothol – AE1	6.05	0.91	0.12	-7.19	-10.09	0.35	3.05	-0.37
Pella – AE2	-11.95	-45.29	1.10	-6.75	-14.30	0.52	4.39	-44.91
Mothol – AE4	-7.92	1.21	0.76	-7.01	-1.77	0.09	3.51	-0.99
Mothol – AE3	1.34	-35.46	-0.80	17.97	2.11	0.04	-0.50	7.30
Gerio – AE1	-1.37	20.54	1.20	20.51	-6.27	0.46	3.33	-6.37
Gerio – AE2	-5.30	-22.10	-0.74	-1.49	-5.27	0.10	2.03	-46.58
S.E	0.98	1.72	0.61	0.47	0.63	0.09	0.45	3.39

Table 4. Estimates of SCA effects of crosses pooled over locations for the traits.

Crosses	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Internode distance (cm)	Fruit length (cm)	Fruit diametre (cm)	Number of Fruits per palnt	Yield per plant (g)
P_1 x P_2	0.86	20.46	-3.78	3.03	2.05	0.49	-0.31	44.20
P_1 x P_3	-12.99	-5.09	-0.75	3.66	-7.16	0.63	3.15	61.24
P_1 x P_4	12.29	97.55	0.75	9.67	16.26	-0.61	-2.66	145.55
P_1 x P_5	21.58	59.29	1.91	-15.54	15.77	-0.51	-7.27	29.74
P_1 x P_6	1.14	4.57	0.69	-8.09	5.69	0.03	-2.94	91.88
P_1 x P_7	23.95	67.62	0.32	-16.99	25.28	-0.61	-8.17	258.32
P_1 x P_8	12.66	56.83	1.34	8.33	13.53	-0.59	-3.10	193.92
P_1 x P_9	24.94	-119.56	-2.98	-26.89	-14.32	0.30	4.80	-37.34
P_2 x P_3	5.93	21.40	2.67	7.55	11.35	-0.42	-4.48	66.27
P_2 x P_4	6.94	-22.76	0.07	-18.76	14.46	-0.56	-7.75	6.01
P_2 x P_5	-7.96	-5.64	1.01	-23.07	-2.01	-0.22	0.38	-37.79
P_2 x P_6	-6.14	-20.18	1.09	5.17	-0.93	-0.20	1.19	-57.09
P_2 x P_7	4.87	20.05	0.89	-17.64	-1.08	0.22	0.66	21.40
P_2 x P_8	-11.26	15.94	-1.23	29.69	-7.50	0.12	2.61	-20.64
P_2 x P_9	-2.41	-78.59	-0.10	3.02	-24.85	-0.92	-0.22	-114.66
P_3 x P_4	16.65	78.49	2.93	-14.11	13.55	0.40	-6.02	80.18
P_3 x P_5	-8.24	-34.90	0.59	5.04	-10.51	0.16	3.63	-79.18
P_3 x P_6	9.22	-12.21	1.30	2.57	-10.28	-0.11	4.00	18.61

Table 4. contd.

$P_3 \times P_7$	-2.33	1.01	-1.4	3.99	-0.99	0.29	0.46	28.52
$P_3 \times P_8$	-10.23	62.75	0.99	10.22	17.38	-0.32	8.87	121.64
$P_3 \times P_9$	1.08	-4.78	2.12	-19.38	0.96	0.31	2.31	-4.63
$P_4 \times P_5$	-5.51	-12.65	0.22	0.64	-4.87	-0.23	0.01	-89.46
$P_4 \times P_6$	-1.97	-32.72	0.87	5.16	-5.88	0.26	-0.74	-101.22
$P_4 \times P_7$	21.04	82.72	1.18	-14.87	23.61	0.60	-11.00	216.73
$P_4 \times P_8$	-0.51	2.01	0.11	-0.45	-0.94	0.77	16.09	-34.88
$P_4 \times P_9$	8.85	50.83	0.15	-19.11	0.99	0.02	-2.69	-66.40
$P_5 \times P_6$	-0.22	25.73	0.59	5.04	-10.51	0.16	3.63	-129.18
$P_5 \times P_7$	3.33	-8.91	0.96	-14.75	-6.58	0.05	2.74	-26.74
$P_5 \times P_8$	-9.79	-22.05	-0.70	6.09	-0.24	-0.19	0.29	-12.75
$P_5 \times P_9$	-19.28	-76.75	2.33	-25.65	-32.87	-0.13	2.04	-190.43
$P_6 \times P_7$	11.63	14.57	0.04	8.19	5.61	-0.10	-2.79	66.46
$P_6 \times P_8$	-0.73	8.52	4.11	8.54	-5.67	-1.16	3.84	29.80
$P_6 \times P_9$	3.11	-83.22	5.16	-2.60	-17.11	-0.38	5.04	-120.17
$P_7 \times P_8$	2.13	-4.31	-1.28	3.82	2.73	-0.04	0.21	55.96
$P_7 \times P_9$	-3.95	19.24	-0.06	5.14	-0.51	-0.26	-0.46	46.45
$P_8 \times P_9$	-17.77	19.99	0.43	9.75	-2.27	-0.26	-391	27.63
SE	0.97	2.65	0.60	5.39	0.57	0.10	0.52	3.37

