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COMBINING ABILITY FOR YIELD AND YIELD COMPONENTS IN SUNFLOWER

B. R. Bakheit[1], A.M. Mahmoud[1], A.A. El- Shimy[2], M.A. Attia[2]

1- Agronomy Depart., Fac. of Agric. Assiut Univ., Assiut, Egypt.
2- Oil Crops Res. Depart., Field Crop Res. Institute, A.R.C. Egypt.

ABSTRACT

The present investigation was carried out during three successive summer seasons, 2005, 2006 and 2007 to study combining ability and proportional contribution (%) of lines, testers and line x tester interaction in sunflower hybrids for yield and yield contribution traits. Twenty four crosses produced by crossing between six introduced cytoplasmic male sterile lines (CMS-lines) with four restorer lines (RF-lines) using line x tester mating design at Shandaweel Agric. Res. Station, Sohag, in 2005 season. These genotypes were: twenty four crosses, four restorers, six fertile lines (B-lines) along with two check cultivars (Sakha53 and Giza102) were evaluated during 2006 and 2007 seasons. The experiment was conducted in a three replicated, randomized complete block design with three replicates in the two seasons. Data were recorded on: days to 50% flowering, days to maturity, plant height, stalk diameter, head diameter, 100-achene weight, achene yield/plant, achene yield/plot and achene oil percentage. Separate and combined analysis of variance and line x tester were completed for the studied traits. Besides, estimated combining ability estimates and proportional contribution of lines, testers and line x tester interaction were also computed. The obtained results revealed that the ratios of δ^2gca/ δ^2sca were less than unity for all studied traits; indicating that the dominance gene action (non-additive effects) had an important role in the inheritance of the trait. Proportional contribution (%) of lines, testers and their interaction showed that the non-additive components were predominant for plant height, head diameter, achene yield/plot and oil percentage characters. General and specific combining ability effects were estimated for studied traits over the two years. The restorer lines Rf1, Rf4, Rf5 and Rf10 showed significant or highly significant GCA for 50% flowering. Also, GCA effect of L5 was the highest and it was significantly negative. These lines might be considered as good combiners for earliness. For achene yield/plot, nine crosses registered positive and significant or highly significant SCA effects, these crosses were exerted the best combinations for this trait. For achene oil percentage, two lines (L1 and L7) had positive and significant or highly significant GCA effects. Besides the Rf10 showed also positive and highly significant gca values. The single crosses (L1 x Rf1) and (L21 x Rf10) had positive and significant or highly significant SCA effects for achene oil percentage. These crosses may be considered as the best combinations for this trait.

Key words: ***Sunflower, Helianthus annus, CMS-lines, Combining ability, GCA, SCA.***

INTRODUCTION

In Egypt, due to severe shortage of edible oil, it imports more than 90% of its consumption of vegetable oil. This indicates the size of the problem and shows the need for horizontal and vertical improvement of oil crops in Egypt. Thus, more care should be given to this crop for increasing its productivity to minimize the gap between the production and consumption. In Egypt the cultivated area was 18 thousand hectares producing 43 thousand tons with an average of 2.39 ton/ha (F.A.O. 2006). Sunflower breeders have extensively used and exploited heterosis to improve seed and oil yield in sunflower. The cytoplasmic male sterility and fertility restorer system is used to produce hybrid seed. Rao *et a* (1992) found that the non-additive components of the genetic variances were predominant for all the characters. Madrap and Makne (1993) found that the specific combinations were highly adaptable with high levels of heterosis. Alone *et al* (1996) found significant sum of squares due to males and females for all the characters which indicated enough variability among the males and females used in their study. In addition the nature of gene action was predominantly non-additive for all the characters. Hussain *et al.* (1998) and Burli *et al.* (2001) illustrated that the specific combining ability (SCA) variances were higher than general combining ability (GCA) variances for all the traits studied which were generally controlled by non-additive gene action. However, substantial amounts of additive variance were detected for plant height and oil content (Sassikumar *et al* (1999). Besides, Ravi *et al* (2004) discussed the preponderance of non-additive gene effects in the expression of seed yield and its component traits. Radhika *et al* (2001) and Uttam *et al* (2005) found that the non-additive type of gene action was important in the expression of days to 50% flowering, plant height, capitulum diameter, 100 seed weight, oil percent and seed yield/plant. Majority of the good specific combinations for different characters resulted from the crosses among the parents with high x high or high x low GCA effects. Masood *et al.* (2005 & 2006) found that the SCA effects were of greater magnitude than that of GCA effects, which showed high contribution of non-additive gene effects. The GCA:SCA ratio also revealed predominance of non-additive gene effects. Khan et al (2008) showed that the contribution of maternal and paternal interaction (line x tester) was very high for all traits. It revealed preponderance of paternal and maternal interaction influence for all these traits. The objective of this study was to estimate general and specific combining ability effects to identify the parental lines of the best crosses.

