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Combining Ability and Heterosis Studies for Yield and its Components in Some Cultivars of Okra (*Abelmoschus esculentus* L. Moench)

[1]*Hazem A. Obiadalla-Ali*, [2]*M.H.Z. Eldekashy and* [3]*A.A. Helaly*

[1]Department of Horticulture, Faculty of Agriculture, Sohag University, Sohag, Egypt
[2]Department of Horticulture, Faculty of Agriculture, Assuit University, Assuit, Egypt
[3]Department of Horticulture, Faculty of Agriculture, AL-Azhar University, Cairo, Egypt

Abstract: Two Egyptian and four exotic parental genotypes of okra were self pollinated for one generation and crossed in half diallel design to study heterosis and combining ability for earliness, vegetative and yield components traits. Mean squares of genotypes were found to be highly significant for all studied traits, providing evidence for presence of considerable amount of genetic variation among studied genotypes. The results showed that the majority of crosses exhibited significant heterosis estimates over mid parents for all studied traits. The general combining ability (GCA) and specific combining ability (SCA) mean squares were highly significant for all studied traits. Pusa Sewani (P_6) was excellent general combiners for all studied traits except average fruit weight per plant (gm). The cross combination (P_1xP_6) showed desirable SCA effects and significant heterosis values for all studied traits except number of branches per plant. These promising crosses could be used for constitution of okra hybrids.

Key words: General Combining Ability % Specific Combining Ability % Yield % Heterosis % Diallel

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is one of the most important vegetable crops in the tropical and subtropical region of the world [1-2]. Okra has wide popularity in terms of cultivation and acceptability all over the world [3].

Yield is one of the most important characters of okra cultivars and hybrids. Great efforts have been directed to improve yield production and quality properties in okra [4-6].

Heterosis and combining ability provides important information for improving economic characteristics in okra. Several researchers have reported the occurrence of heterosis in considerable quantities for earliness, fruit yield and its various components [7-14].

Diallel cross analysis is one of the most powerful tools for characterizing the genetic architecture of plant genotypes and estimating the GCA of parents and selecting of desirable parents and crosses with high SCA for the exploitation of heterosis [15]. Diallel mating design has been used extensively by several researchers to measure combining ability and gene action for earliness, yield and yield components in okra [16-26]. They found that the estimates of GCA and SCA were significant for earliness and yield components, suggesting the importance of additive and non additive gene action in the inheritance of these traits.

Therefore, the objective of this research was to study heterosis and combining ability controlling the inheritance of economical characteristics of okra.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Farm of Agriculture Faculty, Sohag University, during the three summer seasons of 2010, 2011 and 2012 where, the soil was sandy calcareous (surface layer contains transported Nile sediments over desert soil).

Six different okra cultivars (*Abelmoschus esculentus* L. Moench) represented a wide range of variability in their economic traits, were used in this study. These cultivars were: Balady (P_1), Escandarany (P_2), Clemson Spineless (P_3), Emerald (P_4), White Valvet (P_5) and Pusa Sewani (P_6).

Corresponding Author: Hazem A. Obiadalla-Ali, Department of Horticulture, Faculty of Agriculture, Sohag University, Sohag, Egypt. E-mail: drhazemaoa@yahoo.com

In the summer season of 2010, the seeds of six parental genotypes were planted and the selfing was undertaken to produce the six inbred lines.

In the following summer season 2011, the six inbred lines seeds (S_1) were sown on April, 1 and crossed according to a half diallel mating design to pr oduce fifteen F_1 hybrids.

In the summer season of 2012, parents (six inbred lines seeds) and their fifteen F_1 hybrids were sown on April, 7 in a randomized complete block design with three replications. Each replicate contains 21 plots. Each plot was 3 ridge 3.0 m. long and 0.70 m. wide. Hills were spaced at 0.30 m. apart. Thinning to one plant per hill was done after 21 days from sowing. All agricultural practices were applied as recommended for okra production.

Data were recorded for the following traits: {number of days to 50% flowering [No. D 50% F], Plant height [PH (cm)], number of branches per plant [No. B/P], number of fruits per plant [No. F/P], average fruit weight per plant [AFW/P (gm)], Fruit length [FL (cm)], Fruit diameter [FD (cm)] and average total fruit weight yield per feddan (ton) [ATFWY/F (ton)]}. Data were subjected to the analysis of variance in order to test the significance of the differences among the 21 genotypes including the six inbred lines and their 15 F_1 hybrids according to Cochran and Cox [11].

