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PERFORMANCE , COMBINING ABILITY AND HETEROSIS OF CANOLA (*Brassica napus,* L.) CROSSES GROWN UNDER SOIL SALINITY CONDITIONS.

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ABSTRACT

The present work was conducted on a half-diallel set of crosses among 6 canola genotypes differed in salt or drought tolerance and seed yield. Field experiments were undertaken in salt affected soil. Significant differences among parents and their hybrids were observed for all studied characters . P_5 and P_6 were of better performance than P_1 and P_2 followed by P_3 and P_4. Eight crosses surpassed their corresponding better parent, in at least one character, due to their different parental genetic constitutions. The best two hybrids combined high seed yield and seed oil content(%) were P_1xP_6 and P_4xP_6. Both GCA and SCA effects were significant for all characters. GCA/SCA ratios indicated that additive component of variation predominated for number of branches and pods/plant, seed index, seed yield /plant and seed protein content(%), while non-additive was more important for plant height and first branch height . Seed oil content(%) seemed to be affected by both types of gene actions. P_5 was the best general combiner , while P_3 appeared to be the worst. Five crosses have shown positive and significant SCA effects for seed yield /plant . (P_2x P_4) hybrid was the best combination where it expressed significant SCA values for almost all characters, P_3 x P_4 ranked as the second follwed by P_4 x P_6 and then P_2 x P_5 and P_1 x P_5. The results revealed that seed oil content (%) behaved oppositely to seed protein content(%) , due to their negative association. Number of hybrids showing heterosis (relative to mid parents) and true heterosis (relative to better parents) were: one (plant height), 6 (1st branch height), 3(no. of branches), 6 (no. of pods), 3(seed index), 4(oil content), 4(protein content) and 12 for seed yield/plant. The highest yielding two hybrids were P_3 x P_4 (103.05 and 52.57%) over their MP and BP, respectively. The obtained results indicated that the crosses P_3 x P_4 (for seed yield, its attributes and seed oil content), P_4 x P_6 and P_1 x P_6 (for both seed yield and oil content), P_2 x P_4 (for seed yield without effect on oil content) and P_1 x P_2, P_2 x P_3, P_2 x P_5 and P_2 x P_6 (for seed yield, its components and seed protein content) could be exploited, directly or indirectly according to their gene action nature.

Key words: ***Canola, Brassica napus, Performance, Diallel crosses, GCA, SCA , Heterosis.***

INTRODUCTION

Canola (*Brassica napus* L.) as oil crop having 40-50% oil and tolerate harsh environments (Weiss 1983) in addition to its success for winter planting in Egypt (Sharaan 1986) can help in reducing local oil defficiency gap, especially if it is cultivated in newly reclaimed lands. However, these lands oftenly suffer from some production constraints such as salinity. So, great efforts must be paid to breed high yielding and salt tolerant canola genotypes.

The precise knowledge about the nature and magnitude of gene effects of different metric characters, are valuable for the breeder in formulating an efficient improvement program. Combining ability analysis, proposed by Griffing (1956), for parental diallel enables the breeder to exploite the elevate type of gene action in his pursue breeding program. The relative magnitudes of general (GCA) and specific (SCA) combining ability are of great importance since they dictate the proper breeding program that should be followed for improvement of the genetic material used.

Recently, employment of heterosis, in self pollinated crops, becomes one of the important developmental components in plant improvement. Several studies have suggested that canola is a crop with high heterotic advantage (Grant and Beversdorf 1985, Banga and Gurjeet 1994, Ali *et al* 1995 and Thakur and Sagwal 1997). Heterosis as a biological phenomenon may be raised from genetic heterozygosity, allelic and nonallelic interaction, gene epistasis, dominance and over dominance. Heterosis is important in identifying the promising crosses for further use in breeding programs.

The present work was undertaken to study the heterotic performance of F_1. hybrids and to estimate GCA and SCA and their relative magnitude involved in the variation of different quantitative characters of a diallel set of crosses among 6 canola parents, grown in saline soil.