MATERIALS AND METHODS

Four restorer lines (Rf-lines), i. e., Rf1, Rf4, Rf5 and Rf10 of sunflower, were crossed with six introduced cytoplasmic male sterile (CMS) lines (A-lines) during the flowering period at Shandaweel Agriculture Research Station, Agric. Res. Center in 2005 summer season, for characterization and developing twenty four crosses. The geographical origin and agronomic characteristics of the six male sterile lines (CMS) and the four restorer lines (Rf-lines) along with check varieties are presented in Table (1). The twenty four single crosses were obtained by bagging the sterile heads before flowering and pollinated with the pollen grains which collected from each of the four restorer lines. in 2005 season. The twenty four obtained sunflower crosses, the four testers, the six B-lines and the two check cultivars (Sakha 53 and Giza 102) were planted at Shandaweel Research Station, Sohage governorate on 30th and 26th July, 2006 and 2007 seasons, respectively. A randomized complete block design (RCBD) with three replications was used in the two seasons. The plot size was 2 rows, 4 meter long and 60 cm apart. Planting was done in hills spaced 20 cm apart. Seedlings were thinned to one plant per hill before the first irrigation (two weeks after planting in both seasons).

Table 1. Type, geographical origin and agronomic characteristics of materials used (Shandaweel 2005 season).

No.	A. Male Sterile(A) lines and fertile (B) lines				Agronomic characteristics			
	Lines	Geographical Origin	Lines	Geographical Origin	Days to 50% flowering	Plant height, (cm)	Stalk diameter, (cm)	Head diameter, (cm)
1	A1	Romania	B1	Romania	56	140	2.00	16.50
2	A3	,,	B3	,,	54	160	2.04	18.00
3	A5	,,	B5	,,	52	156	2.03	14.50
4	A7	Local	B7	Argentine	55	158	1.81	16.00
5	A19	,,	B19	,,	54	145	2.05	17.00
6	A21	,,	B21	Russia	57	148	2.08	16.60
No.	B. Restorer (Rf) lines							
1	Rf1	Local			53	110	1.44	6.70
2	Rf4				54	108	1.30	7.50
3	Rf5				54	126	1.83	14.00
4	Rf10				55	118	1.40	8.50
No	C. Check varieties							
1	Sakha 53	A. R. C.			56	177	2.11	19.50
2	Giza 102				52	137	1.58	12.50

The cultural practices were followed as the recommendations for oil seed sunflower production. The traits studied in this research could be divided into three groups: earliness, growth traits and yield components.

Earliness traits

1- Days to 50% flowering: number of days from sowing date until 50% of the plants showed their heads.
2- Days to maturity: was measured as number of days from sowing date until the head became yellow.

Growth traits

The following traits were taken from a random sample of five guarded plants. These plants were chosen from each plot. These samples were assigned to be fixed for the following measurements.

1- Plant height (cm): average length in cm from soil level to the tip of the head.
2- Stalk diameter (cm): measured at 30cm above the soil surface with vernier-calipers, at nearest 0.1cm.
3- Head diameter (cm): estimated as an average of maximum width of the head.