Sum of squares for genotypes was partitioned according to Griffing [12] as method 2 model 1 into sources of variations due to GCA and SCA. The variances of GCA (F^2g) and SCA (F^2s) were obtained on the basis of the expected mean squares for all studied traits. Additive (F^2A) and non-additive (F^2D) genetic variances were estimated according to Matzinger and Kempthorne [13] as follow:

$$F^2A = 2\,F^2g$$
$$F^2D = F^2s$$

Estimates of heterosis % were calculated according to Singh and Khanna [14] as following equations: Mid-parent heterosis (%) = ($\bar{F}$ 1-M.P./M.P.) x 100 where, M.P. = ($\bar{P}$ i - $\bar{P}$ j)/2.

RESULTS AND DISCUSSIONS

Genotypic Variations: Analyses of variance for all genotypes are presented in Table 1. Mean squares of genotypes were found to be highly significant for all studied traits. This provides evidence for presence of considerable amount of genetic variation among studied genotypes. These results are in harmony with those previously obtained by El-Gendy Soher *et.al*. [16], Srivastava *et al*. [18], Abass [20], Kumar *et al*. [21], Rajani *et al*. [25] and Nichal *et al*. [26].

Mean Performance: Mean performance of the 15 F_1 hybrids for all studied traits are shown in Table 2. A considerable variation were obtained among all F_1 hybrids for all studied traits. The cross (P_1xP_6) was the earliest cross in comparison with the other crosses. Moreover, the cross (P_1xP_6) was the best for PH (cm) and FD (cm), with the mean of 86.33 and 2.62, respectively. Meanwhile, the crosses (P_1xP_3), (P_1xP_6) and (P_4xP_6) exceeded all other crosses in ATFWY/F (ton). In addition, the crosses ((P_3xP_6), (P_4xP_6), (P_2xP_5) and (P_4xP_5) had the highest crosses for No. B/P, No. F/P, AFW/P (gm) and FL (cm). These results are in agreement with those reported by Medagam *et al*. [7] and El-Gendy Soher *et al*. [16].

Therefore, these promising crosses among F_1 hybrids could be used for further breeding studies to improve the economic traits in okra.

Estimates of Heterosis: Estimates of heterosis over mid parents for all studied traits are shown in Table 3. Earliness is an important aim in okra, thus, the negative heterosis value for No. D 50% F is desirable in breeding program. In this direction, most of crosses flowered highly significant earlier than their mid parents with negative heterosis values ranging from-1.77% to-5.73%. Respecting to vegetative traits, most crosses exhibited significant positive heterosis values relative to mid parents and ranged from (3.76% to 24.82%), (4.76% to 85.71%), (2.33% to 41.10%), (11.67% to 37.67%), (7.82% to 34.96%) and (0.05% to 24.10%) for PH (cm), No. B/P, No. F/P, AFW/P (gm), FL (cm) and FD (cm), respectively. Concerning ATFWY/F (ton), most crosses were also significantly better yielding than their mid parents and ranged from (2.35% to 21.80%). In general, these results indicate that most crosses were significantly earlier and higher yielding than their mid parents, suggesting the important role of non-additive gene action in the inheritance of studied traits. These results are in agreement with those previously reported by Medagam *et al*. [7], Wammanda *et al*. [8], Jaiprakashnarayan *et al*. [10], Mehta *et al*. [11] and Bendale *et al*. [13].

Combining Ability Analysis: Mean squares of general and specific combining ability for all studied traits are given in Table 4. The mean squares of GCA and SCA were highly significant for all studied traits. These results indicate that both GCA and SCA were important in the inheritance of these traits. However, the magnitudes of

Table 1: Analysis of variance and mean squares of the F_1 hybrids and their parents for studied traits

SV	df	No. D 50% F	PH (cm)	No.B/P	No.F/P	AFW/P (gm)	FL (cm)	FD (cm)	ATFWY/F (ton)
Reps.	2	0.3359	0.0313	0.0476	0.683	0.0048	0.0006	0.0007	0.0025
Geno.	20	122.43**	442.35**	1.1048**	52.42**	1.948**	5.114**	12.20**	0.2854**
Error	40	0.3664	0.3484	0.3310	0.2992	0.0028	0.0014	0.0018	0.0010