MATERIALS AND METHODS

Six parental canola genotypes, selected from previous studies (Ghallab and Sharaan 2002 and Ghallab 2002), were crossed in all possible combinations, excluding reciprocals, during 2002/2003 winter seasons at the Experimental "Demo" Farm of the Faculty of Agriculture at Fayoum to obtain F_1 seeds. These selected parental stocks were different in their yielding ability; three of them were salt tolerant i.e. P_1 {BPSF (C.6) L31 (Egypt)}, P_2 {Canola 104 x Hanna (Egypt)} and P_4{Semu DNL206/84 x Lirasol} while the remaining three were drought tolerant i.e., P_3 {Silva variety (Germany)}, P_5 {BPSF(C.7) L13 (Egypt)} and P_6 {BPSF (C.7) L16 (Egypt)}.

In the second growing seasons (2003/2004), the parents and their fifteen hybrids were sown in salt affected soil using a randomized complete block design with three replications. The soil of 0-60 cm depth in the experimental site was characterized by high salt (ECe 13.6 dS/m) and mildly alkaline (pH 8.5) with loamy sandy texture. Each entry was planted in 2 rows plot (4 m long and 50 cm apart) with three seeds/hill spaced at 10 cm within the row. Plants were thinned one month after emergence to two plants/hill. All recommended cultural practices for growing the crop were adopted throughout the season. At maturity, data of eight characters (i.e., plant height, height to first branch, number of branches, number of pods, seed yield and seed index) were recorded as average of ten individual guarded plants randomly chosen from each entry in each plot. Seed oil and protein content percentages were measured on plot basis using NMR apparatus (Grunland and Zimmerman 1975).

The data were subjected to analysis of variance and the means were compared by LSD test (Gomez and Gomez 1984). Partioning the genetic variance into general (GCA) and specific (SCA) combining ability as well as GCA/SCA effects were estimated as illustrated by Griffing (1956) Method 2, Model 1 (fixed model). For each cross, comparisons among F_1 with both mid-parent (MP) and better parent (BP) were made to compute heterosis and true heterosis using the following formula; $\left((\overline{F}_1 - \overline{MP}) / \overline{MP}\right) x100$ and $\left((\overline{F}_1 - \overline{BP}) / \overline{BP}\right) x100$, respectively. A test of significance for the $\overline{F}_1$ from $\overline{MP}$ and $\overline{BP}$ means was calculated by the appropriate "t" value as suggested by Bhatt (1971).

RESULTS AND DISCUSSION

Mean performance

Character means listed in Table (1) revealed significant differences among the tested genotypes for all studied characters. This was expected where the used parents, as selections, were already different from each other and consequently their hybrids varied genetically and phenotypically. In addition, all these genotypes, grown in salt affected soil, responded differently to the available edaphic conditions depending on the extent of the genetic-environment interaction of each. In this concern, Pal *et al* (1984) suggested that canola varieties as well as breeding genotypes oftenly differ in their response to salt stress. This may be due to the effect of salinity on the absorption feature of plant root which could be reflected on the behaviour of physiological and metabolic activities (Afiah 2000) which are genetically controlled somehow in each genotype.

Table 1. Average of different canola characters for six parents and their 15 single crosses.

Parents & hybrids	Plant height cm	Height 1st branch	No. of branches	No. of pods /plant	Seed yield /plant, g	Seed index, g	Oil percentage	Protein percentage
P_1	115.36	41.54	3.20	86.20	6.83	2.04	43.46	22.96
P_2	114.65	46.39	3.33	83.16	6.98	1.99	43.86	24.23
P_3	119.10	66.61	2.20	49.28	5.70	1.92	43.71	26.67
P_4	109.72	52.68	2.36	44.95	3.51	1.94	42.95	22.68
P_5	119.10	49.12	3.76	113.29	8.99	1.78	44.37	24.23
P_6	117.22	55.76	3.36	104.17	9.13	1.89	44.42	24.09
$P_1 \times P_2$	114.69	52.23	3.34	130.89	9.79	2.02	42.90	24.00
$P_1 \times P_3$	117.02	55.48	2.69	111.72	7.65	2.02	43.15	24.42
$P_1 \times P_4$	109.27	49.77	2.49	103.06	8.77	2.02	42.79	24.79
$P_1 \times P_5$	117.16	46.74	3.03	99.20	10.41	2.03	44.07	21.47
$P_1 \times P_6$	111.81	48.32	2.98	70.66	10.25	2.03	44.98	22.63
$P_2 \times P_3$	109.27	33.63	3.24	91.45	8.05	2.03	41.67	24.70
$P_2 \times P_4$	126.59	32.15	3.36	104.93	10.64	1.70	43.05	25.88
$P_2 \times P_5$	124.72	56.48	3.03	77.74	11.17	2.03	43.35	25.46
$P_2 \times P_6$	120.23	53.78	2.83	77.63	9.40	1.67	43.76	24.37
$P_3 \times P_4$	126.38	51.69	2.45	87.67	8.76	1.68	44.78	23.81
$P_3 \times P_5$	117.89	47.94	2.39	86.99	8.12	1.70	43.20	23.11
$P_3 \times P_6$	108.69	51.88	2.17	83.63	8.55	1.66	40.86	21.36
$P_4 \times P_5$	122.01	58.64	2.35	84.12	6.84	1.68	45.03	22.53
$P_4 \times P_6$	123.00	43.07	2.97	78.54	10.00	1.68	44.63	24.32
$P_5 \times P_6$	117.03	54.87	2.85	128.08	9.15	2.23	44.22	23.05
$LSD_{0.05}$	6.28	14.70	0.34	27.10	2.29	0.16	1.49	1.46

