



PERFORMANCE AND COMBINING ABILITY FOR STRAW YIELD AND RELATED CHARACTERS IN A DIALLEL CROSS OF FLAX (*Linum usitatissimum*, L.) UNDER DIFFERENT SOWING DATES

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ABSTRACT

Thirty six entries of flax (*Linum usitatissimum*, L.) involving eight parental genotypes and their twenty eight hybrids were evaluated for straw yield and its related traits in the F₁ during (2015/2016) and F₂ populations during (2016/2017) under early (F₂D1) and late (F₂D2) sowing dates (two environments) in the Agricultural Research Station, Faculty of Agriculture, Ain Shams Univ., Shalakan, Kalubia Governorate. Mean squares due to genotypes, parents and crosses were highly significant for straw yield, plant height, technical stem length, fiber yield/plant, fiber percentage, fiber length and fiber fineness in the F₁ and F₂ generations (at early and late sowing dates), indicating that parental genotypes as well as their F₁ and F₂ generations exhibited reasonable degree of variability for all studied traits. Highly significant variations mean performance were found for parental genotypes and hybrids for straw yield/plant and its related traits in the F₁, F₂D1 and F₂D2, indicating presence of wide genetic variability among studied genotypes. The highest mean values were recorded under all studied environments, for straw yield/plant, fiber yield/plant and fiber fineness were found by S. 402/1 genotype, while Sakha 5 gave the highest mean values for plant height, technical stem length and fiber length.

General and specific combining ability mean squares were highly significant for all studied traits in F₁, F₂D1 and F₂D2 with the exception of a few cases, indicating the importance of both additive and non-additive gene effects in the expression of

straw yield and its components. The additive effects were more important than non-additive effects under all studied environments for straw yield/plant (except at F₂D2), plant height (except at F₁), fiber percentage and fineness. On the other hand, the non-additive effects were more effective than additive effects for technical stem length, fiber yield/plant and fiber length. Results showed that the parents; Giza 11 and Giza 12 for straw yield/plant, Sakha 5 for plant height and fiber length, Sakha 6 for fiber yield/plant, Jowhar for fiber percentage and S. 402/1, Sakha 2, Giza 12 and Sakha 5 for fiber fineness, these parents appeared to be the best general combiners for these traits. Some of the crosses exhibited highly significant and positive SCA effects included high x high and high x low general combiner parents, suggesting that the breeding procedure which utilize both additive and non-additive genetic variances would be more useful for improvement of straw yield and its components of flax.

Keywords: Flax, Performance, Combining ability, Additive, Non-additive, Sowing dates.

INTRODUCTION

Linseed or Flax (*Linum usitatissimum*, L.) is a traditional oilseed just as a fiber yield and has a place with Linaceae family with chromosome number 30. Flax has dependably had mechanical utilizations; as of late its uses have extended to incorporate a scope of new potential outcomes, for example, cigarette papers, vehicle entryway boards

and packed sheets. In any case, to an ever-increasing extent, flax is cutting a specialty as a wellbeing nourishment. Alpha-linolenic corrosive (an omega-3 unsaturated fat found in seed flax) is fundamental in the human eating routine. It can diminish coronary illness and lower cholesterol. Flax is developed in Egypt for two purposes, seeds and filaments.

The diallel cross strategy proposed by **(Griffing, 1956)** has been broadly utilized for assessment of general joining capacity which is because of added substance quality activity and explicit consolidating capacity which is expected to non-added substance quality impacts. The trouble in delivering enough F_1 mixture seeds in some self-pollinated crops have constrained the utilization of diallel examination, and in such cases, F_2 diallels might be increasingly fitting **(Shehata and Comstock, 1971 and Patil and Chopde, 1981)**. In any case, F_2 diallels gauge predominance with just a large portion of the effectiveness of F_1 diallels **(Al-lard 1960)**. The added substance hereditary change had increasingly vital job in the legacy of straw yield, plant stature and specialized stem length as detailed by **Foster et al 1998, El-Kady, Eman and Abo-Kaied 2002, Abo-Kaied et al 2007 and Abo-Kaied and El Refaie, Amany 2008**. The targets of the present investigation are to estimate the magnitude of both general and specific combining ability for straw yield and its related characters in an eight parental diallel crosses of flax in F_1 and F_2 generations under two distinct conditions with an extreme objective of choosing appropriate guardians and the superiority crosses which can be utilized in reproducing program.

MATERIALS AND METHODS

Eight flax genotypes were chosen on basis of their diversity in some agronomic traits to achieve this study, i.e. two new strains (S.2465/1/3 and S402/1), five local cultivars (Sakha 6, Sakha 5, Giza 11, Sakha 2 and Giza 12) and the introduced cultivar (Gowhar). Seeds of the genotypes were obtained from Fiber Crops Research Section, Field Crops Research Institute, Agriculture Research Center (ARC), Giza. Genotype characteristics of the material used according to their names, type, pedigree and origin of the parental genotypes are presented in **Table (1)**. This investigation was carried out during the three successive seasons 2014/15, 2015/16 and 2016/17. In the first growing season (2014/15), the eight parents were crossed

to form a half diallel set to obtain the seeds of parents and their 28 F_1 crosses. Hybridization was made in the Experimental Farm at the Faculty of Agriculture, Ain Shams Univ. at Shoubra El-Kheima, Kalubia Governorate, Egypt. In the second growing season (2015/16), seeds of parents and their twenty eight F_1 hybrids (36 entries) were sown on 14th November 2015/2016 in the Agricultural Research Station, Faculty of Agriculture, Ain Shams University at Shalakan, Kalubia Governorate to obtain the seeds of parents and their twenty eight F_2 hybrids. In the third growing season (2016/17), seeds of each parent as well as seeds of each segregating F_2 cross were cultured in three rows. Parents and F_2 populations were sown in two sowing dates (two environments) one early date and the other late. The early date was on 6th November (D1) while the late date was on 28th November (D2). The preceding summer crop in the second and third growing seasons was soybean (*Glycin max*, L.). Other cultural practices were followed as recommended for flax production. The field experiments were designed in a randomized complete blocks (RCBD) with three replications in the second and third growing seasons. Each experimental plot consisted of one row for each genotype in 2015/16 growing season and three rows in 2016/17 growing season. Each row was 2.5 m in length and 30 cm width, seeds were spaced at 10 cm within rows and one plant was left per hill.

At harvest, sample of 10 plants from each plot were collected from parents or F_1 's whereas samples of 70 plants were collected from each plot of F_2 segregating crosses. Data of the following characters were recorded for the two generations as follow:

1. Straw yield per plant: total weight in grams of the air-dried straw per plant after removing the capsules.
2. Plant height (cm): measured as the distance from the cotyledonary nodes up to uppermost capsule.
3. Technical stem length (cm): the length of the main stem between the cotyledons and the apical branching point.
4. Fiber yield/plant (g).
5. Fiber percentage: [fiber weight per plant (g)/straw weight per plant (g)] x 100.
6. Fiber length (cm): the majority fiber length/plant.
7. Fiber fineness (Nm): estimated in metrical number (mg/mm) according to **(Radwan and Momtaz, 1966)**.

Table 1. Name, type, pedigree and origin of the eight parental flax genotypes

Name		Type	Pedigree	Origin
S. 2465/1/3	P1	Dual	Selected from Neelum (Indian)	Local strain
Sakha 6	P2	Dual	Giza 8 x S. 2419/1	Local c.v.
S. 402/1	P3	Dual	Giza 5 x I. 235 U.S.A	Local strain
Sakha 5	P4	Oil	I. 2561 X I. 370	Local c.v.
Giza 11	P5	Dual	Giza 8 x S. 2419/1	Local c.v.
Sakha 2	P6	Dual	I. 2348 x Hera	Local c.v.
Giza 12	P7	Dual	S. 2419/1 x S. 148/6/1	Local c.v.
Jowhar	P8	Oil	Introduction from India	India

Statistical procedures used in this study were done according to analysis of variance for randomized complete blocks design as outlined by (Snedecor and Cochran, 1980).

