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COMBINING ABILITY ANALYSIS OF EARLINESS, SEED YIELD AND RELATED TRAITS IN SUNFLOWER

Ezzat E. Mahdy[(1)], Elsayed Hassaballa[(1)], Abdeen Al-sheemy[(2)] and Heba A. A. M. Hassan[(2)]

[(1)]Assiut Univ. Fac. Agric. Agron. Dept, [(2)]ARC, Crop Res. Inst. Oil Crops Sec.

Corresponding author: Ezzat E. Mahdy,
e-mail: ezzat_mahdy@agr.au.edu.eg

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ABSTRACT

Twenty-six genotypes of sunflower (16 F_1-hybrids, four female lines, four restorer lines and two check varieties; Sakha 53 and Giza 102) were evaluated under two contrasting environments, i.e., loamy sand and clay soils in season 2016. Genotypes mean squares of the studied traits was significant ($P \leq 0.01$) either in the separate or in the combined analysis. The differences between the two environments were significant for all traits except head diameter (HD). The genotype x environment interaction was significant for all traits. Furthermore, most of the variability was for environment, except for husk %. Mean squares of the combined analysis of female and testers lines was significant ($P \leq 0.01$) for all traits. These results indicate the presence of additive variance. Mean squares of parents vs. crosses and lines x testers were significant for all traits, indicating the presence of non-additive in the inheritance of these traits. The combined analysis indicated that mean squares of lines x environment was significant for all traits, except for HD. Mean squares of testers x environment was significant except for days to 50% flowering and HD. The interaction mean squares of LxTxE were significant for all traits, indicating the interaction of non-additive gene effects with environment. The results of the combined analysis indicated that the ratio σ^2A/σ^2D was less than unity for all traits, and the role of dominance was more important than that of additive effects. The results of GCA indicated that none of the female or male lines was the best combiner for all traits. Thirteen out of the 16 hybrids were significantly ($P\leq0.01$to $P\leq0.05$) earlier than the earliest check cultivar Giza 102. The performance of the F_1-hybrids in days to 50% flowering were mostly related to the GCA of the parents rather than the SCA of the hybrids. The combined analysis of plant height showed that eight hybrids gave negative SCA effects. All the F_1-hybrids were significantly ($P\leq0.01$) shorter than the two check cultivars. Based on the combined analysis; eight hybrids had positive SCA for head diameter; but none exceeded the check variety in head diameter. Based on the combined analysis 8 hybrids showed negative SCA for husk%, the performance of all hybrids was significantly ($P\leq0.01$) lower in husk % than the better check Sakha 53. The combined analysis of oil % indicated that five hybrids showed significant positive SCA, four of them exceeded significantly ($P\leq0.01$ to $P\leq0.01$) the better check cultivar Giza 102. The combined SCA effects of seed yield/head (SY/P) were positive and significant for three hybrids (A7 x RF1, A15 x RF3 and A21 x RF5). The performance of the first hybrid (46.45 g/head) was significantly ($P\leq0.01$) better than the better check Giza 102 (41.21 g/head). The hybrids performance was not in accordance with sign and significance of SCA of SY/P. Furthermore, the GCA of the parents was far from yielding ability. The combined SCA of five hybrids for oil yield/head were positive and significant ($P\leq0.01$). The performance of the first hybrid (A7 x Rf1) (18.18 g) exceeded significantly ($P\leq0.01$) the better check Giza 102 in oil yield/head (15.43 g). It could be concluded that the performance of the hybrids was not in accordance with the sign and significance of the SCA effects. This could be due to that the ratio of σ^2A/σ^2D was less than unity and the dominance effects were more important than additive in the inheritance of all traits, and evaluation of hybrids should be at a variety of environments.

Key words: ***Line tester analysis, Helianthus annuus L., GCA, SCA.***

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a wide spread edible oil crop all over the world. It ranked the second after soybean (Peniego *et al.*, 2002). It is a short duration crop, and can be grown at any time of the year in tropical and sub-tropical, tolerant to drought, high oil content and yield potential. Egypt faces severe shortage of edible oil, and spends a big amount of foreign exchange on its import annually. Self-sufficiency of edible oil was12.4% as an average of 1995 to 1999. Imports of edible oils reached 2.0 million tons in 2015/2016. The cultivated area of sunflower in Egypt in 2016 was 8000 ha gave 22000 tons (FAO, 2016). Line x tester analysis developed by Kempthorne (1957) is one of the breeding strategies that efficiently evaluates the combining ability variances and effects of inbred parents, and provides information regarding genetic mechanisms controlling polygenic traits. Various statistical approaches including additive and dominant gene action, genetic advance, broad sense and narrow sense heritability, provides an opportunity to plant breeder for selecting suitable breeding program for crop yield improvement. Jan *et al*. (2006), Farrokhi *et al*. (2008) Khan *et al*. (2008), Dudhe *et al*. (2011), and Ahmad *et al*. (2012) studied combining ability for various traits in sunflower, and indicated that the non-additive effects were pronounced for all traits except for plant height and head diameter (Tan (2010). The ratio of gca to sca variances were lower than 1 for all characters except plant height Turkec et al. (2006). However, Mijic *et al*. (2008) noted that additive and dominant part of the variance had influence on inheritance of seed and oil yields, although the influence of the additive part of variance was greater. Khan *et al*. (2009) indicated that gene action was predominantly additive for days to first flowering and plant height. Machikowa *et al*. (2011) and Saleem-Ud-Din *et al*. (2014) found that components of variance showed that the GCA variance was higher than the SCA variance for yield, head diameter and oil content. Arshad *et al*. (2010) found that heritability and genetic advance under selection were 0.90 and 8.63% for days to flower initiation, 0.83 and 13.62% for plant height, 0.10 and 1.46 % for head diameter, 0.62 and 0.18% for seed yield/ha, 0.30 and 9.73 for 100-seeed weight and 0.44 and 4.87% for oil%. Dhillon and Tyagi (2016) studied combining ability of agronomic traits in seven lines, six testers and their 42 hybrids. Mean squares of lines, testers, lines vs testers, hybrids, parents vs hybrids and lines x testers was significant for days to 50% flowering, plant height head diameter, 1000-seed weight, seed yield and oil %. The aims of the present study were to evaluate the combining ability variances and effects of inbred parents and crosses, and to study the role of additive and dominance effects in the inheritance of earliness, seed and oil yields and related traits under two contrasting environments.

MATERIALS AND METHODS

A- Genetic materials

Four cytoplasmic male sterile (CMS) lines (A-Lines; A7 and A19 from Argentine, and A15 and A21 from Russia), and four fertility restorer lines (RF-lines from Egypt), along with two check varieties of sunflower (*Helianthus annuus* L.) were planted at Assiut Agric. Res. Stn. Agric. Res. Center in summer season 2015, to develop 16 crosses. The sixteen obtained sunflower crosses, the four testers, the four fertile lines (B-Lines) and the two check varieties; Sakha 53 and Giza 102 were evaluated at two contrasting environments; loamy sand and clay soils (Table1).

