RESULTS AND DISCUSSION

The present study was carried out to investigate the heterosis and the type of gene action for some growth and yield characteristics as well as the fatty acids composition of some rapeseed varieties and their crosses. To achieve this target, half-diallel of (F_1 and F_2 crosses) were studied in two different planting dates.

For better representation and discussion of the results obtained, it was prefered to outline these results into two parts; i.e. growth and yield characteristics, and seed oil content and fatty acids.

I. Growth and yield characteristics:

A. Analysis of variance, means, heterosis and inbreeding depression:

a. F_1-generation:

The analysis of variance for each of the two planting dates as well as the combined data for; plant height, height of first siliquae, number of racemes/plant, number of siliquas/branch, number of seeds/siliquae, 1000-seed weight and seed yield/plant, is presented in Table (6).

Results indicated that planting date mean squares were highly significant for all of the studied traits indicating an overall differences between the early and late plantings.

Table (6): Observed mean squares from ordinary analysis for growth and yield characteristics in both planting dates as well as the combined analysis in the F_1-generation.

Source of variation	D.F.			Plant height (cm)			Height of 1st siliquae (cm)			No. of racemes/plant			No. of siliquas/branch			No. of seeds/siliquae			1000-seed weight (g)			Seed yield/plant (g)		
	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
Planting dates (D)			1			2487.3**			1.20**			74.19**			775.56**			79.57**			0.27**			208.9**
Replications	2	1	3	378.7**	79.0	278.8*	0.21	0.05	0.15	0.11	0.75	0.32	3.76	7.54	5.02	0.64	0.09	0.46	0.05	0.0003	0.03	5.23	9.33	6.6
Genotypes (G)	20	20	20	285.4**	47.1	165.9**	0.69**	0.12	0.36**	9.13**	3.12**	11.69**	40.67**	17.27**	48.12**	4.08**	4.49	7.42**	0.04**	0.04**	0.06**	76.20**	30.35**	102.5**
Parents (P)	5	5	5	107.9	30.3	52.2	0.31**	0.03	0.19*	4.80**	1.39**	5.92**	55.26**	14.84**	50.92**	9.15**	8.31	16.33**	0.05**	0.06**	0.09**	4.39	1.49	4.8
Crosses (C)	14	14	14	211.1**	51.9	147.8*	0.29**	0.15	0.19*	2.68**	0.98**	3.23**	36.77**	17.54**	47.20**	0.87	3.20	3.02	0.02**	0.04**	0.04**	18.37**	6.03	20.6**
P vs. C	1	1	1	2214.3**	63.3	986.9**	8.24**	0.24	3.58**	121.09**	41.74**	159.00**	22.29**	25.60*	47.02**	23.63**	3.44	24.40**	0.20**	0.005	0.15**	1244.90**	515.30**	1737.0**
G x D			20			166.6**			0.46**			0.56**			9.82**			1.14			0.03**			4.0
P x D			5			86.0			0.16			0.27			19.18**			1.12			0.03**			1.1
C x D			14			115.1			0.25**			0.43*			7.11*			1.05			0.02**			3.7
P vs. C x D			1			1290.7**			4.90**			3.83**			0.87			2.67			0.05**			22.4*
Error	40	20	60	56.3	85.8	66.1	0.06	0.14	0.08	0.22	0.22	0.22	3.11	3.49	3.24	1.66	2.96	2.11	0.006	0.004	0.005	3.98	6.97	5.0

D_1 and D_2 : Early and late planting dates, respectively.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

Except for height of first siliquae, mean values of early planting for all characters were higher than those of late planting (Table 7). This result may be due to the prevailing of favourable temperature and day length leading to greater vegetative growth, yield and its components of rape-seed plant. Similar results were found by Singh (1973) and Degenhardt and Kondra (1981).

Highly significant genotypes mean squares were detected for all of the studied characters in the two planting dates as well as the combined analysis except, plant height, height of first siliquae and number of seeds/siliquae in late planting (Table 6). Meanwhile, highly significant genotype x planting date interaction mean squares were obtained for all the studied traits except, number of seeds/siliquae and seed yield/plant. Such results indicated that the performance of genotypes differed from planting date to another. On the contrary, for the exceptional cases which showed insignificant genotype by planting date interaction, it revealed that the genotypes responded in a similar manner to the environmental differences.

Results also showed that mean squares due to parents were significant in all cases except plant height and seed yield/plant in both planting dates as well as combined analysis; and height of first siliquae and number of seeds/siliquae at late planting date. Highly significant

Table (7): The genotypes mean performance for all the studied traits at both planting dates and average over the two experiments in the F_1-generation.

Genotype	Plant height (cm)			Height of 1st siliquae (cm)			No. of racemes/plant			No. of siliquas/branch			No. of seeds/siliquae			1000-seed weight (g)			Seed yield/plant (g)		
	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
N.A.24	117.3 a-c#	121.0 a	118.8 ab	7.41 b	8.27 a	7.79 a-d	6.36 a	5.50 a	6.02 a	43.9 f	30.7 b-d	38.6 ef	19.7 a-c	17.6 a	18.9 a-c	2.93 ab	3.16 f-h	3.02 b-e	16.0 a	15.8 a-d	15.9 a
N.A.50	121.1 a-d	127.0 a	123.4 a-c	7.25 ab	8.29 a	7.66 ab	7.33 b	6.10 a-c	6.84 b	33.6 ab	31.5 b-d	32.7 b	21.8 c	20.0 a	21.1 de	2.91 a	2.92 a-c	2.91 a	16.0 a	15.0 ab	15.6 a
N.A.60	125.5 b-e	116.0 a	121.7 a-c	7.63 bc	8.09 a	7.81 a-d	6.76 ab	6.05 ab	6.48 ab	38.1 de	32.0 b-e	35.7 cd	21.1 bc	21.7 a	21.3 de	3.03 a-d	2.78 a	2.93 ab	16.3 a	15.7 a-c	16.0 a
N.A.69	126.0 b-e	118.4 a	122.9 a-c	7.26 ab	8.31 a	7.68 a-c	9.76 e-g	7.85 d-f	9.00 e-g	31.7 a	25.5 a	29.2 a	17.8 a	16.9 a	17.5 a	3.25 fg	3.17 gh	3.21 hi	16.5 a	15.0 ab	15.9 a
N.A.71	116.1 ab	119.2 a	117.3 ab	7.86 cd	8.46 a	8.10 a-d	6.76 ab	6.15 a-c	6.52 ab	37.7 de	32.9 c-e	35.7 cd	22.1 c	20.6 a	21.5 de	2.98 a-c	2.88 ab	2.94 ab	16.2 a	13.9 a	15.3 a
N.A.72	110.4 a	123.2 a	115.5 a	6.93 a	8.41 a	7.52 a	8.20 c	6.95 b-d	7.70 c	35.1 b-d	32.5 c-e	34.1 bc	18.7 ab	17.0 a	18.0 ab	3.16 d-f	3:19 gh	3.17 f-i	19.1 ab	16.5 a-d	18.1 ab
N.A.24 X N.A.50	122.2 a-d	125.9 a	123.7 a-c	8.06 c-e	8.87 a	8.38 cd	9.53 de	7.70 de	8.80 d-f	43.6 f	34.9 d-f	40.1 ef	22.1 c	21.0 a	21.7 de	3.17 d-g	3.21 gh	3.18 g-i	26.2 d-f	21.9 c-e	24.5 d-f
X N.A.60	133.7 d-f	122.0 a	129.0 b-d	8.49 e-h	8.33 a	8.43 d	9.16 de	7.65 de	8.56 de	34.9 a-d	33.5 de	34.3 bc	21.5 c	18.6 a	20.3 c-e	3.16 d-g	3.07 c-g	3.12 e-h	20.4 bc	21.2 b-e	20.7 bc
X N.A.69	137.7 e-g	122.5 a	131.6 cd	8.16 d-g	8.16 a	8.16 a-d	10.56 g-i	9.00 g	9.94 h-k	36.1 b-e	27.5 ab	32.7 b	22.2 c	21.6 a	22.0 e	3.03 a-d	3.00 b-e	3.01 a-d	26.5 d-f	23.9 e	25.4 d-g
X N.A.71	143.0 fg	129.0 a	137.4 d	7.92 cd	8.41 a	8.12 a-d	9.66 d-f	9.15 g	9.46 g-i	39.4 e	35.2 d-f	37.7 de	21.8 c	20.5 a	21.3 de	3.23 fg	2.89 ab	3.09 d-g	28.8 e-g	25.6 e	27.5 fg
X N.A.72	126.0 b-e	119.5 a	123.4 a-c	7.95 cd	8.02 a	7.98 a-d	10.43 f-h	7.85 d-f	9.40 f-h	43.6 f	36.5 e-f	40.7 fg	21.2 bc	19.7 a	20.6 c-e	3.24 fg	3.01 b-f	3.15 f-h	26.1 d-f	21.5 c-e	24.2 d-f
N.A.50 X N.A.60	149.9 g	116.7 a	136.6 d	8.06 c-e	8.01 a	8.04 a-d	11.33 i-k	9.00 g	10.40 k-m	45.4 f	38.5 f	42.7 g	20.7 bc	17.9 a	19.5 b-d	3.25 fg	3.28 h	3.26 i	30.9 g	24.0 e	28.1 g
X N.A.69	137.8 e-g	111.7 a	127.3 a-d	8.23 d-g	8.16 a	8.20 a-d	10.96 hi	8.85 fg	10.12 i-l	36.3 b-e	30.9 b-d	34.1 bc	22.0 c	20.2 a	21.3 de	3.03 a-d	3.09 d-g	3.06 c-f	26.6 d-f	24.8 e	25.9 e-g
X N.A.71	138.3 e-g	113.7 a	128.5 b-d	8.72 h	7.84 a	8.37 b-d	10.46 f-i	8.55 e-g	9.70 h-j	37.6 de	32.3 c-e	35.5 cd	22.0 c	19.9 a	21.1 de	3.14 d-f	3.12 d-g	3.13 f-h	25.2 de	21.7 c-e	23.8 de
X N.A.72	138.2 e-g	112.5 a	127.9 a-d	8.52 f-h	8.12 a	8.36 b-d	8.90 cd	7.15 cd	8.20 cd	36.7 b-e	31.4 b-d	34.5 bc	21.8 c	20.9 a	21.4 de	3.12 c-f	2.82 a	3.00 a-d	23.6 cd	20.7 b-e	22.5 cd
N.A.60 X N.A.69	128.6 b-e	117.4 a	124.1 a-c	7.94 cd	8.31 a	8.09 a-d	11.33 i-k	9.50 g	10.60 k-m	34.9 a-d	30.7 b-d	33.2 bc	21.5 c	18.2 a	20.2 c-e	3.14 d-f	3.15 e-h	3.14 f-h	26.8 d-f	22.1 de	24.9 d-g
X N.A.71	117.6 a-c	114.8 a	116.5 ab	7.63 bc	7.87 a	7.72 a-c	10.90 hi	8.85 fg	10.08 i-k	37.3 c-e	33.5 de	35.8 cd	21.0 bc	18.0 a	19.8 b-e	3.32 g	3.19 gh	3.26 i	26.7 d-f	25.2 e	26.1 e-g
X N.A.72	127.5 b-e	115.0 a	122.5 a-c	8.09 c-f	7.96 a	8.04 a-d	11.10 h-j	9.00 g	10.26 g-m	35.5 b-d	30.9 b-d	33.7 bc	21.4 c	20.9 a	21.2 de	3.22 e-g	2.97 b-d	3.12 e-h	29.5 fg	25.4 e	27.9 g
N.A.69 X N.A.71	131.3 c-f	112.5 a	123.8 a-c	8.59 gh	7.83 a	8.28 b-d	11.90 jk	9.05 g	10.76 lm	36.3 b-e	28.4 a-c	33.1 bc	22.2 c	20.1 a	21.4 de	3.07 b-e	2.80 a	2.96 a-c	27.8 e-g	23.6 e	26.1 e-g
X N.A.72	127.8 b-e	119.0 a	124.3 a-c	8.51 e-h	8.04 a	8.32 b-d	12.10 k	9.15 j	10.92 m	34.1 a-c	33.7 de	33.9 bc	20.5 bc	18.2 a	19.6 b-d	3.22 e-g	2.99 b-d	3.13 f-h	27.6 e-g	23.7 e	26.0 a-g
N.A.71 X N.A.72	128.2 b-e	118.9 a	124.5 a-c	7.99 cd	8.13 a	8.04 a-d	10.66 hi	9.15 g	10.06 h-k	38.2 de	31.0 b-d	35.3 b-d	21.6 c	18.6 a	20.4 c-e	3.20 e-g	3.00 b-e	3.12 e-h	25.2 de	20.8 b-e	23.4 c-e
r	0.189	-0.081	0.225	-0.261	-0.244	-0.277	0.611 *	0.458	0.588 *	0.337	0.492	0.460	0.069	-0.399	-0.184	-0.234	-0.519 *	-0.264	0.003	-0.235	-0.119

D_1 and D_2: Early and late planting dates, respectively.

\# : Values followed by the same letter are not different at $P < 0.05$ by Duncan's L.S.R. test.

r : Correlation coefficient between mid-parent and F_1 mean performance.

* : Significant at 0.05 level of probability.

mean squares due to interaction between parental varieties and planting dates were obtained only for number of siliquas/branch and 1000-seed weight.