The analyses of variance for general and specific combining abilities were estimated according to (Griffing's, 1956) method 2 model 1.

RESULTS AND DISCUSSION

Mean square estimates

Analysis of variance presented in **Table (2)** indicated that mean squares due to all 36 genotypes as well as mean squares due to parents and crosses were highly significant for straw yield/plant, plant height, technical stem length, fiber yield/plant, fiber percentage, fiber length and fiber fineness in the F_1 and F_2 generations, revealing the presence of sufficient genetic variability existed in the studied genotypes. Consequently, various comparisons suggested to be done are valid and should be conducted to achieve the objectives of the present study. Hassanein et al (2012) stated that the mean squares exhibited highly significant effect for plant height, technical stem length and straw yield/plant.

Mean performance of genotypes

Straw yield/plant

Mean performance for parental genotypes and hybrids for straw yield/plant was presented in **Table (3)**. Highly significant variations were found between genotypes for this trait in both seasons, indicating presence of wide genetic variability among studied genotypes. With regard to parents, S. 402/1 recorded the heaviest straw yield/plant in

F_1 and F_2 (at early and late sowing dates) which gave values of 29.13, 28.50 and 23.63g, respectively. Jowhar variety recorded the lowest mean values for straw yield/plant giving 24.00, 21.67 and 21.33g in the same order.

With respect to the crosses, the average mean performance for straw yield for all crosses recorded 28.38, 27.21 and 23.73g in both seasons (F_1 , F_2D1 and F_2D2), respectively. The highest mean performance values for this trait were obtained by flax crosses; $P2 \times P5$ (36.30, 34, 83 and 31.00g), $P2 \times P7$ (35.10, 35.67 and 30.67g) and $P5 \times P7$ (36.60, 33.50 and 27.17g) in F_1 , F_2D1 and F_2D2 , respectively. On the other hand, the lowest mean performance values for this trait were obtained by the crosses $P2 \times P4$ (21.13g), $P2 \times P6$ (21.33g) and $P4 \times P8$ (20.33g) in F_1 , F_2D1 and F_2D2 , respectively.

It is clear from the results that the delay in the planting date (F_2D2) gave low values than the earlier in planting date (F_2D1) for straw yield/plant, indicating that the delay in planting date has a detrimental effect on this trait.

Plant height

Highly significant differences were observed between parents as well as crosses for plant height in the F_1 and F_2 generations (**Table 3**), indicating presence of wide genetic variability among genotypes. Regarding to mean performance of parents, data indicated that Sakha5 and S. 402/1 were the tallest among all genotypes recording the highest mean values of (114.50, 113.80 and 107.43cm) and (110.70, 113.30 and 107.06 cm) in the first season (F_1) and early and late sowing dates in the second season (F_2), respectively, while Giza 11 was the shortest parent which having mean values of 90.57, 90.29 and 84.67cm in the same above order, respectively. The average

Table 2. Mean squares for studied characters in eight parent-half diallel crosses of flax in 2015/2016 (F₁) and 2016/2017 (F₂) at early (F₂D1) and late (F₂D2) sowing dates

Source of variance	d.f.	Straw yield/plant (g)			Plant height (cm)			Technical stem length (cm)			Fiber yield/plant (g)		
		F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2
Replicates	2	3.50	2.45	3.35	111.12	33.47	4.76	37.23	6.97	20.04	0.28*	0.04	0.01
Genotypes	35	46.49**	41.92**	23.43**	164.05**	139.70**	119.18**	142.13**	118.45**	99.71**	0.29**	0.31**	0.34**
Parents	7	13.04**	20.10**	7.77**	263.19**	241.01**	234.86**	214.32**	179.73**	124.76**	0.46**	0.38**	0.28**
Crosses	27	53.86**	46.94**	26.00**	132.54**	118.33**	91.76**	117.52**	83.43**	93.60**	0.26**	0.29**	0.30**
P vs C	1	81.67**	59.23**	63.48**	320.80**	7.78	49.71	301.22**	635.08**	89.16*	0.06	0.33**	2.03**
Error	70	2.54	7.84	1.21	43.63	42.80	26.86	40.23	29.87	19.17	0.09	0.02	0.02
Source of variance	d.f.	Fiber percentage (%)			Fiber length (cm)			Fiber fineness (mm/mg)					
		F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2			
Replicates	2	5.00*	0.22	0.36	12.29	52.78	5.41	18.00*	1.06	3.44			
Genotypes	35	10.47**	10.80**	9.98**	140.70**	97.04**	121.10**	837.86**	843.72**	851.24**			
Parents	7	6.36**	2.32*	3.14**	190.84**	97.93**	113.78**	1443.20**	1534.28**	1521.10**			
Crosses	27	11.81**	13.39**	11.68**	120.71**	86.28**	114.68**	489.69**	534.43**	540.54**			
P vs C	1	2.98	0.02	12.02**	329.47**	381.31**	345.62**	6001.01**	4360.78**	4551.18**			
Error	70	1.52	1.47	0.78	34.66	18.50	31.92	3.81	1.10	2.77			

* and ** denote significant differences at 0.05 and 0.01 levels, respectively.

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mean performance of parents recorded 100.76, 102.33 and 96.63cm at the first season (F_1) and early and late sowing dates in the second season (F_2), respectively. These results showed that the delay in the planting date (F_2D2) gave low values than the earlier in planting date (F_2D1) for plant height, indicating that the plant height has been affected by environmental influences.

With respect to crosses, results illustrated that P1xP3 and P4xP8 were the tallest crosses in the first season (F_1) and early and late sowing dates in the second season (F_2) which recording 113.30, 110.70 and 106.39cm and 111.14, 111.00 and 105.72cm, respectively. On the other hand, P1xP8 cross was the shortest parent with mean values of 87.70, 88.80 and 85.63cm in the same order, respectively, with an average values of 104.91, 102.97 and 98.26cm in the first and early and late sowing dates in the second seasons, respectively. These results showed that the delay in the planting date (F_2D2) gave low values than the earlier in planting date (F_2D1) for plant height, indicating that the plant height has been affected by environmental influences.

Technical stem length

The mean performance of the studied genotypes for technical stem length was shown in **Table (3)** indicated that highly significant differences were observed between parents as well as crosses for technical stem length in the F_1 and F_2 (under two sowing dates) generations.

Mean performance values of the tested parental genotypes indicated that Sakha 5 and S. 402/1 were surpassed the other parents in this trait and gave values of 78.83, 76.87 and 74.04 and 75.47, 72.53 and 69.66 cm in the first season (F_1) and at early and late sowing dates in the second season (F_2), respectively. On the other hand, Sakha 6 gave the lowest technical stem length giving respectively values of 54.41 and 54.27cm in the F_1 and at early sowing date in F_2 generations, while Giza 11 gave the lowest value (53.72cm) at late sowing date in the F_2 generation. The average mean performance of crosses for technical stem length recorded 71.01, 69.55 and 65.52cm in the F_1 and F_2 generations, respectively. The values of the 28 hybrids ranged from 54.72, 59.53 and 51.68cm for (P2xP3) in F_1 and F_2D1 and F_2D2 generation, respectively, to 80.23cm for (P1xP7), 78.37cm for (P2xP5) and 72.34cm for (P3xP6) in the F_1 and F_2D1 and F_2D2 generations, respectively. The general mean performance of technical

stem length gave values of 70.12, 68.25 and 65.04cm for the same above order, respectively. It is clear from the results that the delay in the planting date (F_2D2) gave low values than the earlier in planting date (F_2D1) for technical stem length, indicating that the delay in planting date has a reduction effect on technical stem length.

