COMBINING ABILITY ANALYSIS IN SOME SUNFLOWER HYBRIDS UNDER WATER STRESS CONDITIONS

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ABSTRACT: ***This investigation was carried out at Sakha Agricultural Research Station Farm, ARC, Egypt during the two growing summer seasons (2015 and 2016). Six parents namely; Line 4, Line 10, Line 16, Line 17, Line 63 and Giza 102, were crossed in half diallel mating design, giving a total of 15 crosses, which were evaluated under three water treatments; (T_1) normal irrigation every 14 days, irrigation every 21 days (T_2) and irrigation every 28 days (T_3) and compared with a check variety namely; Sakha 53. Through this study, general and specific combining ability were estimated for earliness attributes, yield and its components, seed oil percent and oil yield.***

Data revealed that, most of the variance due to irrigation treatments (I), genotypes (G), G × I, crosses (Cr), (GCA), (SCA), Crosses × I, GCA × I and SCA × I, showed highly significant differences for most traits under the three irrigation treatments and their combined analysis. The parents; (Giza 102) and (Line 63) considered as good combiners for earliness under the three irrigation treatments and their combined analysis. The parents; (Line 4), (Line 10), (Giza 102) and (Line 63) considered as good combiners for yield and its components under the three water treatments and their combined analysis. These parents could be used in breeding program aiming to regenerate genotype (s) characterized by high seed and oil yields. Based on the estimates of ($\hat{s}_{ij}$), it could be summarized that the best crosses were; (Line 10 x Giza 102) and (Line17 x Giza 102) for earliness under T_1, T_2 and T_3 and their combined data. For yield and yield components, the crosses; (Line 4 x Line 63), (Line 17 x Line 63), (Line 16 x Line 17), (Line 10 x Giza 102) and (Line 4 x Giza 102) under T_1, T_2, T_3 and their combined data are the best crosses. These parents and crosses could be used as a hybrid varieties in sunflower cultivation under water stress conditions to cover a part of oil production gap in Egypt.

Key words: ***General combining ability, specific combining ability, water stress conditions, sunflower hybrids.***

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the important oil crops allover the world. The total cultivated area reached 23.99 million hectars that produced 40.19* million metric ton seeds which produced 15.44 million metric ton, of oil in 2018 year representing the fourth source of edible oils in the world. In Egypt, the local production of vegetable oils does not exceed 1% of local consumption and the total production and consumption of edible oils are (20-25,000 MT) and (2.8 MMT)* in 2017, respectively, and fulfill this gap by importation. The main source of edible oils production in Egypt is cotton seed oil, which produced about 18 thousand ton beside 7 thousand ton, from sunflower and soybean oil during 2018.

* Foreign Agricultural Service, United States Department of Agriculture, October, 2018.

Water plays an important role in augmenting the growth and development of crop plants in their different stages of ontogeny (Kadasiddappa *et al*., 2017). Since, water is the life line for accruing desired yield levels, its time of application and method of application plays an important role in increasing the yield levels besides saving water. Further, water is the prime natural resource, which is often costly and limiting input particularly in arid and semi-arid regions, hence needs judicious use to reap the maximum benefit from this limiting resource.

The main aims of this study are to obtain new sunflower hybrids characterized by high seed yield and oil percent as well as evaluating these hybrids under water stress conditions in North Delta region. Therefore, it was nessesary to determine general and specific combining abilities (GCA and SCA) and nature of gene action for many traits. Analysis of half diallel data is usually conducted according to the methods of Griffing (1956) which partition the total variation of half diallel data into GCA of the parents and SCA of the crosses. Combining ability information is necessary for selection of suitable advanced lines for hybridization and identification of promising hybrids that could be recommended to hybrid sunflower breeding program (Darvishzadeh *et al*., 2011 and Pourmohammad *et al*., 2014).

MATERIALS AND METHODS

This investigation was setup to obtain and evaluate some sunflower hybrids under water stress conditions. The present study was carried out at Sakha Agricultural Research Station Farm during 2015 and 2016 growing summer seasons.

The parents used in this study were six inbred lines *via*., Line 4, Line 10, Line 16, Line 17, Line 63 and Giza 102, in addition to, Sakha 53 as a check cultivar. These parents were chosen to represent awide range of variability for some agronomical characters, seed yield, its components and seed oil percentage.

A brief summary of the origin and main characters of the parental lines are given in Table (1).

Table (1): Origin and some agronomic characteristics of the parental lines used in this work.

Genotypes	Origin	Characteristics			
		Days to 50% flowering	Plant height (cm)	Seed yield/plant (g)	Seed oil (%)
1- P_1 (Line 4)	Bulgarian line	56.00	167.00	41.50	39.00
2- P_2 (Line 10)	Local inbred line	54.00	163.00	42.00	39.65
3- P_3 (Line 16)	Local inbred line	51.00	145.00	40.00	38.00
4- P_4 (Line 17)	Local inbred line	51.00	150.00	39.25	37.98
5- P_5 (Line 63)	Local inbred line	49.00	140.00	40.90	38.73
6- P_6 (Giza 102)	Indian line x mayak	47.00	155.00	43.00	40.00
Ch. Var. (Sakha 53)	Mayak x Bulgarian line	55.00	160.00	43.50	40.61

The parents were obtained from Oil Crop Res. Sec., FCRI, ARC, Egypt.

In June, 2015 summer season, a half diallel mating design was made among the six parents giving a total of fifteen crosses.

The plants used as a females, were made sterile by a solution of gibberelic acid with a concentration of 0.16% (0-5 mg GA/3 mL H_2O) per plant at the beginning of the stage of budding (Skoric, 1981).

The sunflower hybrids were obtained by bagging the sterile heads (female parents) before flowering and, therefore, the pollen grains were collected from the fertile parents (male parents), which were covered by paper bags before flowering to prevent foreign pollen grains to contaminate from other sources.

In June, 2016 summer season, three field experiments were carried out i.e, the first one was irrigated every 14 days as (T_1), the second one was irrigated every 21 days as (T_2) and third one was irrigated every 28 days as (T_3). A randomized complete blocks design with three replications was used in each experiment.

Each replicate consists of 16 plots (15 F_1- crosses) and Sakha 53 as check cultivar and each plot consists of four rows, (4m long and 60 cm apart), the distance between hills was 20 cm and the plot area was (9.6 m^2).

All agricultural practices were carried out as recommended for oil seed sunflower production in this region. The inner two rows were harvested at the maturity stage and seeds were air dried. Data were recorded on an individual plant basis from a random sample of ten guarded plants from each plot.

The following characters were scored:

Days to first flowering, days to 50% flowering, days to full flowering, days to physiological maturity, plant height (cm), stem diameter (cm), head diameter (cm), 100-seed weight, seed yield per plant (g), seed yield (kg/fad.), oil content and oil yield (kg/fad.).

Statistical analysis procedure:

Combining ability analysis.

General (GCA) and specific (SCA) combining ability effects were estimated according to Griffing (1956) method 4, model 1.

RESULTS AND DISCUSSION

1. Analysis of variance:

Analysis of variance of 15 F_1 crosses and one check for the studied traits of the three irrigations and their combined data are presented. Results indicated that, irrigations (I) mean squares were highly significant for all studied traits. These results revealed that, there were overall differences between the three irrigations for these traits.

Genotypes (G) mean squares were highly significant for all traits in the three irrigations and their combined data, indicating the wide diversity of genotypes used in this study and providing evidence for presence of large amount of genetic variability, which considered adequate for further biometrical assessment Therefore, the genetic analysis was felt valid to be undertaken to reveal the inheritance and gene action controlling the economic characters in sunflower.

The mean squares of G x I interactions were highly significant for all traits revealing that the genotypes respond differently to water regime for these traits and reflecting the possibility of selecting the most tolerant genotypes, except for plant height, stem diameter and head diameter which exhibited non significant differences suggesting that the response of these three characters to water treatments by a given genotypes does not vary between water treatments. These results are in agreement with those obtained by, Rauf and Sadaqat

(2007) and Kazemeini *et al*. (2009) who found that genotypes differed significantly for all the studied traits.

2. Mean performance of the genotypes:

The mean performance of the fifteen F_1 crosses and the check variety under the three irrigation treatments for all studied traits are presented in Table (2).

