HETEROSIS AND COMBINING ABILITY IN A DIALLEL CROSS OF OKRA (*Abelmoschus esculentus* (L.) MOENCH)

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ABSTRACT

A diallel analysis on 8 pure lines of *Abelmoschus esculentus* was done at 3 sites in Cameroon (Dibang, Yaoundé and Yagoua) in a randomized complete block design, with 3 replications, to estimate both the heterosis and the combining ability. The heterosis over mid-parent and the combining abilities were significant for all the studied traits. Reciprocal effects were observed for all traits, except for the 50 % flowering day. The best results of heterosis, over mid-parent, were recorded by combination 1 x 2 for seeds number per pod parameter (54.78 %). These parameters are supposed to improve the characters in okra.

Key-words : Okra, heterosis, diallel analysis.

RESUME

*HETEROSIS ET APTITUDE A LA COMBINAISON EN CROISEMENT DIALLELE CHEZ LE GOMBO (*Abelmoschus esculentus *(L.) MOENCH)*

Une analyse diallèle a été menée dans 3 localités du Cameroun (Dibang, Yaoundé et Yagoua) sur 8 lignées de Abelmoschus esculentus*, selon un dispositif en blocs complets randomisés, à 3 répétitions. Les résultats montrent que tous les caractères étudiés ont présenté une hétérosis moyenne et une aptitude aux combinaisons significatives. Des effets réciproques existent chez ces caractères, excepté la date à 50 % de floraison. Les meilleurs résultats de l'hétérosis ont été enregistrés, avec la combinaison 1 x 2, pour le nombre de graines par gousse (54,78 %). Ces deux paramètres favoriseraient l'amélioration des caractères chez le gombo.*

Mots-clés : *Gombo, hétérosis, analyse diallèle.*

INTRODUCTION

Abelmoschus esculentus, is an autogamous crop of the Malvaceae family. The great importance of this crop in the nutrition of populations in many countries throughout the world militate in favor of its improvement. However, this requires the ability to select higher-performing individuals from a population (Murtaza, 2005). That leads to a study of both combining ability and heterosis characteristics. A knowledge of the combining ability can help to identify the best parents that can be hybridized amongst them to use the heterosis or to accumulate some genes fixable through a selection process (Metha *et al.,* 2007).

With regard to the principle, the autogamous crops lead to the selection of pure lines and the phenomenon of heterosis is only important for the allogamous species (Schnell and Becker, 1986). But, it happens that, for some autogamous species, certain level of heterosis, occurs justifying the existence of hybrid varieties. Hybrids show evidence of qualities that cannot be obtained by selection within a species (Wright, 1964). Hybrid vigor (heterosis) occurs relatively frequently in the F1's generation. In particular, when species are exotic or when one experiments on habitats altered by man.

Several studies have been conducted on heterosis while achieving hybridizations between distant crops of okra. The results, although often

disappointing are very variable. However, some crossing between varieties originated from the United States and Malaysia showed good hybrid vigour (Hamon and Charrier, 1997).

It is known that, in the active region spaning from Guinea to Cameroon, there is a multiplicity of varieties of okra (Hamon and Charrier, 1997). The existence of a considerable range of varieties in this region should be an asset to optimize the research of heterosis in *Abelmoschus esculentus* and to identify superior individuals with good combining abilities.

MATERIAL AND METHODS

Experiments were initiated in the year 2004 at the University of Yaoundé I and at Dibang and Yagoua localities. Seeds were obtained from the market, for exotic varieties and from field and local markets for local varieties. Plants were grown three times and self-pollinated to obtain pure lines. Three seeds from pure line parents were then sown in whole at 70 cm between and within rows and thinned to two plants per hole after plants reached 3 leaf stage. The experimental design was a randomised complete block design, with three replications. Each plot consisted in three rows and each row contain six plants.

The plants were supplemented with a daily artificial watering in the dry season. Crosses were attempted among the 8 pure lines parents to obtain 56 F1 (direct and reciprocal) crosses.

