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COMBINING ABILITY AND HETEROSIS FOR YIELD AND ITS COMPONENTS IN CANOLA

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ABSTRACT

Five different parental canola genotypes were employed to obtain half diallel of 10 F_1 crosses. The parents and their F_1s were evaluated in a randomized complete block design in three replications at Ismailia Research Station farm of Agricultural Research Center (ARC), for plant height, height of first racemes /plant, number of racemes /plant, number of silique/plant, seed weight/plant , 1000-seed weight and oil percentage. Both general combining ability (additive) and specific combining ability (non-additive) gene actions were involved in controlling the expression of all the studiea yield characters. The additive genetic variance was more important than dominance genetic variance for most studied characters. Parental genotypes P_2(Int.55) and P_5(Int.373) proved to be good combiners for No. of racemes, No. of silique /plant and seed weight/plant. Moreover, P_4(Int.21) was good general combiner for plant height, No. of silique /plant and oil percentage. The cross combinations (1x2, 1x3, 3x4 and 4x5) showed significant specific combining ability effects for most yield contributing characters including seed weight/ plant. The results revealed positive and significant heterobeltiosis for most studied characters. The estimates of heritability in broad sense (h^2_b) were larger than their corresponding value in narrow sense (h^2_n) for most studied characters. Narrow sense heritability was moderate for number of racemes/plant, number of silique/plant and seed weight/plant, while, it was high for plant height, height of first racemes/plant, 1000-seed weight and oil percentage.

Key words: ***Canola, Brassica napus, Combining ability, Heterosis, Gene action, Heritability.***

INTRODUCTION

Canadian breeders have developed new rapeseed *(Brssica napus* L.) varieties under the name of (canola) which yield oil contains less than 2% erucic acid and defatted meal contained less than 30 μ mol/g aliphatic glucosinolates. Canola is considered as one of the most important oilseed crop allover the world, ranking the third largest source of edible oils following soybean and palm oil.

Every year, Egypt imports a large amount of edible oils for domestic consumption due to low production of local edible oils. The availability of high yielding oilseed cultivars required more efforts from plant breeders. Rapeseed could be the second major source of edible oil after cotton seed, hence enhancement of *Brassica* production can help to reduce the import of edible oils. Advancement in the yield of brassica requires certain information regarding the nature of combining ability of parents available to be involved in the hybrid program. In addition, information about the nature of gene action of quantitative and qualitative traits of economic importance is also required to develop desirable lines. According to Zhang (1987) the selection of parents for hybrid cultivar breeding is facilitated by combining ability analysis. Many researches have reported GCA and SCA effects (Dhillon *et al* 1990, Diwakar and Singh1993, Satwinder *et al* 2000 and Abdul Wahab *et al* 2006) whereas a few studies on gene action concerning yield and yield components in *Brassica* have been recorded. However, significant heterosis have been reported by several investigatores(Dhillon *et al*1990, Leon 1991, Diers *et al* 1996, Hu *et al* 1996, Kumar *et al* 1997 and Teklewold and Becker 2005).

The main objective of the present study was to identify the best combiners of parents and their crosses on the basis of their general and specific combining ability and heterosis for yield and yield components.

MATERIALS AND METHODS

The present study was conducted at Ismailia Agricultural Experimental Station. Five genotypes were crossed manually in all possible combination in half diallel crosses without reciprocal during 2007/2008 season. Parents and their F_1 hybrids were grown in a randomized complete bl[illegible] design with three replications at the experimental station of the A[illegible]ultural Research Center (ARC), Ismalia during 2008/2009 season. Each plot comprised five rows of 4m long, one plant in hill and 15 cm between plants.

Data were recorded on 5 randomly selected plants from each parent and hybrid. Traits studied were plant height, height of first racemes, number of racemes, number of silique/plant, seed weight/plant, 1000-seed weight and oil percentage. Table (1) shows the parents used. All of them belong to B. napus.