It's to be noted that, for seed،oil yield and it's components showed that among crosses; No. 9 (Line 10 x Giza 102), No. 5 (Line 4 x Giza 102), No. 1 (Line 4 x Line 10) and 4 (Line 4 x Line 63) gave the highest values for these traits and they were higher than the check variety also, they were earlier than the check variety under T_1, T_2, T_3 and combined data. Similar trend of results were obtained by Gholinezhad *et al.* (2012), Heidari and Karami (2014) and Kadasiddappa *et al* (2017).

3. Combining ability analysis:

The results in Table (3) showed that, crosses (Cr) mean squares were highly significant for all traits at the three irrigation treatments and their combined data, indicating the wide diversity between the crosses used in this study. Mean squares due to general combining ability (GCA) and specific combining ability (SCA) were highly significant for all traits at the three irrigation treatments and their combined, indicating that additive and non-additive gene actions had important role in the inheritance of all studied traits.

On the other side, the interactions mean squares between crosses, GCA and SCA mean squares with irrigations were highly significant for all traits, indicating that the behavior of the two types of gene actions varied from irrigation regime to another, except for plant height and stem diameter, which exhibited non significant variances for the interactions between crosses, GCA and SCA mean squares with irrigations, this might indicated that, the two types of gene actions did not changed from, irrigation treatment to another for the traits in view. Also, for head diameter which exhibited non significant variances for the interactions between crosses and SCA with irrigations, in addition to, 100-seed weight, which exhibited non significant variances for the interactions between SCA with irrigations, which might revealed that the non-additive gene effects seems to be stable at the three irrigation regimes. Similar trend of findings were obtained by Tyagi and Dhillon (2016).

Regarding GCA / SCA mean square ratio, the data pointed out that, this ratio exceeded the unity for all studied traits at the three irrigations and their combined data. This might indicate that, additive and additive x additive gene effects were more important than non-additive ones for the inheritance of all studied traits. Thus, superior genotypes could be identified from their phenotypic expression and selection in early generations, would be effective to improve these traits.

Moreover, the ratio of GCA x I / SCA x I interaction mean squares was more than unity for all traits, except for No. of days to full flowering, No. of days to physiological maturity, plant height and stem diameter indicated that the additive gene effects were more suitable to interacted with irrigation treatments than non-additive genes for all traits and , in another words, the additive gene effects were more influenced by irrigation changes than non-additive ones for these traits. For the expected traits, where the same ratio was approximately one for No. of days to full flowering, plant height and stem diameter, which might indicated that both types of gene actions were suitable to estimate and were equally

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interacted with irrigation environments for the traits in question. While, for No. of days to physiological maturity, where the ratio was less than one, which might indicating that non-additive gene effects were more interacted and more suitable to estimate than additive ones for the trait in focusing. Similar trend of findings were obtained by Darvishzadeh *et al*. (2011), Hladni *et al*. (2011). In addition to Rauf and Sadaqat (2007), who found that both additive and non additive gene actions were involved in the expression of the most studied traits.

4. General combining ability effects ($\hat{g}_i$):

Estimates of ($\hat{g}_i$) for all parental genotypes for each trait under normal irrigation and the two water stress treatments are presented in Table (4). The detection of the general combining ability of the parental genotypes provide better information not only for selection the parent for hybridization, but also in choosing the proper breeding scheme. High positive values would be interest for the most traits, except for the No. of days to first flowering, No. of days to 50% flowering, No. of days to full flowering, No. of days to physiological maturity and plant height.

For No. of days to first flowering, No. of days to 50% flowering, No. of days to full flowering and No. of days to physiological maturity, estimates of ($\hat{g}_i$) for the parental genotypes Table (4) revealed that P_5 (Line 63) and P_6 (Giza 102) as a parental genotypes had highly significant ($\hat{g}_i$) in negative direction under the three water treatments and their combined analysis. These parents may possess favorable genes, which could be utilized in breeding for earliness in sunflower (*Helianthus annuus* L.). Ashok *et al*. (2000) and Ćirić *et al*. (2013) found some sunflower genotypes gave desirable ($\hat{g}_i$) for these traits in their respective studies.

In case of plant height, data showed that highly significant negative ($\hat{g}_i$) were detected by P_4 (Line 17), P_6 (Giza 102) and P_5 (Line 63) under the three water treatments and their combined analysis. These parents could be used as good combiner for shortness under normal, stresses irrigation regimes and their combined data. On the other hand, P_1 (Line 4) and P_2 (Line 10) showed highly significant positive ($\hat{g}_i$) indicating tendency towards tall plants under normal irrigation, the two water stress treatments and their combined analysis. Similar trend of results in sunflower (*Helianthus annuus* L.) were obtained by Ćirić *et al*. (2013) who found significant ($\hat{g}_i$) for plant height.

Concerning stem diameter, estimates of ($\hat{g}_i$) for each parent showed that P_5 (Line 63), P_2 (Line 10) and P_1 (Line 4), under T_1, T_2, T_3 and their combined analysis gave highly significant positive direction ($\hat{g}_i$). So, these parents seem to be the best combiners for stem diameter under the previous conditions. Similar trend of results in sunflower were obtained by Kholghi *et al.* (2014) who found that the additive gene effects were important for stem diameter.

For head diameter, seed yield per plant, 100-seed weight, seed yield per faddan, seed oil content and oil yield per faddan, the ($\hat{g}_i$) revealed that the parental genotypes P_1 (Line 4), P_2 (Line 10), P_5 (Line 63) and P_6 (Giza 102), could be considered good combiners as their ($\hat{g}_i$) values were highly significant in positive direction under T_1,T_2 , T_3 and their combined analysis. These results indicated the great values of such parental lines as promising progenitor for high expression of high yielding ability due to highly significant ($\hat{g}_i$) of these traits. Similar trend of results in sunflower were obtained by Turkec and Goksoy (2006) who found that the additive gene effects were important for

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head diameter. On the other hand, Awad (2011) who, found that the non- additive gene effects were important for this trait. In addition to, Abou-Mowafy (2015) who found that the additive gene effects were important for seed yield per plant. Moreover, Sawargaonkar and Ghodke (2008) found that the additive gene effects were important for 100-seed weight. Also, similar trend of results were suggested by Kholghi *et al.* (2014) who found that the additive gene effects were important for seed yield per faddan. Ghaffari *et al.* (2011) and Nasreen *et al.* (2014) found that the additive gene effects were important for seed oil content and oil yield per faddan.

From the above results, it could be concluded that, the parental genotypes; P_5 (Line 63) and P_6 (Giza 102) could be considered as good combiner parents possessing additive and additive x additive genes to their hybrids in breeding program aiming to releasing new genotypes in sunflower characterized by earliness and high yielding potentially for seed and oil either at normal irrigation condition or at stress irrigations due to their highly significant ($\hat{g}_i$) in favorable direction at all irrigation conditions and their combined analysis. On the other side, the parental genotypes; P_1 (Line 4), P_2 (Line 10), P_5 (Line 63) and P_6 (Giza 102) considered as good combiner parents could be used in breeding program aiming to regenerate genotype (s) characterized by high seed and oil yields due their highly significant ($\hat{g}_i$) in positive direction at normal as well as stresses irrigation regimes.

5. Specific combining ability effects ($\hat{s}_{ij}$):

The data listed in Table (5) revealed that, the cross 9 (Line 10 x Giza 102) and cross 14 (Line 17 x Giza 102) exhibited highly significant ($\hat{s}_{ij}$) in negative direction for all earliness attributes i.e., No. of days to first flowering, No. of days to 50% flowering, No. of days to full flowering and No. of days to physiological maturity at normal as well as two stresses irrigation regimes and their combined data. The cross 2 (Line 4 x Line 16) exposed highly significant ($\hat{s}_{ij}$) in negative direction for all earliness attributes at irrigation treatments and their combined analysis, except at T_2 and T_3 for No. of days to first flowering and T_2 for No. of days to physiological maturity, where the values of ($\hat{s}_{ij}$) did not reach to the level of significant and the cross 11 (Line 16 x Line 63) revealed highly significant ($\hat{s}_{ij}$) in negative direction for all earliness attribute at normal as well as the two stresses of irrigation treatments and their combined analysis, except at T_1 for No. of days to first flowering, No. of days to 50% flowering and No. of days to full flowering, where the values of ($\hat{s}_{ij}$) were not significant. However, these crosses could be used in breeding program to releasing genotype (s) characterized by early maturing at the irrigation condition referred. These results are in agreement with those obtained by Sank *et al.* (2003) and Farhatullah and Khalil (2006) where they indicated the predominant role of non additive gene action for flowering. Also, Khan *et al.* (2008) reported that, non additive gene action was important for No. of days to physiological maturity.

