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HETEROSIS AND COMBINING ABILITY FOR YIELD AND ITS COMPONENTS IN CANOLA

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ABSTRACT

A half diallel crosses was practiced among five Canola genotypes having diverse morphological and agronomical characters. The F1 (ten crosses) and the five parents were evaluated. The results indicated that the mean squares of genotypes and crosses were highly significant for all studied traits except for 1000-seed weight. Also the mean squares of parents were highly significant for all studied traits except 1000-seed weight and number of racemes/plant. Both general and specific combining ability (GCA and SCA) variance were found to be highly significant for all studied traits except plant height and number of racemes/plant for GCA and plant height and fruiting zone for SCA. The ratio of GCA / SCA variances were found to be greater than unity for flowering date, plant height and fruiting zone indicating that the additive of gene action was of greater importance in the inheritance of these traits. The ratio of GCA /SCA variances were less than unity for number of racemes / plant, seed weight/plant, 1000-seed weight and oil percentage indicating that non additive gene action was of greater importance in the inheritance of these traits. Estimates of GCA effects revealed that the parental inbred lines NA1012 and Dippe were good combiners for earliness. Moreover, NA1012 was good combiner for 1000-seed weight and oil percentage. On the other hand, Trebiska was a good combiner for seed weight / plant, 1000-seed weight and oil percentage. These results seem important for making the proper decision when initiating a crossing plan. Six crosses: (NA 1012 X Trebiska), (NA 1012 X Serw 4), (Dippe X Trebiska), (Dippe X Serw 4), (Trebiska X Hybridol) and (Serw 4 X Hybridol) showed the highest SCA effect for seed weight / plant. On the other hand three crosses: Dippe X Hybridol, Dippe X Trebiska and Trebiska X Serw 4 showed the highest SCA effect for oil percentage. These crosses also recorded highly significant and positive estimates of heterosis when measured as a deviation from both mid and better parents for these two traits.

Key words: ***Canola, Brassica napus, Heterosis, Heterobeltiosis, Combining ability effects, Yield, Yield components***

INTRODUCTION

Canola (*Brassica napus* L.) is one of the most important oil crops in the world. Canola became a new oil crop in Egypt, which may reduce the gab between the local production and consumption of the edible oil. However, growing this crop in Egypt is still facing many problems, among which is the competition with the major winter field crops and the availability of limited numbers of adapted varieties for the Egyptian agricultural conditions.

Combining ability studies are frequently used by plant breeders to evaluate newly developed cultivars for their parental usefulness and to asses the gene action involved in various characters. This study helps also in designing an efficient breeding plan for further genetic upgrading of the existing materials. The parents of the best potentiality to transmit their superiority to the progeny are those exhibiting the highest value for general combining ability (GCA) effects whereas, combinations of highest specific combining ability effects (SCA) demonstrate exploitation of heterosis concept. General and specific combining ability effects and heterosis have been studied in Canola by several investigators (Habetinek 1993, Krzymanski *et al*1993and 1994, Kudla 1993 and 1996, Wos *et al* 1997, Satwinder *et al* 1997, Tyagi *et al* 2000, Wael 2003, Mahmoud 2004 and Mohamed 2004)

The main objectives of this study were to detect the magnitude of both GCA and SCA as well as heterosis and heterobeltiosis for seed yield and some other characters.

MATERIALS AND METHODS

Five canola parental genotypes i.e. NA1012 (P_1) Australia, Dippe (P_2) Czecho, Trebiska (P_3) Czecho., Serw 4 (P_4) Egypt and Hybridol (P_5) France, were used in the present study. These parents were chosen to represent a wide range of variability in most of the economic characters.

In 2003/2004 season the five canola parental genotypes were crossed in diallel combinations excluding reciprocals at Giza Research Station ARC. In 2004/2005 season, the parental genotypes along with F_1's (15 genotypes) were planted at El-Gemmeiza Agricultural Research Station. A randomized complete block design with three replications was used.Each experimental plot consisted of four rows, 4 m. long and 60 cm. apart, plant spacing was 20cm. At harvest, 5 individual guarded plants were chosen at random from a one inner row and the following characters were recorded, days to 50% flowering, plant height (cm), length of fruiting zone (cm), number of racemes/plant, 1000-seed weight (g), seed weight / plant (g) and oil percentage which was determined according to the standard Method of A.O.A.C.(1990) using Soxhlet apparatus and hexane as solvent. The data obtained were statistically analyzed on individual plant mean basis. Combining ability analysis and various effects were estimated according to Griffing (1956) Method 2 Model 1. Heterosis (%) as F_1 mid parent/mid parent and heterobeltiosis as F_1 – higher parent / higher parent x 100 were calculated. Significance of heterosis and heterobeltiosis x 100 were computed by Bhatt (1971).

