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HETEROSIS OF SOME CANOLA HYBRIDS UNDER DIFFERENT PLANT POPULATION DENSITY.

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ABSTRACT

Two field experiments were carried out at the Experimental Station, Fac. of Agric., Mansoura Univ. during the growing seasons of 1997/98 and 1998/99. This investigation was aimed to evaluate heterosis estimations of different seed yield, its components and some related traits in some canola parents and their hybrids under different plant population density. The genetic materials used in this investigation included four lines of canola representing a wide range of diverse origins. These four lines are Drakkar, Fido, Serw 4 and Serw 6. These four parental genotypes were made according to a complete diallel matting design to produce 6 F_1 hybrids and 6 F_1 reciprocals. A split plot design with three replicates was used to evaluate canola parents and their hybrids at different plant population density. It could be summarized the main findings as follows:

The cross combination between S 33 X S 30 also recorded the highest heterosis values over the mid-parents for leaf area index (LAI), number of siliqua per plant, seed yield per plant and seed yield (t/fed) in most of cases. While, the cross combination S 33 X S 34 showed the best cross for oil percentage. Also, the F_{1r} hybrid S 33 X S 30 recorded the highest heterosis value over better parent for seed yield per plant and seed yield (t/fed). The F_1 hybrid S 30 X S 34 recorded the highest values of percent heterosis over better parent for number of primary branches per plant and 1000 seed weight. In the case of oil percentage, the cross combination between S 33 X S 34 recorded the best heterosis values over better parent.

It could be concluded that maximum seed yield of canola at Dakahlia district could be gained by planting the F_{1r} hybrid S 33 x S 30 at dense plant population of 20 plants/m^2 (84000 plants/fed).

INTRODUCTION

Rapeseed (*Brassica napus, L.*) is one of the important oil crops all over the world. It has the third position in world oil production crops, second position in total world area for oil crops and the fifth in world international trade for crops. Canola is grown mainly for its edible oil, providing good quality oil, meal, straw and honey.

Heterosis may be defined as the increases in percentage of the F_1 hybrids performance above the average of its parents or better parent .The majority of international research reports indicated that most of F_1 hybrids were better or such as their parents for yield and its components. In this respect, Davik (1997) carried out a 4 X 4 diallel cross and a 4 X 9 factorial mating design using 13 cultivars of *Brassica napus* sp. rapifera. Better parent heterosis of dry matter yield (on average 10.5%) and marketable yield were found for the majority of hybrids. Parkash *et al.* (1997) found an appreciable increase in oil content of toria *(Brassica campestris* L.*)*. Six hybrids showed

heterosis over their better parent and heterosis was the highest (10.67%) in the cross (White flower X TS61).

Thakur and Sagwal (1997) evaluated 36 F_1hybrids which were produced from nine diverse inbred lines of *Brassica napus* L. Estimates of heterosis over the better parent (BP) for the various traits were significant for seed yield (-14.8 to 82.8%), primary branches (-26.0 to 193.6%) and number of siliqua per plant (-21.9 to 162.0%). The cross (GSB7027 X HNS8803) gave the highest positive heterosis for seed yield per plant. Yadav *et al.* (1997) evaluated 6 lines and their 15 F_1 hybrid for yield components. The cross (White flower X TC113) gave the highest negative heterosis (being desirable) for plant height. The crosses (White flower X TS61), (TH68 X TC113), (White flower X Sangam) and (White flower X TS61) were the best for seed yield.

Varshney and Roa (1997) estimated heterosis in yellow sarson *(Brassica campestris* L.*)* for 11 quantitative characters. Heterosis over better parent was highest for siliqua per plant (162.9%), followed by economic yield per plant (129.4%), biological yield per plant (118.7%), and primary branches per plant (88.1%). Yadav *et al.* (1998) evaluated crosses between 9 female and 3 male sarson *(Brassica campestris)* parents for 7 yield components. Eighteen hybrids exhibited significant positive heterosis. Highest heterotic response for seed yield was observed in (DBI X Pusa Kalyani) and (BSIK1 X BSIK2).

MATERIALS AND METHODS

The genetic material which were used in this investigation included four canola (*Brassica napus*, L.) lines, S 30, S 32, S 33 and S 34, which refers to inbred lines of Drakkar, Fido, Serw4 and Serw6, respectively. Drakkar and Fido are French and English homozygous lines, respectively. While Serw4 is a homozygous line obtained via anther culture and Serw6 is a homozygous double haploid line obtained from natural haploid plant. All these lines were supplied by the Oil Crop Research Section, Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Giza, Egypt.

During the growing season of 1996/97 at El–Serw Experimental Station, A. R. C. Seeds of these lines was sown. At the flowering stage, all possible combinations among these four parental lines were made according to a complete diallel cross. Hybridization was done by hand. Bud of female plants were emasculated 2–3 days before flower opening and bagged to avoid out–crossing. Crossing was practiced 2–3 days after emasculation according to artificial pollination method. At maturity, the hybrid seed was obtained.