For plant height, the crosses 2 (Line 4 x Line 16), 7 (Line 10 x Line 17), 8 (Line 10 x Line 63) and 12 (Line 16 x Giza 102) had highly significant values of ($\hat{s}_{ij}$) in negative direction at normal as well as the stresses of irrigation treatment for short stature plants. On the other side, the crosses 1 (Line 4 x Line 10), 6 (Line 10 x Line 16), 10 (Line 16 x Line 17), 11 (Line 16 x Line 63) and 13 (Line 17 x Line 63) exhibited highly significant ($\hat{s}_{ij}$) in positive direction for the tall plants at normal as well as the two stresses of irrigation regimes and their combined analysis. Similar trend of results were

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obtained by Sank *et al.* (2003), who found significant ($\hat{s}_{ij}$) for plant height.

For stem diameter, the crosses 1 (Line 4 x Line 10), 4 (Line 4 x Line 63), 6 (Line 10 x Line 16), 9 (Line 10 x Giza 102), 10 (Line 16 x Line 17), 13 (Line 17 x Line 63) and the cross 15 (Line 63 x Giza 102) had highly significant values of ($\hat{s}_{ij}$) in positive direction for the trait in view at all irrigation treatments and their combined data. Similar trend of results were obtained by Farhatullah and Khalil (2006) who found significant ($\hat{s}_{ij}$) for stem diameter.

The crosses 4 (Line 4 x Line 63), 5 (Line 4 x Giza 102), 9 (Line 10 x Giza 102), 10 (Line 16 x Line 17) and the cross 13 (Line 17 x Line 63) had highly significant inter and intra - allelic interactions in positive direction for all seed and oil yields and their yield components studied herein at normal as well as the two irrigation stresses and their combined analysis with one exception i.e., head diameter in the cross 4 (Line 4 x Line 63), where the values of ($\hat{s}_{ij}$) did not reach to the level of significant at all irrigation regimes and their combined analysis. However, from the obtained data, it could be concluded that the previous crosses could be used as a hybrid varieties in sunflower cultivation after more evaluation in yield trials, especially with possibility to obtain cytoplasmic male sterile line in sunflower to overcome the difficulties of emasculation. Similar trend of results were obtained by Abou-Mowafy (2010), who reported that non additive gene action was important for head diameter. Also, several researchers obtained significant ($\hat{s}_{ij}$); e.g. Kholghi *et al.* (2014) and Tyagi and Dhillon (2016), who investigated that non additive gene action was important for seed yield per plant. Nasreen *et al.* (2016) reported that, non additive gene action was important for 100-seed weight. Karasu *et al.* (2010) determined that non additive gene action was important for seed yield per feddan. Nasreen *et al.* (2016) found significant ($\hat{s}_{ij}$) for seed oil content. Ghaffari *et al.* (2011) suggested that, non additive gene action was important for oil yield per faddan.

The results obtained herein concerning general and specific combining ability effects could indicate that, the excellent hybrid combinations were obtained from the three possible combinations between the parents i.e. high x high, high x low and low x low. Consequently, it could be concluded that general combining ability effects of the parental lines in some time were unrelated to the specific combining ability effects of their respective crosses.

From the results, it could be concluded that P_6 (Giza 102) and P_5 (Line 63) are the best combiners for earliness. Also, P_6 (Giza 102), P_2 (Line 10), P_1 (Line 4) and P_5 (Line 63) appeared to be good combiners for seed and oil yields and their yield components studied. The progeny of the cross 9 (Line 10 x Giza 102) and cross 14 (Line 17 x Giza 102) are the best for earliness. Also, the crosses; 4 (Line 4 x Line 63), 5 (Line 4 x Giza 102), 9 (Line 10 x Giza 102), 10 (Line 16 x Line 17) and13 (Line 17 x Line 63) are the best for seed and oil yields and their yield components studied and these crosses could be used as a good hybrids to cultivate sunflower under water stress conditions to cover a part of oil production gap in Egypt.

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تحليل القدرة على التآلف فى بعض هجن دوار الشمس تحت ظروف الأجهاد المائى

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الملخص العربى

أجريت هذه الدراسة بمزرعة محطة البحوث الزراعية بسخا خلال الموسمين الزراعيين الصيفيين 2015، 2016م بهدف دراسة القدرة على التآلف لـ 15هجين من محصول دوار الشمس بحيث تلائم الزراعة تحت ظروف الإجهاد المائي (الرى كل 14 , 21 , 28 يوما على الترتيب) باستخدام التهجين نصف الدائرى بين ست تراكيب وراثية من دوار الشمس متباعدة وراثياً لصفة تحمل الاجهاد المائي. وكانت هذه التراكيب هى: سلاله 4، سلاله 10، سلاله 16، سلاله 17، سلاله 63 وصنف جيزه 102 بالإضافه إلي الصنف الإختباري سخا 53. وتمت دراسة الصفات التالية : عدد الأيام لكل من بداية التزهير ، 50% تزهير ، تمام التزهير ، النضج الفسيولوجى ، ارتفاع النبات (سم) ، سمك الساق (سم) ، قطر القرص (سم) ، محصول النبات الفردى (جم) ، وزن الـ 100 بذرة (جم) ، محصول الفدان (كجم) ، النسبة المئوية للزيت بالبذرة (%) ، محصول الزيت (كجم).

وتمت زراعة ثلاث تجارب منفصلة باستخدام تصميم القطاعات كاملـة العشوائية في ثلاث مكررات بحيث تشتمل كل تجربة على معاملة رى . كما تمت دراسة التحليل الوراثي للصفات بواسطة الطريقة الرابعة للموديل الأول لجريفنج 1956 تحت ظروف الأراضى الطينية.

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

- أوضحت النتائج أن الفعل الجيني المضيف كان الاكثر أهمية في وراثة كل الصفات محل الدراسة فى كل معاملات الري والتحليل المشترك، كما أوضحت النتائج أن الفعل الجيني المضيف كان الاكثر تفاعلا مع معاملات الري عن الفعل الجيني غير المضيف فى معظم الصفات محل الدراسة .
- كانت أفضل التراكيب الوراثية الأبوية التى لها قدرة عامة على التآلف هما سلاله 63 والصنف جيزه 102 بالنسبه للتبكير. وبالنسبة لصفة المحصول ومكوناته كانت أفضل الأباء هى سلاله رقم 4 وسلاله رقم 10 والصنف جيزه 102 وسلاله رقم 63.
- وبناء على تقديرات القدرة الخاصة على التآلف ، فإن أفضل الهجن هى: الهجين (سلاله 10 × جيزه 102) والهجين (سلاله 17 × جيزه 102) بالنسبة للتبكير . وبالنسبة لصفة المحصول ومكوناته كانت أفضل الهجن هى (سلاله 4 × سلاله 63)، (سلاله 4 × جيزه 102) ، (سلاله 10 × جيزه 102)، (سلاله 16 × سلاله 17) و(سلاله 17 × سلاله 63) .

ولذلك توصي الدراسه بإستخدام هذه الآباء وكذلك الهجن السابق ذكرها في برامج التربيه لإنتاج أصناف من محصول دوار الشمس في مصر تلائم الزراعه تحت ظروف الإجهاد المائي فى منطقة شمال الدلتا.

أسماء السادة المحكمين

أ.د/ السيد حامد الصعيدى كلية الزراعة – جامعة طنطا ، أ.د/ إبراهيم حسينى درويش كلية الزراعة – جامعة المنوفية

Table (2): Mean performance of 16 genotypes and the check variety for 12 traits under three water treatments and their combined data.