Among parents, P_3 was the best for plant height and seed protein content (%) whereas, it had the lowest 1st branch height and number of branches and lightest seed yield/plant. P_4 yielded similar to that of P_3, but it was the worst parent for number of pods and seed protein content (%). P_5 possessed tallest plants similar to that of P_3 and had greatest number of branches and heaviest seed yield/plant. P_6 gave the highest seed yield/ plant although it had low seed index similar to that of P_5. On the other hand, P_1 and P_2 failed to exhibit any advantage and showed moderate character means.

Among F_1 hybrids; 2, 1, 1, 1, 1 and 2 cross means surpassed the corresponding better parent for plant height ($P_2 \times P_4$ and $P_3 \times P_4$), height to 1st branch ($P_2 \times P_4$), number of pods ($P_1 \times P_2$), seed yield/plant ($P_2 \times P_5$), seed index ($P_5 \times P_6$) and seed protein content percentage ($P_1 \times P_4$ and $P_2 \times P_4$). Whereas, none of crosses surpassed their better parent for number of branches and seed oil content (%). Superiority of these hybrids may be attributed to the different parental genetic constitutions. Most cases resulted from crossing two parents of middle averages (1st branch height, number of pods, seed yield/plant and partially seed protein content percentage) and then their advantage may be due to complementary and / or interacting gene actions. While few cases were resulted from low x middle (plant height) or low x hight parental averages (seed protein content) which may be ascribed to heterozygosity. It is worth to note that seed yield superiority depended not only on the parental yield averages but also on the parental interacting yield components. These results indicated that accurate selection of parental performance could yield gained improved hybrids. Connecting with this, Agrawal and Badwal (1998) and Katiyar *et al* 2000) suggested the possibility of production of successful commercial hybrids in this crop by judicious choice of parents. The above results revealed that the best two hybrids combined high seed yield and oil content (%) were P_1 x P_6 and P_4 x P_6 and one hybrid (P_2 x P_5) for the former two characters in addition to protein content(%).

Analysis of varianccs

As shown in Table (2) both general (GCA) and specific (SCA) combining ability were significant for all studied characters indicating the importance of additive and non-additive components of their genetic variation. In such situation, the suitable breeding procedure for improving seed yield and its attributes would be the one which elevate the genetic plateau, by accumulating the favourable additive genes and simultaneously maintaining heterozygosity. These results are in full agreement with those reported by Thakur and Sagwal (1997), El-Hosary *et al* (1999) and Sharief *et al* (2002) as well as by Hammad (1998) except SCA for plant height and Abo-Ghazala (2001) except GCA for seed index.

Table 2. Mean squares for different characters of the 6x6 diallel crosses of canola.

Source of variation	d.f.	Mean squares							
		Plant height (cm)	Height 1st branch	No. of branches	No. of pods /plant	Seed yield /plant (g)	Seed index (g)	Oil percentage	Protein percentage
Genotypes	20	90.347**	187.[illegible]9**	0.614**	1419.29**	9.907**	0.090**	3.286**	5.376**
GCA	5	18.993**	51.166**	0.459**	520.887**	4.308**	0.037**	1.038**	2.017**
SCA	15	33.823**	66.273**	0.120**	457.165**	2.967**	0.028**	1.115**	1.717**
Error	40	4.824	26.440	0.014	89.930	0.641	0.003	0.273	0.259
GCA/SCA	-	0.56	0.77	3.83	1.14	1.45	1.33	0.93	1.17