*,**Significant at 5% and 1% levels of probability, respectively

Table 2: Mean performance of F_1 hybrids for all studied traits

Hybrids		No. D 50% F	PH (cm)	No. B/P	No. F/P	AFW/P (gm)	FL (cm)	FD (cm)	ATFWY/F (ton)
1	P_1 x P_2	74.67	76.33	13.33	3.67	6.73	7.15	2.13	8.45
2	P_1 x P_3	52.67	68.67	10.33	2.67	6.13	11.52	1.93	9.56
3	P_1 x P_4	50.33	64.33	16.33	2.67	7.18	12.08	1.77	8.04
4	P_1 x P_5	56.33	73.33	15.00	2.67	9.17	10.65	1.62	7.21
5	P_1 x P_6	46.33	86.33	22.33	3.67	6.45	8.92	2.62	9.07
6	P_2 x P_3	55.33	57.67	12.33	2.67	6.72	11.37	1.98	8.05
7	P_2 x P_4	56.33	56.33	17.67	3.33	7.82	12.25	1.73	8.71
8	P_2 x P_5	59.33	82.33	14.67	2.67	9.40	10.65	1.58	7.04
9	P_2 x P_6	52.33	71.33	20.33	3.67	7.05	8.70	2.17	8.71
10	P_3 x P_4	56.67	54.33	18.67	3.33	8.08	12.52	2.00	8.00
11	P_3 x P_5	59.33	73.67	13.33	2.67	9.07	11.60	2.03	7.20
12	P_3 x P_6	49.33	86.33	24.33	4.00	6.65	11.07	2.13	8.00
13	P_4 x P_5	55.67	64.67	14.67	2.67	9.03	12.73	1.72	8.61
14	P_4 x P_6	49.33	71.67	21.33	4.33	7.83	12.47	1.88	9.21
15	P_5 x P_6	52.33	92.67	18.33	3.67	8.97	11.07	1.63	7.81
LSD	0.05	0.999	0.974	0.949	0.903	0.087	0.062	0.070	0.052
	0.01	1.337	1.303	1.270	1.208	0.117	0.065	0.094	0.070

Table 3: Estimates of heterosis over mid parents for all studied traits

Hybrids		No. D 50% F	PH (cm)	No. B/P	No. F/P	AFW/P (gm)	FL (cm)	FD (cm)	ATFWY/F (ton)
1	P_1 x P_2	44.05	9.569	22.222	26.984	23.547	13.492	-4.478	12.888
2	P_1 x P_3	4.63	7.013	-15.789	-17.333	15.979	34.961	-11.450	21.804
3	P_1 x P_4	3.072	3.763	-11.111	10.112	21.889	33.764	-8.621	-2.179
4	P_1 x P_5	7.987	-4.762	-11.111	26.761	37.672	29.483	-14.159	-2.612
5	P_1 x P_6	0.050	8.368	4.762	41.063	17.988	22.988	20.307	10.860
6	P_2 x P_3	4.323	-2.535	6.667	15.625	13.107	28.679	0.050	13.780
7	P_2 x P_4	0.020	-1.170	42.857	35.897	19.460	31.250	0.030	16.913
8	P_2 x P_5	-0.559	14.352	14.286	46.667	28.620	24.927	-5.941	6.171
9	P_2 x P_6	-2.786	-4.464	57.143	45.238	15.259	15.232	9.705	17.580
10	P_3 x P_4	3.343	5.502	25.000	24.444	26.665	8.213	18.812	2.348
11	P_3 x P_5	2.006	10.777	0.020	11.111	26.866	7.823	24.490	2.873
12	P_3 x P_6	-5.732	24.819	50.000	52.083	11.671	13.118	10.822	2.864
13	P_4 x P_5	-1.765	0.518	14.286	2.326	16.534	13.101	24.096	16.789
14	P_4 x P_6	-2.951	6.965	85.714	16.364	19.411	21.232	12.438	13.001
15	P_5 x P_6	-3.385	13.008	57.143	19.565	22.412	16.799	-95.504	6.485
LSD	0.05	0.85	0.83	0.81	0.77	0.04	0.06	0.04	0.07
	0.01	1.13	1.11	1.08	1.02	0.05	0.08	0.05	0.10

Table 4: The analysis of variance and mean squares for combining ability analysis

SV	Df	No. D 50% F	PH (cm)	No. B/P	No. F/P	AFW/P (gm)	FL (cm)	FD (cm)	ATFWY/F (ton)
GCA	5	235.97**	1486.05**	2.20**	138.13	14.10**	35.17**	0.760**	3.996**
SCA	15	84.59**	94.44**	0.74**	23.85	2.115**	4.54**	0.127**	1.266**
Error	40	0.37	0.35	0.33	0.30	0.001	0.002	0.001**	0.003