The seed of the six F_1 hybrids and their reciprocals in addition to selfed seed of the four parents were evaluated in 1997/1998 and 1998/1999 growing seasons at the Experimental Station, Fac. of Agric. Mansoura University. In each season of 1997/98 and 1998/99, the experiments were conducted at three plant population densities i.e. 42000, 63000 and 84000 plants / fed (10, 15 and 20 plants / m^2 as D_1, D_2 and D_3 respectively). In each

experiment, the four parents, 6 F_1 and 6 F_1 reciprocals were grown in a split-plot design with three replications. Each plot area consists of 6 ridges 3.5 meters length and 50 cm in row width occupying an area 10.5 m^2. The distance between hills were 10, 13.3 and 20 cm apart and plants were thinned before the first watering to secure one plant per hill. Normal agricultural practices as recommended by Ministry of Agriculture and Land Reclamation were followed. In both seasons canola preceded by corn (*Zea mays* L.). Canola seeds were hand sown with the usual dry method (Afir planting) in Nov^{10th} and Nov^{15th} in 1997/98 and 1998/99 winter seasons, respectively.

The studied characters were leaf area index, number of days to 50% flowering, number of primary branches per plant, number of siliqua per plant, 1000 seed weight, seed yield per plant, seed yield per feddan and seed oil percentage

The amount of heterosis was estimated as percentage increase for every single cross over the average of its parents and above the better parents. Therefore, the values of heterosis could be estimated from the equations:

Heterosis from the mid – parents (M. P.):

$$H\ (F_1, M.\ P.)\ \% = (F_1 - M.\ P.) / M.\ P.\ X\ 100$$

Heterosis from better parent (B. P.):

$$H\ (F_1, B.\ P.)\ \% = (F_1 - B.\ P.) / B.\ P.\ X\ 100$$

All obtained datd were subjected to the statistical analysis of the split plant desing as desribed by Gomez and Gomez(1984).

The differences between any two means were tested for significance using the least significant difference value (LSD) at both 5% and 1% levels of probability .

RESULTS AND DISCUSSION

Heterosis over the mid-parents:

The estimated amounts of heterosis were determined for all studied traits through three plant population densities in the two seasons of 1997/98 and 1998/99 and the results are presented in Tables 1, 2 and 3 for the first, second and third plant population density, respectively in 1997/98 season and Tables 4, 5 and 6 for the first, second and third plant population density, respectively in 1998/99 season.

The results cleared that the cross combination between S 33 X S 30 recorded the highest heterosis values for leaf area index (LAI), number of siliqua per plant, seed yield per plant, seed yield (t/fed) in most cases with values ranged from 29.3% for number of siliqua per plant to 71.36% for leaf area index (LAI). The F_1 hybrid S 30 X S 34 showed the highest values of heterosis percentage for number of primary branches per plant in the first season with the values of 36.6, 47.7 and 16.0% for 10.15 and 20 plants/m^2 respectively. While, the F_1 hybrid S 30 X S 33 recorded the highest values of percent heterosis in the second season especially for the second and third plant population density. In the case of 1000 seed weight, the cross

combination S 30 X S 34 appeared to be the best one especially for the first and third plant population density with values ranged from 3.84 to 6.89%. While, its reciprocal combination S 34 X S 30 recorded the highest amount of heterosis in the second plant population density with the values of 5.25 and 3.83% for the first and second seasons, respectively. Furthermore, the F_{1r} hybrid S 34 X S 30 recorded the favorable values of heterosis for seed yield per plant and faddan for the plant population densities in both seasons. Regarding