Fiber yield/plant

Mean performance for 36 genotypes detected for fiber yield/plant is presented in **Table (3)**. Significant or highly significant values were observed between these genotypes for this trait in both seasons, indicating presence of wide genetic variability among these genotypes. With regard to parents, the results illustrated that S. 402/1, Giza 11 and S. 2465/1/3 ranked in the first fiber yield/plant which gave values of 3.34, 3.26 and 2.58g in the F_1 generation and at early and late sowing dates in the F_2 generation, respectively. On the other side, Sakha 2 produced the minimum values of fiber yield/ plant giving 2.28, 2.26 and 1.64g in the same order, respectively. Respect to mean performance of crosses, the values of fiber yield/plant ranged from 2.33, and 1.94g for (P1xP5) to 3.46 for (P5xP7), 3.73 and 3.35g for (P4xP6) in the F_1 hybrid and early and late sowing dates in the F_2 hybrid, respectively. The average mean performance of crosses recorded 2.97, 2.99 and 2.52g in the first season (F_1) and early and late sowing dates in the second season (F_2), respectively. It is clear from the results that the delay in the planting date (F_2D2) gave low values than the earlier in planting date (F_2D1) for fiber yield/plant, indicating that the environmental impacts have caused a reduction of fiber yield/plant.

Fiber percentage

Data of fiber percentage assessed for 36 flax genotypes at F_1 and F_2 generations during 2015/2016 and 2016/2017 growing seasons are presented in **Table (3)**. The highest parents in fiber percentage were Giza 11, Sakha 6 and S. 2465/1/3 which gave values of 12.50, 12.44 and 10.98 % for fiber percentage in the first season (F_1) and early and late sowing dates in the second season (F_2), respectively. While Sakha 2 parent gave the lowest mean performance values of 8.90, 10.13 and 7.91% for the same order, respectively.

The best crosses for this trait were P2xP4, P2xP6 and P4xP6 with mean values of 15.41, 15.18 and 16.42% in F_1 and early and late sowing

dates in the second season (F_2), respectively, in addition to, the cross (P2xP8) recorded 14.76, 14.33 and 13.60% for fiber percentage in the same order, respectively. On the other hand, the lowest mean values were recorded by P3xP7 (7.77%), P2xP7 (7.89%) and P3xP7 (7.71%) in the F_1 and F_2 generations, respectively. The average mean performance of crosses recorded 10.73, 11.30 and 10.80% for the F_1 and early and late sowing dates in the F_2 generations. It is clear from the results that the delay in the planting date (F_2D2) gave low values than the earlier in planting date (F_2D1) for fiber percentage, indicating that the delay in planting date has a reduction effect on fiber %.

Fiber length

Significant or highly significant differences were observed between parents as well as crosses for fiber length in the F_1 and F_2 generations (**Table 3**), indicating presence of wide genetic variability among genotypes. Mean performance of parents, data indicated that Sakha 5 was the tallest among all genotypes recording the highest mean values of (76.30, 68.50 and 67.18 cm) in the first and second seasons, respectively, while Giza 11 was the shortest fiber length parent with mean values of 53.70 and 48.78cm in the F_1 and late sowing date in the F_2 generations, respectively, but Sakha 6 was the shortest for the same trait which recorded 51.50cm at early sowing date in the F_2 generation.

With respect to crosses, results illustrated that the values of fiber length ranged from 52.10 and 44.69cm for (P2xP3) to 77.53 and 69.48cm for (P1xP7) in the first season (F_1) and late sowing date in the second season (F_2), respectively, and from 51.32 for (P1xP8) to 71.68 for (P5xP7) at early sowing date in the F_2 generation. The average mean performance of crosses recorded 68.40, 62.66 and 60.37cm, in the F_1 and early and late sowing dates in the F_2 generations, respectively. These results showed that the delay in the planting date (F_2D2) gave low values than the earlier in planting date (F_2D1) for this trait, indicating that the fiber length has been affected by environmental influences.

Fiber Fineness

As shown in **Table (3)** the results indicated that significant or highly significant mean performance among parents and crosses for fiber fineness were detected in the two F_1 and F_2 generations, revealing that there are sufficient variability existed in these populations. The mean performance of par-

ents suggested that Giza 11 parent was more fiber fineness than the other parents which recorded lowest values of fiber fineness; 122.10, 124.07 and 110.44mm/mg in F_1 , F_2D1 and F_2D2 , respectively, followed by Sakha 6 which gave values of 127.61, 125.88 and 112.54mm/mg for the same order, respectively. Whereas S. 402/1 parent was low fiber fineness which having highest means values of 188.01, 189.85 and 175.17mm/mg in, respectively F_1 , F_2D1 and F_2D2 .

Respect to crosses performance, data illustrated that the crosses P1xP5, P1xP2 and P2xP5 were extra of fiber fineness which recorded lowest values of 141.22, 139.65 and 125.70 mm/mg, 143.66, 140.95 and 127.51 mm/mg and 143.75, 140.82 and 125.71 mm/mg in the first season (F_1) and early and late sowing dates in the second season (F_2), respectively, with note that Giza 11 and Sakha 6 were extra of fiber fineness parents which involved in this crosses. On the other side, P1xP3 cross was the more roughness and gave highest values of 198.45, 195.35 and 180.48 mm/mg followed by P3xP4 and P3xP6 crosses which giving 188.79, 190.36 and 177.81mm/mg and 186.65, 190.53 and 176.32 mm/mg in F_1 , F_2D1 and F_2D2 , respectively.

Similar results of mean performance for straw yield and its related characters were obtained by **Kandil et al (2010)**, **Kandil et al (2011)**, **Abd El-Mohsen et al (2013)**, **Ghanbari-odivi et al (2013)**, **Bakry et al (2014)**, **Elayan et al (2015)** and **Mau-rya et al (2017)**.

Analysis of combining ability variances for different traits

The analysis of variance for combining ability was performed using Method 2 Model 1 of **Griffing, 1956**. Partitioning of genetic variance to general (GCA) and specific (SCA) combining abilities are given in **Table (4)**. GCA variances are in general attributed to additive and additive x additive gene effects, while SCA variances are attributed to non-additive gene effects which involve dominance and epistasis components of the genetic variation. Partitioning of the genetic variance to GCA and SCA variances for each trait were given in Table (4). General and specific combining ability mean squares were found to be highly significant for straw yield and its components in the F_1 , F_2D1 and F_2D2 (except of GCA for technical stem length in F_1 and fiber length in F_2D2), indicating the importance of both additive and non-additive gene effects in the expression of these traits.