DATA COLLECTION

The data was collected separately at the 3 sites. Three plants per plot, 8-9 plants were chosen at random and the following characters assessed : number of fruits per plant, plant height, stem basal diameter.

Number of seeds, length of fruit peduncle, fruit diameter and length was counted randomly on a number of 9 fruits retained on the plants of the 3 repetitions on account of 3 per plot. The basal stem diameter was determined for every treatment.

In order to take the weight 3 shares of 100 seeds were randomly selected from the nine retained fruits on the studied genotypes and weighted.

Fruit peduncle and fruit lengths were measured. The 50 % flowering day was considered as the day when half of 18 plants (9 of them) flowered in the 3 plots. Estimates of general and specific combining ability variances were obtained as follows, using the diallel analysis described by Griffing as model I, where parents, F1's and reciprocals were included (Griffing, 1956).

For the general combining ability :

$GCA_i = (\tilde{Y}_{io} + \tilde{Y}_{oi}) / 2 - \tilde{Y}_{oo}$, with,

GCA_i = general combining ability of the i line ;

$\tilde{Y}_{io}$ = sum between the averages of the i line, as male parent ;

$\tilde{Y}_{oi}$ = sum between the averages of the i line, as female parent ;

$\tilde{Y}_{oo}$ = general average of the test.

The SCA were calculated for the hybrids reciprocal F1 from the following equation :

$SCA_{ij} = (\tilde{Y}_{ij} + \tilde{Y}_{ji}) / 2 - \tilde{Y}_{oo} - GCA_i - GCA_j$, where

SCAij = specific combining ability of the i and j lines ;

$\tilde{Y}_{ij}$ = average of the i line, as male parent, and j, as female ;

$\tilde{Y}_{ji}$ = average of the i line as female parent and j as male ;

$\tilde{Y}_{oo}$ = general average of the test ;

GCA_i = general combining ability of the i line ;

GCA_j = general combining ability of the j line.

Reciprocal effects were given by the following equation :

$EM_{ij} = Y_{ij} - Y_{ji} / 2$, where :

Y_{ij} = value of the parent i took as male and j as female ;

and Y_{ji} = value of the parent j took as male and i as female.

RESULTS

The variances due to GCA, SCA and reciprocal effects are presented in Table 1. Variance analysis shows that GCA effects were highly significant for all the traits studied ($P < 0.001$), except for pod peduncle length and 50 % flowering day ($P < 0.01$ and $P < 0.05$,

respectively). On the other hand, the SCA effects are highly significant for all the traits.

The estimates of the GCA effects for the 8 parents are presented in Table 2. These results show that Indiana and Clemson Spineless are two parents, whith the highest positive GCA for plant height parameter, with values of 19.15 and 7.05, respectively. The local varieties 3 and 4, with values of -10.00 and -13.50, respectively presented for this same parameter that was significant, but with negative values. No variety presented a positive and significant GCA for all the studied characters.

Table 1 : Analysis of variance on the combining ability for the traits studied.

Analyse de variance sur l'aptitude à la combinaison des caractères étudiés.

Traits	Mean square for each parameter			
	GCA	SCA	RE	Error
PH	1770.95***	11255.580***	288.420964***	45.32428571
HSW	0.498601786***	69.8671474***	0.531***	0.06517
PPL	0.325342857**	14.92908371***	0.057717857***	0.010191485
PL	661.6649875***	638.683739***	5.43858928***	0.7158127
SNP	1258.587825***	11337.99681***	119.84885***	2.8671428
PG	1.72824821***	15.5673558***	0.1080035***	0.016978
PNP	0.45640982***	12.53551615***	0.234717857**	0.07222857
SD	0.3259375***	3.13530133***	0.10264285***	0.007142857
FD	40.6316571*	5779.9853***	6.008657	12.54129

GCA : general combining ability/*aptitude générale à la combinaison* ; SCA : specific combining ability/*aptitude spécifique à la combinaison* ; RE : reciprocal effect/*effet réciproque* ; SD : stem diameter/*diamètre au collet* ; FNP : pod number per plant/*nombre de gousses par plante* ; PG : pod girth/*grosseur de la gousse* ; SNP : seeds number per pod/*nombre de graines par gousse* ; PL : pod length/*longueur de la gousse* ; PPL : pod peduncle length/*longueur du pédoncule de la gousse* ; HSW : 100 seeds weight/*masse de 100 graines* ; FD : 50 % flowering day/*jour de 50 % de floraison* ; PH : plant height/*taille de la plante*

Table 2 : General combining ability estimates of the 8 parents.