Table 1: The amount of heterosis over the mid-parents estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the first plant population (10 plants/m^2) in 1997/98 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran. /plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield /plant (g)	Seed yield (t/fed)	Oil %
30 X 32	3.59	13.9**	- 2.7	- 3.3	- 6.67*	8.9	6.19	4.0**
30 X 33	52.06**	10.2**	5.7	28.0**	- 10.63**	30.6**	37.18**	- 3.5**
30 X 34	26.02*	11.2**	36.6**	- 5.8	4.89	21.9	37.37**	- 2.9**
32 X 33	12.24	10.6**	- 14.8*	- 30.3**	- 17.79**	- 30.6**	2.24	- 4.4**
32 X 34	51.34**	7.6**	13.6*	7.4	- 14.53**	19.3	29.85**	5.4**
33 X 34	41.16**	9.0**	- 19.8**	- 23.4**	- 9.60**	- 19.3	- 3.98	16.7**
32 X30	4.04	14.4**	- 8.9	- 8.8	- 10.14**	3.1	1.73	1.1**
33 X30	50.77**	14.4**	18.9**	32.2**	- 12.07**	39.9**	48.61**	- 2.1**
34 X 30	47.43**	8.0**	9.9	17.4**	- 1.22	33.7**	35.93**	- 5.4**
33 X 32	21.17	12.6**	- 5.6	- 3.9	- 8.26**	4.9	14.34**	- 0.5
34 X 32	33.33**	6.6**	33.3**	4.5	- 17.09**	4.2	17.86**	2.1**
34 X 33	25.71	4.7**	- 10.4	26.6**	- 20.62**	11.6	14.16**	12.8**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 2: The amount of heterosis over the mid-parents estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the second plant population (15 plants/m^2) in 1997/98 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	5.45	13.5**	4.3	- 6.5	- 6.97	14.6*	- 3.39	5.8**
30 X 33	63.97**	9.8**	15.6**	29.3**	- 12.05**	37.2**	34.28**	- 0.7*
30 X 34	49.25**	11.7**	47.7**	8.5	4.26	25.2**	23.97**	- 2.6**
32 X 33	22.79**	10.5**	- 5.4	- 23.7**	- 18.90**	- 22.7**	- 4.79	- 5.0**
32 X 34	50.99**	8.2**	14.4*	10.8	- 12.11**	13.2	19.80**	4.6**
33 X 34	37.97**	8.0**	- 15.1*	- 25.8**	- 12.04**	- 16.4*	- 2.04	16.2**
32 X30	32.74**	15.6**	5.3	- 5.3	- 10.91**	2.9	- 2.81	2.8**
33 X30	71.36**	14.5**	34.4**	39.0**	- 14.16**	42.6**	44.42**	- 3.5**
34 X 30	65.36**	8.3**	11.4*	23.9**	5.25	36.5**	37.96**	- 3.8**
33 X 32	21.77**	12.5**	8.7	0.2	- 15.76**	4.4	5.57	- 2.1**
34 X 32	36.26**	7.0**	14.4*	- 0.9	- 10.56**	8.3	18.07**	0.7*
34 X 33	37.70**	4.3**	- 7.0	14.1	- 20.99**	0.5	12.86**	11.6**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 3: The amount of heterosis over the mid-parents estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the third plant population (20 plants/m^2) in 1997/98 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	12.44	15.0**	4.2	- 10.8*	- 5.66*	6.3	13.18**	5.0**
30 X 33	58.26**	11.0**	11.0*	36.8**	- 14.69**	35.2**	45.16**	2.9**
30 X 34	44.58**	14.3**	16.0**	12.0	3.84	23.8*	24.97**	-3.7**
32 X 33	35.81**	11.1**	0.0	- 27.1**	- 17.17**	- 29.1**	- 8.69*	-3.5**
32 X 34	39.45**	9.5**	7.3	4.6	- 5.41*	37.0**	31.56**	4.8**
33 X 34	33.26**	6.2**	- 18.8**	- 23.2*	- 6.73**	- 19.0*	- 7.75	17.5**
32 X30	32.17**	17.7**	13.1*	- 13.8	- 15.09**	0.6	5.87	0.7
33 X30	66.96**	15.3**	13.4*	47.5**	- 15.63**	37.6**	42.39**	- 3.7**
34 X 30	64.62**	9.8**	13.6*	36.7**	2.46	38.4**	52.11**	- 7.8**
33 X 32	33.95**	14.0**	- 3.6	- 7.5	- 12.65**	0.6	- 3.05	- 0.5
34 X 32	48.37**	8.8**	1.2	4.5	- 11.82**	3.0	17.21**	1.0*
34 X 33	28.75**	6.5**	- 5.0	36.2**	- 17.51**	11.0	6.88	14.2**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 4: The amount of heterosis over the mid-parents estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the first plant population (10 plants/m^2) in 1998/99 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	18.50**	10.3**	19.2**	- 8.6**	- 4.02**	10.6	- 10.38*	3.4**
30 X 33	59.41**	11.5**	27.9**	17.6**	- 8.22**	28.9*	27.26**	- 1.6**
30 X 34	55.22**	10.1**	26.1**	- 4.4	6.89**	18.4	37.52**	- 3.2**
32 X 33	24.64**	9.6**	- 13.9**	- 26.7**	- 16.49**	- 24.4*	- 8.69*	- 6.5**
32 X 34	60.70**	7.8**	14.7**	4.4	- 15.69**	16.9	10.61**	5.9**
33 X 34	37.29**	8.4**	- 5.8	- 24.5**	- 10.22**	- 21.4	- 12.88**	16.9**
32 X30	28.41**	15.0**	1.3	- 11.3**	- 9.48**	0.3	- 11.46**	0.9*
33 X30	52.47**	12.9**	18.7**	31.7**	- 12.18**	33.0**	43.78**	- 5.2**
34 X 30	64.29**	6.9**	32.8**	21.1**	- 2.10**	22.4	50.70**	- 5.3**
33 X 32	24.17**	12.3**	- 2.4	- 1.3	- 16.22**	6.4	- 15.54**	- 4.4**
34 X 32	37.70**	7.8**	17.0**	8.1**	- 15.69**	10.1	18.17**	- 1.0**
34 X 33	20.06*	4.2**	4.4	32.8**	- 21.55**	- 1.7	- 12.97**	13.81**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Oil percentage, the cross combination S 33 X S 34 showed the best cross for all densities in both seasons and the amount of heterosis ranged from 16.2 to 17.5%. However, the F_1, hybrid S 32 X S 30 recorded the highest values of heterosis percentage for number of days to 50% flowering for all densities in both seasons with the values ranged from 14.4 to 17.7%.

Table 5: The amount of heterosis over the mid-parents estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the second plant population (15 plants/m^2) in 1998/99 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	11.79**	9.1**	17.5**	- 12.5**	- 7.04**	5.0	- 8.96	3.5**
30 X 33	45.38**	10.7**	31.2**	12.4**	- 11.11**	30.3**	25.99**	- 1.7**
30 X 34	44.91**	11.0**	16.6**	- 7.9*	3.51**	16.0	24.10**	- 4.1**
32 X 33	16.94**	9.7**	- 6.2	- 24.1**	- 19.56**	- 24.6*	- 13.90*	- 5.8**
32 X 34	49.94**	8.2**	23.9**	8.4**	- 12.28**	16.3	10.47	4.7**
33 X 34	28.99**	8.8**	- 6.9	- 19.8**	- 12.24**	- 18.6	- 13.94	17.2**
32 X30	25.98**	15.4**	- 0.6	- 9.8**	- 11.73**	1.8	- 7.78	0.7
33 X30	58.55**	12.8**	31.2**	29.3**	- 14.62**	33.5**	32.81**	- 5.0**
34 X 30	60.91**	6.9**	25.9**	15.3**	3.83**	39.9**	55.83**	- 4.8**
33 X 32	18.03**	10.2**	13.3**	- 1.8	- 17.36**	2.9	- 11.84	- 3.9**
34 X 32	33.20**	5.8**	22.6**	0.7	- 12.57**	5.7	13.22	- 2.2**
34 X 33	15.96**	3.2*	6.9	15.2**	- 21.79**	- 1.7	- 8.05	13.6**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 6:The amount of heterosis over the mid-parents estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the third plant population (20 plants/m^2) in 1998/99 season.