Table 1. Parents used in the study

Parent	Name	Origin
1	Introduction 129	Canada
2	Introduction 55	Czechoslovakia
3	Introduction 172	Canada
4	Introduction 21	Czechoslovakia
5	Introduction373 (Serw4)	Local variety

The data collected were subjected to analysis of variance according to Steel and Torri (1980). Estimates of combining ability (GCA and SCA)

The data collected were subjected to analysis of variance according to Steel and Torri (1980). Estimates of combining ability (GCA and SCA) were computed according to Griffing's method 2 model 1. Partitioning of genetic variance were calculated according to procedure outlined by Hayman (1954a,b). Heterobeltiosis percentage were determined for individual crosses deviation from better parents according to Bhatt (1971).

RESULTS AND DISCUSSION

Analysis of variances

The analysis of variance for genotypes, general and specific combining ability was significant or highly significant for all studied characters except 1000-seed weight (Table 2). The obtained results indicated that the presence of considerable amount of genetic variability valid for estimating GCA and SCA. Both additive and non-additive gene action played an important role in gene expressing of these characters. Mean squares due to GCA was higher than SCA for all characters, indicating the prevalence of additive gene action in the inheritance of these characters, thus, characters could be improved through phenotypic selection. The ratio of both GCA and SCA estimates was exceeded the unity for plant height, height of first racemes, No. of racemes/plant, No. of silique/plant and oil percentage, indicating that most of the genetic variation among the investigated genotypes for these characters appears to be under the control of additive genes.

Combining ability effects

Table (3) shows estimates of GCA effects and mean performance for the studied characters in five parents. Results indicated that genotypes (P_2) and (P_5) have positive and significant GCA effects for No. of racemes/plant, No. of silique/plant and seed weight/plant, so these genotypes could be used in Canola breeding programs to improve these characters. Moreover, (P1) could be considered as a good source for improving plant height and oil percentage. It is worthy noting that the previous conclusion was in harmony with the mean performance of parental genotypes indicating the efficiency of phenotypic performance for detecting the potentiality of parents for inclusion in cross breeding programs. These results are confirmed by Kumar *et al* (1997), Satwinder *et al* (2000), Aflash *et al* (2000), Teklewoed *et al* (2005), Abdul Wahab Nassimi *et al* (2006) .

Data given in Table (4) indicated that four out of the ten crosses (1x2, 1x3, 3x4 and 4x5) showed significant positive SCA positive effects for height of first racemes, No. of silique/plant and seed weight/plant. Meanwhile, only one cross (2x3) exhibited significant negative effect for plant height. The cross (3x5) exhibited significant positive effect for 1000-

Table 2. Mean squares of genotypes, general (GCA) and specific (SCA) combining ability and their ratio for the studied characters.

S.O.V	Plant height (cm)	Height of first raceme (cm)	Number of racemes/plant	Number of silique/plant	Seed weight/plant(g)	1000-seed weight(g)	Oil percentage (%)
Genotypes	174.93**	416.155**	1.951**	4809.651**	17.161**	0.376	2.860**
GCA	119.08**	374.319**	1.233**	3110.447**	7.585**	0.151	2.362**
SCA	34.005**	44.478	0.048**	1000.325**	4.975	0.098	0.380**
GCA/SCA	1.401	3.366	1.182	1.243	0.609	0.159	2.430

Table 3. Mean performance of five parental genotypes of canola ($\bar{x}$) and general combining ability (GCA) effects for studied traits.

Characters / Genotypes	Plant height (cm)		Height of first raceme (cm)		Number of racemes/plant		Number of silique/plant		Seed weight/plant(g)		1000-seed weight (g)		Oil percentage (%)	
	GCA	$\bar{x}$	GCA	$\bar{x}$	GCA	$\bar{x}$	GCA	$\bar{x}$	GCA	$\bar{x}$	GCA	$\bar{x}$	GCA	$\bar{x}$
P_1	-5.4**	122.1	2.45*	41.40	-0.49	3.60	-14.3**	92.20	-0.27	5.34	0.01	4.31	0.72**	46.75
P_2	0.520	139.53	-12.9**	14.67	0.61*	6.20	15.7**	197.93	1.02*	9.40	-0.04	4.23	-0.50	44.49
P_3	-1.8**	132.60	4.24**	60.13	-0.23	3.80	-30.1**	102.20	-1.7**	5.74	0.13	4.38	-0.68*	43.67
P_4	0.9*	133.00	1.64	47.00	-0.05	4.47	12.09**	174.07	0.002	7.01	-0.12	4.37	0.33**	45.59
P_5	5.3**	138.47	4.564**	55.93	0.17*	4.40	16.60**	179.73	0.71*	8.39	0.03	3.94	0.14	46.17
S.E(gi)	0.83	**	2.03	**	0.07	**	3.26	**	0.32	N.S	0.11	N.S	0.13	**