Planting dates were on September 10th at Assiut Agric. Res. Stn. ARC. (loamy sand soil), and on September 20th ,2016 at Fac. Agric. Assiut Univ. Exper. Farm (clay soil). Randomized complete block designs (RCBD) with three replications were used in the two locations. The plot size was one row, 4-meter-long and 60 cm apart. Planting was done by hand in hills spaced 25 cm apart. Seedlings were thinned to one plant per hill after two weeks from planting in both locations. The recommended cultural practices for oil seed sunflower production were adopted throughout the growing season. Five guarded plants were tagged. At flowering, days to 50 % flowering from sowing date until 50% of the plants showed their anthesis was recorded. The recorded characters on **the** tagged plants were; Plant height; cm (PH), head diameter, cm (HD, 100 seed weight; g(100-SW), husk percentage (Husk%) (a sample of seeds was peeled to husk and kernel; Husk% = (husk weight in the sample)/sample weight * 100, oil percentage: was determined by Soxcelt apparatus using petroleum ether (BP60-80 c) as a solvent, according to the official method (A. O. A. C. 1980), number of seed per head (NS/H), seed yield / head (SY/H; g) and oil yield per head (OY/H; g): was estimated as oil % * average seed yield/head.

B- Statistical analysis and procedures

Combined analysis of variance was performed as outlined by **Gomez and Gomez (1984)** after carrying out the homogeneity of variances using Bartlett test. The line tester analysis was performed as Kempthorne (1957) and Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

It is obvious that the loamy sand soil has a light texture (Table 1), resulting in a proper porosity that causes a good balance between soil moisture and air contents compared to those of clay soil that display a heavy texture. Thus, plant roots can penetrate and spread in a greater area of the loamy sand soil relative to that of the clay one. Moreover, the loamy sand soil has a good physical properties and conditions that encourage plant roots to extend in more rhizosphere area to absorb water and nutrients. Also, the irrigation water goes through the clay soil very slowly causing the root zone to be saturated with water on the charge of soil air that is necessary for root respiration and spread. For the chemical and nutritional point of view, the loamy sand soil has a lower salt content (0.68 ds/m), and higher available phosphorus “P” (29.9 mg/kg) than the clay soil (1.07 ds/m and 11.17 mg/kg; respectively), even though, both are not saline. The available P content of the loamy sand soil is extremely sufficient for plant needs. However, the available P of the clay soil is considered marginal. In conclusion, the physical properties (soil texture, porosity and water distribution) and some chemical and nutritional properties (salinity and available P) of loamy sand soil are preferable. However, organic matter, extractable K, total nitrogen, soluble Ca, Mg, Na, K were higher in clay than in loamy sand soil.

Table 1. Some physical and chemical properties of representative soil samples in the experimental sites before sowing (0-30 cm depth)

Soil property	Assiut Res. Stn	Fac. Agric. Res. Farm
Particle - size distribution		
Sand (%)	78.24	27.4
Silt (%)	9.76	24.3
Clay (%)	12.00	48.3
Texture grade	Loamy sand	Clay
EC (1:1 extract) dSm^{-1}	0.68	1.07
pH (1:1 suspension)	8.19	8.01
Total $CaCO_3$ (%)	25.0	3.4
Organic matter (%)	0.06	0.24
$NaHCO_3$-extractable P (mg kg^{-1})	29.9	11.17
NH_4OAC-extractable K (mg kg^{-1})	130	300
Total nitrogen (%)	0.04	0.08
Soluble Ca (mg kg^{-1})	100	190
Soluble Mg (mg kg^{-1})	12	72
Soluble Na (mg kg^{-1})	4.6	140
Soluble K (mg kg^{-1})	11.7	39
Soluble Cl (mg kg^{-1})	177.5	142
Soluble HCO_3 (mg kg^{-1})	610	427

* Each value represents the mean of three replications

Line tester analysis

Separate and combined analyses of variance

Separate and combined analyses of variance (Table 2) showed that mean squares of the environment was significant for all traits ($P \leq 0.01$) except for head diameter (HD). Furthermore, most of the variability was for environment, except for husk %. This provides evidence of large differences in edaphic and climatic factors prevailed in the two environments.

Mean squares of genotypes and female lines was significant ($P \leq 0.01$) for all traits, and testers mean squares were significant for all traits except husk % at loamy sand soil. These results indicate the presence of additive variance. Mean squares of parents vs. crosses and lines x testers were significant for all traits, indicating the presence of non-additive in the inheritance of these traits. The combined analysis indicated that mean squares of lines x environment was significant for all traits, except for HD. Mean squares of testers x environment was significant except for days to 50% flowering and HD. The significant interaction of lines x environment and/or testers x environment denotes to the interaction of additive variance with environment. The interaction mean squares of LxTxE were significant for all traits, indicating the interaction of non-additive gene effects with environment, meaning that the dominance and epistatic effects controlled the inheritance of a trait varied from environment to another. Kaya and Atakisi (2004) noted significant mean square for location (L), years (Y), YxL, females, males and FxM for flowering, plant height, head diameter and 100 seed weight. Kaya (2005) found change in seed yield, oil yield, oil % and hull rate from year to year. Cvejic *et al*. (2015) noted that environmental factors had the highest influence on the formation of seed and oil yield. Khan *et al*. (2017) found significant differences between hybrids and years for seed yield/head, head diameter, number of seeds/head, and their interactions with years.

Table 2. Mean squares of separate and combined analysis of the studied traits.