The mean performances of the six parental varieties of rapeseed at each planting date and the average over the two planting dates are given in Table (7). It is clear that the parental variety N.A.72 gave the lowest values for hight of first siliquae in the early planting and the combined analysis. Meanwhile, it produced the highest seed yield without significant difference from the other parents under study. The variety N.A.69 was the best performing one for No.of racemes/plant and 1000-seed weight in both planting dates and the combined analysis. However, N.A.24 gave the highest No.of siliquas/branch. Meanwhile, N.A.50, N.A.60 and N.A.71 had the highest No.of seeds/siliquae in early planting and combined analysis.

Data in Table (6) revealed that crosses mean squares were significant for all the studied traits except plant height, height of first siliquae and seed yield/plant in late planting date, and No.of seeds/siliquae in both plantings and the combined. Significant mean squares due to interaction between F_1 crosses and planting dates were detected for height of first siliquae, No. of racemes/plant, No.of siliquas/branch and 1000-seed weight. Such results indicated that these hybrids varied in their response to environmental fluctuations.

Mean performances of F_1 crosses at each planting date and the combined analysis over both planting dates are presented in Table (7). It is noticed that all F_1 crosses surpassed the highest performance parent for all studied characters.

Results indicated that the greatest value of plant height was obtained from the cross N.A.24 x N.A.71 in the combined analysis. Whereas, the cross N.A.60 x N.A.71 had the lowest value of height of first siliquae without significant differences from the parental varieties. The two crosses N.A.69 x N.A.72 and N.A.24 x N.A.69 exhibited the highest values for No.of racemes per plant and No.of seeds/siliquae, respectively. Results also showed that the hybrid N.A.50 x N.A.60 gave the highest values for the No.of siliquas/branch, 1000-seed weight and seed yield/plant with significant difference compared with the best parent in two out of the three casses.

Correlation coefficient values between mid-parent and F_1 performance for all of the studied traits are presented in Table (7). Significant positive correlation coefficient values were only detected for No.of racemes/plant in early planting as well as the combined analysis. Such results clearified good agreement between mid-parent values and F_1 performance. Consequently, the best performance of F_1-combinations could be acheived by crossing between parental varieties of high values. On the contrary, significant negative correlation coefficient value was obtained for 1000-seed weight in late planting, revealing that the most desirable crosses could be attained through hybridization between poor parents.

On the other hand, nonsignificant values were recorded for the other cases, indicating that the most important F_1-hybrid might be produced from crossing between either high or low parental varieties.

With respect to parents vs. crosses component of variation, the results showed its significance for all cas~~s~~es except, plant height, height of first siliquae, No. of seeds/siliquae, and 1000-seed weight in late planting (Table 6). Also, significant interactions between parents vs. crosses and planting dates were obtained for plant height, height of first siliquae, No.of racemes per plant, 1000-seed weight and seed yiled/plant. These results indicated that the heterotic effects were unstable by changing the planting dates. Similar conclusions were found by Singh (1973); Grant and Beversdorf (1985) and Paul *et al.* (1987). On the contrary, Brandle and McVetty (1989) reported that the expression of heterosis was consistent across environments.

Heterosis values measured of F_1 crosses from mid and better parent for each planting date as well as combined data are presented in Table (8).

For plant height, nine and four crosses significantly exceeded the mid and better parent, respectively in the early planting date. Whereas, three and two hybrids showed better performance than the respective cases in the combined analysis. It was clear that the crosses N.A.24 x N.A.71 and N.A.50 x N.A.60 gave the highest heterosis for this trait.

With respect to height of first siliquae, non of the studied hybrids expressed significant negative heterotic effects relative to mid or better parent in the early planting date. However, the most desirable heterotic effect relative to better parent in the combined analysis was obtained by the cross N.A. 60 x N.A. 71.

Concerning No. of racemes per plant, almost all crosses significantly exhibited positive heterotic effects relative to the mid and better parent in each planting date as well as combined analysis. However, the best level of mid-parent heterosis (56.16%). was observed for cross N.A.50 x N.A.60. The cross N.A.60 x N.A.71 expressed the highest heterosis over better parent in the combined data. Singh (1973) found moderately high heterotic values for No.of primary and secondary branches in a diallel crossing system involving six cultivars and four strains of *B. juncea* L.

Table (8): Percentage of heterosis in the F_1-generation over both mid parent (Mp) and better parent (Bp) for the studied traits.

Cross	Plant height (cm) D1 Mp	Plant height D1 Bp	Plant height Comb. Mp	Plant height Comb. Bp	Height of 1st siliquae (cm) D1 Mp	Height of 1st siliquae D1 Bp	Height of 1st siliquae Comb. Mp	Height of 1st siliquae Comb. Bp	No. of racemes/plant D1 Mp	No. of racemes/plant D1 Bp	No. of racemes/plant D2 Mp	No. of racemes/plant D2 Bp	No. of racemes/plant Comb. Mp	No. of racemes/plant Comb. Bp	No. of siliquas/branch D1 Mp	No. of siliquas/branch D1 Bp	No. of siliquas/branch D2 Mp	No. of siliquas/branch D2 Bp	No. of siliquas/branch Comb. Mp	No. of siliquas/branch Comb. Bp	No. of seeds/siliquae D1 Mp	No. of seeds/siliquae D1 Bp	No. of seeds/siliquae Comb. Mp	No. of seeds/siliquae Comb. Bp	1000-seed weight (g) D1 Mp	1000-seed weight D1 Bp	1000-seed weight D2 Mp	1000-seed weight D2 Bp	1000-seed weight Comb. Mp	1000-seed weight Comb. Bp	Seed yield/plant (g) D1 Mp	Seed yield/plant D1 Bp	Seed yield/plant D2 Mp	Seed yield/plant D2 Bp	Seed yield/plant Comb. Mp	Seed yield/plant Comb. Bp
N.A.24 X N.A.50	2.53	0.90	2.15	0.24	9.96**	8.77**	8.41**	7.57**	39.12**	30.01**	32.76**	26.23**	36.86**	28.65**	12.47**	-0.77	12.06*	10.60	12.33**	3.78	6.35	1.24	8.35*	2.65	8.56**	8.19**	5.59**	1.58	7.07**	5.30**	63.60**	63.44**	42.21*	38.61*	55.23**	53.77**
N.A.60	10.09*	6.48	7.23	6.00	12.90**	11.27**	8.08**	7.94**	39.63**	35.50**	32.35**	26.45**	36.96**	32.10**	-15.02**	-20.59**	6.86	4.69	-7.62**	-11.13**	5.29	1.90	1.19	-4.60	6.04**	4.29*	3.37	-2.85**	4.70*	3.31*	26.32*	25.15*	34.77*	34.18	29.66**	29.18**
N.A.69	13.18**	9.29	8.85*	7.08	11.17**	10.12**	5.43**	4.75*	31.02**	8.20*	34.73**	14.65*	32.36**	10.44**	-4.42	-17.70**	-2.14	-10.42	-3.66	-15.38**	18.37**	12.97*	20.86**	16.31**	-1.94	-6.77	-5.36**	-5.36*	-3.53**	-6.23**	63.23**	60.90**	55.07**	50.95**	60.10**	59.80**
N.A.71	22.54**	21.91**	16.34**	15.66**	3.66	0.80	2.14	0.25	47.26**	42.90**	56.95**	48.78**	50.88**	45.09**	-3.31	-10.18**	10.76*	7.15	1.51	-2.28	4.06	-1.49	5.35	-1.02	9.12**	8.39**	-4.31*	-8.54**	3.69**	2.32	79.07**	77.96**	71.71**	61.71**	76.30**	72.86**
N.A.72	10.67*	7.42	5.29	3.87	10.88**	7.29**	4.18*	2.44	43.27**	27.20**	26.00**	12.95	37.03**	22.08**	10.22**	-0.77	15.51**	12.31*	12.08**	5.49	10.57*	7.60	11.82**	9.22	6.23**	2.53	-5.35**	-5.64**	1.61	-0.63	48.42**	36.28**	33.29*	30.70	42.67**	34.22**
N.A.50 X N.A.60	21.55**	19.39**	11.42**	10.70*	8.33**	5.64*	3.88	2.94	60.71**	54.57**	48.03**	47.54**	56.16**	52.05**	26.72**	19.15**	21.26**	20.31**	24.70**	19.56**	-3.73	-5.31	-7.87*	-8.35	9.43**	7.26**	15.09**	12.33**	11.64**	11.27**	90.97**	89.39**	56.23**	53.04**	77.51**	75.19**
N.A.69	11.54*	9.37	3.33	3.16	13.36**	13.36**	6.91**	6.77**	28.19**	12.30**	26.79**	12.74*	27.78**	12.44**	11.34**	8.25	8.25	-2.06	10.20**	4.28	10.94*	0.80	10.27*	0.76	-1.62	-6.77**	1.31	-2.52**	0.00	-4.67**	63.69**	61.51**	65.55**	65.33**	64.42**	63.18**
N.A.71	16.65**	14.26**	6.73	4.13	15.34**	10.94**	6.22**	3.33	48.37**	42.70**	39.48**	39.02**	45.21**	41.81**	5.67	-0.08	0.37	-1.67	3.68	-0.67	0.10	-0.50	-0.70	-1.58	6.44**	5.37*	7.59**	6.85**	6.83**	6.46**	56.38**	55.56**	49.86**	44.67*	53.95**	52.37**
N.A.72	19.38**	14.12**	7.03	3.65	20.17**	17.52**	10.14**	9.14**	14.54**	8.54	9.49	2.88	12.79**	6.49	6.72*	4.36	-2.03	-3.54	3.38	1.35	7.51	-0.28	9.46*	1.42	2.63	-1.27	-7.84**	-11.60**	-1.32	-5.36**	34.41**	23.52**	31.60*	25.84	33.37**	24.36**
N.A.60 X N.A.69	2.29	2.11	1.47	0.98	6.58**	4.06	4.31*	3.59	36.80**	15.78**	36.69**	21.02**	36.95**	17.78**	0.03	-8.39*	6.61	-4.22	2.37	-6.89*	10.43*	1.90	3.97	-5.44	0.00	-3.39	5.71**	-0.63	2.28	-2.18	63.38**	62.54**	44.12**	40.89*	55.99**	55.11**
N.A.71	-2.64	-6.29	-2.51	-4.27	-1.55	-2.93	-3.02	-4.69*	61.24**	61.24**	45.08**	43.90**	55.08**	54.60**	-1.50	-2.10	3.30	1.98	0.25	0.17	-2.78	-5.00	-7.57	-7.91	10.30**	9.57**	12.72**	10.76**	11.07**	10.81**	64.31**	63.80**	70.27**	61.02**	66.56**	62.72**
N.A.72	8.10	1.59	3.29	0.66	11.13**	6.03*	4.82*	2.94	48.40**	35.37**	38.46**	29.50**	44.71**	33.25**	-3.00	-6.82	-4.34	-5.08	-3.50	-5.66	7.74	1.56	7.83	-0.56	3.87*	1.90	-0.67	-6.90**	2.30	-1.58	66.65**	54.36**	57.94**	54.10**	63.40**	54.26**
N.A.69 X N.A.71	8.50	4.25	3.08	0.73	13.62**	9.29**	4.94*	2.22	44.07**	21.93**	29.29**	15.29**	38.66**	19.56**	4.67	-3.61	-2.84	-13.70*	1.97	-7.33*	11.32*	0.59	9.71*	-0.56	1.60	-5.54**	-7.59**	-11.67**	-3.90**	-7.79**	70.13**	68.79**	63.32**	57.86**	67.65**	64.69**
N.A.72	8.11	1.43	4.28	1.14	19.86**	17.22**	9.47**	8.33**	34.74**	23.98**	23.65**	16.56*	30.78**	21.33**	1.92	-3.05	16.03**	3.54	7.11*	-0.53	12.33*	9.80	10.32*	8.67	0.31	-0.92	-5.98**	-6.27**	-1.88	-2.49	55.06**	43.01**	50.96**	44.07*	53.54**	44.19**
N.A.71 X N.A.72	13.20**	10.42	6.96	6.14	7.97**	1.65	2.94	-0.74	42.51**	30.00**	39.69**	31.65**	41.49**	30.65**	4.95	1.43	-5.14	-5.63	1.17	-1.18	5.79	-2.40	3.14	-5.21	4.24*	1.27	-1.32	-5.96**	1.96	-1.58	42.78**	31.89**	36.51*	26.14	40.53**	29.79**

D_1 and D_2: Early and late planting dates, respectively.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

Considering No.of siliquas/branch, the average of heterotic effects in the combined analysis ranged from -7.62 to 24.70 and from -15.38 to 19.56% over mid and better parent, respectively. Meantime, hybrid N.A. 50 x N.A. 60 had the highest useful heterosis of the studied cases.

For No.of seeds/siliquae, six and one hybrids showed significant positive heterotic effect relative to mid and better parent, respectively in the early planting. The highest heterotic effect for this character over the two planting dates was detected in hybrid N.A. 24 x N.A.69 which scored 20.86 and 16.31% over mid and better parent, respectively. These results are in harmony with that recorded by Ibrahim (1989).

Regarding 1000-seed weight, cross N.A. 50 x N.A. 60 exhibited the highest significant positive heterotic effects of 11.64 and 11.27% for mid and better parent, respectively, over the two planting dates. Also, six and five crosses showed significant positive heterosis relative to mid and better parent, respectively, in the combined analysis.