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Table 3. Mean performance of the eight parents and their 28 hybrids for studied characters during 2015/2016 (F₁) and 2016/17 (F₂) at early (F₂D1) and late (F₂D2) sowing dates

Genotypes		Straw yield/plant (g)			Plant height (cm)			Technical stem length (cm)			Fiber yield/plant (g)		
		F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2
S. 2465/1/3	P1	27.23	26.83	23.50	104.13	104.03	98.99	69.58	63.81	64.55	3.30	3.24	2.58
Sakha 6	P2	24.53	23.25	23.33	91.56	91.91	85.81	54.41	54.27	57.98	2.96	2.89	2.26
S. 402/1	P3	29.13	28.50	23.63	110.70	113.30	107.06	75.47	72.53	69.66	3.34	3.18	2.43
Sakha 5	P4	24.07	26.25	19.17	114.50	113.80	107.43	78.83	76.87	74.04	2.90	2.72	2.04
Giza 11	P5	26.57	28.25	22.48	90.57	90.29	84.67	56.53	55.47	53.72	3.32	3.26	2.43
Sakha 2	P6	25.67	22.67	20.74	106.47	106.97	101.43	69.84	61.37	63.50	2.28	2.26	1.64
Giza 12	P7	29.07	26.00	20.87	92.55	101.63	96.81	66.67	61.33	59.61	2.61	2.68	1.93
Jowhar	P8	24.00	21.67	21.33	95.60	96.68	90.84	64.64	64.10	63.62	2.61	2.59	2.23
Parents mean		26.28	25.43	21.88	100.76	102.33	96.63	67.00	63.72	63.34	2.92	2.85	2.19
P1xP2		32.37	28.17	23.67	104.31	107.64	102.59	71.41	66.60	66.25	3.01	2.98	2.29
P1xP3		25.47	25.83	22.83	113.30	110.70	106.39	78.37	75.47	71.86	2.97	2.95	2.39
P1xP4		29.47	25.00	22.86	102.67	103.91	100.59	72.52	72.57	69.40	3.15	3.17	2.71
P1xP5		23.30	23.33	22.00	108.20	107.85	100.87	73.40	68.83	67.37	2.33	2.33	1.94
P1xP6		32.33	29.17	24.17	104.50	98.63	91.07	72.10	70.70	66.58	3.43	3.38	2.84
P1xP7		28.63	28.00	24.50	111.86	101.03	97.33	80.23	72.97	69.82	2.89	2.85	2.34
P1xP8		26.97	22.67	21.50	87.70	88.80	85.63	60.43	59.57	55.47	2.87	2.83	2.36
P2xP3		25.97	23.17	21.33	94.95	91.56	88.68	54.72	59.53	51.68	3.18	3.20	2.68
P2xP4		21.13	23.17	21.33	104.37	104.62	100.48	72.93	72.27	69.30	3.27	3.24	2.76
P2xP5		36.30	34.83	31.00	110.09	95.30	92.08	77.16	78.37	70.07	2.99	2.99	2.54
P2xP6		23.43	21.33	20.83	103.57	108.15	97.88	68.39	60.40	62.83	3.17	3.24	2.71
P2xP7		35.10	35.67	30.67	109.47	103.50	100.76	77.80	78.00	71.29	2.74	2.80	2.63
P2xP8		23.00	23.33	21.67	111.63	101.03	98.23	74.03	75.03	68.28	3.38	3.33	2.94
P3xP4		31.60	28.83	25.50	105.88	106.53	102.28	71.30	70.10	65.33	3.10	3.08	2.72
P3xP5		24.87	23.67	21.00	98.52	102.00	98.28	63.08	66.00	57.45	2.56	2.55	2.04
P3xP6		24.70	23.33	23.33	110.05	107.63	102.43	76.90	69.90	72.34	3.18	3.18	2.76
P3xP7		32.37	31.00	27.00	100.97	102.30	98.20	66.93	69.70	60.98	2.51	2.51	2.08
P3xP8		23.17	23.83	22.17	106.07	105.07	100.55	71.60	71.50	65.81	3.14	3.19	2.68
P4xP5		30.47	30.00	22.67	102.67	100.07	95.80	64.13	67.37	61.18	2.76	2.59	2.08
P4xP6		27.70	26.67	20.50	106.87	105.70	101.01	72.03	68.03	69.19	3.31	3.73	3.35
P4xP7		30.13	30.33	25.50	102.34	101.40	96.50	63.80	64.80	60.67	2.51	2.60	2.14
P4xP8		24.47	23.17	20.33	111.14	111.00	105.72	77.75	72.00	71.05	2.94	3.11	2.66
P5xP6		29.30	29.17	25.83	113.63	107.23	103.69	77.23	71.13	71.83	3.04	3.09	2.54
P5xP7		36.60	33.50	27.17	110.17	115.35	105.37	73.67	73.23	66.95	3.46	3.28	2.80
P5xP8		29.57	28.50	23.33	109.23	104.97	99.18	75.30	74.30	68.33	2.77	2.83	2.40
P6xP7		26.47	26.17	21.83	91.51	91.40	87.53	62.90	60.33	56.79	2.71	2.70	2.35
P6xP8		32.63	32.33	28.50	107.67	105.50	101.53	73.07	73.73	67.34	3.08	3.07	2.53
P7xP8		27.00	27.67	21.33	94.02	94.37	90.68	65.20	65.00	59.19	2.75	2.79	2.32
Crosses mean		28.38	27.21	23.73	104.91	102.97	98.26	71.01	69.55	65.52	2.97	2.99	2.52
General mean		27.91	26.81	23.32	103.98	102.83	97.90	70.12	68.25	65.04	2.96	2.96	2.45
L.S.D. at 0.05		2.60	4.56	1.79	10.76	10.65	8.44	10.33	8.22	7.13	0.49	0.20	0.24
L.S.D.at 0.01		3.44	6.06	2.38	14.28	14.14	11.21	13.71	10.92	9.47	0.64	0.27	0.32

Table 3. Cont.

Genotypes		Fiber percentage (%)			Fiber length (cm)			Fiber fineness (mm/mg)		
		F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2
S. 2465/1/3	P1	12.15	12.09	10.98	67.13	54.38	56.10	134.70	135.35	119.51
Sakha 6	P2	12.10	12.44	9.70	57.80	51.50	49.51	127.61	125.88	112.54
S. 402/1	P3	11.52	11.15	10.27	72.37	55.78	62.34	188.01	189.85	175.17
Sakha 5	P4	12.08	10.50	10.65	76.30	68.50	67.18	151.75	155.15	140.97
Giza 11	P5	12.50	11.54	10.80	53.70	52.85	48.78	122.10	124.07	110.44
Sakha 2	P6	8.90	10.13	7.91	67.67	58.45	54.81	165.11	167.22	153.94
Giza 12	P7	8.92	10.31	9.24	56.80	62.80	53.86	163.06	164.69	150.29
Jowhar	P8	10.86	11.96	10.45	61.83	60.90	55.99	153.39	154.37	139.96
Parents mean		11.13	11.27	10.00	64.20	58.15	56.07	150.72	152.07	137.85
P1xP2		9.31	11.06	9.69	69.17	58.88	60.63	143.66	140.95	127.50
P1xP3		11.75	11.47	10.50	76.13	64.55	68.18	198.45	195.35	180.47
P1xP4		10.74	12.78	11.86	71.10	64.65	62.37	159.25	157.35	142.44
P1xP5		9.98	10.16	8.82	71.00	60.75	62.70	141.22	139.65	125.70
P1xP6		10.64	12.16	11.79	69.97	63.38	62.26	173.43	170.66	156.48
P1xP7		10.11	10.20	9.53	77.53	65.05	69.48	172.47	170.62	155.83
P1xP8		10.62	12.59	10.99	58.03	51.32	50.17	159.68	169.91	156.89
P2xP3		12.28	13.83	12.61	52.10	52.68	44.69	164.26	160.67	147.61
P2xP4		15.41	14.08	12.96	70.87	67.15	62.13	165.53	161.64	146.68
P2xP5		8.29	8.63	8.20	75.00	70.78	66.34	143.75	140.82	125.71
P2xP6		13.60	15.18	13.02	65.77	53.08	58.40	173.33	171.18	156.24
P2xP7		7.91	7.89	8.60	74.90	69.65	66.15	177.42	175.82	161.82
P2xP8		14.76	14.33	13.60	71.20	67.62	63.10	161.98	159.98	146.90
P3xP4		9.92	10.71	10.66	68.73	62.15	61.31	188.79	190.36	177.81
P3xP5		10.35	10.94	9.74	59.87	58.88	51.26	166.15	163.12	150.89
P3xP6		12.87	13.65	11.85	74.57	62.65	65.81	186.65	190.53	176.32
P3xP7		7.77	8.10	7.71	64.40	62.48	55.98	184.39	180.87	166.72
P3xP8		13.58	13.41	12.16	68.90	63.98	60.14	167.69	165.69	153.28
P4xP5		9.12	8.68	9.18	61.50	60.08	53.47	168.08	165.43	152.62
P4xP6		11.95	13.94	16.42	69.20	65.90	60.82	174.56	171.67	156.23
P4xP7		8.32	8.59	8.41	61.30	58.05	53.09	171.48	169.97	156.35
P4xP8		12.04	13.46	13.11	74.87	64.28	66.79	166.46	163.84	149.21
P5xP6		10.43	10.59	9.85	74.77	63.42	67.58	171.53	169.45	156.19
P5xP7		9.44	9.81	10.31	70.30	71.68	62.62	172.69	169.20	155.38
P5xP8		9.36	10.01	10.37	72.00	70.42	64.79	160.25	158.70	144.60
P6xP7		10.29	10.45	10.80	59.73	56.48	53.39	172.28	176.23	164.16
P6xP8		9.43	9.54	8.90	70.43	66.02	62.53	169.55	172.42	157.70
P7xP8		10.18	10.11	10.86	61.90	58.60	54.30	167.18	163.88	149.37
Crosses mean		10.73	11.30	10.80	68.40	62.66	60.37	168.65	167.36	153.47
General mean		10.82	11.29	10.63	67.47	61.66	59.42	164.66	163.96	150.00
L.S.D. at 0.05		2.00	1.98	1.43	9.59	7.00	9.20	3.18	1.71	2.71
L.S.D. at 0.01		2.66	2.63	1.90	12.73	9.30	12.22	4.22	2.26	3.60