Table 4. Mean performance of F_1's($\bar{x}$) and specific combining ability (SCA) effects for the studied characters.

	plant height (cm)		height of first raceme (cm)		No. of racemes /plant		No. of silique/plant		Seed weight/plant (g)		1000-seed weight		Oil percent %	
	$\bar{x}$	SCA	$\bar{x}$	SCA	$\bar{x}$	SCA	$\bar{x}$	SCA	$\bar{x}$	SCA	$\bar{x}$	SCA	$\bar{x}$	SCA
1×2	127.67	-1.67	32.400	-0.483	5.26	0.267*	216.46	46.88**	13.35	3.731**	4.40	0.140	45.31	-0.393*
1×3	130.47	3.45**	49.93	-0.092	4.56	0.405*	150.13	26.313**	8.27	1.348*	4.28	-0.217	45.16	-0.362*
1×4	131.66	1.87	55.13	7.713**	4.73	0.400*	163.13	-2.844	8.13	-0.461	4.14	-0.097	47.81	1.276
1×5	133.53	-1.08	56.86	6.522**	4.07	-0.49*	197.87	24.379**	11.06	1.750*	4.70	0.314*	46.15	-0.184
2×3	121.07	-11.95**	36.36	1.689	5.06	-0.205*	106.00	-47.344**	5.27	-2.747**	4.45	0.000	45.13	0.823*
2×4	134.53	-1.264	34.60	2.527	4.66	-0.77**	193.83	-2.168	10.75	1.067*	4.23	0.040	45.03	-0.286
2×5	147.13	6.517**	37.00	2.003	6.20	0.533*	207.00	6.489	10.96	0.562	4.24	-0.103	44.97	-0.149
3×4	134.06	0.594	42.33	-6.88**	4.83	0.229*	181.46	31.232**	8.10	1.103*	4.11	-0.257	45.66	0.525
3×5	142.40	4.108**	40.80	-11.34**	5.66	0.838**	156.80	2.056	7.18	-0.522	5.45	0.934*	44.88	-0.065
4×5	142.36	5.791**	45.40	-4.13	5.76	0.767**	207.33	10.432**	10.98	1.609*	4.05	-0.026	45.16	-0.407*
S.E.(Si)	**	2.162	**	5.24	**	0.192	**	0.418	N.S	0.824	N.S	0.273	**	0.291

seed weight. Moreover, three crosses (1x4, 2x3 and 3x4) exhibited significant positive effects for oil percentage.

Heterobeltioss

Heterobeltiosis (heterosis relative to the better parent) for studied traits are presented in Table (5). Significant heterobeltiosis were recorded for most of the characters under investigation. Cross (P_2x P_3) showed negative and significant heterobeltiosis for height of first racemes. Four crosses (1x2, 1x3, 1x5 and 4x5) gave positive and highly significant heterobeltiosis for plant height and seed weight/plant.

Also, one cross (3x5) revealed significant and positive heterotic value for 1000-seed weight., Moreover, two out of the ten crosses (1x3and 4x5) exhibited significant and positive heterobeltiosis for number of silique/plant.

Regarding oil percentage, one cross (1x4) showed positive and significant deviation from better parent. Similar results was recorded by some researchers (Leon 1990 and Diers *et al* 1996).