RESULTS AND DISCUSSION

The analysis of variance for days to 50% flowering, plant height, length of fruiting zone, number of racemes/plant, seed yield/plant, 1000-seed weight and oil percentage are presented in Table (1). Significant differences among genotypes were detected in all traits except 1000-seed weight and accounted for major portion of the phenotypic variation. Significant mean squares related to parents were obtained for all traits except number of racemes / plant and 1000-seed weight. Meantime, significant mean squares due to crosses were detected for all traits except 1000-seed weight revealing over all differences among genotypes. Mean squares for parents vs. hybrids as an indication to average heterosis over all crosses were observed for all traits except number of racemes / plant. The partitioning of genetic variations into general (GCA) and specific (SCA) combining ability showed that both general and specific combining ability variances were found to be highly significant for all studied traits except plant height and number of racemes/plant for GCA and plant height and fruiting zone for SCA. This indicated the importance of both additive and non-additive genetic variance in determining the performance of these characters.

Table 1. Mean squares for the studied characters in the parents and F_1 for the diallel crosses.

S.V	df	Days to 50% flowering	Plant height, cm	Length of fruiting zone, cm	Number of racemes/ plant	Seed weight/ plant	1000-seed weight	Oil %
Genotypes	14	40.88**	617.21**	316.41**	3.42**	391.46**	1.15 NS	34.10**
Parents	4	22.45**	336.38**	101.10**	0.79 NS	12.20**	0.09 NS	12.06**
Crosses (F_1)	9	49.82**	619.75**	437.95**	4.96**	373.79**	1.26 NS	45.78**
P. vs C.	1	34.13**	1717.6**	83.84**	0.02 NS	2067.5**	4.32*	17.10**
G.C.A	4	11.52**	159.36NS	95.82*	0.57 NS	64.81**	0.27**	3.37**
S.C.A	10	9.66**	153.55 NS	61.94 NS	1.07**	111.15**	0.32**	10.75**
Error	42	1.66	314.59	126.50	1.35	21.29	0.15	0.15
GCA/SCA		1.19	1.04	1.55	0.53	0.58	0.84	0.31

Indicate significant at 0.05 and 0.01 levels of probability, respectively

Results also revealed that additive type of gene action was the most important part of the total genetic variability in days to 50% flowering, plant height and length of fruiting zone. For such case, one would accept the hypothesis that the performance of single cross progeny can be adequately predicated on the basis of additive. The best performing progeny, therefore, may be produced by crossing the two parents which had the highest GCA effects.

The mean performance of the five canola parental genotypes are presented in Table 2. It is obvious from this table that the genotype Hybridol (P5) possessed the earliest plants. Moreover, genotype Dippe (P2) had the tallest plants. Meanwhile, the genotype NA 1012 (P1) gave the highest value of number of branches/plant and oil seed percentage. On the other hand, genotype Trebiska (P3) exhibited the highest value of seed weight / plant and 1000-seed weight.

The mean performance of the F_1's is presented in Table (2). Data indicated that two crosses (P_1 x P_2 and P_1 x P_4) presented the earliest plants and recorded less days to flowering the earliest parent (93 and 94.3 days , respectively). In addition, the crosses $P_3 \times P_4$ recorded the highest values for plant height, fruiting zone and number of racemes / plant. On the other hand, the cross $P_1 \times P_4$ gave the highest values of seed weight / plant and 1000-seed weight. Finally, the cross $P_2 \times P_3$ possessed the highest value of seed oil percentage.

Table 2. Mean performance of canola genotypes for studied traits during 2004/2005 season.