Source of variation	d.f	Mean squares								
		50 % flowering			PH; cm			HD; cm		
		Loamy sand soil	Clay soil	Combined	Loamy sand soil	Clay soil	Combined	Loamy sand soil	Clay soil	Combined
Env. (E)	1	—	—	124.69**	—	—	26732.25**	—	—	0.16
Rep/Exp.	4	—	—	0.21	—	—	512.69	—	—	0.38
Reps	2	0.26	0.16	—	9.41	1015.94**	—	0.27	0.48	—
Genotypes (G)	23	11.85**	5.31**	10.96**	396.32**	1621.18**	1621.52**	24.02**	19.53**	34.36**
Parents (P)	7	5.99*	1.02	4.78	716.8**	989.8**	1533.62**	46.29**	21.56**	44.1**
P. vs C.	1	32.11**	7.56	4.22	1820.44**	17600.5**	15370.69**	145.21**	165.77**	310.62**
Crosses (C)	15	13.24**	7.17**	14.3**	151.82**	850.52**	745.93**	5.55**	8.83**	11.4**
Lines (L)	3	28.47**	5.07**	25.09**	418.69**	2382.48**	2360.75**	8.37**	3.52*	10.7**
Testers (T)	3	27.14**	8.13**	31.34**	88.52**	564.15**	515.67**	14.43*8	11.21**	23.18**
L × T	9	3.53	7.54**	5.02	83.97**	435.33**	284.42**	1.66	9.81**	7.7**
Error	46	3.02	1.96	—	18.51	70.29	—	1.12	1.01	—
G × E	23	—	—	6.2*	—	—	395.98**	—	—	9.19**
P × E	7	—	—	2.24	—	—	172.98**	—	—	23.75**
P. vs. C × E	1	—	—	35.47**	—	—	4050.31**	—	—	0.36
C × E	15	—	—	6.11*	—	—	256.41**	—	—	2.99*
L × E	3	—	—	8.46**	—	—	440.42**	—	—	1.19
T × E	3	—	—	3.93	—	—	137*	—	—	2.46
L × T × E	9	—	—	6.05*	—	—	234.88**	—	—	3.76**
Error (com)	92	—	—	2.49	—	—	44.4	—	—	1.07

*, **; significant at 0.05 and 0.01levels of probability; respectively

Table 2. Cont.

Source of variation	d.f	Mean squares								
		100 SW; g			N.S./H			Husk %		
		Loamy sand soil	Clay soil	Combined	Loamy sand soil	Clay soil	Combined	Loamy sand soil	Clay soil	Combined
Env. (E)	1	—	—	159.43**	—	—	218448**	—	—	14.13**
Rep/Exp.	4	—	—	0.47	—	—	23827	—	—	0.58
Reps	2	0.26	0.69	—	44	47610	—	0.84	0.32	—
Genotypes (G)	23	7.63**	1.97**	7.05**	113789.1**	138517.1**	198990.1**	20.79**	26.78**	31.13**
Parents (P)	7	11.17**	3.26**	9.01**	232885**	320722.3**	441553.6**	32.74**	48**	46.97**
P. vs C.	1	77.16**	14.03**	78.49**	389982**	51904*	363237**	132.29**	64.73**	191.02**
Crosses (C)	15	1.34**	0.57**	1.37**	39798.27**	59262**	74844**	7.78**	14.34**	13.08**
Lines (L)	3	1.82**	1.04**	2.79**	64693.33**	142645.3**	193529.3**	8.51**	27.36**	32.67**
Testers (T)	3	1.53**	0.46**	0.84**	30727.34**	53801.33**	59404**	0.6	16.67**	6.95**
L × T	9	1.11**	0.45**	1.08*|*	34523.56**	33287.78**	40428.89**	9.93**	9.23**	8.59**
Error	46	0.32	0.08	—	4493.35	8169.57	—	1.36	0.85	—
G × E	23	—	—	2.55**	—	—	53316.18**	—	—	16.43**
P × E	7	—	—	5.41**	—	—	112053.3**	—	—	33.76**
P. vs. C × E	1	—	—	12.7**	—	—	78651**	—	—	6**
C × E	15	—	—	0.54*	—	—	24216.27**	—	—	9.04**
L × E	3	—	—	0.07	—	—	13809.33	—	—	3.21*
T × E	3	—	—	1.16**	—	—	25124*	—	—	10.31**
L × T × E	9	—	—	0.48*	—	—	27382.67**	—	—	10.56**
Error (com)	92	—	—	0.2	—	—	6331.17	—	—	1.1

Table 2. Cont.

Source of variation	d.f	Mean squares								
		Oil %			OY/H; g			SY/H; g		
		Loamy sand soil	Clay soil	Combined	Loamy sand soil	Clay soil	Combined	Loamy sand soil	Clay soil	Combined
Env. (E)	1	—	—	1400.02**	—	—	1386.98**	—	—	4397.27**
Rep/Exp.	4	—	—	2.13	—	—	4.43	—	—	29.61
Reps	2	3.1	1.16	—	1.57	7.3	—	3.38	55.84	—
Genotypes (G)	23	50.92**	17.02**	32.69**	132.2**	35.92**	127.19**	758.15**	307.44**	853.95**
Parents (P)	7	104.17**	16.38**	50.07**	248.33**	59.93**	231.38**	1378.79**	563.89**	1568.41**
P. vs C.	1	66.7**	2.25	46.75**	744.7**	96.3**	688.3**	4911.78**	733.48**	4720.67**
Crosses (C)	15	25.02**	18.31**	23.64**	37.16**	20.69**	41.16**	191.6**	159.36**	262.75**
Lines (L)	3	14.97**	2.83*	2.57	49.69**	38.95**	83.41**	381.56**	283.82**	626.21**
Testers (T)	3	47.47**	13.06**	52.63**	38.3**	28.1**	36.63**	187.36**	162.77**	165.15**
L × T	9	20.88**	25.22**	21**	32.61**	12.14**	28.58**	129.7**	116.74**	174.13**
Error	46	1.2	0.85	—	1.17	1.34	—	8.74	10.4	—
G × E	23	—	—	35.25**	—	—	40.93**	—	—	211.64**
P × E	7	—	—	70.47**	—	—	76.89**	—	—	374.27**
P. vs. C × E	1	—	—	22.19**	—	—	152.69**	—	—	924.58**
C × E	15	—	—	19.69**	—	—	16.7**	—	—	88.22**
L × E	3	—	—	15.23**	—	—	5.22**	—	—	39.17*
T × E	3	—	—	7.9**	—	—	29.77**	—	—	184.98**
L × T × E	9	—	—	25.1**	—	—	16.17**	—	—	72.31**
Error (com)	92	—	—	1.02	—	—	1.25	—	—	9.57

The role of additive and non-additive gene effects in the inheritance of different traits

The additive variance (σ^2A) was larger at loamy sand than at clay soil for days to 50% flowering, HD, 100 seed weight, oil % and SY/H, however, it was larger in clay soil for PH, husk %, NS/H and OY/H (Table 3). The dominance variance (σ^2D) was larger at loamy sand than at clay soil for 100 seed weight, husk weight and percentage, oil weight, kernel weight, NS/H, SY/H and OY/H, and *vice versa* for the other traits.

