J. of Plant Production, Mansoura Univ.,Vol 12 (4): 423-428, 2021

Journal of Plant Production

Journal homepage: www.jpp.mans.edu.eg
Available online at: www.jpp.journals.ekb.eg

Combining Ability Analysis of F$_1$ And F$_2$ Generation in Flax Diallel Crosses

Doaa I. Mahmud; Maysa S. Abed Alsadek and T. A. Omar*

Field Crops Inst. ARC, Giza

ABSTRACT

Six parental flax genotypes i.e. three dual type G 8 (P1), S.997 (P2), S.954) (P3) and three fiber type (S. 888/22 (P4), S.103 (P5) and Bombay (P6) were crossed in all possible combinations excluding reciprocals for generating 15 F1,s then 15 F2,s in 2018/2019. For estimating combining ability and gene action for straw and seed yields and their components in flax, six parents and their 15 F1,s and 15 F2,s progenies were evaluated in a randomized complete block design with three replications in 2018/2019, 2019/2020 at Giza Agric. Res. Station Farm, Giza Governorate, Egypt. P2 (S. 997) and P5 (S. 103) exhibited significant positive GCA effects for straw yield, plant height and fiber percentage. Whereas, P1 (Giza 8) showed significant positive ĝi values for seed yield/plant and oil percentage. . Significant positive SCA effects were detected in P1× P2, for straw yield/plant, P1× P6 for plant height and P1× P5 for both of technical stem length and fiber percentage which involved high × low general combiner parents. It could be concluded that the these breeding materials are suitable in breeding for increasing the above-mentioned characters. Significant positive correlation coefficients between GCA values and parental means as well as between cross means and their SCA values were observed. Hence, selection of parents and their crosses in flax breeding program could be depended on their higher mean performance for studied traits.

Keywords: Flax, half diallel, combining ability, correlation, performance

INTRODUCTION

Flax is grown for the seed and fiber. The plant type and production system for fiber flax are different than that of the oilseed cultivars grown in Canada, leading to different fiber properties (SAFR, 2004). Since, oilseed flax plants are naturally shorter than those of fiber flax, they inherently produce shorter fibers. The new applications of flax fiber for industrial uses do not require the very long and fine fibers found in fiber flax. Therefore, oilseed flax fiber could be used, creating the potential for a dual-purpose crop(Foster *et al.*,1998). In this respect, De Haan (1952) stated that present breeders try also to obtain, by crossing fiber flax and seed flax, varieties combining a high yield of fiber with a high yield of seed. The present study assesses 15F$_1$ and F$_2$ crosses with the objective of identifying the most parent cross or crosses for producing pure breeding lines that will give high seed/oil and high straw/fiber yields Therefore, the current research aimed to identify the suitable genotypes for future breeding program.

MATERIALS AND METHODS

1. Experimental procedures

The material used for the present investigation consisted of 15 possible diallel crosses among six flax genotypes could be classified into three categories. These genotypes included three genotypes (P$_1$= G 8, P$_2$= S.997, P$_3$= S.954) dual purpose type and three fiber types (P$_4$= S. 888/22, P$_5$= S.103 and Bombay).The 15F$_1$ and F$_2$ populations as well as their six parents were sown to evaluate concerning the breeding value of these parents and their cross combinations.

Genotypic characteristics of the parent according to their pedigree, classification, and origin and release date are presented in Table 1.

Table 1. Pedigree, classification (dual type, D; oil type, O; fiber type F.) of six flax genotypes.

No	Genotypes	Pedigree	Classification
1	Giza 8	Giza 6 × Santa Catalina 6 (I. Argentina)	D
2	S. 997	119/7/8 × 54 1 /C/3	D
3	S. 954	Romania 10 × S local	D
4	S.888/22	2465/1/3 × Romania 20	F
5	S. 103	Introduction	F
6	Bombay	B12 × C.I. 42	F

Parental lines had been maintained by self-pollination for several generations, and therefore may be considered as homozygous pure lines. The parents were coded from 1 to 6 and a single cross code is a combination of the two parental codes, with the female parent appearing on the left.

Investigations of combining ability may be facilitated by testing in the F$_2$ generation, in which there is usually sample seed, if F$_2$ performance is closely related to F$_1$ performance (Shehata and Comstock, 1971, and Patil and Chopde, 1981 in flax and **Bhullar** *et al*, 1979 in wheat) with this point of view in mind.

---

* **Corresponding author.**
E-mail address: drtahaomar@yahoo.com
DOI: 10.21608/jpp.2021.71272.1028

In 2018/2019 season, 36 entries (6 parents, 15 F_1's and 15F_2's) were evaluated in: clay loam soil (at Giza Agricultural Research station).

The soil of the experimental area varied from clay with organic matter ranged from 1.71 : 1.75%, pH ranged from 7.2 : 7.7, E.C ranged from 0.7 : 0.8 ds/cm* in Giza Research Station.

Layout of the experimental material.