	Days to 50% flowering	Plant height, cm	Length of fruiting zone, cm	Number of racemes/ plant	Seed weight/ plant, g	1000-seed weight, g	Oil%
Parents							
NA 1012	100.8	143.7	128.3	6.9	40.0	3.40	46.17
Dippe (P_2)	98.0	162.1	132.3	6.1	36.0	3.28	41.50
Trebiska	100.5	143.0	132.9	6.7	40.1	3.46	44.22
Serw 4 (P_4)	101.0	159.6	140.0	6.4	38.1	3.13	44.38
Hybridol	95.5	157.9	139.5	5.8	37.4	3.13	45.10
Crosses							
$P_1 \times P_2$	93.0	142.5	126.7	5.2	41.2	3.53	43.91
$P_1 \times P_3$	95.3	173.3	123.3	6.4	59.2	4.66	46.52
$P_1 \times P_4$	94.3	162.9	128.3	6.1	60.8	4.79	47.63
$P_1 \times P_5$	96.5	147.1	118.3	4.6	47.9	4.22	44.04
$P_2 \times P_3$	95.3	176.3	136.6	5.5	54.5	4.07	49.06
$P_2 \times P_4$	100.8	175.4	134.6	7.4	55.8	3.20	45.61
$P_2 \times P_5$	95.3	166.2	147.5	7.4	28.8	3.79	48.40
$P_3 \times P_4$	102.0	179.5	148.3	8.1	49.1	3.53	48.38
$P_3 \times P_5$	102.0	164.6	126.2	7.0	54.0	3.55	42.81
$P_4 \times P_5$	101.3	158.3	129.9	6.2	56.3	3.20	38.00
$LSD_{0.05}$	1.8	25.3	16.1	1.7	6.5	0.55	0.55

Data in Table (3) illustrated heterosis and heterobeltiosis. For days to 50% flowering the negative value of heterosis indicate that the hybrid is earlier than the earliest parent. However, four out of ten crosses (P_1xP_2, P_1xP_3, P_1xP_4 and $P_2\times P_3$) were earlier than their corresponding earlier parents and recorded highly significant negative heterosis percentage relative to both mid and better parents. Therefore, these crosses may be considered as source for earliness in breeding programs.

With respect to plant height, three crosses (P_1xP_3, $P_2\times P_3$ and $P_3\times P_4$) out of ten exhibited positive and significant as heterosis .On the other hand, one of the ten crosses P_1xP_3 exhibited significant positive heterobeltiosis.

For number of racemes / plant, two crosses ($P_2\times P_5$ and $P_3\times P_4$) had significant positive heterosis.

For seed weight / plant all crosses except two had highly significant positive heterosis. On the other hand, four crosses ($P_1\times P_3$, $P_1\times P_4$, $P_1\times P_5$ and $P_2\times P_3$) also exhibited significant positive heterosis for 1000-seed weight.

Taking oil percentage into consideration, five crosses (P_1xP_4, $P_2\times P_3$, $P_2\times P_4$, $P_2\times P_5$ and $P_3\times P_4$) showed significant positive heterosis.

From these results in Table (3) it could be noticed that the two crosses (P_1xP_4 and $P_2\times P_3$) were promising with respect to different economic traits (flowering data, seed weight / plant, 1000-seed weight and oil percentage). These results are in harmony with those of Tyagi *et al* (2000), Wael (2003) and Mohamed (2004).

Estimates of general combining ability effects for individual parental inbred lines in each trait are illustrated in Table 4. High positive values would be of interest under traits in question except flowering date where negative value would be useful from the breeder point of view. NA 1012 (P_1) and Dippe (P_2) showed significant negative GCA effect for flowering date indicating that these inbred lines could be considered as good combiners for developing early genotypes, Moreover, NA 1012 (P_1) showed high significant positive general combining ability effects for 1000-seed weight and oil percentage, while, Trebiska (P_3) was a good combiner for seed weight / plant, 1000-seed weight and oil percentage. The local commercial cultivar Serw 4 (P_4) showed significant positive general combining ability effects for seed weight / plant.

Specific combining ability effects of the ten F_1 crosses for all studied trait are presented in Table 5. Five crosses $P_1\times P_2$, $P_1\times P_3$, $P_1\times P_4$, $P_2\times P_3$ and $P_2\times P_5$ showed negative significant specific combining ability effects for flowering date. Also one ,two, two, six, five and five crosses showed significant positive specific combining ability effects for plant height ,fruiting zone, number of branches/ plant , seed weight /plant, 1000 seed weight and oil percentage. Crosses $P_1\times P_4$, $P_2\times P_3$ and $P_2\times P_4$ are

Table 3. Heterosis (MP=mid parent)and heterobeltiosis (BP= better parent) for the studied character.