*,**Significant at 5% and 1% levels of probability, respectively

Table 5: Estimates of general combining ability effects (g_i) of each parent for all studied traits

Genotypes	No. D 50% F	PH (cm)	No. B/P	No. F/P	AFW/P (gm)	FL (cm)	FD (cm)	ATFWY/F (ton)
P1	-1.708	2.861	0.125	-1.194	-0.783	-1.353	0.199	0.315
P2	4.250	-2.764	-0.125	-1.986	-0.202	-1.228	0.041	-0.241
P3	0.417	-5.931	-0.125	-0.903	-0.416	0.883	0.076	-0.076
P4	-0.958	-10.681	0.083	1.472	0.299	1.631	-0.172	0.331
P5	2.542	6.236	0.333	-1.611	1.392	0.558	-0.261	-0.667
P6	-4.524	10.278	0.542	4.222	-0.289	0.490	0.116	0.338
SE(gi)	0.0305	0.029	0.027	0.498	0.001	0.002	0.001	0.002

Table 6: Estimates of Specific combining ability effects (S_{ij}) of each cross for all studied traits

Genotypes	No. D 50% F	PH (cm)	No. B/P	No. F/P	AFW/P (gm)	FL (cm)	FD (cm)	ATFWY/F (ton)
P_1 x P_2	7.46	5.458	0.571	0.577	0.357	-0.718	-0.012^{NS}	0.327
P_1 x P_3	-0.708	0.958	-0.429	-3.506	-0.029	1.538	-0.248	1.276
P_1 x P_4	01.667	1.375	-0.470	0.119	0.306	1.357	-0.167	-0.648
P_1 x P_5	0.833	-6.540	-0.220	1.869	1.96	0.997	-0.227	-0.483
P_1 x P_6	-2.083	2.417	-0.095	3.369	0.161	0.311	0.396	0.372
P_2 x P_3	-4.00	-4.417	-0.179	-0.174	-0.027	1.263	-0.040	0.325
P_2 x P_4	-1.625	-1.000	0.446	2.244	0.358	1.399	-0.042	0.577
P_2 x P_5	-2.125	8.083	0.030	2.327	0.848	0.872	-0.102	-0.095
P_2 x P_6	-2.042	-6.958	0.155	2.161	0.180	-0.030^{NS}	0.104	0.571
P_3 x P_4	2.542	0.167	0.446	2.161	0.839	-0.445	0.190	-0.298
P_3 x P_5	1.708	2.583	0.030	-0.089	0.729	-0.289	0.313	-0.101^{NS}
P_3 x P_6	-1.208	11.21	0.488	5.077	-0.006	0.226	0.035^{NS}	-0.307
P_4 x P_5	-0.583	-1.667	0.012	-1.131	-0.019	0.097	0.244	0.902
P_4 x P_6	0.167	1.292	0.780	-0.298	0.462	0.878	0.033^{NS}	0.496
P_5 x P_6	-0.333	5.375	0.363	-0.214	0.503	0.551	-0.127	0.91
SE (S_{ij})	0.0654	0.0913	0.0867	0.0784	0.0004	0.0003	0.0003	0.0008

GCA were larger than those of SCA for all studied traits pointed out the predominance of the additive gene action. These results are in agreement with those previously reported by Reddy *et al*. [15], Singh *et al*. [17], Dahake and Bangar [19], Jindal and Ghai [22], Rewale *et al*. [23] and Liou *et al*. [24].

Gca Effects (Gi): Estimated of general combining ability effects (gi) of each parent for all studied traits are presented in Table 5. Pusa Sewani (P_6) was the best general combiner for all studied traits except AFW/P (gm). Balady (P_1) and Emerald (P_4) were good general combiner for earliness. Moreover, Balady (P_1) was the best general combiners for ATFW/P (ton). Emerald (P_4) and White Valvet (P_5) were good combiner for AFW/P (gm). Consequently, Pusa Sewani (P_6) which exhibited useful general combining ability effects could be utilized in breeding programs to improve earliness and yield components. Similar results were obtained by El-Gendy Soher *et al*. [16] and Abass [20].