Yield and yield components

1- 100- achene weight (g): One hundred seed were counted and weighed from the bulk of the guarded plants in grams.
2- Achene yield/plant (g): estimated as average of seed weight per head.
3- Achene yield/plot (g): measured from the adjusted seed yield per plot.
4- Achene Oil percentage: determined by soxalet apparatus using petroleum ether (Bp40-60 c°) as solvent according to the official method (A.O.A.C. 1980).

Statistical analysis

Data on a plot mean basis in each season and combined over the two seasons were subjected to analysis of variance for the randomized complete block design (RCBD) according to Gomez and Gomez (1984). The line x tester analysis was calculated according to Kempthorne (1957).

The expectation of the mean squares for the combined analysis of variance is presented in Table (2). Mean squares were equated to obtain estimates of the components of variance for lines (δ^2_l), testers (δ^2_t) and lines x testers ($\delta^2_{l\,x\,t}$) and their interaction with years ($\delta^2_{l\,x\,y}$, $\delta^2_{t\,x\,y}$ and $\delta^2_{l\,x\,t\,x\,y}$). Variance components were estimated according to Singh and Chaudhary (1977&1985). General combining ability effects for the lines and testers and specific combining ability effects of the crosses and the proportional contributions of lines, testers and their interaction to total variance were estimated.

RESULTS AND DISCUSSION

Combining ability

Estimates of general comining ability (gca) and specific combining ability (sca) variances are given in Table 3. The magnitude of δ^2sca was higher than that for δ^2gca for all studied traits. The ratios of δ^2gca/ δ^2sca were less than unity for all studied traits, indicating that the dominance gene action (non-additive effects) had an important role in the inheritance of these trait. Similar results were reported by Sassikumar *et al* (1999), Burli *et al.* (2001), Goksoy and Turan (2004), Ravi *et a* (2004) and Masood *et al* (2006).

Table 2. Combined ANOVA for F_1 single crosses and expectations of mean squares.

Source of variance	D . F	Mean squares	Expectation of mean square
Year (Y)	y-1		
Rep/year	Y(r-1)		
F_1 single crosses (C)	(lt-1)		
Line (females) L	(l-1)	M1	$\delta^2 + r\delta^2_{lty} + ry\delta^2_{lt} + rt\delta^2_{ly} + rty\delta^2_{l}$
Tester (males) T	(t-1)	M2	$\delta^2 + r\delta^2_{lty} + ry\delta^2_{lt} + rl\delta^2_{ty} + rly\delta^2_{t}$
L x T	(l-1) (t-1)	M3	$\delta^2 + r\delta^2_{lty} + ry\delta^2_{lt}$
F_1single crosses x Years	(lt-1) (Y-1)		
L x Y	(l-1) (Y-1)	M4	$\delta^2 + r\delta^2_{lty} + rt\delta^2_{ly}$
T x Y	(t-1) (Y-1)	M5	$\delta^2 + r\delta^2_{lty} + rl\delta^2_{ty}$
L x T x Y	(l-1) (t-1) (Y-1)	M6	$\delta^2 + r\delta^2_{lty}$
Error	Y (r-1) (c-1)	M7	δ^2

Where ,c, r, y, l and t are the number of crosses, reps, years, lines and testers, respectively. Subscript denotes to the variance symbol designate the type of variance.

Contribution of lines, testers and their interaction to total variance

Proportional contribution (%) of lines, testers and their interaction for the studied traits, combined over two seasons (Table 4) showed that both additive and non-additive gene effects controlled days to 50% flowering, stalk diameter, 100-achene weight and achene yield/plant. While, days to maturity showed the predominance of additive gene action. However, the non-additive components were predominant for plant height, head diameter, achene yield/plot and oil percentage characters. These results are in line with those reported by Khan *et al* (2008).