Character		$P_1 \times P_2$	$P_1 \times P_3$	$P_1 \times P_4$	$P_1 \times P_5$	$P_2 \times P_3$	$P_2 \times P_4$	$P_2 \times P_5$	$P_3 \times P_4$	$P_3 \times P_5$	$P_4 \times P_5$
Days to 50% flowering	MP	-6.44**	-5.32**	-6.54**	-1.68*	-3.98**	1.31	-1.50	1.24	4.08**	3.10**
	BP	-5.10**	-5.46**	-6.45**	1.05	-2.76**	2.86**	-0.21	1.49	6.81**	6.07**
Plant height, cm	MP	-6.80	20.89**	7.42	-2.45	15.57*	9.05	3.87	18.45*	9.41	-0.28
	BP	-12.09	20.60**	2.07	-6.84	8.76	8.20	2.53	12.47	4.24	-0.81
Length of fruiting zone, cm	MP	-2.76	-5.59	-4.36	-11.65*	3.02	-1.14	8.54	8.68	-7.34	-7.05
	BP	-4.23	-7.22	-8.36	-15.20*	2.78	-3.86	5.73	5.93	-9.53	-7.21
Number of racemes/ plant	MP	-20.00	-5.88	-8.27	-27.56*	-14.06	18.40	24.37	23.66*	12.00	1.64
	BP	-24.64*	-7.25	-11.59	-33.33**	-17.91	15.63	21.31	20.90	4.48	-3.13
Seed weight/plant, g	MP	8.42	47.82**	55.70**	23.77**	43.23**	50.61**	-21.53**	25.58**	39.87**	49.14**
	BP	3.00	47.63**	52.00**	19.75**	35.91**	46.46**	-22.99**	22.44**	35.16**	47.77**
1000-seed weight, g	MP	5.69	35.86**	46.71**	29.25**	20.77*	-0.16	18.25*	7.13	7.74	2.24
	BP	3.82	34.68**	40.88**	24.12**	17.63*	-2.44	15.55	2.02	2.60	2.24
Oil %	MP	0.2	2.9**	5.2**	-3.5**	14.5**	6.2**	11.8**	9.2**	-4.1**	-15.1**
	BP	-4.9**	0.8	3.2**	-4.6**	10.9**	2.8**	7.3**	9.0**	-5.1**	-15.7**

Table 4. General combining ability effects for studied traits.

	Days to 50% flowering	Plant height, cm	Fruiting zone, cm	Number of racemes/ plant	Seed weight/plant, g	1000-seed weight, g	Oil%
GCA effects							
P1 NA 1012	-1.14**	-7.47*	-6.26**	-0.33**	1.42	0.24**	0.65**
P2 Dippe	-1.18**	2.85	1.74	-0.11	-3.90**	-0.19*	-0.11
P3 Trebiska	1.00**	2.10	0.45	0.24	2.53**	0.17*	0.70**
P4 serw 4	1.68**	4.39	3.45	0.35	22.56**	-0.15*	-0.26*
P5 Hybridol	-0.36	-1.86	0.63	-0.15	-2.61**	-0.09	-0.97**
S.E.for gi	0.22	3.00	1.98	0.21	0.77	0.08	0.10
S.E.for Gi-gj	0.35	4.75	3.14	0.33	1.22	0.12	0.16

Table 5. Specific combining ability effects for studied traits.

	Flowering date	Plant height, cm	Fruiting zone, cm	No. of branches/ plant	Seed weight/ plant, g	1000-seed weight, g	Oil %
$P_1 \times P_2$	-2.76**	-13.76	-1.82	-0.69	-2.90	-0.19	-1.89**
$P_1 \times P_3$	-2.69**	17.74*	-3.79	0.20	8.92**	0.45*	0.30
$P_1 x P_4$	-4.37**	4.95	-1.54	-0.16	10.13**	0.77**	2.25**
$P_1 \times P_5$	-0.08	-4.55	-8.71	-1.41**	2.31	0.70**	-0.70**
$P_2 \times P_3$	-2.66*	10.67	1.71	-1.62**	9.24**	0.38*	3.40**
$P_2 \times P_4$	2.17**	7.38	-3.54	0.88	10.45**	-0.05	1.02**
$P_2 \times P_5$	-1.30*	4.38	12.29*	1.38*	-11.12**	0.38*	4.40**
$P_3 \times P_4$	1024*	12.38	11.50*	1.27*	-2.23	0.35	2.87**
$P_3 \times P_5$	3.27**	3.38	-7.93	0.52	7.45**	-0.23	-1.75**
$P_4 \times P_5$	1.85**	-4.90	-6.93	-0.33	9.67**	-0.41*	-5.79**
S.E.for Sij	0.56	6.13	4.05	0.42	1.57	0.15	0.21
S.E.for Sij-sik	0.85	11.63	7.68	0.80	2.98	0.29	0.39

Considered promising for seed weight/plant and oil percentage improvement as they showed high specific combining ability effects. In such hybrids, desirable transgressive segregates would be expected in the subsequent generations. Normally, SCA would not contribute directly to improvement of autogamous crops except where commercial exploitation of heterosis is possible. If the crosses exhibiting high SCA involve both cultivars which also are good general combiners, they could be exploited for breeding improved varieties as well.