***and** ; significant at 5% & 1% probability, respectively.**

As detected by GCA/SCA ratio, the magnitude of GCA values were larger than the corresponding SCA ones for seed yield/plant and some of its components, i.e. numbers of branches and pods and seed index, in addition to seed protein (%), indicating that additive and additive x additive gene action types played a major role in the inheritance of these characters and then, could be improved by selection procedures. This result supports those reached by El-Hosary *et al* (1999) and Abo-Ghazala (2001). However, dominance and dominance x dominance gene actions predominated for plant height and 1^{st} branch height. Seed oil content percentage, which exhibited GCA/SCA ratio closely near to one, appeared to be controlled by approximately equal effect of both additive and non-additive types of gene actions. These findings could be taken as evidence for the possibility to additionally improve these genetic materials by further selection.

Combining ability

From the data listed in Table (3), it is evident that the P_5 parent, which exhibited good performance, was the best general combiner where it showed positive and significant GCA values for five characters, i.e., plant height, number of branches and pods /plant, seed yield/plant and seed oil content (%) but showed negative value for seed protein content(%). P_1 ranked as the second best general combiner, where it showed positive and significant GCA values for number of branches and pods/ plant and seed index, while it had negative values for plant height and seed protein content (%). The third good general combiner was P_2 which exhibited valuable GCA effects on height to 1^{st} branch, number of branches/plant and seed protein content (%), while showed insignificant negative value for seed oil content (%), followed by P_6 which had significant positve value for only seed yield, whereas P_3 and P_4 were bad general combiners for most characters. These findings, together with the parental performance presented in Table (1), indicated that the parental seed yield/plant was associated mainly with number of branches and pods as well as height to 1^{st} branch and partially with seed index as shown by P_1. These results are in harmony with those reported by Khahra and Singh (1988), Kandil *et al* (1996) and Pandey and Zehr (1999). The results suggest that primary assessment of GCA effect for plant yield and its attributes has considerable importance in selecting parents for yield improvement.

Specific combining ability (SCA) effects estimated for the studied characters varied from one cross to another with either positive or negative values (Table 3). Five crosses have shown the highest positive and significant SCA effects for seed yield/plant, revealing the existence of sufficient amount of variance due to non-additive gene action, and indicating the possibility of using them in developing hybrid varieties if hybrids became feasible.

Table 3. Estimates of general and specific combining abilities for different canola characters for six parents and their 15 single crosses.

Parents & hybrids	Plant height cm	Height 1st branch	No. of branches	No. of pods /plant	Seed yield /plant g	Seed index g	Oil percentage	Protein percentage
P_1	-2.45**	-1.75	0.10**	6.94*	0.12	0.12**	-0.03	-0.46**
P_2	0.56	-3.57*	0.29**	2.06	0.43	0.02	-0.33	0.74**
P_3	-0.36	3.03	-0.35**	-9.05*	-0.88**	-0.04*	-0.50**	0.48**
P_4	0.80	-1.12	-0.22**	-10.53**	-0.94**	-0.08**	0.14	-0.03
P_5	2.09**	1.66	0.13**	8.78*	0.51*	0.00	0.44*	-0.35*
P_6	-0.64	1.73	0.05	1.80	0.76**	-0.03*	0.28	-0.38*
$P_1 \times P_2$	-0.61	7.60*	0.08	31.54**	0.73	-0.02	-0.33	-0.13
$P_1 \times P_3$	2.65	4.25	0.06	23.49**	-0.10	0.05	0.10	0.56
$P_1 \times P_4$	-6.27**	2.69	-0.27**	16.31*	1.08	0.09*	-0.89*	1.44**
$P_1 \times P_5$	0.34	-3.12	-0.07	-6.86	1.27*	0.02	0.08	-1.56**
$P_1 \times P_6$	-2.28	-1.60	-0.04	-28.43**	0.87	0.04	1.16**	-0.38
$P_2 \times P_3$	-8.12**	-15.77**	0.43**	8.09	-0.01	0.16**	-1.08**	-0.37
$P_2 \times P_4$	8.05**	-13.11**	0.41**	23.05**	2.65**	-0.14**	-0.34	1.32**
$P_2 \times P_5$	4.88**	8.45*	-0.27**	-23.46**	1.72**	-0.10*	-0.34	1.22**
$P_2 \times P_6$	3.12	5.67	-0.38**	-16.59*	-0.30	-0.08*	0.23	0.16
$P_3 \times P_4$	8.75**	-0.17	0.14	16.90*	2.07**	-0.10*	1.56**	-0.48
$P_3 \times P_5$	-1.03	-6.70	-0.26**	-3.09	-0.03	-0.08*	-0.33	-0.86*
$P_3 \times P_6$	-7.50**	-2.82	-0.41**	0.53	0.16	0.00	-2.50**	-2.58**
$P_4 \times P_5$	1.94	8.15*	-0.43**	-4.49	-1.24*	-0.14**	0.87*	-0.93*
$P_4 \times P_6$	5.65**	-7.49*	0.27**	-3.08	1.68**	0.00	0.63	0.88*
$P_5 \times P_6$	-1.61	1.54	-0.21*	27.14**	-0.63	0.37**	-0.08	-0.06
S.E. (g_i)	0.709	1.660	0.039	3.06	0.26	0.018	0.169	0.164
S.E. (S_{ij})	1.608	3.764	0.088	6.94	0.59	0.041	0.382	0.373
S.E. ($g_i - g_j$)	1.098	2.571	0.060	4.74	0.40	0.028	0.261	0.255
S.E ($S_{ij}-S_{ik}$)	2.196	5.142	0.120	9.48	0.80	0.056	0.522	0.509
S.E ($S_{ij}-S_{kl}$)	2.906	6.802	0.159	12.55	1.06	0.075	0.691	0.674