Almost all crosses expressed highly significant heterotic effect for seed yield/plant. The heterosis values over two planting dates ranged from 29.66 to 77.51% and from 29.18 to 75.19% over mid and better parent, respectively.

The seven crosses: N.A.24 x N.A.69, N.A.24 x N.A.71, N.A. 50 x N.A.60, N.A.50 x N.A.69, N.A.60 x N.A.71, N.A.60 x N.A.72, and N.A.69 x N.A.71 exceeded the mid-parent by 60.10, 76.30, 77.51, 64.42, 66.56, 63.40, and 67.65%, respectively. Moreover, the heterosis values relative to better parent for the respective crosses were 59.80, 72.86, 75.19, 63.18, 62.72, 54.26, and 64.69%. It was also, clear that hybrid N.A.50 x N.A.60 had the highest heterotic effect for seed yield/plant over the two planting dates. It could be concluded that these crosses would be efficient and prospective in rapeseed breeding programs for improving seed yield/plant.

Significant positive heterotic effects for seed yield/plant were obtained by several researchers (Singh, 1973; Grabiec, 1981 a; Sernyk and Stefansson, 1983; Grant and Beversdorf, 1985; and Beversdorf *et al.*, 1988).

b. F_2-generation:

Results in Table (9) showed the analysis of variance for all of the studied traits in each planting date and their combined analysis. Planting dates mean squares were highly significant for all of the studied characters except, 1000-seed weight. Such results indicated the presence of significant differences between the early and late plantings for these traits. It was clear that the mean values of early planting were much higher than these of late planting for

Table (9): Observed mean squares from ordinary analysis for growth and yield characteristics in both planting dates as well as the combined analysis in the F_2-generation.

Source of variation	D.F.			Plant height (cm)			Height of 1st silique (cm)			No. of racemes/plant			No. of siliquas/branch			No. of seeds/siliquae			1000-seed weight (g)			Seed yield/plant (g)		
	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
Planting dates(D)			1			1705.0**			2.79**			99.60**			766.27**			81.94**			0.0009			163.15**
Replications	2	1	3	70.5	1.17	47.4	0.038	0.002	0.03	0.15	1.34*	0.54	4.68	9.52*	6.29*	0.59	2.48	1.22	0.006	0.011	0.007	5.96	1.68	4.53
Genotypes (G)	20	20	20	179.6**	27.98	92.81	0.482**	0.068	0.23**	11.90**	3.75**	14.93**	26.13**	13.73**	31.51**	3.93	4.81	7.66*	0.053**	0.037**	0.072**	50.62**	15.10	60.71**
Parents (P)	5	5	5	107.9	30.30	52.22	0.31**	0.03	0.19*	4.80**	1.39**	5.92**	55.26**	14.84**	50.92**	9.15**	8.31	16.34**	0.054**	0.063**	0.09**	4.39	1.49	4.80
Crosses (C)	14	14	14	128.7*	21.3	83.2	0.175**	0.071	0.10	2.57**	1.11**	3.31**	12.72**	12.23**	19.95**	2.03	3.88	4.99	0.056**	0.029**	0.072**	25.61**	3.22	23.02**
P vs. C	1	1	1	1250.8**	110.2	430.9*	5.631**	0.191	2.36**	177.9**	52.6**	222.6**	68.21**	29.18**	96.31**	4.46	0.25	1.74	0.0001	0.009	0.003	632.0**	249.3**	867.90**
G x D			20			114.7*			0.32**			0.72**			8.35**			1.08			0.018**			5.01
P x D			5			86.0			0.16			0.26			19.18**			1.12			0.031**			1.08
C x D			14			66.8			0.15*			0.37*			5.00**			0.92			0.014*			5.81
P vs. C x D			1			930.0**			3.50**			7.92**			1.10			3.12			0.009			13.46
Error	40	20	60	59.3	71.8	63.5	0.055	0.136	0.08	0.18	0.19	0.18	1.82	1.26	1.63	3.64	4.82	4.03	0.006	0.006	0.006	6.25	8.49	6.99

D_1 and D_2 : Early and late planting dates, respectively.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

plant height, height of first siliquae, and seed yield per plant. On the contrary, late planting mean values were higher for the other studied traits (Table 10). These results are in agreement with those of Degenhardt and Kondra (1981).

Genotypes mean squares were significant for all of the studied traits in both planting dates and the combined analysis with some exceptions. Among these exceptions were; the height of first siliquae and seed yield/plant in the late planting; plant height at late planting and the combined analysis, and No.of seeds/siliquae in the two planting dates. Also, significant interaction effects of genotypes x planting dates were detected for all characters except, the No.of seeds/siliquae and seed yield/plant. This means that genotypes behaved somewhat differently from planting date to another.

Parents mean squares were significant for No.of racemes per plant, No.of siliquas/branch and 1000-seed weight in the two planting dates and their combined analysis, and for the height of first siliquae and No.of seeds/siliquae in two out of the three studied cases. Meanwhile,highly significant interaction effect between parental varieties and planting dates were only obtained for the No.of siliquas/branch and 1000-seed weight. Such results may reflect the inability of the parental varieties to buffer against environmental fluctuations.

Table (10): The genotypes mean performance for all the studied traits at both planting dates and average over the two experiments in the F_2-generation.

Genotype	Traits: Plant height (cm)			Height of 1st siliquae (cm)			No. of racemes/plant			No. of siliquas/branch			No. of seeds/siliquae			1000-seed weight (g)			Seed yield/plant (g)		
	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
N.A.24	117.3 ab#	121.0 a	118.8 a	7.41 bc	8.27 a	7.79 a-d	6.36 a	5.50 a	6.02 a	43.9 i	30.7 d-g	38.6 j	19.7 a	17.6 a	18.9 a-d	2.93 a-c	3.16 e-g	3.02 bc	16.0 a	15.8 a	15.9 ab
N.A.50	121.1 a-c	127.0 a	123.4 a	7.25 ab	8.29 a	7.66 ab	7.33 b	6.10 ab	6.84 b	33.6 a-e	31.5 e-h	32.7 d-g	21.8 a	20.0 a	21.1 c-f	2.91 ab	2.92 a-d	2.91 ab	16.0 a	15.0 a	15.6 ab
N.A.60	125.5 bc	116.0 a	121.7 a	7.63 b-d	8.09 a	7.81 a-e	6.76 ab	6.05 ab	6.48 ab	38.1 h	32.0 f-h	35.7 hi	21.1 a	21.7 a	21.3 d-f	3.03 b-e	2.78 a	2.93 ab	16.3 ab	15.7 a	16.0 ab
N.A.69	126.0 b-d	118.4 a	122.9 a	7.26 ab	8.31 a	7.68 a-c	9.76 d	7.85 cd	9.00 d	31.7 ab	25.5 a	29.2 a	17.8 a	16.9 a	17.5 a	3.25 f	3.17 fg	3.21 e	16.5 ab	15.0 a	15.9 ab
N.A.71	116.1 ab	119.2 a	117.3 a	7.86 d-h	8.46 a	8.10 c-g	6.76 ab	6.15 ab	6.52 ab	37.7 h	32.9 gh	35.7 hi	22.1 a	20.6 a	21.5 d-f	2.98 a-d	2.88 a-c	2.94 ab	16.2 ab	13.9 a	15.3 a
N.A.72	110.4 a	123.2 a	115.5 a	6.93 a	8.41 a	7.52 a	8.20 c	6.95 bc	7.70 c	35.1 d-g	32.5 gh	34.1 gh	18.7 a	17.0 a	18.0 ab	3.16 ef	3.19 fg	3.17 de	19.1 a-c	16.5 a	18.1 a-c
N.A.24 X N.A.50	125.7 b-d	124.3 a	125.1 a	7.70 c-e	8.43 a	7.99 b-g	11.40 g	7.70 cd	9.92 fg	37.5 gh	32.2 f-h	35.4 hi	20.2 a	20.0 a	20.1 a-f	3.24 f	3.10 d-g	3.18 de	27.6 g	21.7 a	25.2 f-h
X N.A.60	123.2 a-c	121.1 a	122.4 a	8.14 e-i	8.53 a	8.29 g	9.70 d	8.00 d	9.02 d	34.2 b-f	33.9 h	34.0 gh	20.8 a	19.0 a	20.1 a-f	3.23 f	3.20 g	3.22 e	20.8 b-e	20.0 a	20.5 c-e
X N.A.69	140.7 de	120.4 a	132.6 a	7.77 c-g	8.42 a	8.03 b-g	10.03 de	7.95 d	9.20 de	36.5 f-h	29.3 c-e	33.6 g	22.1 a	21.2 a	21.7 ef	2.97 a-c	2.83 ab	2.92 ab	21.4 c-e	19.2 a	20.5 c-e
X N.A.71	135.8 c-e	113.5 a	126.9 a	8.06 d-i	8.22 a	8.12 d-g	11.60 gh	9.45 fg	10.74 hi	38.8 h	32.2 f-h	36.1 i	19.8 a	17.2 a	18.7 a-d	3.24 f	3.19 fg	3.22 e	27.2 f-g	22.1 a	25.2 f-h
X N.A.72	131.1 b-e	115.1 a	124.7 a	8.10 e-i	8.30 a	8.18 d-g	9.53 d	8.00 d	8.92 d	33.8 b-e	27.0 a-c	31.1 b-d	20.1 a	17.3 a	19.0 a-e	3.13 d-f	3.13 e-g	3.13 de	19.5 a-d	19.0 a	19.3 b-d
N.A.50 X N.A.60	143.1 e	117.5 a	132.9 a	8.24 hi	8.02 a	8.15 d-g	12.23 h-j	10.05 g	11.36 j	34.3 c-f	27.9 a-c	31.7 b-f	20.3 a	17.6 a	19.2 a-f	2.98 a-d	3.01 b-g	2.99 a-c	28.3 g	21.8 a	25.7 h
X N.A.69	130.1 b-e	114.8 a	124.0 a	8.35 i	8.04 a	8.23 e-g	11.17 fg	9.35 e-g	10.44 gh	33.8 b-e	27.5 a-c	31.3 b-e	21.6 a	18.9 a	20.5 b-f	2.91 ab	3.11 d-g	2.99 a-c	24.1 d-g	22.4 a	23.4 e-h
X N.A.71	130.3 b-e	115.9 a	124.5 a	7.73 c-f	7.99 a	7.83 a-f	11.60 gh	9.10 e-g	10.60 h	32.1 a-c	29.7 c-f	31.1 b-d	20.0 a	18.2 a	19.3 a-f	3.07 c-e	3.14 e-g	3.09 cd	21.8 c-e	19.5 a	20.9 c-e
X N.A.72	131.3 b-e	113.8 a	124.3 a	8.36 i	8.12 a	8.26 fg	10.60 ef	8.35 de	9.70 ef	34.5 c-f	26.2 ab	31.1 b-d	21.2 a	19.7 a	20.6 b-f	3.03 b-e	2.83 ab	2.95 ab	20.8 b-e	18.9 a	20.0 c-e
N.A.60 X N.A.69	125.9 b-d	118.7 a	123.0 a	8.17 f-i	7.96 a	8.08 b	12.43 ij	9.85 g	11.40 j	31.1 a	25.4 a	28.8 a	21.3 a	19.2 a	20.4 b-f	2.94 a-c	3.00 b-f	2.96 ab	27.8 g	21.9 a	25.4 gh
X N.A.71	121.9 a-c	114.0 a	118.7 a	7.62 b-d	8.17 a	7.84 a-f	11.30 fg	8.65 d-f	10.24 f-h	35.3 e-g	29.7 c-f	33.0 e-g	19.4 a	16.9 a	18.4 a-c	3.22 f	3.20 g	3.21 e	22.6 c-f	20.8 a	21.9 c-g
X N.A.72	119.9 ab	114.6 a	117.8 a	8.02 d-i	7.93 a	7.98 b-g	12.57 j	9.40 fg	11.30 ij	34.7 c-f	28.7 b-d	32.3 c-g	22.0 a	21.6 a	21.8 f	2.86 a	2.93 a-d	2.88 a	21.5 c-e	22.3 a	21.8 c-g
N.A.69 X N.A.71	125.3 bc	120.3 a	123.0 a	8.03 d-i	8.14 a	8.07 b-g	11.77 g-i	9.25 e-g	10.76 hi	32.2 a-c	27.2 a-c	30.2 ab	21.0 a	18.4 a	19.9 a-f	2.99 a-d	3.05 c-g	3.01 bc	23.7 c-g	20.8 a	22.5 d-h
X N.A.72	127.4 b-d	119.0 a	124.1 a	8.19 g-i	8.03 a	8.13 d-g	11.57 gh	9.30 e-g	10.66 h	34.4 c-f	31.4 e-h	33.2 fg	20.8 a	18.1 a	19.7 a-f	2.95 a-c	2.97 a-e	2.96 ab	25.5 e-g	20.8 a	23.6 e-h
N.A.71 X N.A.72	127.2 b-d	115.2 a	122.4 a	8.29 hi	8.02 a	8.18 d-g	11.30 fg	9.25 e-g	10.48 gh	32.6 a-d	27.2 a-c	30.4 a-c	21.5 a	18.9 a	20.4 b-f	2.87 a	3.02 b-g	2.93 ab	22.7 c-f	19.6 a	21.5 c-f
r	0.076	-0.101	0.353	-0.494	-0.195	-0.481	0.160	0.371	0.238	0.549*	0.131	0.556*	-0.593*	-0.288	-0.455	-0.696**	-0.404	-0.139	0.406	-0.147	-0.393

D_1 and D_2: Early and late planting dates, respectively.