Combining ability effects

Estimates of general and specific combining ability effects for studied traits over the two seasons are shown in Table 5. For days to 50% flowering, the fertility restorer lines Rf1, Rf4, Rf5 and Rf10 showed significant or highly significant values. While, GCA effects of L5 recorded the highest significantly negative estimates, indicating that, this line had favorable gene action for earliness and this line might be considered as good combiners for earliness. The data clearly showed that three crosses had negative significant or highly significant SCA values, indicating that these crosses were earlier when compared to their parents.

Table 3. Estimates of general and specific combining ability variance and their interaction with years for studied traits over the two seasons.

Variance component	Days to 50% flowering	Days to maturity	Plant height (cm)	Stalk diameter (cm)	Head diameter (cm)	100-achene weight (g.)	Achene yield/plant (g.)	Achene yield/plot (g.)	Achene oil percentage
$\delta^2 gca_f$	0.7921	1.2535	-9.1613	0.0068	-0.0566	0.0522	7.8414	-9974.662	-0.1771
$\delta^2 gca_m$	0.1400	0.8752	18.7700	0.0022	0.1576	0.2319	-2.9169	-2064.219	-0.1191
$\delta^2 gca$	0.0604	0.1343	0.5087	0.0006	0.0056	0.0172	0.3432	-778.451	-0.0187
$\delta^2 sca$	0.9450	0.8533	56.2730	0.0050	2.3650	0.4000	25.9183	44717.832	1.0550
$\delta^2 gca_{f\,x\,y}$	0.2042	0.1333	-6.4730	0.0008	0.0675	-0.0008	-1.5058	-143.151	0.2300
$\delta^2 gca_{m\,x\,y}$	0.0394	0.3406	-4.7970	0.0001	-0.0139	0.0967	-1.5767	213.432	0.3289
$\delta^2 sca_{x\,y}$	0.1000	0.6700	37.2100	0.0100	0.4767	0.0833	8.5667	4006.107	2.2600
$\delta^2 gca/\delta^2 sca$	0.0639	0.1574	0.0094	0.1200	0.0024	0.0430	0.0132	-0.0174	-0.0177

All negative estimates of variance are considered equal to zero.

Table 4. Proportional contribution (%) of lines, testers and their interaction to total variance for the studied traits, the combined mean over the two seasons 2006 and 2007.

Studied traits	lines	testers	Line x tester
Days to 50% flowering.	46.900	29.243	23.855
Days to maturity.	48.881	13.328	37.790
Plant height, cm.	7.593	33.768	58.639
Stalk diameter, cm.	47.029	17.313	35.659
Head diameter, cm.	19.104	17.630	63.266
100-achene weight, g.	21.136	36.375	42.490
Achene yield/ plant, g.	40.486	3.805	55.709
Achene yield/ plot, g.	3.499	12.269	84.232
Oil percentage.	9.971	5.884	84.145

For days to maturity, the highest negative effect was recorded by the restorer line Rf1. While the female lines L5 and L21 exhibited negative and highly significant GCA effects, indicating that, these lines had favorable genes for earliness. Four crosses; L3 x Rf1, L3 x Rf4, L5 x Rf10 and L21 x Rf5 exhibited negative and significant or highly significant SCA effects. These crosses could be considered as the best combinations for days to maturity.

For plant height, the female lines L21 recorded the highest negative and significant GCA effects. While, male lines Rf1 and Rf5 had negative and significant or highly significant values, indicating that, the lines had favorable genes for shortness. Four crosses recorded negative and significant or highly significant SCA effects. These crosses were considered to be the best combinations for shortness.

For stalk diameter, the highest positive significant GCA effect was only registered by the restorer line Rf4. While, only the female line; L19 showed the highest significant positive value. Only two crosses showed positive and significant SCA values. These crosses were considered as good combinations for stalk diameter.

For head diameter, the tester Rf4 possessed positive and highly significant GCA effect. Also, the lines L7 and L19 had positive and highly significant GCA effects, indicating that these lines could be considered as good combiners for head diameter. Eleven crosses had positive and significant or highly significant SCA effects. These crosses could be considered as the best combinations of head diameter.