***and** ; significant at 5% & 1% probability, respectively**

Another possibility is to select transgressive segregants in subsequent generations where the non-additive genes involved in these crosses would give wider trangressive segregation. Among these five hybrids, (P_2 x P_4) hybrid seemed to be the unique combination. Where it showed positive and significant SCA effects for all the studied characters except height to the 1st branch and seed oil content (%). The second top hybrid was (P_3 x P_4) which exhibited positive and significant SCA values for plant height, number of pods/plant and seed oil content (%) although it showed negative values for seed index and seed protein content (%). (P_4 x P_6) hybrid ranked as third best combination for plant height, 1st branch height, number of branches and seed protein content (%), while it gave negative effect for number of pods/plant. It is worth to note that the cross (P_4 x P_6) involved low and high general combiners and hence its superiority in seed yield may be attributed to heterotic effect resulted from both non-additive in the former parent and additive effect in the latter one. Sheikh and Singh (1998) found that the majority of crosses showing high SCA effects for seed yield involved high x low GCA parents. Whereas, (P_3 x P_4) though involved low GCA parents, it had high SCA for seed yield due to the complementary epistatic gene effects. The other two promising hybrids, i.e. (P_2 x P_5) and (P_1 x P_5) which both share a good general combiner parent (P_5), reflected in high SCA for seed yield/plant due mainly to additive action and additive x additive interaction effects. The GCA and SCA results revealed that seed oil content (%) behaved oppositely to seed protein content (%) and this may be attributed to the negative association between both characters as detected early by Hu-Zi (1988).

Heterosis

As shown in Table (4), only one hybrid (P_2 x P_4) surpassed both MP (12.85) and BP (10.42%) for plant height. Superiority of this hybrid may be ascribed to hybrid vigour resulted from crossing between the shortest (P_4) and tallest (P_2) parents. Five F_1 hybrids gave plant height insignificantly exceeded their MP and BP due to their positive and significant SCA. These resultes are in line with those reported by Schuler *et al* (1992) and Abo Ghazala (2001) who recorded similar heterosis for this character. The rest of the hybrids were shorter than their MP values.

Concerning height to the first branch, four hybrids, i.e., (P_2 x P_3), (P_2 x P_4), (P_4 x P_6) and (P_3 x P_5) showed clear improvement for this character where the first branch of each was located at lower height than those of the corresponding ones of MP (- 13.34 to – 40.47) and BP (-2.40 to- 30.69%). These hybrids, which showed negative SCA values, can be utilize as a base population for improving this character by selection in subsequent generations, especially (P_2 x P_4) cross which showed the tallest plant and consequently had increased fruiting zone length.