The ratio σ^2A/σ^2D was less than unity for all traits except for flowering and SD at loamy sand soil, indicating that the role of dominance was more important than additive effects in the inheritance of these traits. It is worth noting that the negative σ^2A indicates that the males and/or females mean squares were less than the line x tester interaction. The results of the combined analysis indicated that the ratio σ^2A/σ^2D was less than unity for all traits, and the role of dominance was more important than that of additive effects. Skoric *et al*. (2000) found that both additive and non-additive gene action were responsible for the inheritance of plant height, seed yield/ha, oil %, and oil yield/ha, and the ratios of GCA/SCA were lower than one indicating the higher importance of non-additive in the inheritance of these traits. Jan *et al.* (2006), Karasu *et al*. (2010) and Dudhe *et al*. (2011) came to the same conclusion. Farrokhi *et al*. (2008) supported these results respect for seed yield and oil %. Khan *et al*. (2008) noted that the ratio GCA/SCA revealed predominance of non-additive in the inheritance of days to 50% flowering, 100-seed weight, seeds/head, oil content and seed yield. However, Khan *et al*. (2009) indicated that gene action was predominantly additive for days to first flower and plant height, and for yield, head diameter and oil content (Machikowa *et al*. 2011).

General combining ability (GCA) effects

The GCA effects in other words; the additive and additive x additive gene actions are the main contribution of parental lines. Respect to days to 50% flowering, the negative GCA effects of lines and testers are preferable. Line A21 gave negative significant GCA under both environments and their combined analysis (Table 4). The restorer line RF2 showed negative significant GCA under both environments and their combined analysis, while RF3 showed significant GCA at loamy sand soil only. Furthermore, these female lines and testers recorded fewer days to 50% blooming across environments. A7, A19 and RF3 showed negative significant ($P\leq0.01$) GCA effects for plant height, and could be considered good combiners for shortening plant height. A15 and RF5 gave positive significant ($P\leq0.01$) GCA effects for head diameter and could be considered good combiners for increasing head diameter. The combined analysis indicated positive significant (P≤0.01) GCA effects for A21 and RF2 for 100 seed weight.

The female lines A15 and A19, and the restorer line RF2 showed negative significant combined GCA for husk % and could be good combiners to reduce husk %. It depends on the ratio of σ^2GCA/σ^2SCA. The restorer lines RF1, RF3 and RF5 showed positive significant GCA for oil %, however, non- of them was significant for oil weight. The combined analysis showed that A7, A15 and RF5 were the good combiners for number of seeds/head, seed yield/head and oil yield/head, and showed significant (P≤0.01) GCA effects. The results indicated that none of the female or male lines was the best combiner for all traits. It should be indicating that the parents with high performance may not transmit their characteristics to their hybrids. It depends upon the ratio of (σ^2GCA/ σ^2SCA) of the characters (**Baker, 1978**). If the ratio of (σ^2GCA/σ^2SCA) equal one or more, parents of high performance transmit their characteristics to their hybrids. If this ratio is less than unity, the performance of the hybrids could not be expected (**Baker, 1978**). **Laureti and Gatto (2001)** stated that the GCA of a line can change in function of the germplasm with which it is combined.

Specific combining ability (SCA) effects

Estimates of SCA effects of the hybrids at loamy sand, clay soil and their combined for all traits are presented in Table 4. The combined analysis indicated that 7 hybrids showed negative insignificant SCA for days to 50% flowering, and one hybrid (A19 x RF5) gave significant negative SCA effects. However, this hybrid (A19 x RF5) was not early. It depends on the ratio of σ^2A/σ^2D, it was less than unity (0.3821, Table 3). Otherwise, the female parent A21 and male parent RF2 which showed significant (P≤0.01) negative GCA, most of their crosses were early. Furthermore, the female line A19 which gave significant (P≤0.01) positive GCA, its hybrids (A19 x RF1, A19 x RF2, A19 x RF4 and A19 x RF5) were late in days to 50% flowering. It should be recalled that eight out of the 16 hybrids were significantly (P≤0.01) earlier, and five hybrids were significantly (P≤0.05) earlier than the earliest check cultivar Giza 102. It could be concluded that the performance of the F_1-hybrids in days to 50% flowering were mostly related to the GCA of the parents rather than the SCA of the hybrids.

The combined analysis of plant height showed that eight hybrids gave negative SCA effects, only two were significant (A15 x RF5 and A21 x RF1). Most of the hybrids which gave negative SCA were shorter in plant height than those showed significant positive SCA (Table 4). Furthermore, the hybrids involved female and/or male lines of significant negative GCA were shorter in plant height than those involved parents of positive significant GCA. The shortest hybrids were A7 x RF2, A7 x RF3, A19 x RF1 and A19 x RF3. All the F_1-hybrids were significantly (P≤0.01) shorter than the two check cultivars.

Table 3. Additive (σ^2A) and dominance (σ^2D) variances for yield and its components in the two environments and their combined

Traits	Genetic comp	Loamy sand soil	Clay Soil	Combined
50 % flow	Additive(σ^2A)	1.3487	-0.0522	0.6444
	Dominance (σ^2D)	0.6813	7.4360	1.6864
	σ^2A/σ^2D	1.9796	-0.0070	0.3821
PH; cm	Additive(σ^2A)	9.4244	57.6659	32.0498
	Dominance (σ^2D)	87.2780	486.7178	160.0133
	σ^2A/σ^2D	0.1080	0.1185	0.2003
HD; cm	Additive(σ^2A)	0.5412	-0.1359	0.2565
	Dominance (σ^2D)	0.7085	11.7365	4.4243
	σ^2A/σ^2D	0.7639	-0.0116	0.0580
100 SW; g	Additive(σ^2A)	0.0315	0.0169	0.0205
	Dominance (σ^2D)	1.0589	0.4829	0.5831
	σ^2A/σ^2D	0.0297	0.0350	0.0352
Husk %	Additive(σ^2A)	-0.2987	0.7104	0.3115
	Dominance (σ^2D)	11.4248	11.1752	4.9941
	σ^2A/σ^2D	-0.0261	0.0636	0.0624
Oil %	Additive(σ^2A)	0.5745	-0.9598	0.1832
	Dominance (σ^2D)	26.2425	32.4984	13.3201
	σ^2A/σ^2D	0.0219	-0.0295	0.0138
N.S/H	Additive(σ^2A)	732.5988	3607.5310	2389.9380
	Dominance (σ^2D)	40040.2800	33490.9500	22731.1800
	σ^2A/σ^2D	0.0183	0.1077	0.1051
SY/H; g	Additive(σ^2A)	8.5978	5.9199	6.1543
	Dominance (σ^2D)	161.2741	141.7859	109.7028
	σ^2A/σ^2D	0.0533	0.0418	0.0561
OY/H ;g	Additive(σ^2A)	0.6325	1.1877	0.8733
	Dominance (σ^2D)	41.9241	14.4030	18.2192
	σ^2A/σ^2D	0.0151	0.0825	0.0479

The results of SCA effects of head diameter based on the combined analysis showed that eight hybrids had positive SCA, only two were significant (P≤0.01). The other hybrids showed negative SCA, and only two were significant (P≤0.01). The best hybrids in HD were A15 x RF1 (19.97 cm), A15 x RF5 (19.82 cm), A19 x RF5 (19.17 cm) and A21 x RF5 (21.07 cm). All had one or both parents showed positive significant GCA and all had positive SCA except one (A15 x RF5).