Hybrid	L A I	Days to 50% flowering	No.of ri. bran./ plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	6.28	8.4**	5.5	- 21.6**	- 5.57**	3.1	2.89	4.7**
30 X 33	59.94**	9.8**	25.2**	34.4**	- 15.36**	33.5**	32.43**	- 0.7*
30 X 34	29.65**	12.2**	6.3	- 2.5	5.57**	23.0*	18.79**	- 2.8**
32 X 33	6.56	10.8**	- 1.6	- 24.5**	- 19.77**	- 25.5**	- 14.75**	- 7.0**
32 X 34	26.45**	8.8**	9.1	- 1.4	- 6.60**	16.0*	24.08**	4.1**
33 X 34	19.27**	7.2**	- 3.8	- 28.2**	- 7.63**	- 23.5**	- 10.72**	17.1**
32 X30	17.71**	15.6**	- 5.8	- 0.6	- 16.10**	- 1.6	0.13	2.0**
33 X30	63.33**	10.8**	15.9*	57.6**	- 17.47**	36.4**	34.79**	- 4.2**
34 X 30	56.01**	6.6**	20.7**	49.8**	5.24**	41.6**	43.01**	- 4.0**
33 X 32	29.59**	10.7**	- 13.3*	- 6.2	- 16.91**	- 2.0	- 10.04**	- 4.0**
34 X 32	29.27**	6.1**	23.9**	- 2.5	- 9.57**	8.8	11.20**	- 2.5**
34 X 33	11.81**	3.9*	3.3	29.7**	- 3.44**	6.0	- 5.21	13.8**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Concerning the results from combined data over all densities in the first and second seasons (Tables 7 and 8, respectively), the amount of heterosis over the mid-parents ranged from – 24.47 to 63.03% for seed yield per plant and leaf area index (LAI), respectively in the fist season and from – 25.10 to 60.40% for 1000-seed weight and leaf area index (LAI), respectively in the second season. The results cleared that the cross combination between S 33 X S 30 recorded the highest heterosis values for leaf area index (LAI), seed yield per plant, seed yield (t/fed) in the first season, and number of siliqua per plant in both seasons. The F_1 hybrid S 30 X S 34 showed the highest values of heterosis percentage for number of primary branches per plant in the first season with the value of 33.34%. While, the F_1 hybrid S 30 X S 33 recorded the highest value of percent heterosis in the second season with the value of 28.10%. In the case of 1000 seed weight, the cross combination S 30 X S 34 appeared to be the best one with the values of 4.33 and 5.32% in the first and second seasons, respectively. Regarding oil percentage, the cross combination S 33 X S 34 showed the best cross in both seasons and the amount of heterosis were 16.80 and 17.07% in the first and second seasons, respectively. However, the F_{1r} hybrid S 32 X S 30 recorded the highest values of heterosis percentage for number of days to 50% flowering in both seasons with the values of 15.90 and 15.33% in the first and second seasons, respectively.

Heterosis over better parent:

The amount of heterosis over better parent for all studied traits were obtained at three plant population densities and the results of the first season of 1997/98 are presented in Tables 9, 10 and 11 as well as the results of the second season of 1998/99 are presented in Tables 12, 13 and 14 for the first, second and third plant population density, respectively.

The results indicated the cross combination between S 33 X S 30 recorded the highest values of heterosis percentage for leaf area index (LAI) and number of siliqua per plant for most plant population densities in both seasons. Also, The F_{1r} hybrid S 33 X S 30 recorded the highest heterosis percentage for seed yield per plant and seed yield (t/fed) for most plant population densities in the both seasons. The F_1 hybrid S 30 X S 34 recorded the highest values of heterosis percentage for number of primary branches per plant especially in the first season with the values of 25.2, 41.3 and 14.6% for the first, second and third plant population density, respectively. However, the cross combination between S 30 X S 34 recorded the highest values of heterosis percentage for 1000 seed weight especially for the first and third plant population density.

The results also showed that the F_{1r} hybrid S 32 X S 30 appeared to be the best cross for number of days to 50% flowering with amount of heterosis ranged from 13.6 to 16.7%. In the case of oil percentage, the cross combination between S 33 X S 34 recorded the best heterosis values for all densities in both seasons with values ranged from 14.5 to 17.5%.