: Values followed by the same letter are not different at $P < 0.05$ by Duncan's L.S.R. test.

r : Correlation coefficient between mid-parent and F_1 mean performance.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

The mean performance of the six parental varieties were discussed in the F_1-generation. The same trend for the parental varieties was obtained from the F_2-generation.

Signficant F_2 hybrid mean squares were detected for the No.of racemes/plant, No.of siliquas/branch, and 1000-seed weight in the two plantings and their combined; for plant height and height of first siliquae in the early planting; and for seed yield per plant in the early planting and the combined analysis (Table 9). Results also showed significant interaction effect between F_2 hybrids and planting dates for height of first siliquae, No.of racemes per plant, No.of siliquas per branch and 1000-seed weight. The obtained results indicated that these hybrids differed in their performance from planting date to another.

Results in Table (10) showed the mean performance of F_2 rape hybrids at each planting date as well as the combined analysis. The best crosses averaged over the two planting dates were N.A.50 x N.A.60, N.A.50 x N.A.71, N.A.60 x N.A.69, N.A.24 x N.A.71, N.A.60 x N.A.72, N.A.24 x N.A.71, and N.A.50 x N.A.60 for plant height, height of first siliquae, No.of racemes/plant, No.of siliquas/branch, No.of seeds/siliquae, 1000-seed weight, and seed yield/plant, respectively.

It is worth-mentioning that the best performing F_1-crosses had mean values slightly better than those of F_2-crosses in most of the studied traits over the two planting dates. Moreover, the hybrid N.A. 50 x N.A. 60 that exhibited superiority for seed yield/plant and some other traits in F_1-generation also produced the highest seed yield/plant in F_2-generation.

Significant positive correlation coefficient values were detected between the mid-parent values and F_2-performance for the No. of siliquas/branch at early planting and the combined analysis (Table 10). As a result, the superior F_2-crosses could be developed from parents which characterized by the high mean values. However, significant negative correlation coefficients were obtained for the No. of seeds/siliquae, and 1000-seed weight in the early planting. This means that the best F_2-crosses could be resulted from parents of low mean values.

Mean squares for parents vs. crosses as an indication to average heterosis overall crosses were significant for plant height and height of first siliquae in the early planting and the combined analysis; and for No.of racemes/plant, No.of siliquas/branch, and seed yield/plant in all of the studied cases. Also, highly significant heterosis x planting dates interaction effect was detected for plant height, height of first siliquae, and No.of racemes/plant. These results showed that grand means of parental varieties and their F_2-crosses was differed and changed from one planting date to another.

It is worth-noting that significant mean squares for parents vs. crosses for F_1-generation and insignificant ones for F_2-generation were obtained for the No.of seeds per siliquae, and 1000-seed weight. Such results could be attributed to the higher magnitude of non additive type of gene action and effect of inbreeding depression. Moreover, heterosis for seed yield/plant obtained from F_1-data was much higher than that of F_2-data. This conclusion is very well expected since the inbreeding depression in F_2 could reduce the heterosis effects.

Results in Table (11) showed remain heterosis values relative to mid and better parent for all of the studied traits in F_2-generation for the two planting dates and their combined analysis.

Significant positive mid and better parent remain heterosis for plant height was shown by seven and four hybrids in the early planting. However, the best heterotic effect for this trait was recorded in the cross N.A.24 x N.A.71.

None of the studied F_2-crosses possessed desirable heterosis for the height of first siliquae in the early planting as well as their combined analysis. However, nine and five crosses expressed significant positive values of heterosis over mid and better parent, respectively, in the combined data.

In the combined analysis the highest level of remain heterosis for No. of racemes/plant was observed in the cross N.A.24 x N.A.71 and N.A.50 x N.A.60 relative to mid and better parent, respectively.

Regarding expression of remain heterosis for No.of siliquas per branch, only two crosses namely N.A.50 x N.A.60 and N.A.69 x N.A.72 had desirable heterotic effects over mid-parent in the late planting and the combined analysis, respectively.

Concerning the 1000-seed weight, significant positive estimates of Mp and Bp remain heterosis were detected in: five and four; five and two; and five and five crosses for the early, late planting and the combined analysis, respectively. However, the best heterotic values relative to mid and better parent in the combined analysis were detected in the cross N.A. 60 x N.A. 71.

Estimates of heterosis over mid and better parent for seed yield/plant were significant positive for almost all crosses in the early planting and the combined analysis. While, the highest mid and better parent heterosis estimates in the combined analysis were 62.48 and 60.35%, respectively for the cross N.A.50 x N.A.60. Whereas, the lowest respective values were 13.36 and 6.64% in the cross N.A.24 x N.A. 71.

It was worth-noting that the hybrid N.A.50 x N.A.60 that expressed the highest heterotic effect for seed yield/plant in F_1-generation appeared to be the best cross in F_2-generation. This result reflected the importance of this combination in hybrid rapeseed breeding programs.

It could be concluded that the obtained significant positive heterosis for seed yield/plant in both F_1- and F_2-generations proved the efficiency and capability of using F_2-crosses in the commercial production.

Such results are in close harmony with those reported by Singh (1973); Grabiec (1981 a); Sernyk and Stefanson (1983) and Ibrahim (1989), where they found significant positive heterosis for rapeseed yield and most of its components.

Results of inbreeding depression in F_2-generation for all of the studied traits in both planting dates, as well as the combined analysis are presented in Table (11). It was clear that none of the studied crosses showed significant positive inbreeding depression for plant height in the early planting date. For height of first siliquae, three and two hybrids expressed significant positive inbreeding depression percentages in the early planting and the combined analysis. Whereas, six and five crosses expressed negative and nonsignificant values in the respective two cases.

Regarding No. of racemes per plant significant positive inbreeding depression values (8.63 and 5.11%) were recorded in one cross (N.A.24 x N.A.71) for early planting as well as the combined results, respectively. Whereas, the hybrid N.A.24 x N.A.69 only produced significant positive value (11.67%) in late planting date.

It was noticed that the highest number of F_2-crosses which expressed significant positive inbreeding depression values were obtained for the No. of siliquas/branch. These crosses were seven, seven, and ten for the separate planting date as well as the combined analysis, respectively. Moreover, the highest values (24.43, 27.66, and 25.60%) were detected for the cross N.A.50 x N.A.60 for the three respective cases.

There was only one cross (N.A.24 x N.A.71) that expressed significant positive inbreeding depression value (11.85%) for the No.of seeds/siliquae in the combined analysis. However, ten crosses expressed positive and nonsignificant values for such trait.

Significant positive inbreeding depression percentages for 1000-seed weight were recorded in five, three, and five hybrids in early and late planting and their combined analysis, respectively. However, the cross N.A. 50 x N.A. 60 exhibited the highest values in late planting and the combined data as well.

Regarding seed yield/plant, five crosses expressed significant positive inbreeding depression values in both early planting and the combined analysis. These crosses were N.A.24 x N.A.72, N.A.60 x N.A.71, N.A.60 x N.A.72, and N.A.69 x N.A.71. Meanwhile, the cross N.A.60 x N.A.72 produced highest values of 27.19 and 21.68% in the early planting and the combined analysis, respectively.

Results also showed significant positive estimates for both heterosis and inbreeding depression for seed yield/plant in most cases. Both of the heterosis and inbreeding depression effects are two coinside for the same particular phenomenon. Therefore, it is logically to expect that heterosis in F_1 will be accompanied by appreciable reduction in F_2-performance.

Similar results were reported by Singh (1973) and Pal *et al.* (1987).

B. Combining ability:

a. F_1-generation:

Analysis of variance for combining ability as outlined by Griffing's (1956) method 2 model-1 in each planting date as well as their combined results for all studied traits is shown in Table (12).

The variance associated with general combining ability (gca) was significant for: No.of racemes/plant, No.of siliquas/branch, and 1000-seed weight in both planting dates and their combined; for plant height in early planting, and for No.of seeds/siliquae in early planting as well as combined analysis. Specific combining ability (sca) variations were significant for all characters under study except, plant height, height of first siliquae, and No.of seeds/siliquae in late planting.

It is evident that nonadditive type of gene action was the more important part of the total genetic variability for plant height in the combined analysis as well as height of first siliquae and seed yield/plant. For the other studied cases, both additive and nonadditive gene effects were involved in determining the performance of single cross progeny. Also, when gca/sca ratio was used, it was found that, plant height at early planting as well as, 1000-seed weight, and No.of racemes/plant at the two planting dates and their combined exhibited low gca/sca ratios of less than unity, indicating the predominance of nonadditive gene action in the inheritance of such traits.

Table (12): Observed mean squares from F_1-diallel cross analysis for all the studied tratits.

Source of variation	D.F.			Plant height (cm)			Height of 1st silquae (cm)			No. of racemes/plant			No. of siliquas/branch			No. of seeds/siliquae			1000-seed weight (g)			Seed yield/plant (g)		
	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
Genotypes (G.)	20	20	20	95.13**	23.55	33.18**	0.23**	0.06	0.07**	3.04**	1.56**	2.34**	13.56**	8.64**	9.62**	1.36**	2.25	1.48**	0.013**	0.020**	0.012**	25.40**	15.18**	20.50**
General combining ability (gca)	5	5	5	56.05*	30.37	21.52	0.04	0.04	0.02	2.84**	1.43**	2.06**	25.38**	15.65**	18.93**	1.81*	1.27	1.55**	0.010**	0.008**	0.004**	1.56	0.61	0.76
Specific combining ability (sca)	15	15	15	107.58**	21.29	37.13**	0.29**	0.07	0.09**	3.11**	1.72**	2.43**	9.61**	6.30**	6.52**	1.21*	2.57	1.46**	0.014**	0.026**	0.014**	33.34**	20.03**	27.09**
G. x date			20			33.32**			0.09**			0.11**			1.96**			0.23			0.006**			0.80
gca X date			5			24.26			0.02			0.21**			2.56**			0.044			0.005**			0.42
sca X date			15			36.38**			0.112**			0.12**			1.76**			0.294			0.005**			0.93
Error	40	20	60	18.76	42.89	13.22	0.02	0.07	0.02	0.07	0.11	0.04	1.04	1.75	0.65	0.55	1.48	0.42	0.002	0.002	0.001	1.33	3.49	0.99
gca/sca				0.52	-	-	-	-	-	0.91	0.83	0.85	2.64	2.48	2.90	1.50	-	1.06	0.71	0.31	0.29	-	-	-

D1 and D_2: Early and late planting dates, respectively.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

On the other hand, high gca/sca ratios which exceeded the unity were detected for No.of siliquas/branch in both planting dates as well as combined results, and No.of seeds/siliquae at early planting and the combined analysis. Such results indicated that additive and additive x additive types of gene action were more important than non additive effects in controlling these characters.

These results were along the same line of those reported by; Pal *et al.* (1981); Singh *et al.* (1981); Jindal and Labana (1986); and Wang (1986) where they found that both additive and nonadditve gene effects are important in controlling most of rape characters.

Chauhan and Singh (1980); Singh and Yadav (1980); Govil *et al.* (1981); and Grant and Beversdorf (1985) pointed out that the nonadditive variation was the only predominant type of gene action for most characters.

On the other hand, the abundant of additive gene effects for rapeseed yield and its components was recorded by; Buson (1980); Grabiec (1981 a); Brandle and McVetty (1989); and Ibrahim (1989).

The mean squares of interaction between planting dates and both types of combining ability were significant for all of the studied traits except, sca x planting date for No.of seeds/siliquae and seed yield/plant; and gca x planting date for plant height, height of 1st siliquae, No.of seeds per siliquae and seed yield/plant. Such results showed that the magnitude of all types of gene action varied from one planting date to another. For such exceptional cases, insignificant interaction mean squares were obtained, revealing that the magnitude of gca and/or sca did not differ from planting date to another. It is fairly evident that mean square of sca x planting date was much higher than gca x planting date for all traits except for the No.of racemes/plant and No.of siliquas/branch. Such results indicated that nonadditive effects were much more influenced by the environmental conditions than additive genetic effects in these traits. These conclusions are in well agreement with those reported by Gilbert (1958), however, for the exceptional cases, the higher magnitude of gca x planting date interaction showed that the additive and additive x additive effects were more affected by environment than the non-additive effects.

General combining ability effects ($\hat{g}_i$) of each parental variety for plant height in the early planting; for No.of racemes/plant, No.of siliquas/branch and 1000-seed weight in both planting dates as well as their combined; and for No.of seeds/siliquae in early planting and the combined analysis are presented in Table (13). Such effects are being used to compare the average performance of each variety with other varieties and facilitate selection of varieties for further improvement.

Table (13): Estimates of general combining ability effects for all the studied traits from the F_1-generation.