plant attributes which could be exploited for further breeding.

This study identified a good number of desirable cross-combinations for each of the traits studied in the okra population. The inter-crossing of these materials could therefore generate a population with a large gene pool, where genetic linkages and genetic blocks could be broken.

The heterosis over the higher parent cultivar is presented in Table 5. It was observed that heterosis for yield per plant was greatest in crosses where the high yielding parent such as Mothol-AE2, Mothol-AE3, Mothol-AE1 and Gerio-AE1 were involved in the crosses. Thus, the hybrid, Mothol-AE2 × Mothol-AE3 had the highest heterotic effect of 23.8% over the higher parent, followed by Mothol-AE1 × Mothol-AE3, Mothol-AE5 × Gerio-AE1, Mothol-AE2 × Gerio-AE1, Mothol-AE2 × Mothol-AE1 and Mothol-AE1 × Gerio-AE1. 7 crosses expressed positive heterosis for number of fruits per plant, namely, Mothol-AE2 × Mothol-AE1, Mothol-AE2 × Mothol-AE4, Mothol-AE5 × Mothol-AE1, Mothol-AE5 × Mothol-AE4, Mothol-AE1 × Mothol-AE4, Mothol-AE1 × Gerio-AE2, pella-AE2 × Mothol-AE3 and Mothol-AE4 × Mothol-AE3; all the crosses also expressed significant positive SCA effects for number of fruits per plant thus indicating a close relationship between heterosis and SCA effects.

Heterosis was also expressed for fruit diameter. The highest heterosis were expressed by Mothol-AE1 × Gerio-AE1 (17.23%) followed by pella-AE1 × Gerio-AE1 (11.8%) Mothol-AE5 × Mothol-AE1 (9.96%), Mothol-AE5 × Mothol-AE3 (8.69%), pella-AE2 × Mothol-AE3 (7.24%) and Mothol-AE5 × pella –AE2 (6.98%). All these hybrids also had high SCA effects. 6 crosses also exhibited positive heterosis over the higher parent for fruits length; these crosses also had high positive SCA effects. 9 crosses expressed significant positive heterosis for days to 50% flowering. The highest was obtained in pella-AE2 × Mothol-AE3, followed by Mothol-AE4 × Mothol-AE3, Mothol-AE1 × Gerio-AE2, Mothol-AE3 × Gerio-AE1, Mothol-AE5 × Mothol-AE4, Mothol-AE2 × Mothol-AE1, Mothol-AE1 x Mothol-AE3, Mothol-AE4 × Mothol-AE3 and Mothol-AE2 × Gerio-AE2. For plant height, 8 crosses expressed positive heterosis; the top 4

Table 5. Estimates of heterosis (%) over higher – parent for yield and yield components of okra over locations.