Table 7: The amount of heterosis over the mid-parents estimated from combined data over all densities of F_1 hybrids and F_1 reciprocal for all studied traits in 1997/98 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	7.16	14.13**	1.93	- 6.87	- 6.43**	9.93	5.33	4.93**
30 X 33	58.10**	10.33**	10.77	31.37**	- 12.46**	34.33**	38.87**	- 0.43**
30 X 34	39.95**	12.40**	33.43**	4.90	4.33	23.63*	28.77**	- 3.07**
32 X 33	23.61**	10.73**	- 6.73	- 27.03**	- 17.95**	- 27.47**	- 3.75	- 4.30**
32 X 34	47.26**	8.43**	11.77*	7.60	- 10.68**	23.17*	27.07**	4.93**
33 X 34	37.46**	7.73**	- 17.90**	- 24.13**	- 9.46**	- 18.23	- 4.59	16.80**
32 X30	22.98**	15.90**	3.17	- 9.30	- 12.05**	2.20	1.60	1.53**
33 X30	63.03**	14.73**	22.23**	39.57**	- 13.95**	40.03**	45.14**	- 3.87**
34 X 30	59.14**	8.70**	11.63	26.00**	2.16	36.20**	42.00**	- 5.67**
33 X 32	25.63**	13.03**	- 0.17	- 3.73	- 12.22**	3.30	5.62	- 1.40**
34 X 32	39.32**	7.47**	16.30*	2.70	- 13.16**	5.17	17.71**	1.27**
34 X 33	30.72**	5.17**	- 7.47	25.63*	- 19.71**	7.70	11.30*	12.87**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 8: The amount of heterosis over the mid-parents estimated from combined data over all densities of F_1 hybrids and F_1 reciprocal for all studied traits in 1998/99 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	12.19*	9.27**	14.07**	- 14.23**	- 5.54**	6.23	- 5.48**	3.87**
30 X 33	54.91**	10.67**	28.10**	21.47*	- 11.56**	30.90**	28.56**	- 1.33**
30 X 34	43.26**	11.10**	16.33**	- 4.93	5.32**	19.13	26.80**	- 3.37**
32 X 33	16.05**	10.03**	- 7.23	- 25.10**	- 18.61**	- 24.83*	- 12.45**	- 6.43**
32 X 34	45.70**	8.27**	15.90**	3.80	- 11.52**	16.40	15.05**	4.90**
33 X 34	28.52**	8.13**	- 5.50	- 24.17**	- 10.03**	- 21.17	- 12.51*	17.07**
32 X30	24.03**	15.33**	- 1.70	- 7.23**	- 12.44**	0.17	- 6.37**	1.20**
33 X30	58.12**	12.17**	21.93**	39.53**	- 14.76**	34.30**	37.13**	- 4.80**
34 X 30	60.40**	6.80**	26.47**	28.73**	2.32*	34.63**	49.85**	- 4.70**
33 X 32	23.93**	11.07**	- 0.80	- 3.10	- 17.27**	2.43	- 12.47**	- 4.10**
34 X 32	33.39**	6.57**	21.17**	2.10	- 12.61**	8.20	14.20**	- 1.90**
34 X 33	15.94**	3.77**	4.87	25.90**	- 15.59**	0.87	- 8.74	13.74**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 9: The amount of heterosis over better parent estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the first plant population (10 plants/m^2) in 1997/98 season.

Hybrid	L A I	Days to 50% flowering	No. of pri.bran. /plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/pl ant (g)	Seed yield (t/fed)	Oil %
30 X 32	2.90	13.2**	- 4.4	- 12.0*	- 12.50**	0.0	4.02	0.4**
30 X 33	33.48**	6.7**	1.8	12.6*	- 16.84**	28.8*	36.48**	- 2.9**
30 X 34	5.20	7.1**	25.5**	- 9.5	3.00	15.3	27.85**	- 4.2**
32 X 33	- 2.00	7.8**	- 20.0**	- 41.7**	- 18.45**	- 37.5**	1.00	- 4.6**
32 X 34	25.39*	4.3**	1.7	- 2.6	- 18.49**	3.1	18.73**	3.7**
33 X 34	33.53*	8.4**	- 23.8**	- 30.1**	- 14.44**	- 22.7	- 11.07*	14.6**
32 X30	29.18**	13.6**	- 10.4	- 14.1*	- 15.76**	- 6.1	- 0.20	1.3**
33 X30	26.24*	10.8**	14.6*	16.3*	- 18.18**	38.0**	47.85**	- 3.8**
34 X 30	23.08	4.0**	0.9	12.7	- 0.60	26.4*	26.50**	- 6.6**
33 X 32	5.79	9.7**	- 11.3	- 19.7**	- 12.50**	- 5.6	12.75*	- 1.1**
34 X 32	10.47	3.3**	10.4	- 5.2	- 20.92**	- 10.0	7.77	0.5
34 X 33	18.56	4.1**	- 14.9**	15.6*	- 24.87**	7.0	- 4.51	10.7**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 10: The amount of heterosis over better parent estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the second plant population (15 plants/m^2) in 1997/98 season.