Based on the combined analysis of 100 seed weight, the SCA effects of hybrids were significant and positive for four combinations (A7 x RF2, A15 x RF2, A19 x RF5 and A21 x RF5). The results indicated that the above four combinations and another six gave 100-seed weight did not significantly differ from better check Sakha 53.

Table 4. Combined mean, estimates of general combining ability for males and female lines, and specific combining ability of the hybrids for the studied traits at loamy sand soil, clay soil and their combined.

Genotypes	50 %flowering				Plant Height			
	GCA and SCA effects			Combined mean	GCA and SCA effects			Combined mean
	Loamy sand soil	Clay soil	Combined		Loamy sand soil	Clay soil	Combined	
Female (Lines)								
A7	-0.875	0.3958	-0.2396	53.83	-1.2917	-8.625**	-4.9583**	102.67
A15	0.7083	0.0625	0.3854	53.17	8.2917**	20.4583**	14.375**	124.17
A19	1.7917**	0.4792	1.1354**	54.33	-5.7083**	-9.9583**	-7.8333**	121.67
A21	-1.625**	-0.9375*	-1.2812**	53.00	-1.2917	-1.875	-1.5833	118.00
S.E. (GCA) L	0.5015	0.4046	0.3222		1.2419	2.4202	1.3601	
S.E. (gi-gj) (gi-gj) L	0.7092	0.5722	0.4556		1.7563	3.4227	1.9235	
Male (Testers)								
RF1	0.5417	0.1458	0.3438	55.50	2.2917*	0.4583	1.375	93.67
RF2	-1.375**	-1.0208*	-1.1979**	52.67	-1.5417	-1.625	-1.5833	82.83
RF3	-1.0417*	-0.1042	-0.5729	53.50	-3.0417*	-7.7083**	-5.375**	90.67
RF5	1.875**	0.9792*	1.4271**	53.50	2.2917*	8.875**	5.5833**	117.67
S.E. (GCA) T	0.5015	0.4046	0.3222		1.2419	2.4202	1.3601	
S.E. (gi-gj) (gi-gj) T	0.7092	0.5722	0.4556		1.7563	3.4223	1.9235	
Crosses								
A7×RF1	0.625	-0.8125	-0.0937	53.33	5.375*	0.4583	2.9167	127.67
A7×RF2	-1.125	-0.9792	-1.0521	50.83	-2.7917	0.875	-0.9583	120.83
A7×RF3	-1.125	2.7708**	0.8229	53.33	-6.9583**	7.2917	0.1667	118.17
A7×RF5	1.625	-0.9792	0.3229	54.83	4.375*	-8.625	-2.125	126.83
A15×RF1	-0.625	0.521	-0.0521	54.00	2.7917	17.375**	10.0833**	154.17
A15×RF2	-0.0417	-0.3125	-0.1771	52.33	-0.7083	0.7917	0.0417	141.17
A15×RF3	0.625	-1.2292	-0.3021	52.83	-0.875	-7.125	-4.000	133.33
A15×RF5	0.0417	1.0208	0.5313	55.67	-1.2083	-11.0417*	-6.125*	142.17
A19×RF1	0.2917	-0.2292	0.0313	54.83	0.125	-9.875	-4.875	117.00
A19×RF2	0.875	1.2708	1.0729	54.33	2.2917	6.875	4.5833	123.50
A19×RF3	0.5417	0.3542	0.4479	54.33	2.4583	3.2917	2.875	118.00
A19×RF5	-1.7083	-1.3958	-1.5521*	54.33	-4.875*	-0.2917	-2.5833	123.50
A21×RF1	-0.2917	0.5208	0.1146	52.50	-8.2917**	-7.9583	-8.125**	120.00
A21×RF2	0.2917	0.0208	0.1562	51.00	1.2083	-8.5417	-3.667	121.50
A21×RF3	-0.0417	-1.8958*	-0.9688	50.50	5.375*	-3.4583	0.9583	122.33
A21×RF5	0.0417	1.3542	0.6979	54.17	1.7083	19.9583**	10.8333**	143.17
Sakha 53				59.50				156.33
Giza 102				56.17				171.00
S.E. (SCA)	1.0029	0.8093	0.6444	LSD 0.05= 1.76	2.4837	4.8404	2.7202	LSD 0.05= 7.03
S.E. (Sij-Skl)	1.4184	1.1445	0.9113	LSD 0.01= 2.31	3.5125	6.8453	3.847	LSD 0.01= 9.20

Table 4. Cont.

Geno-types	Head Diameter				100 seed weight			
	GCA and SCA effects			Combined mean	GCA and SCA effects			Combined mean
	Loamy sand soil	Clay soil	Combined		Loamy sand soil	Clay soil	Combined	
Female (Lines)								
A7	-0.0875	-0.4354	-0.2615	15.87	0.0785	0.1288	0.1037	3.39
A15	1.1458**	0.7729*	0.9593**	17.83	0.1735	0.1071	0.1403	5.28
A19	-0.8542**	-0.3021	-0.5781**	18.23	-0.5665**	-0.4371**	-0.5018**	5.14
A21	-0.2042	-0.0354	-0.1198	16.47	0.3144	0.2013*	0.2578**	3.87
S.E. (GCA) L	0.3061	0.2896	0.2107		0.1627	0.0838	0.0915	
S.E. (gi-gj) (gi-gj) L	0.4329	0.4095	0.298		0.2302	0.1185	0.1295	
Male (Testers)								
RF1	-0.7375*	0.1479	-0.2948	13.13	-0.479**	0.1321	-0.1734	2.63
RF2	0.2125	0.2646	0.2385	10.87	0.3777*	0.1413	0.2595**	2.25
RF3	-0.94**	-1.3521**	-1.448**	12.43	0.1052	-0.2804*	-0.0876	2.07
RF5	1.4625**	0.9396**	1.2010**	16.80	-0.004	0.0071	0.0016	3.92
S.E. (GCA) T	0.3061	0.2896	0.2107		0.1627	0.0838	0.0915	
S.E. (gi-gj) (gi-gj) T	0.4329	0.4095	0.298		0.2302	0.1185	0.1295	
Crosses								
A7×RF1	0.1042	1.0354	0.5698	18.33	0.1881	0.2979	0.243	5.31
A7×RF2	-0.9125	-0.1479*	-0.5302	17.77	-0.3052	-0.0813	-0.1932	5.30
A7×RF3	0.5708	1.8021**	1.1865**	18.10	0.6706*	0.3171	0.4939**	5.64
A7×RF5	0.2375	-2.6896**	-1.2260**	18.03	-0.5535	-0.5338**	-0.5437**	4.70
A15×RF1	-0.2625	-0.3729	-0.3177	18.67	0.1498	-0.0771	0.0364	5.14
A15×RF2	0.2542	0.6438	0.449	19.97	0.8698**	-0.0529	0.4084*	5.94
A15×RF3	0.2708	0.7938	0.5323	18.67	-0.4210	0.2454	-0.0878	5.10
A15×RF5	-0.2625	-1.0646	-0.6635	19.82	-0.5985	-0.1154	-0.357	4.92
A19×RF1	0.8042	0.7021	0.7531	18.20	0.0865	-0.0462	0.0201	4.48
A19×RF2	0.7875	0.1854	0.4865	18.47	-0.4535	0.0146	-0.219	4.67
A19×RF3	-1.0625	-1.8646**	-1.4635**	15.13	-0.081	-0.5871**	-0.3341	4.21
A19×RF5	-0.5292	0.9771	0.224	19.17	0.4481	0.6188**	0.5334**	5.17
A21×RF1	-0.6458	-1.3646*	-1.0052	16.90	-0.4244	-0.1746	-0.2995	4.92
A21×RF2	-0.1292	-0.6812	-0.4052	18.03	-0.111	0.1196	0.0043	5.66
A21×RF3	0.2208	-0.7312	-0.2552	16.80	-0.1685	0.0246	-0.072	5.23
A21×RF5	0.5542	2.7771**	1.6656**	21.07	0.704	0.0304	0.3672*	5.76
Sakha 53				20.65				5.51
Giza 102				21.68				5.39
S.E. (SCA)	0.6122	0.5792	0.4214	LSD 0.05= 1.04	0.3255	0.1677	0.1831	LSD 0.05= 0.47
S.E. (Sij-Skl)	0.8658	0.8190	0.5959	LSD 0.01= 1.36	0.4603	0.2371	0.2589	LSD 0.01= 0.62