Crosses	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Internode distance (cm)	Fruit length (cm)	Fruit diametre (cm)	Number of fruit per plant	Yield per plant (g)
P_1 x P_2	-18.11	4.86	-20.98	0.50	-39.73	-12.53	-9.20	-3.97
P_1 x P_3	-2.30	-30.24	-26.19	-28.29	-51.72	0.77	-7.43	-4.85
P_1 x P_4	5.53	-10.98	-33.60	-25.59	-14.71	-7.90	8.27	1.96
P_1 x P_5	-3.42	-26.31	-5.88	3.33	-51.60	-1.54	-14.24	-0.26
P_1 x P_6	-8.68	-11.58	-9.85	-14.64	-43.38	-0.88	9.38	-0.43
P_1 x P_7	-15.14	3.96	16.10	15.46	11.34	-15.97	-22.36	23.30
P_1 x P_8	-21.06	-11.46	9.80	5.25	5.06	-6.92	-11.10	2.25
P_1 x P_9	1.05	-2.77	-23.28	-19.88	-40.85	6.59	-34.60	-30.71
P_2 x P_3	-10.43	-16.97	-0.98	22.06	-2.42	2.03	-15.95	-0.30
P_2 x P_4	-11.22	-13.78	-17.06	5.46	-17.52	-2.21	-10.94	-3.70
P_2 x P_5	-4.81	2.94	41.71	17.42	-35.81	-6.42	-20.22	-18.63
P_2 x P_6	-16.54	-24.23	-13.53	-1.93	-7.36	-7.16	-5.32	-12.31
P_2 x P_7	-23.43	-19.73	-11.37	13.03	-27.25	-10.56	-24.34	-0.17
P_2 x P_8	-13.58	24.48	-8.43	-14.43	-25.90	11.80	-27.61	-2.80
P_2 x P_9	-4.72	-25.60	-30.71	-24.28	-53.07	-14.66	-35.33	-26.71
P_3 x P_4	-6.01	4.38	27.36	35.31	-8.07	9.96	4.62	0.54
P_3 x P_5	-7.42	-26.51	-41.77	-43.57	-13.11	6.98	-6.60	-16.56
P_3 x P_6	7.16	-14.02	1.26	-2.76	-15.15	-0.13	2.71	-6.15
P_3 x P_7	-4.35	7.04	-4.59	-11.83	-28.02	8.65	-0.08	-2.96
P_3 x P_8	-9.67	-24.01	-16.69	-17.26	3.57	-9.24	-19.03	2.26
P_3 x P_9	-2.81	-12.74	-6.87	-24.64	2.69	5.10	-17.11	-4.84
P_4 x P_5	-10.38	-21.93	-11.70	-9.39	-12.46	-5.02	20.40	-9.19
P_4 x P_6	-11.78	-8.79	-12.58	-26.35	-11.51	6.18	1.51	-4.89
P_4 x P_7	5.29	-6.41	-5.12	7.07	5.62	2.51	-6.85	13.04
P_4 x P_8	-12.26	-4.53	10.78	2.48	-7.27	17.23	-9.55	-0.94
P_4 x P_9	8.47	-16.98	2.20	8.86	-23.57	5.28	0.04	-9.78
P_5 x P_6	-19.42	-15.92	17.65	-3.46	-20.44	3.81	-17.58	-19.56
P_5 x P_7	13.28	0.82	5.29	-13.98	-18.05	7.24	2.15	-4.06
P_5 x P_8	-3.77	-26.99	-12.43	-9.74	-5.04	-2.24	-21.54	-12.73
P_5 x P_9	-5.43	-12.84	-8.41	-11.09	-23.77	-7.88	-18.90	-33.21
P_6 x P_7	12.26	-23.80	7.34	-15.01	1.45	-3.95	8.45	-5.59
P_6 x P_8	-8.26	-9.13	8.04	13.41	-9.82	-8.02	-19.80	-14.44
P_6 x P_9	5.22	-13.50	-5.45	-24.63	-18.56	-8.13	-8.72	-31.55
P_7 x P_8	7.91	12.43	-0.59	-10.81	-8.58	-0.95	-13.06	1.35
P_7 x P_9	-2.51	-20.36	7.92	3.31	-14.12	-4.45	-18.82	-9.29
P_8 x P_9	-0.71	-33.11	-10.48	-31.43	-5.16	-11.40	-8.74	-14.30

were pella-AE1 × Gerio-AE1, Mothol-AE3 × Gerio-AE1, Mothol-AE5 × Mothol-AE3 and Mothol-AE2 × pella-AE1. All the crosses expressed positive SCA effects.

Ahmad (2002), studied inheritance of some traits in diallel cross of okra and observed a close relationship between the best specific combiners and hybrids exhibiting high heterotic responses over the higher parents for some of the traits he studied. Similar results were obtained in this study. SCA effect could therefore be used to predict or identify heterotic responsive hybrids. He however, cautioned that high heterotic response does not always mean high performance of hybrids, but it may be due to a relatively poor performance of its parents. On the other hand, with the same amount of heterotic response, the SCA effects may be lower when the parental performance is relatively high. This therefore suggests that sometimes the estimates of SCA effect may not lead to the correct choice of hybrid performance for heterosis.

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