Gene action and heritability estimates

Estimates of the genetic and environmental components of variance and other derived statistics are presented in Table (6). The additive component (D) was highly significant and larger in its magnitudes than dominance (H_1 and H_2) for height of first racemes, No. of racemes/plant, No. of silique/plant and oil percentage, indicating that the additive gene action was more important than the non-additive in controlling the inheritance of these characters. The dominance components (H_1 and H_2) were significantly positive and more important for No. of racemes/plant, No. of silique/plant, seed weight/plant and oil percentage. Theoretically, H_2 should be equal to or less than the positive and negative alleles at the loci for these characters were not equal in proportion in the parents. Value of H_1 were greater than the respective D values for plant height, No. of racemes/plant, No. of silique/plant and seed weight/plant, indicating the importance role of dominant genetic variance. On the other hand, values of D were greater than H_1 for height of first racemes, 1000-seed weight and oil percentage.

The over-all dominant effects, as algebric sum over all the loci in heterozygous phase in all crosses (h^2), was positive and highly significant for No. of racemes/plant, No. of silique/plant and seed weight/plant, indicating that most of the dominant genes had positive effects.

The distribution of relation frequencies of dominant versus recessive genes (F) were positive and significant for height of first racemes, suggested greater frequency of dominant alleles in the parents for this character. All estimates of environmental variance (E) were insignificant for all studied

Table 5. Heterobeltiosis % of the studied characters of F_1 crosses.

Crosses	Plant height (cm)	Height of first raceme (cm)	No. of racemes /plant	No. of silique/plant	Seed weight/plant (g)	1000-seed weight	Oil percent %
1×2	-8.50**	-21.73	-15.16**	9.36	42.02**	3.48	-3.08**
1×3	-1.60	-16.96	20.00**	46.89**	44.08**	-228	-3.40
1×4	-1.01	17.29	5.82	-6.28	16.54	-5.26	2.27*
1×5	-3.57	1.66	-7.50	10.09	31.82*	9.04	-1.28
2×3	-13.23**	-39.53**	-18.38**	-46.44**	-43.93**	1.59	1.44
2×4	-3.58	-26.38	-24.84**	-2.07	14.36	-3.20	-1.22
2×5	5.15*	-3384*	0.00	4.58	16.59	0.23	-2.66**
3×4	0.80	-29.60*	8.05	4.24	15.54	-6.16	0.15
3×5	2.83	-32.14*	28.63**	12.76	14.42	24.42*	-2.79**
4×5	5.60*	-18.82	28.85**	15.32*	30.87*	-7.32	-2.19*

Table 6.Estimates of genetic and environmental components values for studied characters

Characters	Plant height (cm)	Height of first raceme (cm)	No. of racemes /plant	No. of silique/plant	Seed weight/plant (g)	1000-seed weight	Oil percent %
D	41.89±22.81	281.0±27.36**	1.003±0.13**	2231.99±476.60**	2.02±2.32	-6.48±0.13	1.44±0.21**
F	-6.82±56.99	148.94±68.34*	0.600±0.33	1108.73±1190.55	-0.74±5.80	-1.91±0.33	0.36±0.53
H_1	135.50±61.61*	105.42±73.89	1.46±0.36**	3542.41±1287.12*	16.16±6.27*	0.39±0.36	1.34±0.57**
H_2	99.24±55.88	62.48±67.02	1.25±0.32**	2981.43±1167.43*	13.50±5.69*	0.31±0.33	1.12±0.52*
h^2	3.95±37.73	-23.33±45.24	0.86±0.22**	2003.06±788.18*	12.14±3.84**	6.68±0.22	6.44±0.35
E	6.15±9.31	38.66±11.17**	4.71±0.05	113.89±194.57	0.94±0.94	9.80±5.52	0.11±8.71
$(H1/D)^{0.5}$	1.798	0.61	1.21	1.25	2.82	0.24	0.96
H2/4H1	0.18	0.14	0.21	0.21	0.20	0.19	0.21
KD/KR	0.91	2.52	1.65	1.49	0.87	0.77	1.30
h^2n	0.57	0.61	0.46	0.49	0.38	0.92	0.62
h^2b	0.91	0.72	0.92	0.93	0.86	0.49	0.88

characters, except height of first racemes, indicating that all characters have not been greatly affected by environmental factors, except height of first racemes. The weighted measure of average degree of dominance $(H_1/D)^{0.5}$ was more than unity for all characters, except height of first racemes, 1000-seed weight and oil percentage, indicating that overdominance is controlling these characters. Consequently, selection for any of these characters in segregation generation will be non effective. To improve these characters, indirect selection for characters correlated in question may be of some help.