Hybrid	L A I	Days to 50% flowerin g	No. of pri. bran./pl ant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/pl ant (g)	Seed yield (t/fed)	Oil %
30 X 32	- 4.58	12.5**	3.2	- 11.7	- 11.27**	- 0.7	- 8.96*	4.4**
30 X 33	54.68**	5.6**	13.0*	16.2	- 16.81**	34.8**	29.31**	- 2.3**
30 X 34	30.07**	7.3**	41.3**	7.6	1.60	22.9*	11.53*	- 5.5**
32 X 33	2.29	7.3**	- 8.4	- 31.2**	- 19.37**	- 29.2**	- 13.40**	- 5.2**
32 X 34	20.95**	5.2**	8.4	5.4	- 18.21**	0.0	2.26	2.8**
33 X 34	27.09**	7.9**	- 17.1*	- 33.8**	- 18.80**	- 19.4*	- 8.75	14.5**
32 X30	11.97**	14.6**	4.2	- 10.6	- 15.03**	- 7.7	- 8.41*	1.4**
33 X30	61.66**	10.1**	31.5**	24.9**	- 18.80**	40.1**	39.08**	- 5.1**
34 X 30	44.44**	4.0**	6.5	22.9**	2.56	33.9**	24.12**	- 6.7**
33 X 32	4.40	9.3**	5.3	- 14.4	- 16.24**	- 4.4	- 3.66	- 2.4**
34 X 32	9.15*	3.7*	8.4	- 5.7	- 16.76**	- 4.4	0.78	- 1.0*
34 X 33	26.85**	4.2**	- 9.1	1.8	- 27.07**	- 3.1	- 13.88**	10.0**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 11: The amount of heterosis over butter parent estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the third plant population (20 plant/m^2) in 1997/98 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	7.70	14.0**	2.4	- 13.6	- 9.09**	- 1.6	4.01	2.3**
30 X 33	41.43**	7.6**	11.0	16.2	- 18.02**	32.7**	43.06**	1.2**
30 X 34	27.17**	9.3**	14.6*	2.7	- 3.59	15.4	15.93**	- 7.5**
32 X 33	16.86*	7.4**	- 2.4	- 39.6**	- 17.42 **	- 33.2**	- 14.95**	- 4.9**
32 X 34	18.17*	5.7**	3.5	- 6.8	- 15.15**	18.9	12.94**	3.2**
33 X 34	30.85**	5.9**	- 19.8**	- 29.4*	- 16.82**	- 29.8**	- 15.56**	17.5**
32 X30	26.60**	16.7**	11.8*	- 16.4	- 18.18 **	- 6.8	- 2.70	- 1.9**
33 X30	49.21**	10.5**	13.4**	25.3**	- 18.92 **	35.1**	43.34**	- 7.5**
34 X 30	44.76**	5.1**	12.2*	25.3**	- 4.90	27.2*	40.34**	- 11.5**
33 X 32	15.26*	10.2**	- 5.9	- 23.0*	- 12.91**	- 5.3	- 9.69*	- 2.0**
34 X 32	25.73**	5.0**	- 2.4	- 6.8	- 20.91**	- 10.5	0.62	- 0.5
34 X 33	26.41*	6.2**	- 6.2	25.2*	- 26.43**	1.8	2.17	14.2**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 12: The amount of heterosis over better parent estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the first plant population (10 plants/m^2) in 1998/99 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	8.91	9.8**	13.6**	- 14.8**	- 9.73**	1.0	- 24.45**	1.3**
30 X 33	55.93**	7.5**	24.7**	4.1	- 14.96**	26.8	15.81**	- 4.2**
30 X 34	36.80**	5.2**	17.4**	- 7.8*	4.08**	13.6	30.25**	- 7.3**
32 X 33	6.48	6.1**	- 15.3**	- 38.9**	- 15.14**	- 31.9**	- 16.15**	7.2**
32 X 34	24.29**	3.4**	2.2	- 5.8*	- 18.65**	2.9	- 10.77**	3.5**
33 X 34	23.35**	7.5**	- 14.3**	- 31.0**	- 14.70**	- 23.45	- 24.50**	15.0**
32 X30	18.02*	14.5**	- 3.4	- 17.3**	- 14.86**	- 8.4	- 25.36**	- 1.1*
33 X30	49.15**	8.8**	15.8**	16.6**	- 18.64*	30.9*	30.85**	- 7.8**
34 X 30	44.79**	2.2*	23.7**	16.9**	- 4.66**	17.4	42.72**	- 9.3**
33 X 32	6.07	8.7**	- 4.6	- 17.8**	- 16.22**	- 4.2	- 22.44**	- 5.1**
34 X 32	6.48	3.4**	4.3	- 2.5	- 19.19**	- 3.1	- 4.67	- 3.2**
34 X 33	7.89	3.2**	- 5.0	21.4**	- 25.46**	- 4.2	- 24.57**	11.9**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 13: The amount of heterosis over better parent estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the second plant population (15 plants/m^2) in 1998/99 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	4.64*	8.4**	15.6**	- 15.4**	- 12.43**	- 3.9	- 18.43**	1.4**
30 X 33	35.78**	6.3**	25.5**	- 1.4	- 16.25**	29.3*	20.23*	- 4.2**
30 X 34	27.89**	6.4**	11.2*	- 10.9**	1.25	9.1	11.41	- 7.6**
32 X 33	2.72	6.2**	- 8.5*	- 35.3**	- 19.34**	- 32.0**	- 19.43**	- 6.3**
32 X 34	24.32**	4.4*	19.6**	1.5	- 19.06**	0.33	- 9.96	2.9**
33 X 34	21.35**	5.3**	- 7.44	- 27.5**	- 19.01**	- 22.9	- 25.88**	15.8**
32 X30	17.92**	14.5*	- 1.0	- 12.7**	- 16.85**	- 6.9	- 17.37*	- 1.4**
33 X30	48.07**	8.4**	25.82**	13.4**	- 19.56**	32.41**	26.73**	- 7.4**
34 X 30	42.02**	2.4	20.1**	11.5**	1.56	31.2*	39.89**	- 8.3**
33 X 32	3.68	6.6**	10.6*	- 16.3**	- 17.13**	- 7.2	- 17.50*	- 4.3**
34 X 32	11.04**	2.1	19.0	- 5.8	- 19.33**	- 8.82	- 7.72	- 3.9**
34 X 33	9.09**	2.9	6.3	4.1	- 27.82**	- 6.8	- 20.80**	12.2**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Table 14: T`he amount of heterosis over better parent estimated from means of F_1 hybrids and F_1 reciprocal for all studied traits at the third plant population (20 plants/m^2) in 1998/99 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	- 2.7	7.7**	5.2	- 24.7**	- 10.29**	- 5.2	- 6.10*	3.7**
30 X 33	52.3**	5.4**	21.4**	15.5**	- 21.29**	29.8**	29.12**	- 2.0**
30 X 34	21.1**	8.2**	0.34	- 3.2	- 1.31	16.5	8.82*	- 10.0**
32 X 33	- 6.6	6.1**	- 4.2	- 37.2**	- 21.57**	- 30.5**	- 20.35**	- 7.2**
32 X 34	8.7	5.6**	3.4	- 5.9	- 16.76**	0.0	4.57	2.0**
33 X 34	16.8*	6.7**	- 6.5	- 37.9**	- 21.01**	- 29.8**	- 20.07**	15.3**
32 X30	7.8	14.8*	- 6.1	- 4.4	- 20.29**	- 9.5	- 8.62**	- 1.0**
33 X30	55.4**	6.4**	12.4	35.5**	- 32.25**	32.6**	31.42**	- 5.4**
34 X 30	45.7**	2.8	13.9	29.1**	- 1.63	34.1**	31.01**	- 6.9**
33 X 32	13.5*	6.9**	- 15.6*	- 22.0 **	- 18.77**	- 8.6	- 15.95**	- 4.7**
34 X 32	11.1*	3.0	17.4*	- 7.0*	- 19.41**	- 6.2	- 6.28*	- 4.5**
34 X 33	9.5	3.3*	0.5	12.2	- 29.13**	- 2.8	- 15.14**	12.1**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