Genotypes	No. of days to first flowering				No. of days to 50% flowering				No. of days to 100% flowering			
	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
1- Line 4 x Line 10	53.00	50.66	47.00	50.22	55.00	53.00	48.33	52.11	57.33	55.00	50.00	54.11
2- Line 4 x Line 16	55.33	54.00	50.66	53.33	57.66	56.00	53.00	55.55	60.00	58.66	54.66	57.77
3- Line 4 x Line 17	54.00	51.00	46.66	50.55	56.33	53.00	49.00	52.78	58.33	55.00	51.00	54.78
4- Line 4 x Line 63	48.33	45.33	42.66	45.44	51.33	47.33	44.00	47.55	53.00	49.00	45.66	49.22
5- Line 4 x Giza 102	49.33	47.00	42.66	46.33	51.66	48.66	45.00	48.44	53.66	51.00	47.00	50.55
6- Line 10 x Line 16	55.00	54.00	50.66	53.22	57.33	57.00	52.66	55.66	60.33	59.66	55.33	58.44
7- Line 10 x Line 17	50.66	49.33	46.00	48.66	53.33	51.66	47.66	50.88	55.33	54.33	49.33	53.00
8- Line 10 x Line 63	45.33	44.00	40.66	43.33	47.33	45.66	42.33	45.11	49.00	49.00	44.00	47.33
9- Line 10xGiza 102	45.33	42.66	38.33	42.11	48.00	44.33	40.00	44.11	49.66	46.00	42.00	45.89
10- Line 16xLine 17	53.00	52.00	47.33	50.78	55.66	54.33	49.00	53.00	58.66	57.66	51.33	55.88
11- Line 16xLine 63	49.33	46.66	43.33	46.44	51.66	48.33	45.33	48.44	54.33	50.33	47.66	50.77
12- Line 16xGiza 102	52.33	49.00	44.33	48.55	55.66	51.33	47.00	51.33	58.00	54.00	49.00	53.67
13- Line 17xLine 63	45.66	43.33	38.66	42.55	48.00	45.00	40.33	44.44	49.66	46.66	42.00	46.11
14- Line 17xGiza 102	45.00	42.00	38.33	41.78	47.00	44.00	40.00	43.67	49.00	46.33	42.33	45.89
15- Line 63xGiza 102	44.66	41.33	37.66	41.22	46.33	43.33	39.33	43.00	48.00	45.00	41.00	44.67
Ch. Var. (Sakha 53)	53.66	51.33	47.00	50.66	56.66	53.66	49.00	53.11	59.66	55.66	51.00	55.44
Mean	50.00	47.73	43.87	47.20	52.43	49.79	45.75	49.32	54.62	52.08	47.71	51.47
LSD 0.05	1.16	1.28	1.24	0.70	1.53	1.45	1.06	0.76	1.19	1.34	0.97	0.66
LSD 0.01	1.56	1.72	1.68	0.92	2.07	1.96	1.43	1.01	1.60	1.81	1.31	0.87

Table (2): Cont.

Genotypes	No. of days to physio. Maturity				Plant height (cm)				Stem diameter (cm)			
	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
1- Line 4 x Line 10	81.00	75.66	69.00	75.22	175.66	165.28	155.61	165.52	2.33	2.19	2.05	2.19
2- Line 4 x Line 16	85.00	81.33	72.66	79.66	155.00	145.39	136.51	145.63	2.13	2.00	1.87	2.00
3- Line 4 x Line 17	83.66	79.00	72.00	78.22	152.85	143.05	134.10	143.33	1.73	1.62	1.51	1.62
4- Line 4 x Line 63	75.66	70.00	64.00	69.89	160.33	151.33	143.02	151.56	2.47	2.32	2.17	2.32
5- Line 4 x Giza 102	76.00	72.00	64.00	70.67	160.00	150.72	142.16	150.96	2.20	2.07	1.94	2.07
6- Line 10 x Line 16	86.00	81.33	74.33	80.55	163.20	153.65	144.78	153.88	2.28	2.15	2.02	2.15
7- Line 10 x Line 17	80.66	78.66	72.66	77.33	146.33	137.33	129.04	137.57	1.90	1.78	1.66	1.78
8- Line 10 x Line 63	72.33	69.33	61.33	67.66	156.28	146.90	138.22	147.13	2.00	1.88	1.76	1.88
9- Line 10xGiza 102	74.00	68.00	61.33	67.78	158.00	149.00	140.66	149.22	2.36	2.22	2.08	2.22
10- Line 16xLine 17	86.00	82.00	72.00	80.00	150.00	140.25	131.34	140.53	1.89	1.77	1.65	1.77
11- Line 16xLine 63	78.00	71.66	67.00	72.22	155.53	145.89	136.95	146.12	2.05	1.93	1.80	1.93
12- Line 16xGiza 102	84.00	78.66	71.66	78.11	150.65	141.16	132.48	141.43	1.93	1.81	1.69	1.81
13- Line 17 x Line 63	72.66	68.00	59.00	66.55	145.55	136.67	128.58	136.93	2.30	2.17	2.04	2.17
14- Line 17xGiza 102	73.00	68.00	60.33	67.11	145.00	135.49	126.79	135.76	1.80	1.69	1.58	1.69
15- Line 63xGiza 102	74.00	68.00	62.00	68.00	150.00	141.20	132.59	141.26	2.37	2.24	2.11	2.24
Ch. Var. (Sakha 53)	85.66	79.33	73.00	79.33	160.03	150.27	141.36	150.55	2.07	1.95	1.83	1.95
Mean	79.23	74.44	67.27	73.64	155.28	145.85	137.14	146.09	2.11	1.99	1.86	1.99
LSD 0.05	1.32	1.41	1.37	0.76	2.21	2.08	1.74	1.13	0.11	0.07	0.11	0.05
LSD 0.01	1.79	1.91	1.85	1.01	2.99	2.81	2.35	1.49	0.14	0.10	0.14	0.07

Table (2): Cont.

Genotypes	Head diameter (cm)				Seed yield/plant (g)				100-seed weight (g)			
	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
1- Line 4 x Line 10	21.21	19.94	17.89	19.68	44.10	40.13	32.00	38.74	5.61	5.40	4.67	5.23
2- Line 4 x Line 16	20.12	18.71	16.63	18.49	42.35	37.27	28.70	36.11	5.52	5.30	4.54	5.12
3- Line 4 x Line 17	15.61	14.05	12.08	13.91	39.11	31.95	22.21	31.09	4.90	4.43	3.43	4.25
4- Line 4 x Line 63	20.30	18.94	16.88	18.71	43.90	39.95	31.82	38.56	5.81	5.66	4.96	5.48
5- Line 4 x Giza 102	22.82	21.59	19.47	21.29	44.41	40.70	32.68	39.26	5.95	5.83	5.15	5.64
6- Line 10 x Line 16	19.43	17.97	15.89	17.76	42.22	36.56	27.97	35.58	5.44	5.18	4.35	4.99
7- Line 10 x Line 17	16.77	15.18	13.16	15.04	39.55	32.63	23.13	31.77	5.00	4.62	3.72	4.45
8- Line 10 x Line 63	20.50	19.19	17.16	18.95	43.62	39.19	30.80	37.87	5.78	5.60	4.87	5.42
9- Line 10 x Giza 102	23.10	21.94	19.90	21.65	44.50	41.03	33.23	39.59	6.20	6.11	5.44	5.92
10- Line 16 x Line 17	18.00	16.38	14.35	16.24	40.10	33.84	25.21	33.05	5.09	4.73	3.85	4.56
11- Line 16 x Line 63	18.78	17.28	15.21	17.09	42.00	36.12	27.45	35.19	5.17	4.85	3.98	4.67
12- Line 16xGiza 102	19.06	17.50	15.40	17.32	41.80	35.66	26.94	34.80	5.40	5.09	4.22	4.90
13- Line 17 x Line 63	17.00	15.47	13.49	15.32	39.70	33.19	24.23	32.37	5.00	4.59	3.63	4.41
14- Line 17xGiza 102	17.21	15.66	13.72	15.53	39.60	32.87	23.67	32.05	4.92	4.49	3.50	4.30
15- Line 63xGiza 102	21.00	19.53	17.38	19.30	42.70	38.00	29.53	36.74	5.50	5.28	4.49	5.09
Ch. Var. (Sakha 53)	20.50	19.06	16.93	18.83	43.00	37.24	28.67	36.30	5.76	5.53	4.70	5.33
Mean	19.46	18.02	15.97	17.82	42.04	36.65	28.02	35.57	5.44	5.17	4.34	4.99
LSD 0.05	0.45	0.33	0.29	0.20	0.24	0.32	0.30	0.16	0.07	0.09	0.12	0.05
LSD 0.01	0.60	0.43	0.40	0.27	0.33	0.43	0.40	0.21	0.10	0.12	0.16	0.07

Table (2): Cont.