Table 4. General and specific combining ability mean squares of parents and F₁ as well as F₂ generations over early (F₂D1) and late (F₂D2) sowing dates for studied traits in 8-parent half diallel crosses of flax

Source of variance	d.f.	Straw yield/plant (g)		Plant height (cm)		Technical stem length (cm)		Fiber yield/plant (g)					
		F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2			
GCA	7	15.53**	18.20**	6.64**	39.37*	54.27**	54.15**	25.51	21.67*	25.01**	0.08**	0.07**	0.06**
SCA	28	15.49**	12.92**	8.10**	58.51**	44.65**	36.12**	52.84**	43.94**	35.29**	0.10**	0.11**	0.13**
Error	70	0.85	2.61	0.40	14.54	14.27	8.95	13.41	9.96	6.39	0.03	0.01	0.01
GCA/SCA		1.00	1.41	0.82	0.67	1.22	1.50	0.48	0.49	0.71	0.80	0.64	0.46
Source of variance	d.f.	Fiber percentage (%)		Fiber length (cm)		Fiber fineness (mm/mg)							
		F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2						
GCA	7	5.64**	6.91**	4.09**	29.67*	23.47**	14.56	837.21**	918.97**	928.35**			
SCA	28	2.95**	2.77**	3.13**	51.20**	34.57**	46.82**	139.80**	121.82**	122.60**			
Error	70	0.51	0.49	0.26	11.55	6.17	10.64	1.26	0.36	0.93			
GCA/SCA		1.91	2.49	1.31	0.58	0.68	0.31	5.99	7.54	7.57			

* and ** denote significant differences at 0.05 and 0.01 levels, respectively.

The ratios of GCA/SCA variances were greater than unity under all studied environments for straw yield/plant (except at F₂D₂), plant height (except at F₁), fiber percentage, fiber fineness, indicating that the inheritance of these traits were mainly controlled by additive gene effects. However, ratios were less than unity under all studied cases for technical stem length, fiber yield/plant and fiber length, illustrated that these traits were mainly controlled by the non-additive gene effects. In this connection, **El-Farouk et al (1998)** found that the mean squares of variances due to general and specific combining ability were significant for straw yield, plant height and technical stem length; also he showed that the higher magnitude of variance due to general combining ability for straw yield, plant height, technical stem length was predominantly influenced by additive gene effects.

Estimates of general and specific combining ability effects

Straw yield/plant

Estimates of general combining ability (GCA) effects for straw yield/plant are recorded in **Table (5)**. Results indicated that the varieties Giza 12 followed by Giza 11 showed high significant positive general combining ability values under all studied cases. Therefore, it could be concluded that these two parent appeared to be the best combiner for straw yield/plant. Contrary, the parents Jowhar and Sakha 5 manifested highly significant negative (GCA) effects. Therefore, the parents behaved as the poor combiners for straw yield/plant.

Estimates of specific combining ability (SCA) effects for straw yield/plant are recorded in **Table (6)**. Data showed that the 12 and 10 out of 28 crosses had highly significant positive (SCA) effects under studied environments (F₁, F₂D₁ and F₂D₂), respectively, ranging from 0.93 for (P₄xP₆), 1.32 for (P₅xP₆) and 0.96 for (P₁xP₄) to 7.64 for (P₂xP₅), 7.95 for (P₆xP₈) and 6.36 for (P₆xP₈) at F₁, F₂D₁ and F₂D₂, respectively. Therefore these crosses were considered as the best F₁ and F₂ cross combination for this trait. On the other side, highly significant negative (SCA) effects for the same trait were observed in 13, 10 and 11 out of 28 hybrids at F₁, F₂D₁ and F₂D₂, respectively. Thus these hybrids seemed to be poor crosses for this trait. Eight crosses showed highly significant negative (SCA) effects under all studied cases.

Seven crosses observed highly significant positive (SCA) effects under all studied cases, while the crosses P₂xP₅, P₂xP₇, P₃xP₇ and P₅xP₇, being the highest specific combinations since they

involved high x low and high x high general combiner parents for improving straw yield/plant. These parents and crosses can be used as useful genetic materials for improving straw yield/plant in flax under various environmental studied.

Plant height

Estimates of general combining ability effects for each parent are presented in **Table (5)**. The data indicated that the parent Sakha 5 is good combiner for tallness due to their highly significant positive GCA values under all studied environments, while the parent line S. 402/1 was good combiner for tallness due to significant positive GCA values under F₂D₁ and F₂D₂. On the other hand, the parents Giza 12 at F₁, Sakha 6 in F₂D₁ and F₂D₂ and Jowhar at F₂D₂ proved to be poor combiners for plant height as they attained highly significant negative GCA values. The rest parents showed insignificant GCA effects under all studied environments for this trait.

Specific combining ability effects calculated for each cross regarding plant height are presented in **Table (6)**. The data observed that 12, 11 and 10 out of 28 crosses had highly significant positive SCA effects under all studied environments, ranging from 3.05 (P₃xP₆), 3.33 (P₂xP₈) and 4.49 (P₁xP₅) to 10.80 (P₂xP₈), 15.02 (P₅xP₇) and 10.23 (P₅xP₇) in F₁, F₂D₁ and F₂D₂, respectively. Nine crosses showed highly significant positive SCA effects under all studied environments. Therefore, all these crosses combination are considered as good F₁ and F₂ hybrids for this trait under their respective environments. These crosses can be used as useful genetic materials for improving plant height in flax under various environmental studied.

On the other side, 7, 8 and 7 out of 28 crosses showed highly significant negative SCA effects in F₁, F₂D₁ and F₂D₂, respectively. Five crosses showed highly significant negative SCA effects under all studied cases. Thus, these crosses are considered as poor cross combination for plant height.

Technical stem length

Concerning to technical stem length, results indicated that the parent Sakha 5 showed high significant positive GCA effects under F₂D₁ and F₂D₂. Therefore, it could be concluded that this genotype appeared to be the best combiner for technical stem length. On the other hand, the two varieties Sakha 6 and Giza 12 in the manifested significant

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negative GCA effects under F_1 and F_2D_2 , respectively, revealing that these two parents behaved as poor combiners for this trait.