Table 4. Cont.

Geno-types	Husk Percent				Oil percent			
	GCA and SCA effects			Combined mean	GCA and SCA effects			Combined mean
	Loamy sand soil	Clay soil	Combined		Loamy sand soil	Clay soil	Combined	
Female (Lines)								
A7	0.9758**	1.9517**	1.4638**	27.65	-1.042**	0.3333	-0.3541	30.67
A15	-0.855*	-1.6433**	-1.2492**	27.09	-0.875**	0.5	-0.1875	37.33
A19	-0.5275	-0.5308*	-0.5292*	27.76	1.125**	-0.4167	0.3542	36.17
A21	0.4067	0.2225	0.3146	34.71	0.7917*	-0.4167	0.1875	33.33
S.E. (GCA) L	0.3367	0.2655	0.2144		0.316	0.2658	0.2065	
S.E. (gi-gj) (gi-gj) L	0.4762	0.3754	0.3032		0.4469	0.3759	0.292	
Male (Testers)								
RF1	-0.1483	1.5167**	0.6842**	31.16	1.375**	0.75**	1.0625**	38.50
RF2	-0.005	-1.24**	-0.6225**	32.01	-2.875**	-1.5**	-2.1875**	39.33
RF3	-0.1625	0.2433	0.0404	26.96	0.2083	0.6667*	0.4375*	37.83
RF5	0.3158	-0.52*	-0.1021	29.35	1.2917**	0.083	0.6875**	37.50
S.E. (GCA) T	0.3367	0.2655	0.2144		0.316	0.2658	0.2065	
S.E. (gi-gj) (gi-gj) T	0.4762	0.3754	0.3032		0.4469	0.3759	0.292	
Crosses								
A7×RF1	-2.15**	-0.7325	-1.4429**	27.85	1.7083**	1.0833*	1.3958**	39.67
A7×RF2	-1.2333	0.4742	-0.3796	27.61	-0.0417	0.3333	0.1458	34.83
A7×RF3	3.1808**	-0.1858	1.4975**	30.15	-2.125**	-0.8333	-1.4792**	36.17
A7×RF5	0.2058	0.4442	0.325	28.83	0.4583	-0.5833	-0.0625	37.50
A15×RF1	0.2908	0.2158	0.2533	26.83	-0.125	-0.4167	-0.2708	38.17
A15×RF2	1.1242	-2.6575**	-0.7667	24.51	-3.875**	-0.5	-2.1875**	33.00
A15×RF3	-1.58*	-0.4042	-0.9913	24.94	4.375**	-2.3333**	1.0208*	38.83
A15×RF5	0.1633	2.8458**	1.5046**	27.30	-0.375	3.25**	1.4375**	39.67
A19×RF1	-0.2067	0.0967	-0.055	27.24	-0.125	-2.5**	-1.3125**	37.67
A19×RF2	0.0733	1.0933*	0.5833	26.58	0.125	0.0833	0.1042	35.67
A19×RF3	-1.0592	1.26*	0.1004	26.76	-0.2917	5.5833**	2.6458**	41.00
A19×RF5	1.1925	-2.45**	-0.6288	25.88	0.2917	-3.1667**	-1.4375**	37.17
A21×RF1	2.0692**	0.42	1.2446**	29.39	-1.458*	1.8333**	0.1875	39.00
A21×RF2	0.0358	1.09*	0.5629	27.40	3.7917**	0.0833	1.9375**	37.50
A21×RF3	-0.5433	-0.67	-0.6067	26.89	-1.96**	-2.4167**	-2.1875**	35.83
A21×RF5	-1.56*	-0.84	-1.2008**	26.16	-0.375	0.5	0.0625	38.50
Sakha 53				32.27				35.67
Giza 102				33.88				37.33
S.E. (SCA)	0.6735	0.5309	0.4289	LSD 0.05= 1.14	0.632	0.5317	0.413	LSD 0.05= 1.43
S.E. (Sij-Skl)	0.9524	0.7508	0.6065	LSD 0.01= 1.49	0.8938	0.7519	0.584	LSD 0.01= 1.87

Table 4. Cont.