Valeurs de l'Aptitude Générale à la Combinaison des huit parents.

Traits	CGA per genotype								
	C	I	T	1	2	3	4	5	LSD
PH	7.050	19.15	0.14	0.825	4.04	-10.005	-13.50	-7.67	3.72
HSW	-0.095	0.19	0.26	-0.135	-0.03	0.05	-0.285	0.045	0.125
PPL	-0.11	0.035	-0.02	-0.115	0.19	0.06	-0.20	0.19	0.049
PL	-3.57	-0.29	1.94	-1.00	4.53	-1.765	0.265	-0.085	0.41
SNP	-0.23	11.12	2.46	2.9	11.09	-3.93	-11.85	-11.56	0.83
PG	0.55	0.215	-0.04	0.215	-0.01	-0.17	-0.285	-0.495	0.06
PNP	-0.195	0.135	-0.055	-0.195	-0.105	0.115	0.265	0.055	0.132
SD	0.045	0.215	0.155	0.008	0.005	-0.125	-0.175	-0.145	0.041
FD	-0.18	-2.035	0.33	1.19	2.64	-2.21	0.42	-0.145	1.74

SD : stem diameter/*diamètre au collet* ; FNP : pod number per plant/*nombre de gousses par plante* ; PG : pod girth/*grosseur de la gousse* ; SNP : seeds number per pod/*nombre de graines par gousse* ; PL : pod length/*longueur de la gousse* ; PPL : pod peduncle length/*longueur du pédoncule de la gousse* ; HSW : 100 seeds weight/*masse de 100 graines* ; FD : 50 % flowering day/*jour de 50 % de floraison* ; PH : plant height/*taille de la plante* ; C : clemson spineless ; I : Indiana ; T : Rouge de Thiès ; L1 : local variety 1/*variété locale 1* ; L2 : local variety 2/*variété locale 2* ; L3 : local variety 3/*variété locale 3* ; L4 : local variety 4/*variété locale 4* ; L5 : local variety 5/*variété locale 5.*

Specific combining ability (SCA) effects of the F1 hybrids for all characters showed that the hybrid 4 x 5 possesses a positive SCA, for all traits, on the contrary, the CxI combination only had negative values (Table 3). Positive significant effects of the SCA have been observed for nearly all parameters in some hybrid combinations.

Heterosis values for the hybrids evaluated at the 3 sites varied largely from negative to positive. The highest value was recorded for 5 x 4 combination for seeds number per pod parameter with the value of 54.78 %. This combination was followed, respectively, for plant height and stem diameter by the 1 x 3 (40.89 %) and 1 x 4 (34.94 %) hybrids. Eight combinations (1 x 3, 2 x 5, 2 x T, 3 x 5, 5 x 3, 5 x 4, 5 x I and T x I) exhibited heterosis for both important traits needed by breeders, such as : pod girth and pod length (Table 4). All the 3 best combinations were provided from local parents.

Estimates of the reciprocal effects show that they exist for all traits except the 50 % flowering day (Table 5). Among hybrids, the combination 3 x 4 exhibited the higher significant positive reciprocal effects (18.51) for the seed number per pod parameter.

Table 3 : Specific combining ability (SCA) estimates of the F1 hybrids.

Aptitude Spécifique à la Combinaison des hybrides F1.