Genotypes	Seed yield (kg/fad.)				Seed oil (%)				Oil yield (kg/fad.)			
	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
1- Line 4 x Line 10	1404.90	1279.85	1023.70	1236.15	40.60	38.22	35.42	38.08	570.39	489.16	362.61	474.05
2- Line 4 x Line 16	1349.78	1189.76	919.80	1153.11	38.91	36.09	33.46	36.15	525.20	429.38	307.77	420.78
3- Line 4 x Line 17	1247.72	1022.18	715.37	995.09	38.00	34.64	31.46	34.70	474.13	354.08	225.06	351.09
4- Line 4 x Line 63	1398.60	1274.18	1018.00	1230.26	40.42	37.99	35.17	37.86	565.31	484.06	358.06	469.14
5- Line 4 x Giza 102	1414.67	1297.80	1045.10	1252.52	40.75	38.48	35.70	38.31	576.48	499.39	373.13	483.00
6- Line 10 x Line 16	1345.68	1167.39	896.81	1136.63	39.83	37.20	34.45	37.16	535.98	434.27	308.95	426.40
7- Line 10 x Line 17	1261.58	1043.60	744.35	1016.51	38.20	34.88	31.80	34.96	481.92	364.01	236.70	360.88
8- Line 10 x Line 63	1389.78	1250.24	985.95	1208.66	40.00	37.26	34.60	37.29	555.92	465.84	341.14	454.30
9- Line 10 x Giza 102	1417.50	1308.20	1062.50	1262.73	41.10	38.81	36.09	38.67	582.59	507.71	383.46	491.25
10- Line 16 x Line 17	1278.90	1081.71	809.87	1056.83	38.50	35.42	32.26	35.39	492.38	383.15	261.26	378.93
11- Line 16 x Line 63	1338.75	1153.53	880.43	1124.24	38.45	35.37	32.49	35.44	514.75	408.01	286.05	402.94
12- Line 16x Giza 102	1332.45	1139.04	864.36	1111.95	39.40	36.90	34.14	36.81	524.98	420.31	295.09	413.46
13- Line 17 x Line 63	1266.30	1061.24	779.00	1035.51	38.65	35.94	33.05	35.88	489.43	381.41	257.46	376.10
14- Line 17x Giza 102	1263.15	1051.61	761.36	1025.37	38.40	35.33	32.45	35.39	485.05	371.38	247.06	367.83
15- Line 63x Giza 102	1360.80	1212.75	945.95	1173.17	40.00	37.46	34.72	37.39	544.32	454.30	328.44	442.35
Ch. Var. (Sakha 53)	1370.25	1188.81	918.86	1159.31	40.20	37.44	34.69	37.44	550.84	445.09	318.75	438.23
Mean	1340.05	1170.12	898.21	1136.13	39.46	36.71	33.87	36.68	529.35	430.72	305.69	421.92
LSD 0.05	7.66	9.93	9.41	5.07	0.07	0.09	0.07	0.04	3.71	4.48	3.71	2.23
LSD 0.01	10.55	13.43	12.72	6.70	0.10	0.12	0.10	0.06	5.01	6.06	5.02	2.95

T_1: (Irrigation every 14 days intervals). T_2: (Irrigation every 21 days intervals). T_3: (Irrigation every 28 days intervals).

Table (3): Analysis of variance using method 4 model 1 according to Griifing (1956) for 12 traits under three water treatments and their combined data.

S.O.V.	d.f.		No. of days to first flowering				No. of days to 50% flowering			
	Single	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
Crosses(cr)	14	14	45.40**	55.61**	57.10**	155.72**	48.90**	62.37**	60.27**	168.45**
GCA	5	5	116.22**	146.09**	149.57**	408.09**	124.36**	161.50**	156.82**	438.84**
SCA	9	9	6.06**	5.35**	5.72**	15.52**	6.98**	7.30**	6.63**	18.23**
Cross × I	-	28	-	-	-	2.39**	-	-	-	3.09**
GCA × I	-	10	-	-	-	3.79**	-	-	-	3.84**
SCA × I	-	18	-	-	-	1.61**	-	-	-	2.68**
Error term	28	84	0.16	0.20	0.22	0.19	0.29	0.23	0.14	0.22
GCA/ SCA	-	-	19.18	27.31	26.14	26.30	17.82	22.13	23.65	24.07
GCA × I / SCA × I	-	-	-	-	-	2.35	-	-	-	1.43
			No. of days to full flowering				No. of days to physio. maturity			
Crosses(cr)	14	14	57.66**	70.66**	64.18**	188.90**	81.13**	94.74**	87.70**	258.47**
GCA	5	5	148.59**	181.96**	167.82**	494.58**	196.03**	228.39**	192.86**	612.96**
SCA	9	9	7.14**	8.83**	6.61**	19.07**	17.30**	20.48**	29.28**	61.53**
Cross × I	-	28	-	-	-	3.60**	-	-	-	5.10**
GCA × I	-	10	-	-	-	3.79**	-	-	-	4.32**
SCA × I	-	18	-	-	-	3.51**	-	-	-	5.53**
Error term	28	84	0.17	0.19	0.12	0.16	0.17	0.25	0.24	0.22
GCA/ SCA	-	-	20.80	20.61	25.40	25.93	11.33	11.15	6.59	9.96
GCA × I / SCA × I	-	-	-	-	-	1.08	-	-	-	0.78

Table (3): Cont.

S.O.V.	d.f.		Plant height (cm)				Stem diameter (cm)			
	Single	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
Crosses(cr)	14	14	191.07**	181.94**	172.15**	544.27**	0.16**	0.15**	0.14**	0.44**
GCA	5	5	425.85**	411.29**	392.95**	1229.22**	0.24**	0.21**	0.19**	0.63**
SCA	9	9	60.64**	54.52**	49.49**	163.75**	0.12**	0.11**	0.11**	0.33**
Cross × I	-	28	-	-	-	0.89	-	-	-	0.01
GCA × I	-	10	-	-	-	0.87	-	-	-	0.01
SCA × I	-	18	-	-	-	0.90	-	-	-	0.01
Error term	28	84	0.60	0.42	0.36	0.46	0.007	0.007	0.007	0.007
GCA/ SCA	-	-	7.02	7.54	7.94	7.51	1.86	1.87	1.83	1.87
GCA × I / SCA × I	-	-	-	-	-	0.97	-	-	-	1.00
			Head diameter (cm)				Seed yield/plant (g)			
Crosses(cr)	14	14	14.58**	16.31**	15.81**	46.66**	11.23**	30.19**	40.70**	77.09**
GCA	5	5	33.11**	37.10**	35.77**	105.89**	28.27**	73.04**	95.28**	185.90**
SCA	9	9	4.30**	4.76**	4.72**	13.75**	1.76**	6.39**	10.37**	16.63**
Cross × I	-	28	-	-	-	0.04	-	-	-	5.03**
GCA × I	-	10	-	-	-	0.09**	-	-	-	10.69**
SCA × I	-	18	-	-	-	0.03	-	-	-	1.89**
Error term	28	84	0.013	0.013	0.01	0.01	0.007	0.013	0.01	0.01
GCA/ SCA	-	-	7.71	7.79	7.59	7.70	16.03	11.44	9.18	11.18
GCA × I / SCA × I	-	-	-	-	-	3.00	-	-	-	5.66

Table (3): cont.