Specific combining ability effects calculated for each cross regarding technical stem length are presented in **Table (6)**. Four crosses exhibited significant or highly significant positive SCA effects were found under all studied environments Viz., P1xP7, P2xP5, P2xP7 and P5xP8, revealing that these crosses seemed to be good crosses combination for technical stem length. These crosses can be used as useful genetic materials for improving technical stem length in flax under various environmental studied. In contrast, four hybrids observed significant or highly significant negative SCA effects were found under all studied environments, this results illustrated that these hybrids are considered as poor cross combinations for technical stem length.

Fiber yield/plant

Estimates of general combining ability effects for each parent are presented in **Table (5)**. The results revealed that Sakha 6 appeared to be the best combiner for fiber yield/plant under each environment due to its significant positive GCA effects. On the other hand, Giza 12 was poor combiner for fiber yield/plant under each environment due to its significant negative GCA effects. While, Giza 11 was poor combiner for fiber yield/plant under F_2D_1 and F_2D_2 because its significant negative GCA effects.

The specific combining ability effects calculated for each cross regarding fiber yield/plant are presented in **Table (6)**. Results show that seven crosses gave the highest significant positive SCA effects under all studied environments. Therefore, these crosses combination are considered as good F_1 and F_2 hybrids for increasing fiber yield/plant under their respective environments. In contrast, five crosses showed highly significant negative SCA effects under all environments. Therefore, these crosses are considered as poor cross combinations for fiber yield/plant.

Fiber percentage

Estimates of general combining ability (GCA) effects for fiber percentage are recorded in **Table (5)**. Results indicated that Jowhar parent showed high significant positive general combining ability values under all studied cases. Therefore, it could be concluded that this parent appeared to be the best combiner for fiber percentage. While Sakha 6, S. 402/1 and Sakha 5 observed significant positive

general combining ability values in F_1 , in addition to Sakha 6 and Sakha 5 gave high significant positive general combining ability values under F_2D_1 and F_2D_2 , respectively. Contrary, the parents Giza 12 and Giza 11 manifested highly significant negative (GCA) effects. Therefore, these parents behaved as the poor combiners for this trait.

With respect to specific combining ability estimates, **Table (6)** indicated that highly significant positive SCA effects were found in six crosses Viz., P2xP4, P2xP6, P2xP8, P3xP6, P3xP8 and P4xP6. Therefore, these crosses combination are considered as the good F_1 and F_2 hybrids for this trait under their respective environments. On the other side, eight crosses Viz P1xP2, P2xP5, P2xP7, P3xP4, P3xP7, P4xP5, P4xP7 and P6xP8 showed highly significant negative SCA effects under all studied environments. Therefore, these crosses are considered as the poor combination for this trait. It is worthy to mention that the crosses which exhibited high significant positive SCA effects, contained two crosses; (Sakha 6 x Jowhar) and (S. 402/1 x Jowhar), included high x low general combiner parents, these parents and crosses can be used to improving fiber percentage under their respective environments.

Fiber length

Concerning fiber length, estimates of general combining ability effects for each parent are presented in **Table (5)**. The data indicated that the parent Sakha 5 was good combiner for fiber length under all studied environments due to its significant positive GCA values. Whereas, the parent line S. 2465/1/3 was significant positive only at F_1 . On the other hand, Giza 12, S. 2465/1/3 and S. 402/1 showed significant negative GCA values at F_1 and F_2D_1 , respectively. Therefore, these crosses are considered as the poor combination for this trait under these cases.

Specific combining ability effects calculated for each cross regarding fiber length are presented in **Table (6)**. Seven crosses exhibited highly significant positive SCA effects were found under all studied environments Viz., P1xP7, P2xP5, P2xP7, P2xP8, P3xP6, P5xP7 and P5xP8, revealing that these crosses seemed to be good crosses combination for increasing fiber length. In contrast, five hybrids observed highly significant negative SCA effects were found under all studied environments, this results illustrated that these hybrids are considered as poor cross combinations for fiber length.

Table 5. Estimates of general combining ability (GCA) effects of parents at F₁ as well as F₂ over early (F₂D1) and late (F₂D2) sowing dates for studied traits in 8-parent half diallel crosses of flax

Parents	Straw yield/plant (g)		Plant height (cm)		Technical stem length (cm)		Fiber yield/plant (g)		
	F ₁	F ₂ D1	F ₁	F ₂ D1	F ₁	F ₂ D1	F ₁	F ₂ D1	
S. 2465/1/3 (P ₁)	0.18	-0.55	-0.13	0.12	0.14	0.01	1.05	0.04	0.01
Sakha 6 (P ₂)	-0.48	-0.51	0.73**	-2.98**	-2.88**	-1.56	-0.97	0.10*	0.10**
S. 402/1 (P ₃)	-0.48	-0.46	0.06	2.69*	2.98**	1.30	-0.06	0.04	0.02
Sakha 5 (P ₄)	-0.81**	-0.16	-1.28**	3.54**	3.62**	2.11	2.89**	0.04	0.05
Giza 11 (P ₅)	1.23**	1.82**	0.81**	-1.21	-1.65	-0.41	-1.47	-0.04*	-0.08**
Sakha 2 (P ₆)	-0.33	-0.78	-0.34	1.27	0.69	-1.73	0.86	-0.01	0.03
Giza 12 (P ₇)	2.32**	2.30**	0.99**	-1.28	-1.11	-0.76	-2.04**	-0.18**	-0.15**
Jowhar (P ₈)	-1.64**	-1.65**	-0.84**	-2.14	-1.79*	0.5	-0.26	-0.05	0.03
gca(j)	0.27	0.48	0.19	1.12	0.89	1.08	0.93	0.75	0.02
Parents	Fiber percentag (%)		Fiber length (cm)		Fiber fineness (mm/mg)				
	F ₁	F ₂ D1	F ₁	F ₂ D1	F ₁	F ₂ D1			
S. 2465/1/3 (P ₁)	0.01	0.30	-0.05	-1.76*	1.32	-6.44**			
Sakha 6 (P ₂)	0.84**	0.83**	0.24	-1.21	-1.43	-11.28**			
S. 402/1 (P ₃)	0.42*	0.28	0.01	-1.60*	-0.27	15.35**			
Sakha 5 (P ₄)	0.43*	0.16	0.83**	2.43**	1.96*	1.49**			
Giza 11 (P ₅)	-0.54*	-0.97**	-0.76**	0.68	-0.84	-12.11**			
Sakha 2 (P ₆)	-0.04	0.42*	0.28	-0.71	0.57	8.09**			
Giza 12 (P ₇)	-1.55**	-1.58**	-1.09**	1.27	-1.20	6.03**			
Jowhar (P ₈)	0.43*	0.58**	0.53**	0.91	-0.10	-1.25**			
gca(j)	0.21	0.21	0.15	0.73	0.96	0.33			
						0.18			
						0.29			

* and ** denote significant differences at 0.05 and 0.01 levels, respectively.