Crosses	Genotypes								
	SD	FNP	PG	SNP	PL	PPL	HSW	FD	PH
L1x L 2	-0.09	-0.365	-0.33	18.195	1.365	0.08	0.57	-0.27	-0.4950
L1x L 3	0.135	0.325	0.205	16.34	1.735	0.34	-0.555	-0.86	20.42
L1x L 4	0.097	-0.205	0.26	-15.345	-2.715	-0.22	-0.16	-1.215	-3.635
L1x L5	-0.105	-0.015	-0.155	-9.295	-1.06	-0.295	0.285	2.52	-15.465
L1xC	-0.06	-0.605	-0.13	-0.530	0.645	-0.155	0.065	0	-1.675
L1xI	0.1	0.075	-0.145	1.740	0.66	-0.01	0.11	-1.98	1.76
L1xT	-0.02	0.45	-0.385	-6.270	-0.83	-0.08	0.085	0.82	-5.51
L2x L3	0.09	-0.175	-0.15	-5.955	-0.935	-0.005	0.385	-0.2	-13.435
L2x L4	-0.083	-0.245	-0.040	4.895	0.180	0.105	-0.425	0	-8.05
L2x L5	0.19	0.285	0.22	7.6	0.06	0.16	-0.21	-0.655	13.7
L2xC	-0.10	-0.01	-0.125	-1.75	1.235	-0.015	0.065	-1,615	-8
L2xI	0.04	0,175	-0.025	-1.78	1.305	-0.005	0.245	1.01	1.18
L2xT	0.035	-0.155	0.25	-0.175	-0.575	0.17	-0.32	0.645	0.165
L3x L4	-0.153	-0.05	-0.020	0.485	-0.92	-0.1	0.25	-0.925	2.255
L3x L5	-0.365	0.25	-0.045	-2.5	0.7	-0.185	0.15	1.75	-12.98
L3xC	-0.065	0.125	0.025	-2.96	0.455	-0.015	-0.38	0.51	2.030
L3xI	-0.165	-0.08	0.06	-1.505	-1.135	-0.165	-0.39	1.085	0.395
L3xT	-0.105	-0.02	0.03	-3.89	0.15	0	-0.28	-2.11	5.935
L4x L5	0.122	0.5	0.03	17.19	1.95	0.145	0.675	-0.1	7.060
L4xC	0.042	0.155	-0.195	4.225	0.695	0.055	0.135	0.21	3.07
L4xI	0.127	-0.275	0.095	1.02	1.4	0.195	0.115	0.845	-2.03
L4xT	-0.073	-0.155	-0.305	-9.70	0.335	-0.105	-0.005	-0.02	-8.435
L5xC	0.095	-0.505	0.04	3.04	-0.055	-0.035	-0.57	-0.445	5.41
L5xI	-0.04	-0.33	0.06	4.27	-1.25	-0.01	0.26	-0.98	6.845
L5xT	0.14	-0.32	0.025	3.65	1.13	-0.04	-0.205	-2.18	0.52
CxI	-0.035	-0.64	-0.075	-2.17	-0.855	-0.095	-0.075	1.5	-6.665
CxT	0.03	-0.435	0.16	5.685	-1.235	-0.18	0.415	0.8	1.38
IxT	0.025	0.03	0.04	3.70	0.385	-0.1	0.275	-0.12	4.78
LSD	0.11	0.35	0.17	2.22	1.11	0.13	0.33	4.65	8.61

SD : stem diameter/*diamètre au collet* ; FNP : pod number per plant/*nombre de gousses par plante* ; PG : pod girth/*grosseur de la gousse* ; SNP : seeds number per pod/*nombre de graines par gousse* ; PL : pod length/*longueur de la gousse* ; PPL : pod peduncle length/*longueur du pédoncule de la gousse* ; HSW : 100 seeds weight/*masse de 100 graines* ; FD : 50 % flowering day/*jour de 50 % de floraison* ; PH : plant height/*taille de la plante* ; C : clemson spineless ; I : Indiana, T : rouge de Thiès, L1 : local variety 1/*variété locale 1* ; L2 : local variety 2/*variété locale 2* ; L3 : local variety 3/*variété locale 3* ; L4 : local variety 4/*variété locale 4* ; L5 : local variety 5/*variété locale 5* ; LSD : least significant difference/*plus petite différence significative.*

Table 4 : Heterosis (%) estimates of the F1 hybrids.