For 100-achene weight, the two lines L7 and L19 had positive and highly significant GCA effects. Also, the restorer lines Rf4 showed positive and highly significant values. Seven crosses registered positive and significant or highly significant SCA effects. These crosses were considered as the best combinations for increasing the 100-achene weight.

For achene yield/plant, the restorer lines, Rf1 and Rf4 had positive and highly significant GCA effects. Also, the female lines L7, L19 and L21 had positive and highly significant GCA effects. Nine crosses were recorded positive and highly significant SCA effects. These crosses could be considered as the best combination of head diameter. Moreover, most of highest crosses in seed yield/plant resulted from crossing lines having positive and significant GCA values. It may be concluded that GCA and SCA effects, were effective in predicting hybrid performance in this trait.

For achene yield/plot, testers Rf4 and Rf10 and the line L7 had positive and highly significant GCA effects. Nine crosses registered positive and significant or highly significant SCA effects. These crosses exerted the best combinations for these traits.

For achene oil percentage, two lines L1 and L7 had positive and significant or highly significant GCA effects. While, Rf10 showed positive and highly significant GCA value. The single crosses (L1 x Rf1) and (L21 x Rf10) were positive and significant or highly significant with respect to SCA effects. These crosses may be considered as the best combinations for achene oil percentage and can be tested in a large scale. Generally, the restores lines Rf4 and Rf10 and Line L7 had significant and positive gca for yield and most of its components and may be considered as the best combiners for these traits. Similar results were obtained by Madrap and Makne (1993) and Goksoy and Turan (2004). They found that variance due to specific combining ability was highly significant for seed yield, number of seeds per head and plant height. These traits of sunflower were influenced, mostly, by dominant gene actions. Neither general nor specific combining ability variances were found to be significant for head diameter and 100-seed weight. Most of the total genetic variation in these characteristics was caused by epistatic gene actions due to SCA effects, which were higher than GCA effects.

Table 5. Estimates of general combining ability effects for male and female lines and specific combining ability for crosses for all studied traits in the combined mean over the two seasons 2006, 2007.

Traits	Female lines	SCA Restorer lines (Males) Rf1	Rf4	Rf5	Rf10	GCA	S.E
Days to 50% flowering	L1	0.639	-0.417	-0.111	-0.111	0.306	gca m=
	L3	-0.986*	-1.375**	1.264**	1.097**	0.431*	0.161
	L5	-0.736	1.875**	-0.486	-0.653	-1.653**	gca f=
	L7	0.806*	-1.250**	-0.444	0.889*	1.472**	0.197
	L19	0.514	0.125	0.097	-0.736	-0.236	sca=
	L21	-0.236	1.042**	-0.319	-0.486	-0.319	0.394
	GCA	-0.597**	0.625**	0.319*	-0.347*		
Days to maturity	L1	-0.069	0.569	0.097	-0.597	0.431*	gca m=
	L3	-1.444**	-0.972*	1.056**	1.361**	-0.194	0.168
	L5	-0.444	0.694	0.889*	-1.139**	-1.361**	gca f=
	L7	0.556	-0.972*	-0.278	0.694	2.139**	0.206
	L19	0.597	0.236	-0.236	-0.597	-0.069	sca=
	L21	0.806	0.444	-1.528**	0.278	-0.944**	0.412
	GCA	-0.889**	1.472**	-0.222	-0.361*		
Plant height	L1	3.965*	6.660*	4.632*	-15.257**	-1.771	gca m=
	L3	-2.285	4.076*	-4.785*	2.993	0.979	0.780
	L5	-1.243	7.451**	-5.743**	-0.465	0.271	gca f=
	L7	-7.535**	-2.010	-1.201	10.743**	4.229**	0.956
	L19	-0.243	-3.215	2.257	1.201	-1.563	sca=
	L21	7.340**	-12.965**	4.840*	0.785	-2.146**	1.911
	GCA	-1.549*	0.424	-5.882**	7.007**		