S.O.V.	d.f.		100-seed weight (g)				Seed yield (kg/fad.)			
	Single	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
Crosses(cr)	14	14	0.49**	0.81**	1.18**	2.39**	11143.75**	29956.93**	40381.98**	76487.42**
GCA	5	5	1.07**	1.79**	2.62**	5.31**	28051.53**	72472.51**	94543.43**	184463.17**
SCA	9	9	0.16**	0.26**	0.38**	0.77**	1750.54**	6337.16**	10292.29**	16500.88**
Cross × I	-	28	-	-	-	0.09**	-	-	-	4995.24**
GCA × I	-	10	-	-	-	0.17**	-	-	-	10604.30**
SCA × I	-	18	-	-	-	0.03	-	-	-	1879.11**
Error term	28	84	0.007	0.01	0.013	0.01	7.10	12.05	10.07	9.74
GCA/ SCA	-	-	6.74	6.95	6.87	6.86	16.02	11.44	9.19	11.18
GCA×I / SCA×I	-	-	-	-	-	5.67	-	-	-	5.64
			Seed oil (%)				Oil yield (kg/fad.)			
Crosses(cr)	14	14	3.22**	5.69**	6.74**	15.24**	4167.27**	8112.44**	8111.03**	19930.79**
GCA	5	5	7.31**	12.54**	15.38**	34.40**	10234.60**	19395.13**	19101.89**	47768.76**
SCA	9	9	0.94**	1.88**	1.94**	4.59**	796.54**	1844.28**	2005.00**	4465.26**
Cross × I	-	28	-	-	-	0.41**	-	-	-	459.95**
GCA × I	-	10	-	-	-	0.83**	-	-	-	962.86**
SCA × I	-	18	-	-	-	0.17**	-	-	-	180.56**
Error term	28	84	0.003	0.007	0.007	0.007	1.55	2.33	1.56	1.81
GCA/ SCA	-	-	7.76	6.67	7.95	7.49	12.85	10.52	9.53	10.70
GCA × I / SCA× I	-	-	-	-	-	4.88	-	-	-	5.33

* and ** significant at 0.05 and 0.01 levels of probability, respectively.
T1: (Irrigation every 14 days intervals). T2: (Irrigation every 21 days intervals). T3: (Irrigation every 28 days intervals).

Table (4): Estimates of general combining ability (GCA) effects of the parental genotypes for the studied traits under the three water treatments and their combined data.

Parents	No. of days to first flowering				No. of days to 50% flowering				No. of days to full flowering			
	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
P_1 (Line 4)	2.81**	2.64**	2.83**	2.76**	2.81**	2.58**	2.89**	2.76**	2.72**	2.36**	2.69**	2.59**
P_2 (Line 10)	0.14	0.81**	1.08**	0.68**	0.06	1.00**	0.81**	0.62**	0.06	1.19**	0.78**	0.68**
P_3 (Line 16)	4.06**	4.56**	4.50**	4.37**	4.31**	4.83**	4.81**	4.65**	4.97**	5.28**	5.19**	5.15**
P_4 (Line 17)	-0.11	0.06	-0.33	-0.13	-0.11	0.08	-0.36*	-0.13	-0.11	0.19	-0.31	-0.07
P_5 (Line 63)	-3.86**	-4.19**	-3.83**	-3.96**	-4.03**	-4.50**	-4.11**	-4.21**	-4.36**	-4.81**	-4.31**	-4.49**
P_6 (Giza 102)	-3.03**	-3.86**	-4.25**	-3.71**	-3.03**	-4.00**	-4.03**	-3.69**	-3.28**	-4.22**	-4.06**	-3.85**
LSD gi 0.05	0.37	0.41	0.43	0.26	0.51	0.45	0.35	0.28	0.39	0.40	0.32	0.27
LSD gi 0.01	0.50	0.56	0.59	0.34	0.68	0.60	0.48	0.38	0.53	0.55	0.44	0.36
LSD gi-gj 0.05	0.58	0.64	0.67	0.40	0.78	0.69	0.55	0.44	0.60	0.63	0.50	0.42
LSD gi-gj 0.01	0.78	0.87	0.91	0.53	1.06	0.93	0.74	0.58	0.82	0.84	0.68	0.56
	No. of days to physio. maturity				Plant height (cm)				Stem diameter (cm)			
P_1 (Line 4)	1.83**	1.72**	1.81**	1.79**	7.22**	7.00**	6.78**	7.00**	0.07**	0.06**	0.06**	0.06**
P_2 (Line 10)	0.01	0.72**	1.06**	0.59**	6.13**	6.10**	6.01**	6.08**	0.07**	0.07**	0.07**	0.07**
P_3 (Line 16)	6.25**	6.22**	5.81**	6.09**	-0.15	-0.36	-0.55	-0.35*	-0.08**	-0.07**	-0.07**	-0.07**
P_4 (Line 17)	0.50*	1.31**	0.39	0.73**	-8.81**	-8.75**	-8.61**	-8.72**	-0.24**	-0.23**	-0.22**	-0.23**
P_5 (Line 63)	-5.33**	-5.86**	-5.28**	-5.49**	-1.69**	-1.45**	-1.23**	-1.46**	0.15**	0.15**	0.14**	0.15**
P_6 (Giza 102)	-3.25**	-4.11**	-3.78**	-3.71**	-2.70**	-2.55**	-2.40**	-2.55**	0.02	0.02*	0.02*	0.02**
LSD gi 0.05	0.39	0.46	0.46	0.32	0.73	0.61	0.56	0.32	0.03	0.02	0.02	0.01
LSD gi 0.01	0.52	0.62	0.62	0.42	0.98	0.82	0.76	0.43	0.04	0.03	0.03	0.02
LSD gi-gj 0.05	0.60	0.72	0.71	0.50	1.12	0.94	0.87	0.50	0.04	0.03	0.03	0.02
LSD gi-gj 0.01	0.81	0.97	0.96	0.66	1.52	1.27	1.17	0.66	0.05	0.04	0.05	0.02

Table (4): Cont.

Parents	Head diameter (cm)				Seed yield/plant (g)				100-seed weight (g)			
	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
P_1 (Line 4)	0.77**	0.86**	0.85**	0.83**	1.00**	1.74**	1.89**	1.54**	0.17**	0.23**	0.29**	0.23**
P_2 (Line 10)	1.01**	1.11**	1.12**	1.08**	1.03**	1.63**	1.82**	1.49**	0.23**	0.30**	0.36**	0.30**
P_3 (Line 16)	-0.40**	-0.48**	-0.51**	-0.46**	-0.35**	-0.90**	-0.90**	-0.72**	-0.12**	-0.14**	-0.17**	-0.14**
P_4 (Line 17)	-3.10**	-3.26**	-3.18**	-3.18**	-2.96**	-4.64**	-5.35**	-4.32**	-0.55**	-0.72**	-0.87**	-0.71**
P_5 (Line 63)	0.15**	0.16**	0.15**	0.15**	0.51**	0.86**	0.99**	0.79**	0.04**	0.07**	0.08**	0.06**
P_6 (Giza 102)	1.56**	1.61**	1.58**	1.58**	0.78**	1.31**	1.55**	1.21**	0.22**	0.27**	0.30**	0.26**
LSD gi 0.05	0.11	0.11	0.10	0.05	0.08	0.10	0.09	0.24	0.02	0.03	0.03	0.03
LSD gi 0.01	0.14	0.14	0.13	0.07	0.11	0.14	0.13	0.32	0.03	0.04	0.05	0.04
LSD gi-gj 0.05	0.17	0.17	0.15	0.08	0.12	0.16	0.15	0.38	0.04	0.05	0.05	0.05
LSD gi-gj 0.01	0.22	0.22	0.20	0.11	0.17	0.22	0.20	0.50	0.05	0.06	0.07	0.07
	Seed yield (kg/fad.)				Seed oil (%)				Oil yield (kg/fad.)			
P_1 (Line 4)	31.37**	54.89**	59.48**	48.58**	0.40**	0.52**	0.53**	0.49**	17.98**	26.81**	25.64**	23.48**
P_2 (Line 10)	32.31**	51.27**	57.28**	46.95**	0.67**	0.76**	0.82**	0.75**	21.80**	28.04**	27.20**	25.68**
P_3 (Line 16)	-11.16**	-28.19**	-28.25**	-22.53**	-0.50**	-0.59**	-0.57**	-0.55**	-11.58**	-18.43**	-16.24**	-15.41**
P_4 (Line 17)	-93.14**	-146.08**	-168.58**	-135.93**	-1.33**	-1.78**	-2.02**	-1.71**	-54.18**	-73.70**	-74.13**	-67.34**
P_5 (Line 63)	16.01**	26.93**	31.29**	24.75**	0.11**	0.17**	0.24**	0.17**	7.53**	11.20**	11.77**	10.17**
P_6 (Giza 102)	24.60**	41.19**	48.77**	38.18**	0.65**	0.91**	1.00**	0.85**	18.45**	26.07**	25.77**	23.43**
LSD gi 0.05	2.49	3.24	2.97	7.67	0.02	0.02	0.02	0.07	1.16	1.43	1.17	2.37
LSD gi 0.01	3.36	4.38	4.00	10.15	0.03	0.03	0.03	0.09	1.57	1.93	1.58	3.13
LSD gi-gj 0.05	3.86	5.03	4.59	11.88	0.03	0.04	0.03	0.11	1.80	2.21	1.81	3.67
LSD gi-gj 0.01	5.20	6.78	6.20	15.73	0.04	0.05	0.05	0.14	2.43	2.98	2.44	4.85

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

T_1: (Irrigation every 14 days intervals). T_2: (Irrigation every 21 days intervals). T_3: (Irrigation every 28 days intervals).