Evaluation de l'hétérosis (%) des hybrids F1.

Crosses	Traits								
	SD	PNP	PG	SNP	PL	PPL	HSW	PH	FD
L1x L2	8.22	-33.68	-11.08	35.32	17.07	7.27	7.95	-6.93	1.04
L1x L3	4.32	20.27	5.56	30.46	15.37	9.96	-15.11	40.89	-4.66
L1x L4	34.94	-12.99	-2.75	-20.88	-22.15	-11.49	0.39	5.69	-3.95
L1x L5	-18.90	-10.25	-14.84	0.25	-8.79	-25.77	2.05	-45.2	4.61
L1xC	-0.42	-42.29	-13.78	3.8	19.06	-12.83	5.34	-0.39	-1.42
L1xI	14.81	-23.81	-13.66	1.07	1.29	-3.77	5.19	-3.78	-1.99
L1xT	8.37	8.48	-23.15	-11.83	-10.26	-15.15	10.46	-10	0.48
L2x1	-15.07	-19.30	-28.77	53.17	25.09	7.66	25.65	-11.8	-5.41
L2x L3	-35.09	-25.48	-6.43	13.55	7.91	7.3	-4.56	-25.92	-3.23
L2x L4	-16.73	-24.16	-6.84	17.81	16.86	8.78	5.02	-24.05	-1.26
L2x L5	4.20	-24.56	16.45	38.59	8.59	5.34	-0.79	-3	-2.66
L2xC	-7.75	-30.54	-10.32	22.47	23.84	-1.63	15.76	-20.26	-3.06
L2xI	20.97	-9.96	-5.63	27.32	24.42	0.63	21.09	-7.61	2.05
L2xT	2.70	-14.20	6.34	20.57	13.15	18.53	-3.94	2.75	-4.97
L3x L1	-22.77	13.51	-11.39	21.49	5.96	-0.71	-9.67	9.8	-1.75
L3x L2	-25.07	9.89	-8.73	-1.47	-2.99	8.88	8.36	-12	-0.8
L3x L4	-11.31	5.67	9.6	26.74	-1.9	1.15	3.02	6.56	-2.42
L3x L5	-39.59	21.62	1.71	11.63	5.12	-12.52	-10.01	-11.8	2.66
L3xC	-25.77	-16.14	-1.3	13.65	21.7	-9.57	-4.79	13.66	-3.35
L3xI	-21.45	-13.34	10.52	2.79	-11.87	-8.71	-6.59	9.27	4.29
L3xT	-27.39	-3.45	-0.95	-7.74	-1.43	-10.4	-8.08	15.77	-10.63
L4x1	-11.65	-28.25	-7	-11.52	-15.34	-13.41	12.43	-30.06	-4.15
L4x L2	13.17	-19.58	-8.59	27.36	10.59	27.19	-4.11	-14.45	-2.61
L4x L3	-39.88	-4.31	-15.23	-21.79	-2.69	-9.23	0.57	-7.28	-4.74
L4x L5	-10.29	-3.92	-11.4	28.99	5.14	0.87	22.9	-7.55	2.43
L4xC	3.51	-28.41	-11.51	17.37	13.25	-4.59	14.26	3.11	0.2
L4xI	23.90	-24.69	3.72	7.09	25.88	11.48	14.11	5.29	0.96