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

Table 5. Continued

Traits	Female lines	SCA				GCA	S.E
		Restorer lines (Males)					
		Rf1	Rf4	Rf5	Rf10		
Stalk diameter	L1	0.018	0.044	-0.056	-0.007	-0.049	gca m=
	L3	0.078	-0.120	-0.038	0.081	-0.035	0.029
	L5	0.058	0.017	0.082	-0.156*	-0.128**	gca f=
	L7	0.025	-0.110	-0.010	0.095	0.005	0.035
	L19	-0.168*	0.094	0.043	0.032	0.148**	sca=
	L21	-0.001	0.075	-0.020	-0.045	0.060	0.071
	GCA	0.039	0.063*	-0.065*	-0.038		
Head diameter	L1	-1.671**	1.024**	1.246**	-0.599**	0.132	gca m=
	L3	1.054**	-1.651**	-0.596**	1.193**	-0.526**	0.082
	L5	0.971**	-0.435*	-0.246	-0.290	-1.143**	gca f=
	L7	1.013**	-2.660**	0.629**	1.018**	0.882**	0.100
	L19	-1.988**	2.307**	0.063	-0.382	0.582**	sca=
	L21	0.621**	1.415**	-1.096**	-0.940**	0.074	0.200
	GCA	-0.213**	1.060**	-0.696**	-0.151		
100-achene weight	L1	-0.224	0.446**	0.261	-0.483**	0.039	gca m=
	L3	0.115	-0.035	-0.440**	0.359**	-0.074	0.062
	L5	-1.013**	-0.565**	0.624**	0.954**	-0.282**	gca f=
	L7	0.494**	0.168	0.216	-0.877**	0.613**	0.076
	L19	-0.029	-0.122	0.360*	-0.209	0.230**	sca=
	L21	0.657**	0.108	-1.021**	0.256	-0.526**	0.153
	GCA	-0.271**	0.810**	-0.399**	-0.140*		

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

Table 5. Continued

Traits	Female lines	SCA				GCA	S.E
		Restorer Lines (Males)					
		Rf1	Rf4	Rf5	Rf10		
Achene yield/plant	L1	-6.113**	8.991**	5.033**	-7.910**	-4.367**	gca m=
	L3	1.226	3.833**	-4.498**	-0.561	-4.868**	0.331
	L5	0.678	-6.379**	3.898**	1.802*	0.660	gca f=
	L7	0.335	-2.814**	-3.353**	5.832**	4.499**	0.406
	L19	-0.223	2.780**	2.339**	0.664	1.458**	sca=
	L21	4.098**	-0.852	-3.418**	0.172	2.619**	0.811
	GCA	0.893**	1.207**	-1.248**	-0.852**		
Achene yield/plot	L1	-107.173**	198.334**	198.344**	-289.504**	-30.072*	gca m=
	L3	34.749	-2.535	-161.117**	128.903**	6.657	11.980
	L5	-278.042**	158.821**	-182.081**	301.303**	-48.774**	gca f=
	L7	251.175**	-273.817**	66.434**	-43.792	58.771**	14.672
	L19	-88.571**	100.531**	20.876	-32.837	-3.986	sca=
	L21	187.861**	-181.333**	57.545	-64.073	17.405	29.345
	GCA	-36.35**	68.123**	-87.055**	55.283**		
Oil percentage	L1	2.125**	-0.534**	-1.233**	-0.357*	0.522**	gca m=
	L3	-0.492*	0.317	0.127	0.048	-0.228*	0.085
	L5	0.111	1.044**	-0.646**	-0.287	-0.197	gca f=
	L7	-0.525*	0.864**	-0.048	-0.291	0.212*	0.104
	L19	-0.643**	-0.719**	1.767**	-0.405*	-0.282**	sca=
	L21	-0.354	-0.973**	0.034	1.293**	-0.028	0.208
	GCA	-0.165*	0.038	-0.215*	0.342**		

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

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القدرة على الائتلاف للمحصول ومكوناته فى دوار الشمس