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Table 6. Estimates of specific combining ability (SCA) effects of parents and F₁ as well as F₂ generation over early (F₂D1) and late (F₂D2) sowing dates for studied traits in 8-parent half diallel crosses of flax

Crosses	Straw yield/plant (g)			Plant height (cm)			Technical stem length (cm)			Fiber yield/plant (g)		
	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2
P ₁ xP ₂	4.76**	2.42**	-0.25	1.26	7.68**	7.43**	2.64	-1.10	1.13	-0.11	-0.11**	-0.26**
P ₁ xP ₃	-2.15**	0.03	-0.41	7.29**	5.06**	5.37**	3.84	5.91	5.82**	-0.12	-0.09**	-0.07*
P ₁ xP ₄	2.18**	-1.10	0.96**	-4.71**	-2.57	-1.06	-8.01	1.65**	0.42	0.11	0.14**	0.22**
P ₁ xP ₅	-6.03**	-4.75**	-1.99**	3.94*	6.12**	4.49**	5.5	0.99	2.75**	-0.68**	-0.62**	-0.43**
P ₁ xP ₆	4.57**	3.68**	1.32**	-1.47	-5.59**	-7.66**	3.23	4.17**	-0.36	0.43**	0.36**	0.36**
P ₁ xP ₇	-1.78**	-0.57	0.33	10.43**	-0.63	0.41	15.31*	5.47**	5.77**	0.05	0.03	0.04
P ₁ xP ₈	0.51	-1.95**	-0.85**	-15.06**	-12.01**	-10.62**	-13.14	-9.20**	-10.36**	-0.10	-0.13**	-0.12**
P ₂ xP ₃	-0.98**	-2.67**	-2.77**	-9.12**	-10.98**	-9.33**	-27.49**	-8.46**	-12.34**	0.05	0.10**	0.11**
P ₂ xP ₄	-5.49**	-2.97**	-1.43**	-1.09	1.24	1.84	-7.48	2.91*	2.35*	0.18**	0.15**	0.16**
P ₂ xP ₅	7.64**	6.72**	6.14**	7.76**	-3.33*	-1.29	36.48**	12.08**	7.47**	-0.06	-0.02	0.07*
P ₂ xP ₆	-3.67**	-4.18**	-2.88**	-0.47	7.03**	2.17	-2.08	-4.57**	-2.10*	0.12	0.15**	0.12**
P ₂ xP ₇	5.35**	7.07**	5.63**	9.96**	4.94**	6.85**	16.70*	12.06**	9.26**	-0.14*	-0.08**	0.23**
P ₂ xP ₈	-2.79**	-1.32*	-1.55**	10.80**	3.33*	5.00**	14.53	7.83**	4.47**	0.37**	0.30**	0.36**
P ₃ xP ₄	4.98**	2.65**	3.41**	-2.54	-2.52	-2.22	-9.55	-2.11	-2.54*	0.05	0.05	0.20**
P ₃ xP ₅	-3.80**	-4.50**	-3.19**	-6.77**	-2.31	-0.95	-16.42*	-3.14*	-6.06**	-0.46**	-0.40**	-0.34**
P ₃ xP ₆	-2.40**	-2.23**	0.30	3.05*	0.84	0.85	1.90	2.08	6.50**	0.17*	0.15**	0.26**
P ₃ xP ₇	2.61**	2.35**	2.64**	-1.5	-1.94	-1.57	-11.31	0.91	-1.96	-0.33**	-0.32**	-0.23**
P ₃ xP ₈	-2.63**	-0.87	-0.37	2.27	1.68	1.46	-5.12	1.44	1.09	0.16*	0.22**	0.18**
P ₄ xP ₅	2.13**	1.53*	-0.18	-4.00**	-5.09**	-4.07**	-18.65**	-3.13*	-5.27**	-0.21**	-0.36**	-0.33**
P ₄ xP ₆	0.93*	0.80	-1.20**	-1.51	-1.94	-1.19	-8.63	-1.15	0.41	0.34**	0.70**	0.82**
P ₄ xP ₇	0.71	1.38*	2.48**	-1.51	-3.68*	-3.91**	-19.07**	-5.35**	-5.21**	-0.29**	-0.22**	-0.21**
P ₄ xP ₈	-1.00**	-1.83**	-0.87**	5.97**	6.77**	6.00**	-1.37	0.58	3.39**	0.01	0.14**	0.14**
P ₅ xP ₆	0.48	1.32*	2.04**	8.38**	4.34**	6.75**	10.58	5.02**	7.40**	0.10	0.14**	0.14**
P ₅ xP ₇	5.13**	2.57**	2.05**	9.45**	15.02**	10.23**	10.5	6.15**	5.42**	0.70**	0.54**	0.59**
P ₅ xP ₈	2.06**	1.52*	0.04	7.19**	5.49**	4.72**	16.49*	5.95**	5.02**	-0.13*	-0.05	0.00
P ₆ xP ₇	-3.44**	-2.17**	-2.14**	-10.92**	-11.42**	-9.95**	-9.95	-5.43**	-7.06**	-0.05	-0.12**	0.20
P ₆ xP ₈	6.69**	7.95**	6.36**	3.91*	3.54*	4.73**	4.62	6.71**	1.71	0.18**	0.11**	0.02
P ₇ xP ₈	-1.60**	0.20	-2.14**	-5.20**	-5.04**	-4.32**	-2.20	-3.00*	-3.54**	0.02	0.03	-0.01
sca(ii)	0.83	1.47	0.58	3.46	3.43	2.71	3.32	2.86	2.29	0.16	0.07	0.08
sca(ij)	0.36	0.64	0.25	1.50	1.49	1.18	1.44	1.24	1.00	0.07	0.03	0.03

* and ** denote significant differences at 0.05 and 0.01 levels, respectively.

Table 6. Cont.

Crosses	Fiber percentage (%)			Fiber length (cm)			Fiber fineness (mm/mg)		
	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2	F ₁	F ₂ D1	F ₂ D2
P ₁ xP ₂	-2.36**	-1.35**	-1.13**	0.96	0.19	1.32	-4.88**	-5.68**	-4.68**
P ₁ xP ₃	0.50	-0.40	-0.09	6.44	6.25**	7.71**	25.18**	22.37**	21.69**
P ₁ xP ₄	-0.52	1.03**	0.46*	-0.66	2.32*	-0.33	-0.54	-2.06**	-2.32**
P ₁ xP ₅	-0.30	-0.45	-1.00*	3.07*	0.17	2.80*	-5.59**	-6.15**	-5.93**
P ₁ xP ₆	-0.15	0.15	0.93**	-0.76	4.19**	0.96	8.25**	4.65**	4.92**
P ₁ xP ₇	0.83**	0.20	0.05	10.42**	3.88**	9.95**	8.04**	6.67**	6.38**
P ₁ xP ₈	-0.64*	0.42	-0.11	-10.81**	-9.49**	-10.47**	3.70**	13.24**	14.67**
P ₂ xP ₃	0.21	1.44**	1.72**	-14.33**	-6.17**	-13.03**	-5.76**	-7.07**	-6.49**
P ₂ xP ₄	3.32**	1.80**	1.26**	2.36	4.27**	2.19	8.98**	7.47**	6.60**
P ₂ xP ₅	-2.83**	-2.52**	-1.91**	10.33**	9.66**	9.19**	0.18	0.25	-1.25**
P ₂ xP ₆	1.98**	2.65**	1.87**	-1.70	-6.66**	-0.15	11.39**	10.40**	9.36**
P ₂ xP ₇	-2.19**	-2.64**	-1.18**	11.05**	7.93**	9.36**	16.23**	17.11**	17.04**
P ₂ xP ₈	2.67**	1.64**	2.20**	5.61**	6.26**	5.21**	9.24**	8.55**	9.35**
P ₃ xP ₄	-1.75**	-1.02**	-0.81**	-1.25	-0.34	0.20	7.52**	9.84**	11.14**
P ₃ xP ₅	-0.35	0.34	-0.15	-6.29**	-1.85	-7.04**	-2.15**	-3.79**	-2.65**
P ₃ xP ₆	1.67**	1.67**	0.93**	5.62**	3.30**	6.10**	-0.02	3.41**	2.85**
P ₃ xP ₇	-1.91**	-1.89**	-1.84**	-0.94	1.16	-1.96	-1.52**	-4.19**	-4.65**
P ₃ xP ₈	1.91**	1.27**	0.99**	1.83	3.01**	1.09	-9.78**	-12.09**	-10.85**
P ₄ xP ₅	-1.59**	-1.80**	-1.52**	-6.73**	-4.69**	-7.07**	13.26**	12.09**	13.09**
P ₄ xP ₆	0.74**	2.07**	4.69**	-1.82	2.52*	-1.12	1.38**	-1.88**	-3.22**
P ₄ xP ₇	-1.38**	-1.28**	-1.96**	-6.11**	-7.31**	-7.08**	-0.96*	-1.51**	-1.00*
P ₄ xP ₈	0.36	1.43**	1.13**	5.72**	-0.72	5.51**	2.47**	-0.37	-0.91*
P ₅ xP ₆	0.19	-0.14	-0.30	7.58**	1.79	8.44**	11.32**	9.51**	9.87**
P ₅ xP ₇	0.71*	1.08**	1.53**	6.72**	8.08**	5.25**	13.23**	11.32**	11.16**
P ₅ xP ₈	-1.35**	-0.89**	-0.03	6.69**	7.17**	6.31**	9.24**	8.10**	7.61**
P ₆ xP ₇	1.06**	0.33	0.99**	-6.64**	-5.73**	-5.39**	-5.55**	-1.85**	0.02
P ₆ xP ₈	-1.79**	-2.74**	-2.54**	2.33	4.16**	2.64*	0.17	1.61**	0.79*
P ₇ xP ₈	0.48	-0.17	0.80**	-2.59	-5.23**	-3.82**	-1.45**	-4.86**	-5.44**
sca(ii)	0.64	0.64	0.46	3.08	2.25	2.96	1.02	0.55	0.87
sca(ij)	0.28	0.28	0.20	1.34	0.98	1.29	0.44	0.24	0.38