Parental variety		Plant height (cm)	No. of racemes/plant			No. of siliquas/branch			No. of seeds/silquae		1000-seed weight (g)		
		D_1	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	Comb.	D_1	D_2	Comb.
N.A.24	$(\hat{g}_i)$	-0.549	-0.75**	-0.55**	-0.63**	2.75**	0.55	1.87**	0.005	0.04	-0.030*	0.034*	-0.005
	Mean	117.30	6.36	5.50	6.02	43.90	30.70	38.62	19.73	18.88	2.93	3.16	3.02
N.A.50	$(\hat{g}_i)$	3.496*	-0.82**	-0.29*	-0.30**	0.42	0.79	0.57*	0.493*	0.49*	-0.050**	0.016	-0.023*
	Mean	121.60	7.33	6.10	6.84	33.56	31.50	32.74	21.83	21.10	2.91	2.92	2.91
N.A.60	$(\hat{g}_i)$	0.849	-0.09	-0.08	-0.05	0.13	0.81	0.40	0.007	0.05	0.027	-0.001	0.015
	Mean	125.50	6.76	6.05	6.48	38.13	32.00	35.68	21.10	21.32	3.03	2.78	2.93
N.A.69	$(\hat{g}_i)$	1.693	1.04**	0.69**	0.88**	-2.77**	-2.82**	-2.79**	-0.514*	-0.51*	0.007	0.017	0.011
	Mean	125.96	9.76	7.85	9.00	31.70	25.50	29.22	17.83	17.46	3.25	3.17	3.21
N.A.71	$(\hat{g}_i)$	-1.356	-0.12	0.16	-0.02	0.11	0.19	0.14	0.564*	0.45*	-0.002	-0.059**	-0.024*
	Mean	116.10	6.76	6.15	6.52	37.66	32.85	35.74	22.10	21.48	2.98	2.88	2.94
N.A.72	$(\hat{g}_i)$	-4.133**	0.19*	0.06	0.12	-0.63	0.48	-0.19	-0.554*	-0.52*	0.048**	-0.008	0.027**
	Mean	110.40	8.20	6.95	7.70	35.13	32.50	34.08	18.66	18.00	3.16	3.19	3.17
L.S.D. $(\hat{g}_i-\hat{g}_j)$	0.05	4.39	0.27	0.35	0.21	1.03	1.38	0.80	0.75	0.65	0.044	0.046	0.032
	0.01	5.87	0.37	0.47	0.28	1.38	1.88	1.07	1.01	0.86	0.059	0.063	0.043
r		0.838*	0.937**	0.907*	0.925**	0.880*	0.924**	0.903*	0.950**	0.892*	0.694	0.446	0.676

D_1 and D_2: Early and late planting dates, respectively.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

r : Correlation coefficient between the parental mean performance and its general combining ability effects.

General combining ability effects estimated in this study were found to be differed significantly from zero in some cases. Highly positive gca values for parental variety under each character in question expressed desirable average performance. It was clear that the parental variety N.A. 50 had the highest positive ($\hat{g}_i$) value for plant height in the early planting date and for the No.of seeds/siliquae in the combined analysis. Therefore, this variety was considered as the best combiner for both traits. Moreover, such variety N.A.50 seemed to be the second best combiner for No.of seeds/siliquae in early planting date. Meanwhile, the parental variety N.A.69 behaved as the best combiner for No.of racemes/plant in both planting dates as well as combined data, and as a poor one for No.of siliquas/branch and No.of seeds/siliquae.

Results also showed that the highest desirable ($\hat{g}_i$) effects for No.of siliquas/branch in early planting and the combined analysis as well as 1000-seed weight in late planting were obtained by the variety N.A.24. Meanwhile, the parental variety N.A.71 appeared to be the best general combiner for the No.of seeds/silquae in early planting followed by the variety N.A.50. On the contrary, this variety expressed significant negative values for 1000-seed weight in the late planting as well as the combined analysis. Significant positive ($\hat{g}_i$) effects were recorded for the variety N.A.72 for 1000-seed weight in early planting and the combined analysis. In addition, this parental variety was considered as a poor combiner for both plant height and No.of seeds/siliquae.

Significant correlation coefficient values between the parental performance and its ($\hat{g}_i$) effects were obtained for all of the studied traits, except for the 1000-seed weight in both planting dates as well as the combined analysis (Table, 13). This finding indicates that the intrinsic performance of parental varieties gave a good index of their general combining ability effects. Therefore, selection with the tested parental population for initiating any proposed breeding program could be practised either on mean performance or ($\hat{g}_i$) effect basis with similar efficiency. Such agreement might add another proof about the preponderance of additive genetic variance in these cases, coinciding with the findings reached above in Table (12). For 1000-seed weight, insignificant correlation coefficient values were detected between the two variables. This disagreement revealed that hybrids characterized with heavy seeds could be expected by crossing between varieties of small seed weight, It could be concluded that the non-additive type of gene action had the greatest role in the expression of this trait which is in complete agreement with the findings reached above in Table (12). A rather good agreement between ranking the parental varieties according to their ($\hat{g}_i$) effects and the ranking based on parental performamnce *per se* was reported; by Badwal *et al.* (1986) for seed yield and eight related characters.

Specific combining ability effects were only computed whenever significant sca variances were obtained (Table 14).

For plant height; five and two crosses exhibited significant positive specific combining ability effects at the early planting date and the combined analysis, respectively. Results indicated that the cross N.A.24 x N.A.71 had the highest sca value in the combined analysis followed by the cross N.A.50 x N.A.60 which expressed the best value for this trait in the early planting date.

It is clear that only cross N.A.60 x N.A.71 showed significant negative sca effects for height of first siliquae in both early planting date and the combined analysis as well. Moreover, this cross behaved as the most desirable cross among the studied fifteen hybrids.

Thirteen, nine, and thirteen crosses had significant positive sca effects for the No. of racemes per plant in the early, late planting and the combined analysis, respectively. Meanwhile, the cross N.A.50 x N.A.60 produced the highest sca value for No.of racemes/plant in the early planting date and the combined data. Whereas, the best value for this trait in the late planting date was obtained in the cross combination N.A. 24 x N.A. 71.

Table (14): Estimates of specific combining ability effects for all the studied traits from F_1 generation.

Cross	Plant height (cm)		Height of 1st siliquae (cm)		No. of racemes/plant			No. of siliquas/branch			No. of seeds/siliquae		1000-seed weight (g)			Seed yield/plant (g)		
	D_1	Comb.	D_1	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
N.A.24 x N.A.50	-9.53**	-4.39	0.08	0.25**	0.83**	0.57*	0.69**	2.77**	1.43	2.23**	0.43	0.66	0.117**	0.127**	0.120**	3.42**	1.45	2.63**
x N.A.60	4.57	3.25	0.59**	0.40**	0.28	-0.69**	0.23	-5.64**	0.06	-3.35**	0.31	-0.22	0.030	0.005	0.020	-2.67**	-0.003	-1.60*
x N.A.69	7.73*	5.25	0.20*	0.07	0.55**	0.90**	0.65**	-1.47	-2.31*	-1.80**	1.56**	1.96**	-0.080*	-0.084*	-0.080**	3.27**	2.79	3.07**
x N.A.71	16.12**	12.50**	-0.12	-0.01	0.81**	1.57**	1.08**	-1.05	2.38*	0.32	0.01	0.30	0.129**	-0.118**	0.030	5.85**	4.89**	5.47**
x N.A.72	1.89	-0.04	0.12	-0.04	1.27**	0.38	0.87**	3.82**	3.40**	3.65**	0.60	0.63	0.089**	-0.049	0.030	2.54**	0.82	1.86*
N.A.50 x N.A.60	16.73**	9.83**	0.09	0.003	1.97**	1.40**	1.71**	7.26**	4.83**	6.29**	-1.02	-1.47**	0.140**	0.232**	0.180**	7.22**	3.07*	5.56**
x N.A.69	3.78	-0.07	0.20*	0.10	0.48*	0.48	0.49**	1.06	0.80	0.96	0.85	0.81	-0.060	0.023	-0.020	2.80**	4.06**	3.30**
x N.A.71	7.37*	2.58	0.61**	0.23*	1.13**	0.71**	0.98**	-0.52	-0.76	-0.62	-0.23	-0.27	0.059	0.023	0.090**	1.65	1.36	1.53*
x N.A.72	10.01**	3.45	0.62**	0.34**	-0.74**	-0.59**	-0.66**	-0.75	-1.99	-1.25*	0.65	0.96*	-0.011	-0.222**	-0.100**	-0.46	0.34	-0.13
N.A.60 x N.A.69	-2.70	-0.93	-0.01	0.09	0.66**	0.93**	0.73**	-0.04	0.58	0.21	0.83	0.15	-0.279	0.100**	0.030	2.67**	0.56	1.83*
x N.A.71	-10.65**	-7.08**	-0.40**	-0.33**	1.39**	0.80**	1.11**	-0.52	0.43	-0.14	-0.75	-1.18*	0.160**	0.217**	0.180**	2.86**	4.11**	3.36**
x N.A.72	2.03	0.38	0.27**	0.11	1.28**	1.06**	1.15**	-1.58*	-2.51*	-1.95**	0.80	1.20*	0.011	-0.054	-0.020	5.15**	4.24**	4.80**
N.A.69 x N.A.71	2.21	-0.38	0.50**	0.18	1.26**	0.23	0.86**	1.35	-1.10	0.37	1.00	0.95*	-0.069*	-0.192**	-0.120**	3.79**	2.65	3.34**
x N.A.72	1.41	1.58	0.63**	0.34**	1.15**	0.44	0.88**	-0.15	3.91**	1.48*	0.39	0.12	0.031	-0.053	-0.001	3.54**	2.73	2.93**
N.A.71 x N.A.72	4.90	3.23	0.03	0.02	0.87**	0.97**	0.92**	1.11	-1.74	-0.04	0.37	-0.04	0.020	0.033	0.020	0.94	0.18	0.65
L.S.D.																		
0.05 $(\hat{S}_{ij}-\hat{S}_{ik})$	11.58	9.62	0.37	0.34	0.72	0.95	0.55	2.72	3.65	2.13	1.99	1.72	0.117	0.123	0.084	3.08	5.15	2.64
0.01	15.49	12.80	0.49	0.45	0.96	1.25	0.74	3.64	4.97	2.83	2.66	2.28	0.157	0.168	0.112	4.12	7.02	3.51
0.05 $(\hat{S}_{ij}-\hat{S}_{kl})$	10.71	8.91	0.34	0.32	0.67	0.85	0.51	2.52	2.09	1.97	1.84	1.59	0.107	0.113	0.078	2.85	4.77	2.44
0.01	14.33	11.85	0.45	0.42	0.89	1.16	0.68	3.37	4.60	2.62	2.47	2.11	0.143	0.154	0.104	3.81	6.50	3.25

D_1 and D_2: Early and late planting dates, respectively.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

Results also indicated that; three, four and four crosses showed significant positive specific combining ability estimates for the No.of siliquas/branch in the early planting, late planting and their combined analysis, respectively. However, the combination N.A. 50 x N.A. 60 seemed to be the best F_1-hybrid for the trait in question.

Concerning No.of seeds/siliquae, the most desirable sca effects were recorded for the cross N.A.24 x N.A.69 in both early planting date and combined analysis.

Also, the best combinations for 1000-seed weight were N.A.50 x N.A.60 and N.A.60 x N.A.71 in early and late planting dates and the combined analysis. In this respect; five, four, and four crosses had significant positive sca effects for this trait on the early panting; late planting, and the combined analysis, respectively.

Regarding seed yield/plant, eleven, five, and twelve crosses showed significant positive specific combining ability estimates on the early planting, late planting dates and the combined analysis, respectively. In conclusion, the best combinations were N.A.50 x N.A.60, N.A.24 x N.A.71, N.A.60 x N.A.72, N.A.60 x N.A.71, N.A.69 x N.A.71, N.A. 50 x N.A.69, and N.A.24 x N.A.69. These crosses also had the highest heterosis values relative to either mid-parent or better parent in the combined analysis.

It could be concluded that the cross N.A.50 x N.A.60 seemed to be the best comination, where it had the highest sca effects for seed yield/plant as well as most of the yield components over the two planting dates. Moreover, this particular cross exhibited the highest heterosis values relative to either mid-parent or better parent as indicated earlier.

b. F_2-generation:

Results in Table (15) showed the partitioning of the genetic variance to general combining ability (gca) and specific combining ability (sca) for each trait in the two planting dates as well as the combined analysis.

General combining ability mean squares were significant only for number of racemes/plant, number of siliquas/branch and 1000-seed weight in the two planting dates and the combined analysis as well. Whereas, significant variances for specific combining ability were detected for most of the studied traits. The gca/sca ratio of variances were calculated to determine the importance of gca relative to sca. High gca/sca ratio was obtained for number of siliquas per branch in the two planting dates as well as combined analysis. Scuh results indicated that the additive and additive x additive types of gene action were responsible for controlling the inheritance of these traits. Similar results were reported by Buson (1980).

Table (15): Observed mean squares from F_2-diallel cross analysis for all the studied tratits.

Source of variation	D.F.			Plant height (cm)	Height of 1st silquae (cm)			No. of racemes/plant			No. of siliquas/branch			No. of seeds/siliquae			1000-seed weight (g)			Seed yield/plant (g)		
	D_1	D_2	Comb.	D_1	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
Genotypes(G.)	20	20	20	59.87**	0.161**	0.034	0.046**	3.97**	1.88**	2.99**	8.71**	6.87**	6.30**	1.31	2.41	1.530*	0.018**	0.019**	0.0140**	16.87**	7.55	12.14**
General combining ability (gca)	5	5	5	37.70	0.015	0.039	0.005	1.69**	1.15**	1.45**	19.95**	8.52**	13.79**	0.53	1.37	0.710	0.006*	0.012*	0.0080**	1.27	0.74	0.81
Specific combining ability (sca)	15	15	15	67.25**	0.209**	0.032	0.060**	4.74**	2.12**	3.50**	4.96**	6.31**	3.80**	1.57	2.75	1.810*	0.022**	0.021**	0.0170**	22.07**	9.82*	15.92**
G. x date			20				0.064**			0.144**			1.67**			0.220			0.0036**			1.00
gca X date			5				0.020			0.024			1.59**			0.156			0.0004			0.25
sca X date			15				0.077**			0.192**			1.70**			0.233			0.0046**			1.25
Error	40	20	60	19.76	0.018	0.068	0.016	0.06	0.095	0.036	0.61	0.63	0.33	1.21	2.41	0.810	0.002	0.003	0.0012	2.08	4.24	1.40
gca/sca				-	-	-	-	0.36	0.54	0.41	4.02	1.35	3.63	-	-	-	0.270	0.520	0.4700	-	-	-

D_1 and D_2: Early and late planting dates, respectively.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

However, non-additive gene action appeared to be more prevalent in the remained of the studied cases. Such results are in harmony with those previously reached by Govil *et al.* (1981) and Grant and Beversdorf (1985).