Geno-types	Number of Seed per Head				Seed yield /head			
	GCA and SCA effects			Combined mean	GCA and SCA effects			Combined mean
	Loamy sand soil	Clay soil	Combined		Loamy sand soil	Clay soil	Combined	
Female (Lines)								
A7	74.5237**	118.9154**	96.7195**	442.64	4.8548**	5.7052**	5.28**	16.81
A15	51.5369**	50.8614	51.1991**	980.03	4.0681**	2.3844**	3.2263**	50.24
A19	-60.069**	-37.3461	-48.71**	847.03	-7.2419**	-4.0248**	-5.6333**	37.71
A21	-65.99**	-132.43**	-99.21**	675.25	-1.681*	-4.0648**	-2.8729**	25.88
S.E. (GCA) L	19.3506	26.0921	16.2419		0.8535	0.9309	0.6315	
S.E. (gi-gj) (gi-gj) L	27.3659	36.8998	22.9695		1.2071	1.3165	0.8931	
Male (Testers)								
RF1	-32.054	53.221*	10.5834	372.45	-4.8644**	3.1885**	-0.8379	9.63
RF2	-9.4138	2.84	-3.2871	306.41	1.6181	0.8435	1.2308	6.44
RF3	-32.6774	-95.25**	-63.964**	249.44	-1.1419	-5.309**	-3.2254**	5.04
RF5	74.1455**	39.1906	56.6679**	749.46	4.3881**	1.2769	2.8325**	30.07
S.E. (GCA) T	19.3506	26.0921	16.2419		0.8535	0.9309	0.6315	
S.E. (gi-gj) (gi-gj) T	27.3659	36.8998	22.9695		1.2071	1.3165	0.8931	
Crosses								
A7×RF1	46.9509	185.777**	116.3638**	908.04	3.7927*	10.4748**	7.1338**	46.45
A7×RF2	-93.423	-60.045	-76.734*	701.08	-7.3665**	-2.8669	-5.1167**	36.27
A7×RF3	-40.2471	-44.2985	-42.2728	674.86	1.9235	-0.2844	0.8196	37.75
A7×RF5	86.7191*	-81.4342	2.6425	840.41	1.6502	-7.3235**	-2.8367*	40.15
A15×RF1	56.03	-66.2739	-5.1219	741.04	4.4194**	-3.321	0.5492	37.81
A15×RF2	-84.4749	52.8901	-15.7924	716.50	0.5102	2.1006	1.3054	40.64
A15×RF3	39.088	99.5012	69.2946*	740.91	-0.2298	5.3198**	2.545*	37.42
A15×RF5	-10.643	-86.1182	-48.3806	743.86	-4.6998**	-4.0994*	-4.3996**	36.53
A19×RF1	50.1375	-18.6314	15.7531	662.01	3.6461*	-1.7052	0.9704	29.37
A19×RF2	130.3813**	6.2916	68.3364*	700.72	4.7236**	0.0831	2.4033*	32.87
A19×RF3	-98.3685*	-37.2067	-67.7875*	503.92	-6.2898**	-4.371*	-5.3304**	20.68
A19×RF5	-82.1506*	49.5457	-16.3024	676.04	-2.0798	5.9931**	1.9567	34.03
A21×RF1	-153.118**	-100.872	-126.995**	468.75	-11.86**	-5.4485**	-8.6533**	22.51
A21×RF2	47.5164	0.8627	24.1896	606.07	2.1327	0.6831	1.4079	34.64
A21×RF3	99.5273**	-17.9969	40.7653	561.97	4.596**	-0.6644	1.9658	30.74
A21×RF5	6.0745	118.0057*	62.0402	703.87	5.1294**	5.4298**	5.2796**	40.11
Sakha 53				653.93				35.14
Giza 102				764.37				41.21
S.E. (SCA)	38.7012	52.1842	32.4838	LSD 0.05= 84.58	1.7071	1.8619	1.263	LSD 0.05= 3.06
S.E. (Sij-Skl)	54.7318	73.7996	45.939	LSD 0.01= 114.82	2.4142	2.6331	1.7861	LSD 0.01= 4.01

Table 4.Cont.

Geno-types	Oil yield/head			
	GCA and SCA effects			Combined mean
	Loamy sand soil	Clay soil	Combined	
Female (Lines)				
A7	1.7442**	1.7231**	1.7336**	5.79
A15	1.2675**	1.3822**	1.3248**	19.70
A19	-2.7783**	-1.6868**	-2.2325**	13.78
A21	-0.2334	-1.4185**	-0.8259**	9.21
S.E. (GCA) L	0.3118	0.3343	0.2286	
S.E. (gi-gj) (gi-gj) L	0.4409	0.4728	0.3232	
Male (Testers)				
RF1	-1.658**	1.3928**	-0.1326	4.02
RF2	-0.4655	-0.1982	-0.3319	2.80
RF3	-0.4138	-2.069**	-1.2414**	1.85
RF5	2.5373**	0.8744**	1.7059**	11.99
S.E. (GCA) T	0.3118	0.3343	0.2286	
S.E. (gi-gj) T	0.4409	0.4728	0.3232	
Crosses				
A7×RF1	2.6629**	3.9419**	3.3024**	18.18
A7×RF2	-3.3641**	-0.6444	-2.0043**	12.68
A7×RF3	-0.8147	-0.3505	-0.5826	13.19
A7×RF5	1.5159*	-2.947**	-0.7155	16.00
A15×RF1	1.7061**	-1.1642	0.2710	14.74
A15×RF2	-2.1269**	0.4553	-0.8358	13.44
A15×RF3	2.5932**	0.8944	1.7438**	15.11
A15×RF5	-2.1724**	-0.1855	-1.179**	15.31
A19×RF1	1.1777	-1.178	-0.0001	10.91
A19×RF2	2.2029**	0.2196	1.2112**	11.93
A19×RF3	-2.2382**	-0.275	-1.2566**	8.55
A19×RF5	-1.1424	1.2334	0.0455	12.80
A21×RF1	-5.5467**	-1.5997*	-3.5732**	8.75
A21×RF2	3.2881**	-0.0305	1.6288**	13.75
A21×RF3	0.4597	-0.2689	0.0954	11.31
A21×RF5	1.7989**	1.8991**	1.849**	16.01
Sakha 53				12.05
Giza 102				15.43
S.E. (SCA)	0.6235	0.6686	0.4571	LSD 0.05= 1.10
S.E. (Sij-Skl)	0.8818	0.9456	0.6465	LSD 0.01= 1.44

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

The combined analysis of husk % indicated that the performance of all hybrids was significantly (P≤0.01) lower in husk % than the better check Sakha 53. Two hybrids (A7 x RF1 and A21 x RF5) showed negative significant (P≤0.01) SCA, but their performance was not the lowest. Three hybrids (A7 x RF3, A15 x RF5 and A21 x RF1) gave positive significant (P≤0.01) SCA and nearly showed high husk %.

The combined analysis of oil % indicated that five hybrids (A7 x RF1, A15 x RF5, A15 x RF3, A19 x RF3 and A21 x RF2) showed significant positive SCA. The oil % of these five hybrids were high. It is worth noting that the restorer lines; RF1, RF3 and RF5 showed significant GCA. The combined negative significant (P≤0.01) SCA of the hybrids A7 x RF3, A15 x RF2, A19 x RF1, A19 x RF5 and A21 x RF3 gave low oil %. It should be indicating that five hybrids exceeded significantly (P≤0.01 to P≤0.01) the better check cultivar Giza 102 in oil % were A7 x RF1, A15 x RF3, A15 x RF5, A19 x RF3 and A21 x RF1.