Sca Effects (S_{ij}): Estimated specific combining ability effects (Sij) of each cross combination for all studied traits are shown in Table 6. The results revealed that the cross combination (P_2xP_3), which resulting from crossing (poor x poor) general combiners, showed desirable negative significant SCA effects for earliness. the cross combination (P_1xP_3), (P_1xP_6), (P_2xP_4), (P_2xP_5), (P_2xP_6), (P_3xP_6), showed desirable negative significant SCA effects for earliness. With respect to vegetative traits, nine, one, eleven and five out of fifteen crosses exhibited positive SCA effects for PH (cm), No. B/P, FL (cm) and FD (cm), respectively. As for yield, six and eleven out of the fifteen crosses showed significant positive SCA effect values for No. F/P and AFW/P (gm), respectively. Concerning to total yield eight out of the fifteen hybrids were the best yielding crosses for ATFWY/F (ton).

It could be noticed that the excellent cross combinations were obtained from crossing (good x good), (good x poor) and (poor x poor) general combiners. Therefore, it is not necessary that parents having estimates of high GCA effects would also give high estimates of SCA effects in their respective cross combinations.These results suggest the important role of non additive gene action in the inheritance of the studied traits. Similar results were reported by Medagam *et al*. [7], Wammanda *et al*. [8], Jindal *et al*. [9]; Mehta *et al*. [11], Singh *et al*. [12], Dhankhar and Dhankhar [14] and Reddy *et al*. [15].

It is interesting to note that the promising crosses which showed desirable SCA effects exhibited as previously mentioned high heterosis values for these studied traits. These promising crosses could be used for okra hybrids and segregating generations for transgressive segregants.

CONCLUSION

From the data presented in this study it could be concluded that the cross combinations (P_2xP_6), (P_4xP_6), (P_3xP_6) and (P_2xP_4) showed desirable SCA effects and significant heterosis values for most studied traits. This finding reflects the presence of considerable heterosis values and suggested that non additive gene effects played the major role in the inheritance of these traits. These promising crosses could be used for improving okra hybrids.

REFERENCES

1. Dilruba, S., M. Hasanuzzaman, R. Karim and K. Nahar, 2009. Yield Response of Okra to Different Sowing Time and Application of Growth Hormones. Journal of Horticultural Science and Ornamental Plants, 1(1): 10-14.
2. Odedara, O.O., E.I. Ayo-John, M.T. Bankole, B.G. Tinuala, O.D. Odetayo, T.I. Adebulehin, O.D. Adesomoju and E.O. Imaku, 2011. Distribution of Viruses on Okra Plants grown in Southwestern Nigeria. Academic Journal of Plant Sci., 4(1): 19-21.
3. Ibe, A.E. and D.K. Madukwe, 2010. Potentials of Tillage and Mulch Application on Imperata cylindrica Control in Okra (*Abelmoschus esculentus* L. Moench) in Isohyperthemic Arenic Kandult. American-Eurasian J. Agric. and Environ. Sci., 9(2): 176-180.
4. Akande, M.O., F.I. Oluwatoyinbo, C.O. Kayode and F.A. Olowokere, 2006. Response of Maize (*Zea mays*) and Okra (*Abelmoschus esculentus*) Intercrop Relayed with Cowpea (*Vigna unguiculata*) to Different Levels of Cow Dung Amended Phosphate Rock. World Journal of Agricultural Sciences, 2(1): 119-122.
5. Ossom, E.M. and V.N. Kunene, 2011. Effect of planting date on Seedling emergence and Vigor of Okra (*Abelmoschus esculentus* L. Moench) in Swaziland. World Journal of Agricultural Sciences, 7(3): 320-326.
6. Ibrahim, U. and I.L. Hamma, 2012. Influence of Farmyard Manure and Weeding Regimes on Growth and Yield of Okra (*Abelmoschus esculentus* L. Moench) in Zaria. World Journal of Agricultural Sciences, 8(5): 453-458.
7. Medagam, T.R., H. Kadiyala, G. Mutyala and B. Hameedunnisa, 2012. Heterosis for yield and yield components in okra (*Abelmoschus esculentus* L. Moench). Chilean Journal of Agricultural Research, 72(3): 316-325.
8. Wammanda, D.T., A.M. Kadams and P.M. Jonah, 2010. Combining ability analysis and heterosis in a diallel cross of okra (*Abelmoschus esculentus* L. Moench). African Journal of Agricultural Research, 5(16): 2108-2115.
9. Jindal, S.K., D. Arora and T.R. Ghai, 2009. Heterobeltiosis and combining ability for earliness in okra (*Abelmoschus esculentus* L. Moench). Crop Improvement, 36(2): 59-66.
10. Jaiprakashnarayan, R.P., S.J. Prashanth, R. Mulge and M.B. Madalageri, 2008. Study on heterosis and combining ability for earliness and yield parameters in okra (*Abelmoschus esculentus* L. Moench). The Asian Journal of Horticulture, 3: 136-141.
11. Mehta, N., B.S. Asati and S.R. Mamidwar, 2007. Heterosis and gene action in okra. Bangladesh Journal Agriculture Research, 32(3): 421-432.
12. Singh, B., S. Singh, A.K. Pal and M. Rai, 2004. Heterosis for yield and yield components in okra (*Abelmoschus esculentus* (L.) Moench). Vegetable Science, 31: 168-171.
13. Bendale, V.W., R.R. Madav, S.G. Bhave and U.B. Pethe, 2004. Heterosis and combining ability of okra (*Abelmoschus esculentus* L. Moench) cultivars. Journal of Soils and Crops, 14(2): 269-272.
14. Dhankhar, B.S. and S.K. Dhankhar, 2001. Heterosis and combining ability studies for some economic characters in okra. Haryana Journal of Horticultural Sciences, 30(3-4): 230-233.
15. Reddy, M.T., K. Haribabu, M. Ganesh, K.C. Reddy, H. Begum, R.S.K. Reddy and J.D. Babu, 2012. Genetic analysis for yield and its components in okra (*Abelmoschus esculentus* L. Moench). Songklanakarin J. Sci. Technol., 34(2): 133-141.