Table (5): Estimates of specific combining ability (SCA) effects of F_1 crosses for the studied traits under the three water treatments and their combined data.

Crosses	No. of days to first flowering				No. of days to 50% flowering				No. of days to full flowering			
	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
1- Line 4 x Line 10	0.30	-0.27	-0.58	-0.18	-0.02	-0.12	-0.92**	-0.35	0.27	-0.40	-0.98**	-0.37
2- Line 4 x Line 16	-1.28**	-0.68	-0.33	-0.77**	-1.60**	-0.95*	-0.25	-0.93**	-1.98**	-0.82*	-0.73*	-1.18**
3- Line 4 x Line 17	1.55**	0.82*	0.50	0.96**	1.48**	0.80*	0.92**	1.07**	1.43**	0.60	1.10**	1.04**
4- Line 4 x Line 63	-0.37	-0.60	0.01	-0.32	0.40	-0.28	-0.33	-0.07	0.35	-0.40	-0.23	-0.09
5- Line 4 x Giza 102	-0.20	0.73*	0.42	0.32	-0.27	0.55	0.58	0.29	-0.07	1.02**	0.85**	0.60*
6- Line 10 x Line 16	1.05**	1.15**	1.42**	1.21**	0.82	1.63**	1.50**	1.32**	1.02**	1.35**	1.85**	1.41**
7- Line 10 x Line 17	0.88**	0.98**	1.58**	1.15**	1.23**	1.05**	1.67**	1.32**	1.10**	1.10**	1.35**	1.18**
8- Line 10 x Line 63	-0.70*	-0.10	-0.25	-0.35	-0.85	-0.37	0.08	-0.38	-0.98**	0.77*	0.02	-0.07
9- Line 10 x Giza 102	-1.53**	-1.77**	-2.17**	-1.82**	-1.18**	-2.20**	-2.33**	-1.91**	-1.40**	-2.82**	-2.23**	-2.15**
10- Line 16 x Line 17	-0.70*	-0.10	-0.50	-0.43	-0.68	-0.12	-1.00**	-0.60*	-0.48	0.35	-0.73*	-0.29
11- Line 16 x Line 63	-0.62	-1.18**	-1.00**	-0.93**	-0.77	-1.53**	-0.92**	-1.07**	-0.57	-1.98**	-0.73*	-1.09**
12- Line 16 x Giza 102	1.55**	0.82*	0.42	0.93**	2.23**	0.97*	0.67*	1.29**	2.02**	1.10**	0.35	1.16**
13- Line 17 x Line 63	-0.12	-0.02	-0.83*	-0.32	-0.02	-0.12	-0.75*	-0.29	-0.15	-0.57	-0.90**	-0.54*
14- Line 17 x Giza 102	-1.62**	-1.68**	-0.75*	-1.35**	-2.02**	-1.62**	-0.83**	-1.49**	-1.90**	-1.48**	-0.82**	-1.40**
15- Line 63 x Giza 102	1.80**	1.90**	2.08**	1.93**	1.23**	2.30**	1.92**	1.82**	1.35**	2.18**	1.85**	1.79**
LSD sij 0.05	0.63	0.70	0.74	0.44	0.86	0.76	0.60	0.48	0.66	0.69	0.55	0.46
LSD sij 0.01	0.86	0.95	0.99	0.58	1.16	1.02	0.81	0.64	0.89	0.92	0.74	0.61
LSD sij-sik 0.05	1.00	1.11	1.17	0.69	1.36	1.20	0.95	0.76	1.05	1.08	0.87	0.73
LSD sij-sik 0.01	1.35	1.50	1.57	0.91	1.83	1.61	1.28	1.01	1.41	1.46	1.17	0.97
LSD sij-skl 0.05	0.82	0.91	0.95	0.56	1.11	0.98	0.77	0.62	0.85	0.89	0.71	0.60
LSD sij-skl 0.01	1.10	1.22	1.28	0.75	1.50	1.32	1.04	0.82	1.15	1.19	0.96	0.79

Table (5): Cont.

Crosses	No. of days to physio. Maturity				Plant height (cm)				Stem diameter (cm)			
	T1	T2	T3	Comb.	T1	T2	T3	Comb.	T1	T2	T3	Comb.
1- Line 4 x Line 10	0.37	-0.87*	-0.75	-0.42	7.32**	6.63**	5.97**	6.64**	0.07**	0.07**	0.07**	0.07**
2- Line 4 x Line 16	-1.88**	-0.70	-1.83**	-1.47**	-7.07**	-6.81**	-6.57**	-6.82**	0.02	0.02	0.02	0.02*
3- Line 4 x Line 17	2.53**	1.88**	2.92**	2.44**	-0.56	-0.76	-0.93	-0.75**	-0.22**	-0.20**	-0.19**	-0.20**
4- Line 4 x Line 63	0.37	0.05	0.58	0.33	-0.19	0.22	0.61	0.22	0.13**	0.12**	0.11**	0.12**
5- Line 4 x Giza 102	-1.38**	-0.37	-0.92*	-0.89**	0.49	0.72	0.92	0.71*	-0.01	0.01	0.01	0.01
6- Line 10 x Line 16	0.95**	0.63	0.58	0.72**	2.23**	2.36**	2.47**	2.35**	0.17**	0.16**	0.16**	0.16**
7- Line 10 x Line 17	1.37**	2.55**	4.33**	2.75**	-5.98**	-5.58**	-5.22**	-5.59**	-0.05*	-0.05**	-0.05**	-0.05**
8- Line 10 x Line 63	-1.13**	0.38	-1.33**	-0.69**	-3.15**	-3.31**	-3.42**	-3.29**	-0.34**	-0.33**	-0.31**	-0.33**
9- Line 10 x Giza 102	-1.55**	-2.70**	-2.83**	-2.36**	-0.42	-0.10	0.20	-0.11	0.15**	0.14**	0.13**	0.14**
10- Line 16 x Line 17	0.45	0.38	-1.08**	-0.08	3.96**	3.80**	3.65**	3.80**	0.09**	0.08**	0.08**	0.08**
11- Line 16 x Line 63	-1.72**	-2.78**	-0.42	-1.64**	2.38**	2.14**	1.88**	2.13**	-0.14**	-0.14**	-0.13**	-0.14**
12- Line 16 x Giza 102	2.20**	2.47**	2.75**	2.47**	-1.50*	-1.49**	-1.42**	-1.47**	-0.13**	-0.13**	-0.12**	-0.13**
13- Line 17 x Line 63	-1.30**	-1.53**	-3.00**	-1.94**	1.06	1.31*	1.56**	1.31**	0.27**	0.26**	0.25**	0.26**
14- Line 17 x Giza 102	-3.05**	-3.28**	-3.17**	-3.17**	1.52*	1.23*	0.94	1.23**	-0.10**	-0.09**	-0.09**	-0.09**
15- Line 63 x Giza 102	3.78**	3.88**	4.17**	3.94**	-0.10	-0.36	-0.64	-0.36	0.08**	0.08**	0.08**	0.08**
LSD sij 0.05	0.66	0.79	0.78	0.54	1.23	1.03	0.95	0.55	0.04	0.04	0.04	0.02
LSD sij 0.01	0.89	1.06	1.05	0.72	1.66	1.39	1.28	0.73	0.06	0.05	0.05	0.03
LSD sij-sik 0.05	1.04	1.24	1.23	0.86	1.95	1.63	1.51	0.87	0.07	0.06	0.06	0.03
LSD sij-sik 0.01	1.40	1.68	1.65	1.14	2.63	2.20	2.03	1.15	0.10	0.08	0.08	0.04
LSD sij-skl 0.05	0.85	1.01	1.00	0.70	1.59	1.33	1.23	0.71	0.06	0.05	0.05	0.03
LSD sij-skl 0.01	1.14	1.37	1.35	0.93	2.14	1.80	1.66	0.94	0.08	0.06	0.07	0.03

Table (5): Cont.