The proportion ($H_2/4\ H_1$) was lower than 0.25, suggesting that the positive and negative alleles were not equally distributed among the parents. The ratio of dominance and recessive genes in the parents (K_D/K_R) was less than unity for plant height, seed weight/plant and 1000-seed weight. Meanwhile, this ratio was greater than unity for height of first racemes, No. of racemes/plant, No. of silique/plant and oil percentage, which indicated an axcess of dominant genes in the parents for these characters.

Heritability estimates in narrow sense (h^2_n) as well as in the broad sense (h^2_b) for studied characters are presented in Table (6). It was obvious that all studied characters had high values in broad sense except 1000-seed weight.

Narrow-sense heritability estimates was low for No. of racemes/plant, No. of silique/plant and seed weight/plant. By contrast, h^2_n was high for plant height, height of first racemes, 1000-seed weight and oil percentage. Therefore, phenotypic selection would be the most efficient method for improving these characters. The low value of narrow sense heritability are mainly due to dominance variance components accounted for a great portion of the genetic variation of these characters.

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القدرة على التآلف و قوة الهجين للمحصول ومكوناته فى الكانولا

على ناصف على عبد العال- رجب محمد فهمى- رحاب حمدان عبد الكريم عبد الرحمن

معهد بحوث المحاصيل الحقلية – قسم بحوث المحاصيل الزيتيه- مركز البحوث الزراعية

أجريت هذه الدراسه خلال الموسم الشتوى ٢٠٠٨/٢٠٠٧، ٢٠٠٩/٢٠٠٨ وقد تم تهجين خمسة تراكيب وراثية متباينة فى صفاتها هى مستورد ١٢٩، م ٥٥، مستورد ١٧٢ ، مستورد ٢١ ، مستورد ٣٧٣. وذلك بنظام الهجن الدائرية في اتجاه واحد (باستبعاد الهجن العكسية). اجري تقييم الهجن وأبائهما فى تصميم القطاعات كامله العشوائية فى ثلاث مكررات فى محطة البحوث الزراعية بالاسماعيلية لصفات ارتفاع النبات (سم).

ارتفاع أول فرع/النبات(سم), عدد الفروع/النبات, عدد الكبسولات/النبات, وزن البذور/النبات(جم), وزن ال ١٠٠٠ بذره و نسبه الزيت.

أظهرت النتائج معنوية تباين كلا من القدرة العامة والخاصة على الائتلاف في وراثة جميع الصفات مع دور أكبر للقدرة العامة على الائتلاف عن القدره الخاصه على الائتلاف لمعظم الصفات المدروسه.

وقد أوضحت الدراسه ان الأب رقم ٢ (م ٥٥), والأب رقم ٥(م ٣٧٣) يعتبر أفضل الأباء في القدره العامــه علــي الائتلاف لصفات عدد الفروع للنبات, عدد الكبسولات/النبات ووزن البذور/النبات وكان الأب الرابع(م ٢١) ذو قدره ائتلافيه عاليه لصفات ارتفاع النبات ونسبه الزيت. وكانت تأثيرات القدره الخاصه على الائتلاف موجبه ومعنويــه للهجن التاليه (١×٢ , ١ ×٣, ٣ ×٤ , ٤ ×٥) لمعظم الصفات متضمنه نسبه الزيت.

كما أوضحت النتائج المتحصل عليها أن التأثير الراجع الي الفعل المضيف يمثــل أهــم المكونــات لصــفتي عــدد الكبسولات/النبات ونسبه الزيت. وقد سجلت معظم الصفات المدروسه قيم عاليه لكفاءه التوريث بمعناها العام.