In regard to number of branches/ plant, (P_3 x P_4) and (P_2 x P_4) followed by (P_1 x P_2) hybrids exhibited positive and significant heterosis (2.49 to 17.98) and true heterosis (0.75 to 3.45%) while (P_4 x P_6) hybrid surpassed the MP only heterosis. Similar findings were previously detected by Hammad (1998), Ali *et al* (2000) and Abo EL-Wafa *et al* (2004). While, Thakur and Sagwal (1997) recorded a wide range of heterosis (- 26.0 to 193.6%) in 36 F_1 crosses. However, the other hybrids were inferior to either MP on BP due to their negative SCA estimates and may be the genes, controlling this character in the parents, acted in different directions.

Table 4. Heterosis for studied characters as percentage of mid and better parent.

Hybrids	Plant height (cm)		Height 1st branch		No. of branches		No. of pods /plant		Seed yield /plant gm		Seed index gm		Oil percentage		Protein percentage	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
$P_1 \times P_2$	-0.27	-0.58	18.80*	25.72*	2.49**	0.57*	54.56*	51.84*	41.78**	40.30**	0.19**	-1.12**	-1.75*	-2.20	5.18**	4.53*
$P_1 \times P_3$	-0.17	-1.74	2.59	33.54*	-0.46**	-16.08**	64.92*	29.60*	22.04**	11.98**	1.91**	-1.25**	-0.99*	-1.28*	3.51*	0.80
$P_1 \times P_4$	-2.91	-5.28	5.64*	19.79*	-10.67**	-22.36**	57.53*	19.84*	69.59**	28.34**	1.48**	-1.08**	-0.94*	-1.52**	-0.09	-7.04**
$P_1 \times P_5$	-0.05	-1.62	3.10	12.50*	-12.86**	-19.33**	-0.55	-12.44	31.60**	15.79**	6.25**	-0.60**	0.35	-0.69	-9.01**	-11.40**
$P_1 \times P_6$	-3.85	-4.61	-0.67	16.32*	-9.07**	-11.20**	-25.77	-32.17	28.42**	12.24**	3.19**	-0.77**	2.37*	1.26	-3.78**	-6.04**
$P_2 \times P_3$	-6.51	-8.25	-40.47*	-27.49*	17.47**	-2.47**	38.11*	9.97	26.94**	15.36**	3.99**	2.07**	-4.82*	-4.99*	5.31**	1.94*
$P_2 \times P_4$	12.85*	10.42*	-35.09*	-30.69*	17.98**	0.91*	63.82*	26.18	103.05**	52.57**	-13.36**	-14.45**	-0.82	-1.86	4.88**	-2.97*
$P_2 \times P_5$	6.71	4.72	18.29*	21.77*	-14.49**	-19.43**	-20.86	-31.38	39.97**	24.29**	7.75**	2.06**	-1.73*	-2.29*	8.54**	5.07*
$P_2 \times P_6$	3.71	2.57	5.30	15.94*	-15.23**	-15.64**	-17.12	-25.48	16.67**	2.90**	-13.86**	-16.09**	-0.86	-1.49*	4.22**	1.16*
$P_3 \times P_4$	10.47	6.12	-13.34	-22.40*	7.24**	3.45**	86.08*	77.91*	90.26**	53.63**	-12.96**	-13.48**	3.35*	2.44**	-6.43**	-10.71**
$P_3 \times P_5$	-1.01	-1.01	-17.15*	-2.40*	-19.68**	-36.38**	7.01	-23.22	10.46**	-9.73**	-8.05**	-11.32**	-1.91	-2.64	-4.63**	-4.63*
$P_3 \times P_6$	-8.01	-8.74	-15.21	-6.95*	-21.94**	-35.44**	9.00	-19.72	15.23**	-6.39**	-12.74**	-13.43**	-7.27*	-8.02*	-11.56**	-11.82**
$P_4 \times P_5$	6.65	2.45	15.21*	19.38*	-23.30**	-37.54**	6.31	-25.75	9.47**	-23.91**	-9.93**	-13.64**	3.15*	1.49	-11.46**	-15.50**
$P_4 \times P_6$	8.40	4.93	-20.57*	-18.24*	3.96**	-11.44**	5.34	-24.60	58.23**	9.50**	-12.29**	-13.50**	2.15*	0.46	-4.18*	-8.82**
$P_5 \times P_6$	-0.95	-1.74	4.64	11.72*	-20.03	-24.30**	17.79	13.05	0.94	0.16	21.65**	18.21**	-0.40	-0.46	-4.58**	-4.86**