Significant interaction effect between planting dates and general combining ability was obtained for number of siliquas per branch. Whereas, significant sca x planting date mean squares were detected for No.of racemes/plant, No.of siliquas/branch and 1000-seed weight. In such cases, results showed that both types of gene action are influenced by environmental flactuations. However, the magnitudes of the interaction effect of sca by planting dates were higher than the corresponding gca ones for all traits. This means that non-additive types of gene action seemed to be were affected by environments than additive genetic type. Highly significant gca x planting date and sca x planting date interactions for number of siliquas/branch, showed that the magnitude of all types of gene action varied from one planting date to another.

It is worth-mentioning that the results of the interaction between both types of gene action and environments obtained from F_2 generation are similar to those of F_1-generation in most cases.

Estimates of gca effects ($\hat{g}_i$) for individual parent for number of racemes/plant, number of siliquas/branch and 1000-seed weight in the two planting dates as well as the combined analysis are presented in Table (16).

Results indicated that the parental variety N.A.24 expressed highly significant positive ($\hat{g}_i$) for number of siliquas/branch and 1000-seed weight in the two planting dates and the combined analysis. So, such variety seemed to be the best combiner for these traits. However, it exhibited significant negative values for number of racemes/plant. The variety N.A.69 was the best combiner for the number of racemes/plant in the two planting dates as well as the combined results because it had significant positive gca effects for this trait. On the other hand, the parental variety N.A.50 appeared to be poor combiner for most of the studied cases.

It could be concluded that the best combiners for the studied traits in F_2 generation were the same for the corresponding traits in the F_1 generation.

Results in Table (16) showed an excellent agreement between the parental performance and its gca effects for number of racemes/plant and number of siliquas/branch in the early planting date as well as the combined analysis. This means that selection for such traits could be practiced either on mean performance or ($\hat{g}_i$) effect basis.

Table (16): Estimates of general combining ability effects for all the studied traits in the F_2-generation.

Parental variety		No. of racemes/plant			No. of siliquas/branch			1000 seed weight (g)		
		D_1	D_2	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.
N.A.24	$(\hat{g}_i)$	-0.79**	-0.66**	-0.74**	2.91**	1.15**	2.21**	0.047**	0.063**	0.049**
	Mean	6.36	5.50	6.02	43.90	30.70	38.62	2.93	3.16	3.022
N.A.50	$(\hat{g}_i)$	0.04	-0.08	-0.01	-0.74**	-0.05	-0.46*	-0.031*	-0.030	-0.035**
	Mean	7.33	6.10	6.84	33.56	31.50	32.74	2.910	2.920	2.912
N.A.60	$(\hat{g}_i)$	0.05	0.08	0.06	0.07	0.34	0.18	-0.001	-0.046*	-0.024*
	Mean	6.76	6.05	6.48	38.13	32.00	35.68	3.030	2.780	2.928
N.A.69	$(\hat{g}_i)$	0.65**	0.50**	0.59**	-1.74**	-1.87**	-1.79**	-0.005	0.004	0.008
	Mean	9.76	7.85	9.00	31.70	25.50	29.22	3.250	3.170	3.214
N.A.71	$(\hat{g}_i)$	-0.03	0.07	0.01	0.12	0.60*	0.32	0.007	0.011	0.018
	Mean	6.76	6.15	6.52	37.66	32.85	35.74	2.980	2.880	2.942
N.A.72	$(\hat{g}_i)$	0.08	0.10	0.09	-0.63*	-0.17	-0.45*	-0.017	-0.001	0.015
	Mean	8.20	6.95	7.70	35.13	32.50	34.08	3.160	3.190	3.172
L.S.D. $(\hat{g}_i-\hat{g}_j)$	0.05	0.24	0.31	0.18	0.79	0.83	0.58	0.044	0.058	0.034
	0.01	0.32	0.43	0.24	1.05	1.14	0.77	0.059	0.080	0.045
r		0.825*	0.858*	0.830*	0.979**	0.790	0.962**	-0.259	0.648	0.194

D_1 and D_2: Early and late planting dates, respectively.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

r : Correlation coefficient between the parental mean performance and its general combining ability effects.

Insignificant correlation coefficient were obtained between the two variables for 1000-seed weight in the two planting dates and the combined analysis. Such results indicated that the best performing hybrids could be obtained by crossing between low performing vrieties.

Results in Table (17) showed sca effects of the 15 F_2 crosses for the studied traits. It was clear that significant sca was obtained for lower number of crosses in the F_2 than F_1 generation. Such results are expected since the inbreeding depression in the F_2 reduced the non-additive and/or increased the additive portion.

Regarding plant height, four F_2 crosses exhibited significant positive specific combining ability effects in the early planting. However, the cross N.A.50 x N.A.60 produced the highest desirable sca effect for such trait.

The most desirable sca effects for height of first siliquae in the combined analysis was detected in two out of the studied 15 crosses. These two crosses were N.A.50 x N.A.71 and N.A.60 x N.A.71 where they expressed significant negative sca effects.

For number of racemes/plant, ten, nine, and twelve crosses exhibited significant positive specific combining ability effects in the early planting, late planting and the combined analysis, respectively. However, the best sca

Table (17): Estimates of specific combining ability effects for all the studied traits from F_2 generation.

Cross	Plant height (cm)	Height of 1st siliquae (cm)		No. of racemes/plant			No. of siliquas/branch			No. of seeds/siliquae	1000-seed weight (g)			Seed yield/plant (g)	
	D_1	D_1	Comb.	D_1	D_2	Comb.	D_1	D_2	Comb.	Comb.	D_1	D_2	Comb.	D_1	Comb.
N.A.24 x N.A.50	-3.71	-0.09	-0.01	1.96**	0.25	1.27**	0.32	1.52*	0.80	0.12	0.182**	0.029	0.125**	5.98**	4.61**
x N.A.60	-3.97	0.28**	0.27**	0.25	0.38	0.30*	-3.85**	2.84**	-1.18**	0.03	0.142**	0.145**	0.146**	-0.68	-0.24
x N.A.69	11.46**	-0.04	0.02	-0.01	-0.09	-0.04	0.29	0.50	0.37	2.35**	-0.114**	-0.275**	-0.185**	-0.30	-0.17
x N.A.71	10.13**	0.20*	0.06	2.23**	1.84**	2.07**	0.69	0.87	0.76	-0.97	0.144**	0.078	0.105**	6.12**	5.04**
x N.A.72	7.33*	0.32**	0.18*	0.05	0.36	0.18	-3.52**	-3.50**	-3.51**	-0.45	0.058	0.030	0.050*	-1.36	-0.84
N.A.50 x N.A.60	14.48**	0.35**	0.18*	1.95**	1.85**	1.91**	-0.04	-1.96**	-0.81	-1.40*	-0.031	0.048	0.008	6.04**	4.48**
x N.A.69	-0.57	0.51**	0.27**	0.29	0.73**	0.47**	1.27*	-0.11	0.72	0.55	-0.097**	0.098*	-0.028	1.62	2.21*
x N.A.71	3.24	-0.16	-0.18*	1.40**	0.91**	1.20**	-2.35**	-0.43	-1.59**	-1.00	0.520**	0.120**	0.067**	-0.06	0.26
x N.A.72	6.11	0.58**	0.31**	0.29	0.13	0.23	0.80	-3.16**	-0.78	0.59	0.036	-0.177**	-0.047	-0.78	-0.56
N.A.60 x N.A.69	-2.59	0.26*	0.10	1.54**	1.07**	1.35**	-2.27**	-2.64**	-2.42**	0.38	-0.097**	0.004	-0.067**	5.43**	4.10**
x N.A.71	-3.01	-0.35**	-0.19*	1.09**	0.30	0.77**	0.07	-0.81	-0.29	-1.99**	0.172**	0.196**	0.173**	0.88	1.17
x N.A.72	-3.14	0.13	0.01	2.25**	1.02**	1.75**	0.19	-1.04	-0.30	1.76**	-0.164**	-0.061	-0.122**	0.03	1.11
N.A.69 x N.A.71	-1.60	0.12	0.16	0.96**	0.48*	0.77**	-1.26*	-1.06	-1.18**	0.26	-0.054	-0.004	0.050*	1.70	1.80*
x N.A.72	2.37	0.36**	0.17	0.65**	0.50*	0.59**	1.70**	3.87**	2.57**	0.57	-0.071*	-0.071	-0.077**	3.78**	2.92**
N.A.71 x N.A.72	5.75	0.40**	0.18*	1.06**	0.88**	0.99**	-1.90**	-2.81**	-2.26**	0.72	-0.162**	-0.029	-0.119**	1.64	1.37
L.S.D.															
$(\hat{S}_{ij}-\hat{S}_{ik})$ 0.05	11.88	0.36	0.34	0.65	0.86	0.50	2.08	2.19	1.52	2.38	0.119	0.156	0.092	3.86	3.12
0.01	15.90	0.48	0.45	0.87	1.17	0.67	2.79	2.99	2.02	3.17	0.160	0.213	0.122	5.16	4.15
$(\hat{S}_{ij}-\hat{S}_{kl})$ 0.05	10.99	0.33	0.30	0.61	0.79	0.46	1.92	2.02	1.40	2.20	0.111	0.144	0.084	3.58	2.98
0.01	14.71	0.44	0.40	0.81	1.08	0.61	2.57	2.76	1.86	2.93	0.149	0.196	0.112	4.79	3.96

D_1 and D_2: Early and late planting dates, respectively.
* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

effects were obtained for the cross N.A.24 x N.A.71 in the early planting and the combined results.

The most desirable sca effects for number of siliquas per branch were detected in the cross N.A.69 x N.A.72 in the two planting dates as well as the combined analysis.

Two out of the studied 15 F_2 crosses exhibited significant positive sca effects for number of seeds/siliqae in the combined analysis. These two crosses were N.A.24 x N.A.69 and N.A.60 x N.A.72.

Regarding 1000-seed weight, five, four, and seven crosses exhibited significant positive sca effects in the early planting, late planting and the combined results, respectively. The most desirable sca value was obtained for the cross N.A.60 x N.A.71 in the late planting and the combined analysis. Whereas, the crosses N.A.50 x N.A.71 and N.A.24 x N.A.60 expressed the best sca effect for such trait in the early planting and both planting dates as well as the combined analysis, respectively.

Significant positive specific combining ability effects for seed yield/plant were detected in five and seven crosses in the early planting and the combined analysis, respectively. The most desirable sca effects for such trait was recorded for the cross N.A. 24 x N.A. 71, followed by N.A.24 x N.A.50 then N.A.50 x N.A.60 in the early planting date and the combined analysis as well.

II. Seed oil content and fatty acids:

A. Analysis of variance, means, heterosis and inbreeding depression in F_1 and F_2 generations:

Percentage of seed oil content and oil yield/plant in the F_1- and F_2-generation as well as fatty acid composition in the F_1-generation was only estimated for the early planting date. Eight fatty acids (Lauric, Myristic, Palmitic, Stearic, Oleic, Lenoleic, Lenolenic, and Erucic) were determined in this study. The arcsin transformation of data was applied whenever it is necessarily.

The analysis of variance for seed oil content and oil yield/plant as well as the analyzed eight fatty acids is presented in Table (18). Results showed that mean squares due to genotypes were significant for oil seed percentage and oil yield/plant in both generations as well as five out of eight fatty acids in the F_1 generation. These fatty acids were Palmitic, Stearic, Oleic, Lenoleic, and Erucic acids.

Parents mean squares were significant for the seed oil content in both generations and the fatty acids; Palmitic, Stearic, Oleic and Erucic in the F_1-generation.

Mean performance of the six rapeseed parents is presented in Table (19). Results of the F_1-generation showed that the parental variety N.A.24 had the highest oil content percentage followed by variety N.A.71 with significant

Table (18): Observed mean squares from ordinary analysis for fatty acids and oil seed content in F_1-generation; and oil seed content in F_2-generation.