* and ** denote significant differences at 0.05 and 0.01 levels, respectively.

**Performance and combining ability for straw yield and related characters in a 1437
diallel cross of flax (*linum usitatissimum*, L.) under different sowing dates**

Fiber Fineness

Fiber fineness results in **Table (5)** present general combining ability effect for each parent. Since positive values of GCA would be of interest for fiber fineness, four parents; S. 402/1 followed by Sakha 2, Giza 12 and Sakha 5 were considered to be the best among the parental set as progenitors in hybridization programs at all studied environments towards fine fiber genotypes. Four parents; S. 2465/1/3, Sakha 6, Giza 11 and Jowhar showed highly significant negative GCA effects across all studied environments. Therefore, these parents behaved as the poor combiners for fiber fineness.

Estimates of specific combining ability effects recorded in **Table (6)** show that 13 out of 28 hybrids had highly significant SCA effects for fiber fineness under their respective environments. Therefore it could be mentioned that these cross combinations are considered as the best hybrids for this trait. Out of these hybrids, one, nine and three hybrids included good x good, good x low and low x low general combiner parents, respectively. These parents and crosses can be used as useful genetic materials for improving fiber fineness in flax under various environmental studied.

Results of general and specific combining ability effects for straw yield and its related characters are in agreement with those reported by **Abo-kaied (2002)**, **Mohammadi et al (2010)**, **Abdel-Moneam (2014)**, **Pali and Mehta (2014)**, **Abd Al-Sadek (2015)**, **Abd El-Haleem and Abd Al-Sadek (2015)** and **Nirala et al (2018)**.

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السلوك والقدرة على التآلف لمحصول القش ومكوناته فى دائرة تهجينات من الكتان تحت مواعيد زراعة مختلفة

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الموجز

الوراثية الأبوية والهجن لجميع الصفات المدروسة تحت البيئات المختلفة، مما يوضح وجود اختلافات وراثية واسعة بين التراكيب الوراثية محل الدراسة. سجلت السلالة الأبوية S. 402/1 أعلى قيم لمحصولي القش والألياف، الطول الفعال للساق ونعومة الألياف، بينما سجل الصنف Sakha 5 أعلى قيم لطول النبات، الطول الفعال للساق وطول الألياف. أظهرت نتائج تحليل القدرة على التآلف وجود اختلافات عالية المعنوية في كل من تباين القدرة العامة والخاصة على التآلف لكل الصفات المدروسة (عدا القدرة العامة على التآلف للطول الفعال للساق في F_1 وطول الألياف في F_2D2) مما يدل على اختلافات وراثية بين الآباء المستخدمة في هذه الدراسة، وكذلك أهمية كلا من الجينات المضيفة وغير المضيفة في وراثة الصفات المدروسة. أوضحت النتائج أن تأثير الجينات المضيفة كان أكثر أهمية عن الجينات غير المضيفة في الـ F_1 و F_2D1 و F_2D2 في وراثة محصول القش/نبات (عدا عند F_2D2)، طول النبات (عدا عند F_1)، النعومة والنسبة المئوية للألياف. أشارت النتائج أن تأثير الجينات غير المضيفة كان أكثر أهمية عن تأثير الجينات المضيفة في الطول الفعال للساق، محصول الألياف/نبات وطول الألياف. سجلت التراكيب الوراثية الأبوية Giza 11 و Giza 12 لمحصول القش/نبات، Sakha 5 لطول النبات والألياف، Sakha 6

أجرى هذا البحث بمحطة البحوث والتجارب الزراعية بشلقان - محافظة القليوبية والتابعة لكلية الزراعة جامعة عين شمس وذلك لتقييم 36 تركيب وراثي من الكتان أشتملت على 8 آباء ذات أصناف وسلالات محلية ومستوردة وذات أصول متباعدة و 28 هجين ناتجة من دائرة تهجينات مع استبعاد الهجن العكسية. فى الموسم الأول 2016/2015 تم تقييم الآباء والجيل الأول (F_1) لجميع الهجن الفردية. أما فى الموسم الثانى 2017/2016 فقد تم تقييم الآباء والجيل الثانى الإنعزالى لجميع الهجن تحت ميعادين للزراعة أحدهما مبكر F_2D1 والآخر متأخر F_2D2 وذلك فى تصميم قطاعات كاملة العشوائية من 3 مكررات لدراسة السلوك والقدرة على التآلف بطريقة **Griffing (1956)** لمحصول القش ومكوناته فى الجيلين الأول والثانى. وفيما يلي أهم النتائج المتحصل عليها أظهر تحليل التباين وجود اختلافات عالية المعنوية لكل من التراكيب الوراثية والآباء والهجن لمحصول القش ومكوناته فى الجيلين الأول والثانى تحت ميعادي الزراعة (مبكر ومتأخر) مما يدل على أن جميع التراكيب الوراثية والهجن الناتجة أظهرت درجات من التباين الوراثي للصفات المدروسة. سجلت النتائج أن هناك اختلافات عالية المعنوية لمتوسط سلوك التراكيب

النتائج أن كل من التأثيرات المضيئة وغير المضيئة للجينات سوف يكون لها أهمية كبيرة في تحسين محصول القش ومكوناته عند استخدام طريقة التربية المناسبة.

الكلمات الدالة: كتان، سلوك، القدرة على التألف، المضيئة، غير المضيئة، مواعيد الزراعة

لمحصول الألياف/نبات، Jowhar للنسبة المئوية للألياف، S. 402/1. لنعومة الألياف قدرة انتلافية جيدة للصفات المذكورة جميع البيئات المدروسة. أظهرت النتائج الخاصة بتأثيرات القدرة الخاصة على الانتلاف وجود اختلافات عالية المعنوية وموجبة لبعض الهجن تحت البيئات المدروسة حيث اشتملت هذه الهجن على أباء ذات قدرة انتلافية تتمثل في (أب عالي X أب عالي) أو (أب عالي X أب منخفض). أوضحت