باهى راغب بخيت[1]، عادل محمد محمود[1]، عابدين احمد الشيمى[2]،

محروس عبد الباسط عطيه[2]

١- قسم المحاصيل – كلية الزراعة- جامعة اسيوط

٢- قسم بحوث المحاصيل الزيتية- معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية

أجريت هذة الدراسة خلال ثلاثة مواسم صيفية متعاقبة هى ٢٠٠٥ و٢٠٠٦ و٢٠٠٧ لدراسة القدرة الائتلافية و نسبة مساهمات كلا من السلالة و الكشاف والتفاعل بينهما فى هجن دوار الشمس الزيتى لكل الصفات تحت الدراسة. وقد تم تكوين أربعة وعشرون هجينا من خلال التهجين ما بين ستة أباء عقيمة الذكر سيتوبلازميا (CMS-lines) مع أربعة أباء معيدة للخصوبة (RF-lines) باستخدام نظام السلالة x الكشاف خلال موسم ٢٠٠٥ فى محطة البحوث الزراعية بشندويل (سوهاج).تم تقييم هذة الهجن (٢٤ هجين) والأربع سلالات المعيدة للخصوبة وستة سلالات (B-lines) وصنفين قياسيين هما (سخا٥٣ وجيزة١٠٢) فى موسمي ٢٠٠٦ و٢٠٠٧ فى محطة البحوث الزراعية بشندويل. وكانت التجربة مصممة بنظام قطاعات كاملة العشوائية فى ثلاث مكررات بالنسبة للموسمين.تم تسجيل البيانات علي صفات عدد الأيام من الزراعة حتي ٥٠% تزهير، عدد الأيام من الزراعة حتي النضج، طول النبات، قطر النبات، قطر القرص، وزن الـ ١٠٠ بذرة، محصول النبات الفردي، محصول القطعة التجريبية ونسبة الزيت في البذور.وقد اجري التحليل الإحصائي لكل موسم ولمتوسط الموسمين كما تم تقدير القدرة الائتلافية باستخدام تحليل السلالة في الكشاف وتم حساب نسبة مساهمة كل من السلالة والكشاف والتفاعل بينهما لكل الصفات تحت الدراسة. وقد اوضحت النتائج المتحصل عليها من هذه الدراسة ان النسبة ما بين التباين المضيف و التباين السيادى كانت اقل من الوحدة فى كل الصفات تحت الدراسة. وهذا يشير إلى أن فعل الجين السيادى يلعب دورا هاما فى توريث هذة الصفات. كما أظهرت نسبة مساهمات كل من السلالات والكشافات والتفاعل بينهما أنة كان يغلب الفعل السيادى (الفعل غير

المضيف) فى صفات طول النبات، قطر القرص، محصول القطعة التجريبية ونسبة الزيت فى البذور. أظهرت السلالات المعيدة للخصوبة Rf1, Rf4, Rf5 ,Rf10 قدرة عامة سالبة و معنوية أو عالية المعنوية لصفة التزهير بينما سجلت السلالة L5 أعلى تأثير معنوي سالب للصفة وأعطت أفضل الهجن من حيث التبكير فى التزهير. كما سجلت تسعة هجن قدرة خاصة موجبة و عالية المعنوية بالنسبة لمحصول القطعة، وتعتبر هذه الهجن من أفضل الهجن فى محصول القطعة التجريبية. واخيرا بالنسبة لصفة نسبة الزيت أظهرت السلالتين L1, L7 تأثير موجب وعالى المعنوية من حيث القدرة على الائتلاف. بينما أظهر الكشاف Rf10 تأثير موجب وعالي المعنوية لصفة محصول القطعة. وأفضل الهجن الفردية في نسبة الزيت كانت (L1 x Rf1) و(L21 x Rf10) حيث اظهروا قدرة تالف خاصة موجبة وعالية المعنوية وتعتبر هذة الهجن من الهجن المبشرة فى نسبة الزيت.

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