the values of 14.97 and 14.60% in the first and second seasons, respectively. Similar results were obtained by many investigators such asfaik *et al* (1999), Hari *et al* (1995), Davik (1997), Parkash *et al.* (1997), Thakur and Sagwal (1997) and Varshney and Rao (1997).

It could be concluded that the amount of heterosis in most of studied traits was higher at the dense plant populationi.e-20 plants/m^2 This might be attributed to heterozygosity in hybrid plants, which make them much efficient. The efficiency of these heterozygous plants clearly shown under more competition between plants for water, nutrients and for light compared with homozygous plants.

Table 15: The amount of heterosis over better parent estimated from combined data over all densities of F_1 hybrids and F_1 reciprocal for all studied traits in 1997/99 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. Bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	2.01	13.23**	0.40	- 12.43	- 10.95**	- 0.77	- 0.31	2.37**
30 X 33	43.20**	6.63**	8.60	15.00	- 17.22**	32.10**	36.28**	- 1.33**
30 X 34	20.81*	7.90**	27.13**	0.27	0.34	17.87	18.44**	- 5.73**
32 X 33	5.72	7.50**	- 10.27	- 37.50**	- 18.41**	- 33.30**	- 9.12*	- 4.90**
32 X 34	21.50**	5.07**	4.53	1.33	- 17.28**	7.33	11.31*	3.23**
33 X 34	30.49**	7.40**	- 20.23**	- 31.10**	- 16.69**	- 23.97*	- 11.79*	15.53**
32 X30	22.58**	14.97**	1.87	- 13.70	- 16.32**	- 6.87	- 3.77	0.27
33 X30	45.70**	10.47**	19.83**	22.17**	- 18.63**	37.73**	43.42**	- 5.47**
34 X 30	37.43**	4.37**	6.53	20.30*	- 0.98	29.17*	30.58**	- 8.27**
33 X 32	8.48	9.73**	- 3.97	- 19.03*	- 13.88**	- 5.10	- 0.20	- 2.07**
34 X 32	15.12*	4.00**	5.47	- 5.90	- 19.53**	- 8.30	3.06	- 0.33
34 X 33	23.94*	4.83**	- 10.07	14.20	- 26.12**	1.90	- 5.41	11.63**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

Concerning the results from combined data over all densities in the first and second seasons (Tables 15 and 16), the amount of heterosis over better parent ranged from – 37.50 to 45.70% in the fist season and from – 37.13 to 50.87% for 1000-seed weight and leaf area index (LAI) in both seasons, respectively. The results cleared that the cross combination between S 33 X S 30 recorded the highest heterosis values for seed yield (t/fed) in the first season and leaf area index (LAI), number of siliqua per plant and seed yield per plant (t/fed) in both seasons. The F_1 hybrid S 30 X S 34 showed the highest values of heterosis percentage for number of primary branches per plant in the first season with the value of 27.13%. While, the F_1 hybrid S 30 X S 33 recorded the highest value of percent heterosis in the second season with the value of 23.87%. In the case of 1000 seed weight,

the cross combination S 30 X S 34 appeared to be the best one with the values of 0.34 and 1.34% in the first and second seasons, respectively. Regarding oil percentage, the cross combination S 33 X S 34 showed the best cross in both seasons and the amount of heterosis were 15.53 and 15.37% in the first and second seasons, respectively. However, the F_{1r} hybrid S 32 X S 30 recorded the highest values of heterosis percentage for number of days to 50% flowering in both seasons with

Table 16: The amount of heterosis over better parent estimated from combined data over all densities of F_1 hybrids and F_1 reciprocal for all studied traits in 1998/99 season.