L4xT	-10.19	-27.53	-15.56	-19.34	8.46	-8.72	12.68	-26.81	-0.69
L5x L1	5.51	-9.02	-9.57	14.5	4.06	-11.18	22.95	9.16	2.6
L5x L2	26.57	23.51	-5.59	44.86	12.97	16.37	5.54	20.32	-1.67
L5x L3	-39.00	13.51	2.86	13.98	7.63	-10.89	7.01	-10.43	2.45
L5x L4	36.63	28.25	10.74	54.78	26.69	4.35	20.61	19.35	-5.09
L5xC	6.44	-40.88	-0.37	28.6	4.55	-13.77	-4.75	-4.55	1.68
L5xI	4.76	-28.42	2.47	27.13	1.46	-12.52	10.39	39.68	-3.4
L5xT	8.60	-20.14	-0.73	19.59	10.28	-7.35	-1.4	19.18	-5.16
Cx L1	-15.48	-53.89	-20.87	10.91	-1.75	-21.05	-2.24	-16.08	1.42
Cx L2	-10.70	-29.53	-15.48	12.3	20.6	4.88	-14.12	-18.02	-2.86
Cx L3	-26.38	-20.66	-5.4	-14.24	-10.47	-8.58	-24.24	-6.91	5.73
Cx L4	0.88	-24.15	-17.99	7.62	10.33	-2.47	-5.81	-14.31	0.2
Cx L5	2.15	-44.55	-3.35	26.25	7.39	-8.02	-14.6	21.69	-1.68
CxI	-12.82	-42.07	-6.02	5.25	-11.14	-9.76	1.62	-13.94	7.6
CxT	3.88	-37.83	-6.18	0.8	-23.2	-13.26	3.57	6.45	1.72
Ix L1	9.26	-12.44	-16.01	23.49	10.53	-14.34	18.36	11.72	-4.74
Ix L2	-8.06	-21.15	-5.28	11.55	12.04	14.95	4.59	0.15	2.25
Ix L3	-39.27	-12.03	-3.09	0.95	3.23	-13.64	-11.43	12.26	1.36
Ix L4	10.24	-32.41	-5.13	9.96	0.66	2.46	13.5	-17.2	2.65
Ix L5	-8.57	-27.19	7	39.1	-3.95	-1.54	17.65	3.42	2.06
IxC	-1.54	-54.02	-13.25	7.36	9.3	-16.38	-0.9	-9.34	2.98
IxT	0.55	-36.08	-10.25	-1.56	1.05	-12.31	7.25	1.83	-6.79
Tx L1	-11.01	-8.48	-28.01	-12.12	-7.09	-10.69	-1.06	-12.12	-3.04
Tx L2	5.02	-28.09	-4.66	0.43	-7.67	0	-2.1	-19.66	1.7
Tx L3	-26.75	-4.98	-2.25	-14.45	0.26	-4	-13.96	8.16	-2.72
Tx L4	0.93	-14.39	-22.57	-16.57	-2.41	-6.67	-3.44	-11.66	-5.25
Tx L5	15.84	-27.92	-0.73	18.55	4.17	-12.06	-0.35	-11.8	-6.77
TxC	-9.71	-47.26	-2.4	16.3	9.14	-19.82	3.24	-11.24	-0.92
TxI	6.01	-6.45	2.98	12.86	2.69	-10.96	12.27	27.79	4.86