***and** ; significant at 5% & 1% probability, respectively.**

The six F_1 crosses; (P_3 x P_4), (P_1 x P_2), (P_1 x P_3), (P_2 x P_4) and (P_1 x P_4) followed by (P_5 x P_6) exhibited positive and significant heterosis for number of pods/ plant relative to their MP (17.79 to 86.60) and BP (13.05 to 77.91%) due to that P_1, P_2 and P_4 were good general combiners for this trait. It was noticed that almost all of these hybrids possessed positive and significant SCA values and may be the dominance and epistatic effects acted together in favour of high number of pods. Only one hybrid (P_2 x P_3) showed heterosis effect, while the other crosses failed to show aany heterosis. Tyagi *et al* (2000) and Ali *et al* (2000) found similar heterosis values for number of pods in almost all crosses studied by them, whereas Sharief *et al* (2002) and Abo El-Wafa (2004) reported that only one cross exceeded its MP for this character.

Regarding seed index, only three F_1 hybrids, viz., (P_5 x P_6) and (P_2 x P_3) followed by (P_2 x P_5) showed heavier seed weight than corresponding MP (3.99 to 21. 65%) and BP (2.07 to 18.21 %). These results support those detected by Tyagi *et al* (2000) and Abo Ghazala (2001). It is worth to note that all five hybrids included P_1 parent showed seed weights significantly heavier than their MP(Table 4). This may be due to the higher seed index of this parent (2.04g, Table 1), in addition to its significant GCA, while its hybrids possessed insignificant SCA, reflecting that additive effect was predominated in the inheritance of this character in these five crosses.

For seed oil content percentage, (P_3 x P_4), (P_4 x P_5) and (P_1 x P_6) followed by (P_4 x P_6) hybrids had positive and significant heterotic effect over their corresponding MP (2.15 to 3.35%) and BP (0.46 to 2.44%). It was observed that these four hybrids showed negative SCA estimates and most of their involved parents had negative GCA values and therefore, the main genetical effect was due to complementary epistatic effect. These results are in agreement with those of Ali *et al* (2000) and Abo-Ghazala (2001). Whereas, Hari *et al* (1995) and Sharief *et al* (2002) found heterosis in only one cross. The other eleven crosses did not exceed their MP and BP values.

Four F_1 hybrids, i.e., (P_2 x P_5), (P_1 x P_2) and (P_2 x P_3) followed by (P_2 x P_6) were superior to their MP (4.22 to 8.54%) and BP (1.16 to 5.07 %) for seed protein percentage. These results confirmed that P_2 was good combiner for this character. (P_1 x P_3) and (P_2 x P_4) crosses showed positive and significant heterosis. The rest of the hybrids failed to exceed their MP and BP values.

All the tested hybrids exhibited considerable improvement for seed yield/plant over their both MP and BP, except three ones (P_3 x P_5, P_3 x P_6 and P_4 x P_5) which surpassed only their MP. The highest yielding two hybrids were P_3 x P_4 (90.26 and 53.63%) and P_2 xP_4 (103.05 and 52.57%) over their MP and BP, respectively. Superiority of these two hybrids was attributed to their advantages in low position of the first branch as well as increased numbers of branches and pods, irrespective seed index. Three other hybrids surpassed their corresponding MP and BP were P_1 x P_2 (41.78 and 40.30%), P_1 x P_4 (69.59 and 28.34%) and P_2 x P_5 (39.97 and 24.29%) due to their advantages in numbers of branches and pods, number of branches, and seed index, respectively. The remainder six hybrids showed sizable vigourity over their MP (16.67 to 58.23%) and BP (2.90 to 15.79%). Varied heterotic effects for seed yield/plant, due to varied genetic materials and environments, were found by various authors over either MP, i.e., 18.0 % (Schuler *et al* 1992) and 7.37 % (Hammad 1998) or BP, i.e., 43.0 % (Sernyle and Stefansson 1983), 82.13 % (Verma *et al* 1989), 0.37 % (Hammad 1998) and 65.30 % (Katiyar *et al* 2000).

The forementioned discussion revealed that the crosses P_3 x P_4 (for seed yield and its components as well as seed oil content %); P_4 x P_6 and P_1 x P_6 (for both seed yield and oil content); P_2 x P_4 (for seed yield without effect on seed oil content) and P_1 x P_2, P_2 x P_3, P_2 x P_5 and P_2 x P_6 (for seed yield and its attributes and seed protein content %) could be utilized as improved hybrids when hybrid varieties became feasible. The other valuable usage of these crosses is subjected them as a base populations for further improvement program by proper selection methods.