Source of variation	D.F.	Fatty acid composition (F_1)								Oil seed (F_1)		Oil seed (F_2)	
		Lauric $C_{12:0}$	Myristic $C_{14:0}$	Palmitic $C_{16:0}$	Stearic $C_{18:0}$	Oleic $C_{18:1}$	Lenoleic $C_{18:2}$	Lenolenic $C_{18:3}$	Erucic $C_{22:1}$	Oil (%)	Oil yield/plant (g)	Oil (%)	Oil yield/plant (g)
Replications	1	5.22	1.48	0.18	13.73	6.20	4.57	17.05	2.78	0.12	1.16	0.014	0.25
Genotypes	20	1.69	9.52	2.49*	22.59*	59.00**	16.67*	31.14	98.13**	1.61**	8.95**	1.280**	5.05**
Parents (P)	5	2.54	3.71	4.20*	54.69**	54.65**	9.11	30.24	110.18**	2.63**	0.28	2.630**	0.28
Crosses (C)	14	1.51	12.28	1.84	4.38	46.13**	20.51*	33.65	73.62**	1.29**	3.19**	0.870**	3.22**
P. vs C.	1	0.004	0.03	3.13	117.08**	260.88**	0.68	0.47	381.10**	0.95**	132.94**	0.150	54.64**
Error	20	1.53	5.45	1.07	9.23	6.03	7.50	16.49	1.81	0.04	0.642	0.054	0.95

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

Table (19): The genotypes mean performance for oil yield/plant (g); and for oil seed content and fatty acids (arcsin value).

Genotype	Oil seed		Oil yield/plant (g)		Fatty acid composition (F_1)							
	$F_1$$	F_2@	F_1	F_2	Lauric $C_{12:0}$	Myristic $C_{14:0}$	Palmitic $C_{16:0}$	Stearic $C_{18:0}$	Oleic $C_{18:1}$	Lenoleic $C_{18:2}$	Lenolenic $C_{18:3}$	Erucic $C_{22:1}$
N.A. 24	39.47 kl#	39.47 h	6.41 a	6.41 a-c	0.86 a	4.58 a	12.65 ab	6.93 ab	47.50 a-c	19.73 a-d	14.09 a	25.29 gh
N.A. 50	38.15 e-g	38.15 d-f	6.01 a	6.01 ab	0.76 a	4.23 a	11.43 a	14.31 bc	44.17 ab	25.56 c-e	11.55 a	22.63 d-g
N.A. 60	36.63 a	36.63 a	5.72 a	5.72 a	3.69 a	5.09 a	15.51 cd	7.56 ab	45.03 ab	19.94 a-d	4.99 a	29.60 i
N.A. 69	37.85 c-e	37.85 cd	6.14 a	6.14 ab	2.77 a	3.40 a	13.37 a-c	20.50 c	43.05 a	21.67 a-d	4.27 a	23.54 e-h
N.A. 71	38.68 h-j	38.68 fg	6.33 a	6.33 ab	1.74 a	3.92 a	13.87 a-d	9.90 ab	57.48 f-h	20.67 a-d	10.66 a	7.86 ab
N.A. 72	36.54 a	36.54 a	6.81 a	6.81 a-c	1.96 a	7.27 a	14.66 b-d	8.47 ab	47.33 a-c	21.56 a-d	10.68 a	24.04 f-h
N.A.24 x N.A.50	38.39 f-h	37.55 bc	9.74 bc	10.35 fg	1.83 a	6.55 a	13.28 a-c	11.63 ab	48.77 a-d	22.42 a-d	11.85 a	19.64 d
x N.A.60	37.94 d-f	37.94 d	7.13 a	7.88 a-e	3.45 a	6.25 a	14.89 b-d	9.22 ab	49.24 b-d	17.31 a	0.70 a	26.49 h
x N.A.69	39.62 l	39.03 gh	10.87 b-e	8.76 c-f	1.72 a	1.67 a	12.39 ab	6.91 ab	49.73 b-e	26.00 de	10.80 a	20.43 de
x N.A.71	39.53 kl	38.50 ef	12.26 e	10.02 e-g	1.00 a	5.69 a	13.94 b-d	7.48 ab	60.50 h	17.98 a	4.72 a	9.10 b
x N.A.72	38.35 f-h	37.08 ab	10.23 b-d	6.92 a-c	2.50 a	4.17 a	15.33 cd	7.13 ab	51.91 c-f	19.86 a-d	4.55 a	20.85 de
N.A.50 x N.A.60	38.15 e-g	37.56 bc	11.88 de	9.92 e-g	1.15 a	4.57 a	13.75 a-d	6.88 ab	53.64 d-g	23.80 a-e	12.04 a	14.14 c
x N.A.69	39.09 jk	38.27 d-f	10.29 b-d	8.38 b-f	2.74 a	9.16 a	14.63 b-d	5.24 a	46.64 a-c	29.28 e	12.23 a	14.89 c
x N.A.71	37.59 b-d	37.02 a	9.95 bc	8.16 b-f	1.44 a	6.39 a	14.24 b-d	7.92 ab	58.68 gh	21.28 a-d	8.53 a	5.08 a
x N.A.72	37.44 bc	36.93 a	9.00 b	7.15 a-d	2.58 a	4.96 a	14.87 b-d	6.16 a	55.13 e-f	21.28 a-d	13.21 a	9.35 b
N.A.60 x N.A.69	37.73 b-e	38.59 fg	9.83 bc	11.36 g	1.88 a	1.25 a	13.50 a-c	7.07 ab	48.07 a-d	24.79 b-e	13.92 a	21.73 d-f
x N.A.71	38.59 g-i	37.94 d	10.29 b-d	8.19 b-f	0.86 a	0.00 a	13.97 b-d	6.91 ab	59.71 h	21.50 a-d	5.68 a	9.45 b
x N.A.72	37.26 b	38.00 de	11.02 c-e	7.75 a-e	1.22 a	6.42 a	12.99 a-c	7.36 ab	49.62 b-e	21.26 a-d	14.39 a	21.25 d-f
N.A.69 x N.A.71	38.97 ij	37.73 cd	11.30 c-e	9.47 d-g	0.81 a	3.00 a	14.48 b-d	7.94 ab	56.17 f-h	19.00 a-c	11.02 a	14.94 c
x N.A.72	37.38 b	37.35 bc	9.86 bc	9.29 d-g	3.05 a	7.38 a	16.19 d	7.04 ab	47.96 a-d	22.50 a-d	12.86 a	14.60 c
N.A.71 x N.A.72	37.26 b	36.78 a	8.94 b	7.80 a-e	2.89 a	4.60 a	14.36 b-d	8.85 ab	58.38 gh	18.81 ab	7.60 a	10.46 b
r.	0.724**	0.232	-0.101	-0.488	-0.116	0.154	0.037	-0.385	0.895**	0.502*	-0.444	0.778**

$: Data of F_1 diallel set.

@ : Data of F_2 diallel set.

: Values followed by the same letter are not different at $P < 0.05$ by Duncan's L.S.R. test.

r : Correlation coefficient between mid-parent and cross mean performance.

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

differences. Moreover, such variety produced the lowest percentage of Stearic acid. On the other hand, the variety N.A.72 had the lowest oil content in its seeds followed by the parent N.A.60 without significant difference. Meanwhile, the later variety exhibited the highest value of Palmitic and Erucic acids percentage. Whereas, the variety N.A.50 contained the lowest Palmitic acid content.

Also, it was clear that the parental variety N.A.69 produced the highest percentage of Stearic and Oleic fatty acids. While, the lowest values of Oleic and Erucic acids percentage were recorded for the vriety N.A.71.

It could be concluded that the parental variety N.A.71 was ranked the second highest parent in producing seed oil percentage which contained the lowest value of Erucic acid (7.86).

Results of the F_2-generation showed that the parental variety N.A.24 produced significantly the highest oil percentage. Whereas, the variety N.A.72 expressed the highest oil yield/plant without significant differences from the othe parents.

Crosses mean squares were significant for seed oil percentage and oil yield/plant in both generations, and the three fatty acids; Oleic, Lenoleic and Erucic in the F_1-generation.

F_2-hybrid N.A.24 x N.A.69 followed by N.A.60 x N.A.69 had the highest desirable value for seed oil content. Meanwhile, the F_2-combinations N.A.60 x N.A.69 exhibited the best oil yield/palnt. Whereas, the lowest value for this trait was recorded for the cross N.A.24 x N.A.72.

Mean squares for parents vs. crosses as indication to average heterosis overall hybrids was significant for: oil seed content, oil yield/plant, and the three fatty acids, Stearic, Oleic, and Erucic, in the F_1-generation, and oil yield/plant in the F_2-generation.

Significant mean squares for parents vs. crosses for F_1-data along with insignificant F_2-data for oil seed content were detected. The absence of heterosis in this case might be due to the lower magnitude of the nonadditive type of gene action (Table 21).

Heterosis expressed as the percentage deviation of F_1-mean performance from the mid and better parent is presented in Table (20).

Results indicated that eight and two crosses significantly exceeded the mid-parent and the better parent values, respectively for seed oil content. The F_1-cross N.A.50 x N.A.69 exhibited the most desirable heterotic effect relative to mid and better parent.

Table (20): Percentage of heterosis over both mid-parent (Mp) and better parent (Bp); and inbreeding depression for the studied crosses.

Cross	Oil seed percentage (arcsine value)					Oil yield/plant (g)					Fatty acid composition F_1 (arcsine value)									
	F_1		F_2			F_1		F_2			Palmitic ($C_{16:0}$)		Stearic ($C_{18:0}$)		Oleic ($C_{18:1}$)		Lenoleic ($C_{18:2}$)		Erucic ($C_{22:1}$)	
	Mp	Bp	Mp	Bp	I.D.	Mp	Bp	Mp	Bp	I.D.	Mp	Bp	Mp	Bp	Mp	Bp	Mp	Bp	Mp	Bp
N.A.24 X N.A.50	-1.08*	-2.74**	-3.25**	-4.86**	2.19**	56.84**	51.95**	66.67**	61.47**	-6.26	10.30	4.98	9.51	-18.73	6.39	2.67	-1.02	-12.28	-18.03**	-22.34**
X N.A.60	-0.29	-3.88**	-0.29	-3.88**	0.00	20.43	14.04	29.82*	22.93	-7.80	5.75	-4.00	27.17	21.96	6.42	3.66	-12.75	-13.19	-3.50	-10.51*
X N.A.69	2.48**	0.38	0.96	-1.11	1.49**	73.09**	69.58**	39.49**	36.66*	19.41**	-4.77	-7.33	-49.64*	-66.29**	9.83*	4.69	25.60*	19.98	-16.34**	-19.22**
X N.A.71	1.15*	0.15	-1.48**	-2.46**	2.61**	92.46**	91.26**	57.30**	56.32**	18.27**	5.13	0.50	-11.16	-24.44	15.26**	5.25	-10.99	-13.01	-45.11**	-64.02**
X N.A.72	0.89	-2.84**	-2.45**	-6.06**	3.31**	54.77**	50.22**	4.69	1.62	32.36**	12.23	4.57	-7.40	-15.82	9.47*	9.28	-3.83	-8.22	-15.48**	-17.56**
N.A.50 X N.A.60	2.03**	0.00	0.45	-1.55*	1.55**	102.39**	97.67**	68.99**	65.06**	16.50*	2.08	-11.35	-37.11	-51.92*	20.27**	19.12**	4.62	-6.89	-45.87**	-52.23**
X N.A.69	2.87**	2.46**	0.71	0.31	2.10**	69.24**	67.59**	37.83*	36.48*	18.56*	17.98*	9.42	-69.90**	-74.44**	6.95	5.59	23.96*	14.55	-35.51**	-36.75**
X N.A.71	-2.16**	-2.82**	-3.64**	-4.29**	1.52**	61.26**	57.19**	32.25*	28.91	17.99*	12.57	2.67	-34.60	-44.65*	15.44**	2.09	-7.96	-16.74	-66.69**	-77.55**
X N.A.72	0.24	-1.86**	-1.12*	-3.20**	1.36**	40.41**	32.16*	11.54	4.99	20.56*	13.95	1.43	-45.92	-56.95*	20.50**	16.48**	-9.68	-16.74	-59.94**	-16.11**
N.A.60 X N.A.69	1.32**	-0.32	3.63**	1.96**	-2.28**	65.77**	60.10**	91.57**	85.02**	-15.56*	-6.51	-12.96	-49.61*	-65.51**	9.15	6.75	19.13	14.40	-18.22**	-26.59**
X N.A.71	2.47**	-0.23	0.74	-1.91**	1.68**	70.65**	62.56**	35.82*	29.38	20.41**	-4.90	-9.93	-20.85	-30.20	16.48**	3.88	5.86	4.02	-49.55**	-68.07**
X N.A.72	1.83**	1.72**	3.85**	3.74**	-1.99**	75.76**	61.82**	23.60	13.80	29.67**	13.92	-16.25*	-8.23	-11.21	7.45	4.84	2.46	-1.39	-20.77**	-28.21**
N.A.69 X N.A.71	1.83**	0.75	-1.41*	-2.46**	3.18**	81.09**	78.52**	51.76**	49.61**	16.19*	6.31	4.40	-47.76*	-61.27**	11.74*	-2.28	-10.25	-12.32	-4.84	-36.53**
X N.A.72	0.48	-1.24*	0.40	-1.32*	0.08	52.16**	44.79**	43.36**	36.42*	5.78	15.48*	10.44	-51.41*	-65.66**	6.13	1.33	4.07	3.83	-38.63**	-39.27**
N.A.71 X N.A.72	-0.93	-3.67**	-2.21**	-4.91**	1.29**	36.07**	31.28*	18.72	14.54	12.75	0.63	-2.05	-3.70	-10.61	11.39*	1.57	-10.94	-12.76	-34.42**	-56.49**

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

Table (21): Observed mean squares from F_1-diallel cross analysis for fatty acids and oil seed; and from F_2 for oil seed

Source of variation	D.F.	Fatty acid composition					Oil seed F_1		Oil seed F_2	
		Palmitic $C_{16:0}$	Stearic $C_{18}:0$	Oleic $C_{18:1}$	Lenoleic $C_{18:2}$	Erucic $C_{22:1}$	Oil (%)	Oil yield per plant(g)	Oil (%)	Oil yield per plant(g)
Genotypes	20	1.25*	11.30*	29.50**	8.34*	49.07**	0.81**	4.48**	0.64**	2.53**
General combining ability (gca)	5	1.45*	9.74	79.57**	18.18**	128.79**	2.40**	0.23	1.40**	0.63
Specific combining ability (sca)	15	1.18*	11.99*	146.14**	5.06	22.49**	0.28**	5.89**	0.39**	3.16**
Error	20	0.535	4.615	3.015	3.750	0.905	0.020	0.321	0.027	0.475
gca/sca		1.23	-	0.54	-	5.73	8.57	-	3.59	-

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

Concerning oil yield/plant, fourteen out of fifteen tested crosses showed significant positive heterosis over both mid and better parent. However, the best heterotic effect was detected in the cross N.A.50 x N.A.60 followed by the cross N.A'.24 x N.A.71.