Nevertheless, if crosses showing high SCA involve only one good combiner, such combinations would be expressed through out desirable transgressive segregations providing that the additive genetic system present in the good combiner and complementary and segregations providing that additive genetic system present in the good combiner, and complementary and specific effect present in the crosses act in the same direction to reduce undesirable plant characteristics and maximize character in view. Therefore the two crosses NA 1012 (P_1) × Serw4 (P_4) and Dippe (P_2) × Trebiska (P_3) may be of prime importance in improvement programs whether towards hybrid field canola production of traditional breeding procedure

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قوة الهجين والقدره على التآلف للمحصول ومكوناته فى الكانولا

هشام محمد البغدادى طاهر

قسم بحوث المحاصيل الزيتيه – معهد بحوث المحاصيل الحقليه- مركز البحوث الزراعيه

أجريت كل التهجينات الممكنه (فى اتجاه واحد) بين خمسة أباء من الكانولا متباينه فى صفاتها المظهريه والزراعيه فى محطة بحوث الجيزه خلال الموسم 2004/2003 . وفى موسم 2005/2004 زرعت الأباء وهجنها العشره (الجيل الأول) فى تجربه حقليه بمزرعة بحوث الجميزه ــ مركز البحوث الزراعيه فى تصميم قطاعات كاملة العشوائيه فى ثلاث مكررات. وسجلت بيانات صفات : عدد الأيام حتى 50% تزهير ، إرتفاع النبات ، وطول المنطقه الثمريه ، عدد الأفرع ، محصول البذور / نبات ، ووزن ال1000بذره ، النسبه المؤيه للزيت

أظهرت النتائج إختلافات معنويه لكلا من التراكيب الوراثيه والأباء لكل الصفات فيما عدا التراكيب الوراثيه لصفة وزن 1000 بذره ، والأباء لصفة عدد الأفرع ووزن ال1000بذره مما يشير الى وجود إختلافات وراثيه لهذه التراكيب الوراثيه و الأباء مما يتيح الى وجود تباينات وراثيه كبيره للصفات المدروسه .

أظهرت الهجن إختلافات عالية المعنويه لكل الصفات فيما عدا صفة وزن ال1000بذره ، مما يشير الى إمكانية الأنتخاب بين هذه التراكيب الوراثيه لتحسين الصفات لهذا المحصول . كان تباين كل من القدرة العامه والخاصه على التآ لف عالى المعنويه لكل الصفات تحت الدراسه ماعدا صفة إرتفاع النبات ، عدد الأفرع بالنسبه للقدره العامه على التآلف ،وصفتى إرتفاع النبات وطول المنطقه الثمرية بالنسبه للقدره الخاصه على التآ لف .

أظهرت النسبه بين تباين كلا من القدرة العامه والخاصه على التآلف أن الجزء الأكبر من التباين الوراثى يرجع الى التباين الغير مضيف وذلك للصفات عدد الأفرع ، محصول البذور / نبات ، وزن ال1000بذره و النسبه المؤيه للزيت .

كان الأب NA1012, والأب Dippe قد أظهرا قدرة تآلف جيده فى التبكير فى التزهير. و كان الأب NA 1012 من احسن الأباء فى صفتى ووزن ال1000بذره ، النسبه المؤيه للزيت . بينما كان الأب Trebiska هو أفضل الأباء فى صفات محصول البذور / نبات , وزن ال1000بذره و النسبه المؤيه للزيت .
اظهرت تأثيرات القدره الخاصه على التآلف ان الهجن الثلاث Dippe X, Hybridol و Dippe x Trebiska وTrebiska x Serw4 أفضل التراكيب الوراثيه التى يمكن استخدامها فى تحسين المحصول ، حيث سجلت قيما عاليه لتأثيرات قدرتها الخاصه على التآلف لصفة محصول النبات الفردى . كما سجلت قيما عاليه المعنويه وموجبه للنسبه المؤية لقوة الهجين وذلك عند قياسها كأنحراف عن متوسط الأبوين وعن قيمة الأب الأعلى لمعظم الصفات المدروسه.

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