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أداء التراكيب الوراثية والقدرة علي التآلف و قوة الهجين في الكانولا النامية تحت ظروف الأراضى الملحية

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اجري تهجين متبادل بين ستة تراكيب وراثية (منتخبة من دراسة سابقة) ومختلفة في تحملها للملوحة والجفاف ومحصول البذرة وذلك من أجل دراسة آدائها والقدرة عي التآلف وقوة الهجين في الجيل الاول علي امل الحصول علي تواليف او هجن متفوقة تحت ظروف الاجهاد الملحي . ونفذت التجارب في مزرعة كلية الزراعة بالفيوم خلال موسمي ٢٠٠٢/٢٠٠٣ لحصول علي البذرة الهجين ، ٢٠٠٣/٢٠٠٤ لتقييم الآباء والهجن.

واوضحت النتائج ان هناك اختلافات معنوية بين الاباء والهجن فاتجة منها لكل الصفات المدروسة ، وكان P_5 ، P_6 أفضل الاباء مظهرا مقارنة بالابوين الاول والثاني متبوعا بالابوين الثالث والرابع، وايضا تفوقت ثمانية هجن علي افضل الآباء (علي الاقل في صفة واحدة) وربما يرجع تفوقها الي اختلافات الاباء في التركيب الوراثي. وكان الهجينين P_1xP_6 , P_4 x P_6 الافضل في المحصول ونسبة الزيت.

وأظهرت قيم القدرة العامه والخاصة علي التآلف علي وجود معنوية لكل الصفات المدروسة كما اشارت النسبة بينهما علي ان التأثير الاضافي للجينات هو التأثير السائد لصفات عدد الافرع وعدد القرون /نبات ودليل البذرة ومحصول النبات الفردي ونسبة البروتين ، بينما كان التأثير غير الاضافي للجينات هو الاهم لصفة طول النبات، وارتفاع اول فرع في حين ان صفة نسبة الزيت يبدو انها تأثرت بكلا التأثيرين من الفعل الجيني. كان الاب P_5 الافضل في القدرة العامة علي التآلف بينما كان الاب P_3 هو الاسوأ ، واظهرت خمسة هجن تأثيرا موجبا ومعنويا للقدرة الخاصة علي التآلف لصفة محصول النبات وكان الهجين P_2x P_4 الافضل وبصورة معنوية في معظم الصفات المدروسة ، بينما الهجين P_3x P_4 يأتي في المرتبة الثانية يلية الهجن P_4xP_6, P_2 x P_5, P_1x P_5 .كما دلت النتائج ايضا علي ان صفة نسبة الزيت لها سلوك معاكس لنسبة البروتين في القدرة علي التآلف وربما يرجع ذلك للارتباط السالب بينهما.

وبالنسبة لقوة الهجين (بالنسبة لمتوسط الأباء) وقوة الهجين الحقيقية (بالنسبة لأفضل الآباء) كان هناك عدد مختلف من الهجن المتميزه في الصفات المختلفة حيث كان هجين واحد في صفة طول النبات و ٣هجن في عدد الافرع/نبات و٦ هجن لعدد القرون/نبات و٣ هجن لدليل البذرة و ٤هجن لنسبة الزيت و٤هجن لنسبة البروتين و١٢هجين لمحصول النبات. وقد اعطي الهجين P_3x P_4 اعلي القيم لقوة الهجين (١٠٣,٠٥ و ٥٢,٥٧%) لصفة محصول النبات وذلك بالنسبة لمتوسط الابوين والاب الافضل علي التوالي؛ وكان هذا الهجين مميزا لصفتي محصول النبات ومكوناتة ونسبة الزيت ، والهجينين

$P_4 \times P_6$, $P_1 x P_6$ لصفتي محصول النبات ونسبة الزيت، $P_2 x P_4$ لصفه محصول النبات بدون تـــأثير علي نسبة الزيت، والهجن $P_1 x P_2$ و $P_2 x P_3$ و$P_2 x P_5$ $P_4 x P_6$ لصفه محصول النبات ومكوناتــة ونسبة البروتين. وهذة الهجن يمكن استغلاها مباشرة أو بطريق غير مباشر في تحسين هذا المحصـــول وذلك طبقا لطبيعة الفعل الجيني بها.