SD : stem diameter/*diamètre au collet* ; FNP : pod number per plant/*nombre de gousses par plante* ; PG : pod girth/*grosseur de la gousse* ; SNP : seeds number per pod/*nombre de graines par gousse* ; PL : pod length/*longueur de la gousse* ; PPL : pod peduncle length/*longueur du pédoncule de la gousse* ; HSW : 100 seeds weight/*masse de 100 graines* ; FD : 50 % flowering day/*jour de 50 % de floraison* ; PH : plant height/*taille de la plante* ; C : clemson spineless ; I : Indiana ; T : rouge de Thiès ; L1 : local variety 1/*variété locale 1* ; L2 : local variety 2/*variété locale 2* ; L3 : local variety 3/*variété locale 3* ; L4 : local variety 4 /*variété locale 4* ; L5 : local variety 5/*variété locale 5.*

Table 5 : Estimates of the reciprocal effects.

Evaluation des effets réciproques.

Crosses	Traits								
	SD	PNP	PG	SNP	PL	PPL	HSW	PH	FD
L1x L2	0.17	-26.49	0.355	-6.275	-0.495	-0.005	-0.495	2.665	1.89
L1x L3	0.235	16.89	0.305	3.240	0.745	0.15	-0.17	12.54	-0.78
L1x L4	0.29	-20.62	0.085	-3.335	-0.425	0.025	-0.31	15.83	0.06
L1x L5	-0.155	-9.63	-0.095	-4.905	-1.140	-0.225	-0.56	-22.925	0.56
L1xC	0.090	-48.09	0.130	-2.240	1.220	0.125	0.22	5.89	-0.78
L1xI	0.030	-18.13	0.040	-6.190	-0.645	0.14	-0.33	-5.13	0.73
L1xT	0.11	0.00	0.08	0.09	-0.225	-0.07	0.325	0.80	1.00
L2x L3	-0.47	-7.79	0.035	5.665	0.965	-0.02	-0.425	-6.815	-0.67
L2x L4	-0.21	-21.87	0.03	-3.555	0.45	-0.215	0.25	-5.075	0.39
L2x L5	-0.16	-0.53	0.335	-2.260	-0.430	-0.155	-0.18	-11.85	-0.28
L2xC	0.02	-30.04	0.08	3.37	0.22	-0.09	0.915	-1.035	-0.06
L2xI	0.18	-15.55	-0.005	4.61	0.98	-0.17	0.44	-3.24	-0.06
L2xT	-0.015	-21.14	0.15	6.535	1.670	0.265	-0.055	10.425	-1.95
L3x L4	0.24	0.68	0.375	18.515	0.07	0.135	0.075	5.33	0.62
L3x L5	-0.005	17.57	-0.015	-0.87	-0.29	-0.025	-0.54	-0.5	0.06
L3xC	0.005	-18.40	0.055	9.5	2.75	-0.015	0.66	6.535	-2.33
L3xI	0.135	-12.69	0.165	0.555	-1.46	0.065	0.145	-0.815	0.72
L3xT	-0.005	-4.21	0.015	2.24	-0.165	-0.10	0.195	2.445	-2.11
L4x L5	-0.285	12.16	-0.335	-9.41	-2.13	-0.05	0.06	-10.855	2.06
L4xC	0.015	-26.28	0.1	3.275	0.2	-0.03	0.57	6.22	0.00
L4xI	0.07	-28.55	0.125	-0.85	2.015	0.11	0.015	7.035	-0.44
L4xT	-0.06	-20.96	0.095	-0.91	0.88	-0.03	0.445	-5.46	1.28
L5xC	0.025	-42.72	0.04	0.76	-0.27	-0.095	0.29	-8.815	0.89
L5xI	0.07	-27.80	-0.055	-3.41	0.575	-0.16	-0.185	10.575	-1.39
L5xT	-0.04	-24.03	0	0.33	0.655	0.08	-0.03	10.52	0.45
CxI	-0.055	-48.05	0.09	-0.54	-1.555	0.095	0.07	-1.13	1.17
CxT	0.07	-42.55	-0.045	-4.465	-2.495	0.11	0.01	5.185	0.72
IxT	-0.025	-21.26	-0.14	-3.59	-0.145	-0.02	-0.135	-6.46	-3.06
LSD	0.12	0.39	0.19	2.51	1.25	0.14	0.37	9.74	5.26

SD : stem diameter/*diamètre au collet* ; FNP : pod number per plant/*nombre de gousses par plante* ; PG : pod girth/*grosseur de la gousse* ; SNP : seeds number per pod/*nombre de graines par gousse* ; PL : pod length/*longueur de la gousse* ; PPL : pod peduncle length/*longueur du pédoncule de la gousse* ; HSW : 100 seeds weight/*masse de 100 graines* ; FD : 50 % flowering day/*jour de 50 % de floraison* ; PH : plant height/*taille de la plante* ; LSD : Least Significant Difference/*plus petite différence significative* ; C : Clemson Spineless ; I : Indiana ; T : Rouge de Thiès ; L1 : local variety 1/*variété locale 1* ; L2 : local variety 2/*variété locale 2* ; L3 : local variety 3/*variété locale 3* ; L4 : local variety 4/*variété locale 4* ; L5 : local variety 5/*variété locale 5.*