Crosses	Head diameter (cm)				Seed yield/plant (g)				100-seed weight (g)			
	T1	T2	T3	Comb.	T1	T2	T3	Comb.	T1	T2	T3	Comb.
1- Line 4 x Line 10	0.03	0.01	0.01	0.02	0.10	0.15	0.32**	0.19	-0.22**	-0.27**	-0.30**	-0.26**
2- Line 4 x Line 16	0.35**	0.38**	0.38**	0.37**	-0.27**	-0.18*	-0.26**	-0.24	0.05*	0.07**	0.10**	0.07**
3- Line 4 x Line 17	-1.46**	-1.51**	-1.50**	-1.49**	-0.91**	-1.76**	-2.30**	-1.66**	-0.15**	-0.22**	-0.31**	-0.23**
4- Line 4 x Line 63	-0.02	-0.04	-0.03	-0.03	0.42**	0.75**	0.97**	0.71**	0.18**	0.23**	0.27**	0.22**
5- Line 4 x Giza 102	1.10**	1.16**	1.13**	1.13**	0.66**	1.04**	1.27**	0.99**	0.14**	0.19**	0.24**	0.19**
6- Line 10 x Line 16	-0.58**	-0.61**	-0.62**	-0.60**	-0.43**	-0.78**	-0.92**	-0.71**	-0.09**	-0.12**	-0.17**	-0.13**
7- Line 10 x Line 17	-0.54**	-0.63**	-0.68**	-0.62**	-0.50**	-0.97**	-1.31**	-0.92**	-0.11**	-0.11**	-0.10**	-0.10**
8- Line 10 x Line 63	-0.06	-0.04	-0.01	-0.03	0.11	0.10	0.02	0.08	0.09**	0.09**	0.11**	0.10**
9- Line 10 x Giza 102	1.14**	1.26**	1.29**	1.23**	0.72**	1.49**	1.89**	1.37**	0.33**	0.40**	0.46**	0.40**
10- Line 16 x Line 17	2.10**	2.17**	2.14**	2.14**	1.43**	2.77**	3.49**	2.56**	0.34**	0.44**	0.56**	0.45**
11- Line 16 x Line 63	-0.37**	-0.35**	-0.33**	-0.35**	-0.13*	-0.45**	-0.62**	-0.40	-0.17**	-0.22**	-0.26**	-0.22**
12- Line 16 x Giza 102	-1.49**	-1.58**	-1.58**	-1.55**	-0.60**	-1.36**	-1.68**	-1.22**	-0.12**	-0.18**	-0.24**	-0.18**
13- Line 17 x Line 63	0.55**	0.62**	0.62**	0.60**	0.17*	0.37**	0.62**	0.39	0.09**	0.10**	0.10**	0.09**
14- Line 17 x Giza 102	-0.64**	-0.65**	-0.59**	-0.63**	-0.20**	-0.41**	-0.50**	-0.37	-0.17**	-0.21**	-0.25**	-0.21**
15- Line 63 x Giza 102	-0.10	-0.20*	-0.26**	-0.18**	-0.57**	-0.77**	-0.98**	-0.77**	-0.18**	-0.20**	-0.21**	-0.20**
LSD sij 0.05	0.18	0.18	0.16	0.09	0.13	0.17	0.16	0.41	0.04	0.05	0.06	0.06
LSD sij 0.01	0.25	0.24	0.22	0.12	0.18	0.24	0.22	0.55	0.06	0.07	0.08	0.07
LSD sij-sik 0.05	0.29	0.29	0.26	0.15	0.21	0.28	0.25	0.65	0.07	0.08	0.09	0.09
LSD sij-sik 0.01	0.39	0.39	0.35	0.19	0.29	0.37	0.34	0.86	0.09	0.11	0.12	0.12
LSD sij-skl 0.05	0.24	0.23	0.21	0.12	0.17	0.23	0.21	0.53	0.05	0.07	0.07	0.07
LSD sij-skl 0.01	0.32	0.32	0.28	0.16	0.23	0.30	0.28	0.71	0.07	0.09	0.10	0.10

Table (5): Cont.

Crosses	Seed yield (kg/fad.)				Seed oil (%)				Oil yield (kg/fad.)			
	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.	T_1	T_2	T_3	Comb.
1- Line 4 x Line 10	3.18	4.85	10.14**	6.06	0.12**	0.27**	0.25**	0.21**	2.70**	4.54**	4.97**	4.07*
2- Line 4 x Line 16	-8.47**	-5.78*	-8.29**	-7.51	-0.41**	-0.51**	-0.32**	-0.41**	-9.12**	-8.77**	-6.45**	-8.11**
3- Line 4 x Line 17	-28.56**	-55.47**	-72.39**	-52.14**	-0.49**	-0.77**	-0.87**	-0.71**	-17.59**	-28.80**	-31.26**	-25.88**
4- Line 4 x Line 63	13.18**	23.51**	30.46**	22.39**	0.49**	0.63**	0.59**	0.57**	11.89**	16.28**	15.84**	14.67**
5- Line 4 x Giza 102	20.66**	32.89**	40.07**	31.21**	0.29**	0.38**	0.35**	0.34**	12.13**	16.75**	16.90**	15.26**
6- Line 10 x Line 16	-13.51**	-24.52**	-29.07**	-22.37**	0.25**	0.36**	0.39**	0.33**	-2.16*	-5.11**	-6.82**	-4.70*
7- Line 10 x Line 17	-15.64**	-30.43**	-41.20**	-29.09**	-0.55**	-0.77**	-0.82**	-0.71**	-13.62**	-20.10**	-21.18**	-18.30**
8- Line 10 x Line 63	3.42	3.20	0.53	2.38	-0.19**	-0.34**	-0.27**	-0.27**	-1.33	-3.17*	-2.64*	-2.38
9- Line 10 x Giza 102	22.55**	46.90**	59.60**	43.02**	0.38**	0.47**	0.45**	0.43**	14.42**	23.84**	25.67**	21.31**
10- Line 16 x Line 17	45.16**	87.14**	109.84**	80.71**	0.91**	1.12**	1.03**	1.02**	30.21**	45.51**	46.82**	40.85**
11- Line 16 x Line 63	-4.14	-14.05**	-19.47**	-12.55	-0.58**	-0.88**	-0.99**	-0.82**	-9.12**	-14.53**	-14.29**	-12.65**
12- Line 16 x Giza 102	-19.02**	-42.79**	-53.02**	-38.28**	-0.16**	-0.09**	-0.11**	-0.12*	-9.81**	-17.10**	-19.26**	-15.39**
13- Line 17 x Line 63	5.39*	11.55**	19.43**	12.12	0.45**	0.88**	1.01**	0.78**	8.15**	14.15**	15.01**	12.44**
14- Line 17 x Giza 102	-6.35**	-12.79**	-15.69**	-11.61	-0.33**	-0.47**	-0.35**	-0.38**	-7.15**	-10.76**	-9.40**	-9.10**
15- Line 63 x Giza 102	-17.85**	-24.21**	-30.96**	-24.34**	-0.17**	-0.29**	-0.34**	-0.27**	-9.58**	-12.73**	-13.92**	-12.08**
LSD sij 0.05	4.23	5.51	5.03	13.01	0.03	0.04	0.04	0.12	1.97	2.42	1.98	4.02
LSD sij 0.01	5.70	7.43	6.79	17.23	0.04	0.06	0.05	0.15	2.66	3.27	2.67	5.32
LSD sij-sik 0.05	6.68	8.71	7.96	20.57	0.05	0.07	0.06	0.18	3.12	3.83	3.13	6.35
LSD sij-sik 0.01	9.01	11.74	10.74	27.24	0.07	0.09	0.08	0.24	4.21	5.17	4.23	8.41
LSD sij-skl 0.05	5.46	7.11	6.50	16.80	0.04	0.05	0.05	0.15	2.55	3.13	2.56	5.18
LSD sij-skl 0.01	7.36	9.59	8.77	22.24	0.06	0.07	0.07	0.20	3.44	4.22	3.45	6.87

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

T_1: (Irrigation every 14 days intervals). T_2: (Irrigation every 21 days intervals). T_3: (Irrigation every 28 days intervals).