16. El-Gendy, E.A. Soher, H.A. Obiadalla-Ali, E.A. Ibrahim and M.H.Z. Eldekashy, 2012. Combining ability and nature of gene action in okra (*Abelmoschus esculentus* L. Moench). J. Agric. Chem. and Biotechn., Mansoura Univ., 3(7): 195-205.
17. Singh, B., S.K. Singh and K.V. Singh, 2011. Study on combining ability in okra (*Abelmoschus esculentus* L. Moench). Indian Journal of Horticulture, 67: 154-159.
18. Srivastava, M.K., S. Kumar and A.K. Pal, 2008. Studies on combining ability in okra through diallel analysis. Indian J. of Horti., 65(1): 120-128.
19. Dahake, K.D. and N.D. Bangar, 2006. Combining ability analysis in okra. Journal of Maharashtra Agricultural Universities, 31(1): 39-41.
20. Abbas, H.S., 2006. Genetic improvement of okra (*Abelmoschus esculentus* L. Moench). Ph.D. Thesis, Assiut Univ., Egypt.
21. Kumar, S.P., P. Sriram and P. Karuppiah, 2006. Studies on combining ability in okra (*Abelmoschus esculentus* L. Moench). Indian Journal of Horticulture, 63(2): 182-184.
22. Jindal, S.K. and T.R. Ghai, 2005. Diallel analysis for yield and its components in okra. Vegetable Science, 32(1): 30-32.
23. Rewale, V.S., V.W. Bendale, S.G. Bhave, R.R. Madav and B.B. Jadhav, 2003. Combining ability of yield and yield components in okra. Journal of Maharashtra Agricultural Universities, 28: 244-246.
24. Liou, M.L., J.W. Guo and S.T. Wu, 2002. Combining ability analysis of yield components in okra. J. Agric. and Forestry, 51: 1-9.
25. Rajani, B., P. Manju, N. Manikantan and P.S. Swathy, 2001. Combining ability in okra (*Abelmoschus esculentus* L. Moench). J. of Trop. Agric., 39: 98-101.
26. Nichal, S.S., S.B. Datke, D.T. Deshmukh, N.P. Patil and V.V. Ujjainkar, 2000. Diallel analysis for combining ability studies in okra (*Abelmoschus esculentus* L. Moench). Ann. Plant Physiol., 14: 120-124.
27. Cochran, W.G. and G.M. Cox, 1957. Experimental designs. 2^{nd} ed., John Wily and Sons, New York, USA.
28. Griffing, B., 1956. Concept of general and specific combining ability in relation to diallel crossing system. Aust. J. Bio. Sci., 9: 463-493.
29. Matzinger, D.F. and O. Kempthorne, 1956. The modified diallel table with partial inbreeding and interactions with environment. Genetics, 41: 822-833.
30. Singh, S.K. and R. Khanna, 1975. Physiological, biochemical and basis of heterosis. Adv. Agron., 27: 123-174.