DISCUSSION

Significant effects in general and specific combining abilities indicate the importance of both additive and non-additive gene action. These results agreed with reports on plant height (Rajani *et al.,* 2001) and on fruit length (Chaudary *et al.,* 1991). Similar results of significance of variances due to general combining ability were also recorded on fruit girth (Rajani *et al.,* 2001 ; Chaudary *et al.,* 1991 and Shivagamasundari *et al., 1*992). These positive results corroborate also those showing that, in okra, the variance of the GCA is meaningful on the first flowering days, the 50 % flowering day and the plant height (Metha *et al.,* 2007).

These results becoming positively widespread for all parameters only confirming the idea that the GCA was in most cases, predominant (Hamon and Charrier, 1997). The significant

values of the GCA recorded by genotype indicate the possibility to have productive hybrids with various others (Bouharmont, 1995). Genotypes presenting a high and positive GCA for plant height trait, such as Clemson Spineless (7.05) and Indiana (19.15) show a negative GCA for fruit length (Table 2). It shows that these traits are correlated negatively, which would entail some difficulties in a process of improvement of the above traits.

The significant effect of SCA indicates changes between the F1 hybrids. Significant results of the SCA have also been reported for seeds number per pod, fruits diameter and length (Hamon and Charrier, 1997) and for the day of 50 % flowering (Hamon and Van Sloten, 1995). The performance of the hybrids indicated by this parameter suggests the possibility of improving these characters in the okra improvement program. The SCA of two populations showed differences in the frequencies of the genes and their divergence as compared to the diallel parents (Viana and Matta, 2003). Ttwo pure lines presented a significant SCA means than the hybrid originated from the combination of these two lines was extremely effective. Therefore, according to Griffing (1956) and Machado *et al.* (2002) these crosses having a high SCA and descents of parents that GCA is also high are efficient in the choice of the most promising hybrid population. It confirms the objective in the analysis of the combining ability because, the analysis of the effects of the GCA leads to the identification of the superior parents (Viana and Matta, 2003). Those parents would finally continue to be self-fertilized to identify by the test of the SCA the pairs of lines which produce the best hybrids (Viana, 2000).

All the three best combinations exhibiting significant heterosis were from local parents. The results show that although these varieties are all local, they remain however genetically distant. Therefore, the heterosis is a special genetic mechanism where by the genotypes of distant origins are brought together in a specific model in order to express their capacity and to change the magnitude of a particular character (Indu *et al.,* 2003). Then, some varieties originated from the same locality can be genetically distant as compared to exotics. A positive heterosis was also observed in diallel crossings for plant height (Fatokun, 1987 ; Poshiva et Shukla, 1986 ; Kumbhani *et al.,* 1993), pod length, stem diameter, pod diameter. A negative heterosis was found for the number of seeds per pod. The values of hybrids were lower than those of the parents (Fatokun, 1987). Similary, for plant height, a heterosis over the best parent of -10.33 % was found (Nimbalkar, 2004).

Reciprocal differences observed for traits studied revealed that maternal effects were significant in the inheritance of these characters. Reciprocal differences were also observed for plant height, single fruit weight and fruit yield per plant (Rajani *et al.,* 2001). The reciprocal differences observed for these traits were probably due to cytoplasmic inheritance.

CONCLUSION

Results of the study show that, combining ability and heterosis were important. Genetic variation for the characters appeared to be influenced predominantly by genes with additive or dominance effects. Seeds per pod is the most heterotic character among the traits studied. Some varieties originated from the same locality were genetically distant, as compared to exotics. Estimates of the reciprocal effects showed no significant difference for the 50 % flowering day implying that the cytoplasmic inheritance did not play any significant role in the expression of this trait. The genetic variability for each of the traits and the importance of both GCA and SCA show that it is possible to improve characters in okra crop. Then hybrids 5 x 4, 2 x 5, 2 x T and 1 x 3 exhibiting good heterosis for both pod girth and pod length can be recommended to breeders.

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