Hybrid	L A I	Days to 50% flowering	No. of pri. Bran./plant	No. of siliqua/ plant	1000 seed weight (g)	Seed yield/plant (g)	Seed yield (t/fed)	Oil %
30 X 32	3.62	8.63**	11.47*	- 18.30**	- 10.82**	- 2.70	- 16.33**	2.13**
30 X 33	48.00**	6.40**	23.87**	6.07	- 17.50**	28.63*	21.72**	- 3.47**
30 X 34	28.60**	6.60**	9.65	- 7.30*	1.34	13.07	16.83**	- 8.30**
32 X 33	0.87	6.13**	- 9.33	- 37.13**	- 18.68**	- 31.47**	- 18.64**	- 2.10**
32 X 34	19.10**	4.47**	8.40	- 3.40	- 18.16**	1.08	- 5.39	2.80**
33 X 34	20.50**	6.50**	- 9.41	- 32.13**	- 18.24**	- 25.38*	- 23.48**	15.37**
32 X30	14.58**	14.60**	- 3.50	- 11.47**	- 17.33**	- 8.27	- 17.12**	- 1.17*
33 X30	50.87**	7.87**	18.01**	21.83**	- 23.48**	31.97*	29.67**	- 6.87**
34 X 30	44.17**	2.47**	19.23**	19.17**	- 1.58	27.57*	37.87**	- 8.17**
33 X 32	7.75	7.40**	- 3.20	- 18.70**	- 17.37**	- 6.67	- 18.63**	- 4.70**
34 X 32	9.54*	2.83*	13.57*	- 5.10	- 19.31**	- 6.04	6.22	- 3.87**
34 X 33	8.83	3.13*	0.60	12.57**	- 27.47**	- 4.60	- 20.17**	12.07**

*, ** Denote significant at 0.05 and 0.01 levels of probability, respectively.

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قوة الهجين لبعض هجن الكانولا تحت مستويات مختلفة من الكثافة النباتية

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**** معهد بحوث المحاصيل الحقلية ، مركز البحوث الزراعية بالجيزة ، مصر.**

أجريت كل التهجينات الممكنة بين أربعة من سلالات الكانولا النقية وهي دراكار ، سرو ٤ ،سرو٦ ،فيدو وذلك في محطة البحوث الزراعية بالسرو خلال الموسم الزراعي ١٩٩٧/٩٦ ثم أجريت تجربتان حقليتان بمزرعة كلية الزراعة جامعة المنصورة خلال موسمي ١٩٩٨/٩٧ و ١٩٩٩/٩٨ على التوالي تم تنفيذ التجارب بنظام القطع المنشقة مرة واحدة في ثلاث مكررات حيث احتوت القطع الرئيسية على ١٦ من التراكيب الوراثية و هي: السلالة دراكار ، السلالة فيدو ، السلالة سرو٤ و السلالة سرو٦ وكل الهجن الممكنة بين هذه السلالات بما فى ذلك الهجن العكسية. بينما احتوت القطع الشقية على معاملات الكثافات النباتية و هي: ٤٢٠٠٠ نبات/فدان (١٠ نباتات/م٢) و ٦٣٠٠٠ نبات/فدان (١٥ نباتات/م٢) و ٨٤٠٠٠ نبات/فدان (٢٠ نباتات/م٢) و يمكن تلخيص أهم النتائج المتحصل عليها فى النقاط الآتية:

١. أوضحت النتائج أن النسبة المئوية لقوة الهجين لمعظم الهجن كانت معنوية ، كما أظهرت النتائج أن الهجين س ٣٠ X س ٣٣ سجل أعلي نسبة مئوية لقوة الهجين بالنسبة لمتوسط أبوية لصفات دليل مساحة الأوراق ، عدد القرون/النبات ، محصول البذور/النبات و محصول البذور (طن/فدان) وذلك لمعظم الكثافات خلال الموسمين.

٢. أشارت النتائج أن النسبة المئوية لقوة الهجين لمعظم الهجن كانت معنوية ، كذلك أظهرت النتائج أن الهجين س ٣٠ X س ٣٣ سجل أعلي نسبة مئوية لقوة الهجين بالنسبة لأعلى أبوية لصفات محصول البذور/النبات ، محصول البذور (طن/فدان) وذلك تحت معظم الكثافات خلال الموسمين بينما سجل الهجين س ٣٤X س ٣٠ أعلي نسبة مئوية لقوة الهجين بالنسبة لأعلى أبوية لصفات عدد الفروع/النبات و وزن ١٠٠٠ بذرة أما بالنسبة لنسبة الزيت فقد سجل الهجين س ٣٤ X س ٣٣ أعلي نسبة مئوية لقوة الهجين بالنسبة لأعلى أبوية.

٣. توصى الدراسة بزراعة الهجين سرو٤ X دراكار و ذلك تحت الكثافة النباتية المرتفعة (٢٠ نباتات/م٢) بهدف زيادة إنتاجية وحدة المساحة لمحصول الكانولا تحت ظروف محافظة الدقهلية.