The combined SCA effects of NS/H were positive and significant for two hybrids (A7 x RF1 and A19 x RF2), the first one exceeded significantly (P≤0.01) the better check Giza 102, while the second did not. Eight hybrids showed negative combined SCA. Seven hybrids were significantly lower in performance than the better check in NS/H, only two of them (A19 x RF3 and A21 x RF1) had negative significant SCA indicating to the weak relation between the SCA and the performance of the hybrids. This could be due to that the ratio σ^2A/σ^2D was lower than one (0.1051) (Table 3). Consequently, the performance of the hybrids could not be expected (Baker, 1978).

The combined SCA effects of SY/H were positive and significant for three hybrids (A7 x RF1, A15 x RF3 and A21 x RF5). The performance of the first hybrid (46.45 g/head) was significantly (P≤0.01) better than the better check Giza 102 (41.21 g/head). The second hybrid (A15 x RF3) was significantly lower in SY/H (37.42 g) than Giza 102. The third hybrid; A21 x RF5 showed insignificant difference with Giza 102. Otherwise, five hybrids gave negative significant SCA, only one (A7 x RF5) yielded 40.15 g/H, which was not significant from Giza 102 (41.21 g/H). The other four hybrids were significantly lower in yield than Giza 102. It could be concluded that the hybrids performance was not in accordance with sign and significance of SCA. Furthermore, the GCA of the parents was far from yielding ability. This could be due to that the ratio of σ^2A/σ^2D was lower than one (0.0561, Table 4).

The combined SCA of five hybrids for oil yield/head were positive and significant (P≤0.01). The performance of the first hybrid (A7 x Rf1) (18.18 g) exceeded significantly (P≤0.01) the better check Giza 102 in oil yield/head (15.43 g). The performance of the second (A15 x RF3) and the fifth hybrid (A21 x RF5) insignificantly differed from the better check.

However, the second (A19 x RF2) and the fourth hybrids (A21 x RF2) were significantly (P≤0.01) lower than the better check Giza 102 in oil yield/head. Four hybrids (A7 x RF2, A15 x RF5, A19 x RF3 and A21 x RF1) showed negative and significant (P≤0.01) SCA. The performance of three of them was lower (P≤0.01) than the better check, while one hybrid (A15 x RF5) gave oil yield/head of 15.31 g, which did not differ from the better check Giza 102 (15.43 g). Therefore, the performance of the hybrids in oil yield/head was not in accordance to the sign and significance of the SCA for the reason mentioned before.

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تحليل القدرة على الائتلاف لصفات التزهير ومحصول البذرة والصفات المتعلقة في دوار الشمس

عزت السيد مهدى، السيد حسب الله، عابدين الشيمى، هبه عبد الرزاق عبد المجيد محمد حسن

اجرى تقييم 26 تركيب وراثي(16 هجين+4 أمهات+ 4 أباء + صنفين كونترول هما جيزة 102 وسخا53) تحت ظروف الأرض الرملية السلتيه والأرض الطينية في موسم 2016 . كانت الفروق معنويه جدا بين التراكيب الوراثية سواء في التحليل المفرد او المجمع للمنطقتين . وكانت الفروق بين المنطقتين معنويه جدا لكل الصفات عدا قطر القرص. كان التفاعل بين المنطقة والتركيب الوراثي معنويا لكل الصفات . وكان تباين الأمهات والآباء معنوي جدا لكل الصفات ، مشيرا إلى وجود التباين المضيف . وكان تباين الآباء ضد الهجن وتفاعل الآباء مع الأمهات معنويا لكل الصفات مؤكدا وجود التباين الغير مضيف في وراثتها . وكان تفاعل الأمهات مع البيئات معنويا لكل الصفات عدا قطر القرص ، كذلك تفاعل الآباء مع البيئات عدا صفه التزهير وقطر القرص .وكان التفاعل بين الأمهات والآباء والبيئات معنويا مشيرا إلى اختلاف تأثير التباين الغير مضيف من بيئة لأخرى. وتشير نتائج التحليل المجمع إلى أن النسبة بين التباين المضيف إلى الغير مضيف اقل من الوحدة لكل الصفات ، موضحا أن التباين الغير مضيف اكثر أهمية من التباين المضيف فى وراثه هذه الصفات . وتؤكد نتائج القدرة العامة على الائتلاف إلى انه لا توجد سلاله اميه او ابويه لها افضل قدره على التوافق لكل الصفات . وتبين النتائج إلى أن 13 هجين كانت ابكر من الكونترول جيزة 102، وكان تبكير هذه الهجن له علاقه بالقدرة العامة للآباء اكثر من القدرة الخاصة .وبالنسبة لارتفاع النبات أظهرت ثمانية هجن قدره خاصه سالبه على الائتلاف ، وكانت كل الهجن اقصر بدرجه معنويه جدا عن أصناف الكونترول .كما أظهرت ثمانية هجن قدره خاصه موجبه على الائتلاف في قطر القرص ولم يزد أي هجين عن الكونترول الأفضل فى قطر القرص . كما يوضح التحليل المجمع إلى أن ثمانية هجن أظهرت قدره خاصه سالبه لصفه نسبه القشر ، وكانت كل الهجن اقل معنويا عن افضل كونترول سخا53 لهذه الصفة . ويوضح التحليل المجمع إلى أن خمسه هجن لها قدره خاصه موجبه لصفه نسبه الزيت ، أربعه منها كانت افضل معنويا عن الكونترول جيزة 102 لهذه الصفة . كانت القدرة الخاصة على الائتلاف لصفه محصول البذرة للراس موجبه ومعنويه لثلاثة هجن ، احدها تفوق بدرجه معنويه جدا (46.45جرام/الراس)على الكونترول جيزة 102(41.21 جرام/الراس). وكان أداء الهجن لمحصول البذرة غير متوافق مع

معنويه أو إشارة القدرة الخاصة على الائتلاف ، كما أن القدرة العامة للآباء ليس لها تأثير على القدرة المحصولية . من التحليل المجمع كانت القدرة الخاصة لخمسه هجن موجبه ومعنويه جدا لصفة محصول الزيت للراس، احد هذه الهجن (A7xRF1,18.18g) تفوق بدرجه معنويه جدا عن الكونترول جيزة 102 (15.43 جرام) .نستخلص من هذه الدراسة إلى أن أداء الهجن لم يكن متوافقا مع معنويه وإشارة القدرة الخاصة على الائتلاف ، وهذا يرجع إلى أن النسبة بين التباين المضيف إلى التباين السيادي اقل من الوحدة ، أي أن تأثير التباين الغير مضيف كان اكبر من التباين المضيف في وراثه كل الصفات ، مما يؤكد ضرورة تقييم الهجن في بيئات متباينة للتعرف على افضل الهجن .