Heterosis in rapeseed oil content was previously reported by Sernyk and Stefansson (1983). on the contrary, Grant and Beversdorf (1985) reported insignificant heterosis for percent of seed oil.

For Palmitic fatty acid, two crosses N.A.50 x N.A.69 and N.A.69 X N.A.72 exhibited significant heterotic effect over the mid-parent value. Whereas,the cross N.A.60 x N.A.72 expressed the highest negative heterosis over the better parent.

Regarding Stearic fatty acid, five and nine F_1-combinations had significant negative heterosis over the mid-parent and the better parent, respectively. While, the hybrid N.A.50 x N.A.69 gave the highest negative heterotic effects in both cases.

Significant positive heterosis over both mid and better parent for Oleic fatty acid was obtained from nine and two crosses, respectively. Moreover, the most desirable heterotic effect was recorded for the cross N.A.50 x N.A.60, followed by the cross N.A.50 x N.A.71.

Regarding Lenoleic fatty acid, the two crosses N.A.24 x N.A.69 and N.A.50 x N.A.69 expressed the highest heterotic effect relative to the mid-parent. Whereas, non of the studied hybrids significantly surpassed better parent value.

Results of Erucic acid showed that thirteen out of the studied fifteen crosses exhibited heterosis relative to mid-parent. While, all of the studied hybrids possessed significant negative better parent heterosis. It was noticed that the cross N.A.50 x N.A.71 had the most desirable heterotic effect for Erucic fatty acid since it expressed the highest negative heterosis over the mid-parent (-66.67%) and better parent (-77.55%).

It worth-noting that the hybrid N.A.50 x N.A.60 ranked the highest fourth and sixth in Erucic acid for both mid and better parent heterosis, respectively. This particular cross exhibited the best heterotic effect for oil yield/plant and Oleic fatty acid content. In addition, it had the most desirable heterotic effect for seed yield/plant. Therefore, it might be useful in hybrid oil seed rape breeding programs.

Results of the F_2-generation, showed that the most desirable effects of remain heterosis over both mid and better parent for oil content was only detected in two out of the studied 15 crosses. These two crosses were N.A.60 x N.A.69 and N.A.60 x N.A.72.

Regardig oil yield per plant, eleven and eight F_2-combinations had significant positive remain heterosis over the mid and better parent, respectively. However, the cross N.A.60 x N.A.69 gave the highest remain heterotic effect 91.57 and 85.02% for the respective cases. Similar results were reported by Sernyk and Stefansson (1983).

Concerning inbreeding depression, results in Table (20) showed significant possitive percentage for oil content and oil yield/plant in eleven and ten F_2-crosses, respectively. The cross N.A.24 x N.A.72 expressed the highest values 3.31 and 32.36% for the two respective traits.

B. Combining ability in F_1 and F_2 generations:

Results in Table (21) indicated that the mean squares for the general combining ability were significant for seed oil percentage in both generations, and four fatty acids (Palmetic, Oleic, Lenoleic and Erucic) in the F_1-generation. However, specific combining ability variances were significant for seed oil content, oil yield/plant in both generations and four fatty acids (Palmitic, Stearic, Oleic and Erucic) in the F_1-generation. The variance associated with gca was highly significant, meanwhile, sca variance did not significantly differ from error variance for Lenoleic fatty acid. For such case, one would accept the hypothesis that the performance of a single-cross progeny can be adequantely predicted on the basis of additive and additive x additive types of gene action.

On comparing the magnitude of gca/sca, results showed that high ratios which largely exceed the unity were detected for seed oil content in both generations as well as the three fatty acids (Palmitic, Lenoleic, and Erucic) in the F_1-generation. So, the additive and additive x additive gene action appeared to be the most important components of variance for these traits. However, non-additive genetic variance played a major role in the expression of oil yield/plant in both generations as well as Stearic and Oleic fatty acids content in the F_1-generation.

Several investigators reported the importance of additive effects of genes on seed oil content and fatty acid composition. Among those are Harvey and Downey (1964); Stefansson and Hougen (1964); Krzymanski and Downey (1969); Jonsson (1977); Grami and Stefansson (1977) and Selim *et al.*(1981).

On the other hand, Shelkoudenko (1974); Grant and Beversdorf (1985); and Gupta *et al.* (1985): found that the non-additive type of gene action was predominant in controlling these traits.

Data on general combining ability effects ($\hat{g}_i$) for individual parental varieties in each trait in both generations are presented in Table (22). It was clear that variety N.A.24 possessed the highest positive ($\hat{g}_i$) effect

Table (22): Estimates of general combining ability effects for oil seed in F_1 and F_2 generation; and in F_1 for fatty acids.

Parental variety		Oil seed (%) F_1	Oil seed (%) F_2	Fatty acid composition: Palmitic $C_{16:0}$	Oleic $C_{18:1}$	Lenoleic $C_{18:2}$	Erucic $C_{22:1}$
N.A.24	$(\hat{g}_i)$	0.74**	0.56**	-0.35	-0.55	-1.13	3.16**
	Mean	39.47	39.47	12.65	47.50	19.73	25.29
N.A.50	$(\hat{g}_i)$	0.01	-0.11*	-0.56*	-1.05	2.14**	-1.68**
	Mean	38.15	38.15	11.43	44.17	25.56	22.63
N.A.60	$(\hat{g}_i)$	-0.49**	-0.16**	0.25	-1.15	-0.44	3.81**
	Mean	36.63	36.63	15.51	45.03	19.94	29.60
N.A.69	$(\hat{g}_i)$	0.20**	0.27**	-0.02	-3.11**	1.61*	1.49**
	Mean	37.85	37.85	13.37	43.05	21.67	23.54
N.A.71	$(\hat{g}_i)$	0.30**	0.10	0.08	6.10**	-1.52*	-7.13**
	Mean	38.68	38.68	13.87	57.48	20.67	7.86
N.A.72	$(\hat{g}_i)$	-0.76**	-0.66**	0.62*	-0.24	-0.65	0.35
	Mean	36.54	36.54	14.66	47.33	21.56	24.04
L.S.D. $(\hat{g}_i-\hat{g}_j)$	0.05	0.15	0.17	0.77	1.81	2.02	1.00
	0.01	0.20	0.23	1.05	2.48	2.76	1.37
r		0.969**	0.842*	0.886*	0.985**	0.800	0.955**

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

r : Correlation coefficient between the parental mean performance and its general combining ability effects.

for seed oil content followed by variety N.A.71 then N.A.69. Therefore, it seemed to be the best general combiner for such trait despite of the nonappreciable expression of gca effects for the studied fatty acids.

Results of the F_2-generation indicated that the parental variety N.A. 24 expressed the highest positive ($\hat{g}_i$) effect for oil content. Therefore, this variety seemed to be the best general combiner for this trait followed by N.A.69. Whereas, the parent N.A.72 was the worst combiner for the trait under study.

Results of F_1-generation, showed that variety N.A.50 appeared to be the best combiner for Lenoleic fatty acid, and the second good combiner for Erucic acid. Meanwhile, the parental variety N.A.71 produced the highest desirable effects for Oleic and Erucic fatty acids. Consequently, this parent behaved as the best general combiner for both fatty acids, and as the lowest one for Lenoleic fatty acid.

Parental variety N.A.72 seemed to be the only best combiner for Palmitic fatty acid since it significantly expressed positive ($\hat{g}_i$) effect among all of the studied varieties.

It was clear that variety N.A.60 exhibited undesirable ($\hat{g}_i$) effects for all of the studied traits. The parental variety N.A.69 seemed to be one of the good combiners for seed oil content and for Lenoleic acid. Whereas, it was poor for the other studied traits.

Significant correlation coefficients between the parental performance and its gca were detected for all of the studied characters except for Linoleic acid (Table 22). Such agreement might be of additional proof about the preponderance of additive genetic variance in these traits.

Estimates of the specific combining ability effects for seed oil content and oil yield/plant in both generations as well as four fatty acids in the F_1-generation are presented in Table (23). Results of the F_1-generation indicated that eight hybrids showed significant positive sca effects for seed oil content. Moreover, the cross N.A.50 x N.A.69 had the highest desirable sca value for such trait, followed by the cross N.A.60 x N.A.71 then N.A.24 x N.A.69.

Concerning oil yield/plant, nine combinations expressed significant positive specific combining ability effects (Table 23). Generally, the cross N.A.50 x N.A.60 exhibited the highest sca vlaue for the trait in question. On the other hand, the lowest sca effect was detected in the hybrid N.A.24 x N.A.60.

Significant desirable sca effects in the F_2-generation were obtained for oil content (three crosses) and oil yield/plant (five crosses). While, the highest desirable sca

Table (23): Estimates of specific combining ability effects for oil seed and fatty acids.

Parental variety	Oil seed (%) F$_1$	Oil seed (%) F$_2$	Oil yield/plant (g) F$_1$	Oil yield/plant (g) F$_2$	Fatty acid composition: Palmitic $C_{16:0}$	Oleic $C_{18:1}$	Lenoleic $C_{18:2}$	Erucic $C_{22:1}$
N.A.24 x N.A.50	-0.48**	-0.69**	0.79	2.29**	0.17	2.77	-1.00	0.76
x N.A.60	-0.43**	-0.26*	-1.66**	-0.25	0.97	2.10	-0.42	2.12**
x N.A.69	0.56**	0.41**	1.72**	0.25	-1.25*	-3.04	2.03	-1.62*
x N.A.71	0.36**	0.05	2.99**	1.92**	0.20	-0.43	3.58*	-4.33**
x N.A.72	0.25*	-0.61**	1.30**	-0.71	1.04	-0.10	1.33	-0.06
N.A.50 x N.A.60	0.51**	0.04	3.11**	1.88**	0.04	-1.52	4.47**	-5.39**
x N.A.69	0.75**	0.33	1.16*	-0.03	0.21*	-4.58**	-0.57	-2.32**
x N.A.71	-0.85**	-0.76**	0.70	0.15	0.71	-1.27	2.26	-3.51**
x N.A.72	0.07	-0.08	0.09	-0.38	0.79	-2.35	5.05**	-6.72**
N.A.60 x N.A.69	-0.10	0.69**	0.86*	2.88**	-0.75	-2.42	0.97	-3.96
x N.A.71	0.65**	0.21	1.20**	0.11	-0.38	-0.54	3.39*	-4.63**
x N.A.72	0.39**	1.03**	2.27**	0.15	-1.90**	0.58	-0.35	-0.31
N.A.69 x N.A.71	0.34**	-0.43**	1.86**	1.02	0.41	-2.34	1.81	3.19**
x N.A.72	-0.18	-0.04	0.76	1.31*	1.58**	-2.57	-0.06	-4.63**
N.A.71 x N.A.72	-0.41**	-0.45**	-0.28	0.23	-0.35	1.28	1.15	-0.16**
L.S.D. $(\hat{S}_{ij}-\hat{S}_{ik})$ 0.05	0.40	0.45	1.56	1.90	2.02	5.92	4.80	2.63
0.01	0.54	0.62	2.13	2.59	2.76	8.08	6.54	3.58
$(\hat{S}_{ij}-\hat{S}_{kl})$ 0.05	0.35	0.42	1.44	1.75	1.88	5.49	4.44	2.44
0.01	0.48	0.57	1.96	2.39	2.56	7.48	6.06	3.33

* and ** : Significant at 0.05 and 0.01 levels of probability, respectively.

effects were detected in the crosses: N.A.60 x N.A.72 for oil content, and N.A.60 x N.A.69 for oil yield/plant.

The most desirable sca effects for Palmitic fatty acid content was obtained in two out of the studied 15 F_1-hybrids. Such hybrids were N.A.69 x N.A.72 and N.A.50 x N.A.69. None of the studied F_1 combinations showed desirable sca effect for Stearic acid, whereas one cross (N.A.50 x N.A.69) exhibited significant negative sca value.

For Oleic fatty acid, four hybrids expressed significant positive sca effects. The best combination was N.A.50 x N.A.72 followed by N.A.50 x N.A.60 then N.A.24 x N.A.71 and N.A.60 x N.A.71.

Results also, showed that eight out of the studied 15 F_1-hybrids exhibited significant negative specific combining ability for Erucic fatty acid content. Generally, the hybrid N.A.50 x N.A.72 showed the best sca value for this trait followed by the cross N.A.50 x N.A.60.