The experiments were laid out in a randomized complete block design with three replications where each replicate consisted of 36 entries (6 parents, 15 F_1 and 15 F_2 crosses) . Each plot consisted of two rows. Rows were 3 m long, spaced 20 cm apart. Single seeds were hand drilled in 5 cm spacing within rows. Normal recommended agronomic practices for maximization of yield in each specific environment were applied at individual years and locations sampled.

Data Collected

1-Yield and yield contributing variables

Ten competitive plants were tagged randomly from each genotype in each replication to record the following measurements for ten traits

1- Plant height, (the height from ground level to the top of the plant measured in cm).

2- Technical height, (the height from ground level to the point from where primary branches starts, measured in cm).

3- Capsules per plant, counted at full maturity.

4- Seeds per capsule, (measured as average number of seeds per capsule from 5 random capsules per plant).

5- Seed weight per plant (g).

6- 1000-seed weight (g).

7- Straw yield per plant (g).

8- Number of basal branches, (measured, stems at the base more than 10 cm in length and bearing at least one capsule).

9- Oil percentage (%), (as given by the A.O.A.C. 2000 using a Soxhlet apparatus and petroleum ether with a boiling range of 60-80^{O}C as solvent for sixteen hours).

10- Oil yield plant (g), by multiplying the seed yield/plant and oil percentage.

2- Statistical manipulation of the data:

Data were subjected to analysis of variance using plot means.

Combining ability analysis

General (GCA) and specific (SCA) combining ability were calculated according to Griffing's method 2, model 1 (fixed effects). Forms of analysis for individual generation as given by Griffing (1956) were used for the combining ability analysis.

GCA/SCA ratio with its significant level plus the relative importance (RI) of general and specific combining ability on progeny performance (i.e., the ratio between additive *vs.* total genetic variance components) as estimated according to Betran *et al.* (2003) as the ratio: $2\delta^2_{GCA} / (2\delta^2_{GCA} + \delta^2_{SCA})$, where δ^2_{GCA}, δ^2_{SCA} are the variance components for GCA and SCA were used as indicator for the relative importance (RI) of additive and non-additive effects

RESULTS AND DISCUSSION

Analysis of variances:

Mean squares (Table 2) due to 36 flax genotypes (6 parents, 15 F_1 crosses and 15 F_2 crosses), were significant for all characters under study (straw yield/plant, plant height, technical stem length, No. of basal branches/plant, fiber percentage, seed yield/plant, No. of capsules/plant, No. of seed index, seeds/capsule in F_1, and oil percentage) with exception for No. of seeds/capsule in F_1 which was non-significant .This indicated that those parents, F_1's and F_2's crosses showed reasonable degree of variability for these characters. Such variability among different flax genotypes for yield and its components was also reported by Abo El-Zahab *et al* (2010) , Abo Kaied (2006) and Abd Al-Sadek, (2015), Also, mean squares due to crosses revealed highly significant for all characters studied. These results indicated wide genetic variability for all variables studied. Mean squares due to parents are significant for straw, seed yield/plant and their components except for No. of seeds/capsule in two generations (F_1's and F_2's). Parents *vs.* crosses (P.*vs*.C.) mean squares as an indication of average heterosis over crosses are found to be highly significant for straw and seed yields/plant and their components with exception for each of No. of seeds/capsule in F_2, fiber percentage in F_1 and oil percentage in F_2. GCA variances was significant for all studied characters except for seed yield /plant in F_1 and No. of seeds/capsule in F_2. SCA variances were highly significant for all studied characters except for No. of seeds/capsule in F_2. This indicating the presence of both additive and dominance type of genetic variances. GCA variances were larger than the corresponding SCA variances for plant height in both F_1 and F_2 indicating the predominant role of additive gene action involved in the expression of this character. Therefore, selection should be possible within this F_2 and subsequent populations for this character. Similar results were reported by Abd Al-Sadek, (2015).While, the ratio of GCA/SCA variances were higher than unit for plant height, fiber % and oil % in F1 and F2, in addition to No. of seeds/capsules and seed index in F2 generation, indicating the predominant role of non-additive gene action involved in the expression of these characters, as suggested by Abo-Kaied (2006).

GCA effects:

The estimates of general combining ability effects ($\hat{g}_i$) are presented in Table (3). P_2 (S. 997) showed significant positive $\hat{g}_i$ for straw yield/plant and its two important components (plant height and technical stem length) in both F_1's and F_2's as well as fiber percentage in only F_2 . Also, P_5 (S. 103) exhibited significant positive $\hat{g}_i$ for each of straw yield/plant in F_1, plant height in F_1, fiber percentage in F_1 and F_2 and No. of seeds/capsule in both generations under study suggesting the importance of these two parents (P_2 and P_5) for increasing straw yield/plant, plant height and fiber percentage. This indicating that the use of these two parents in flax breeding programs could increase straw yield and fiber percentage consequent increasing fiber yield. Also, P_1 (Giza 8) exhibited significant positive GCA effects for oil percentage in both F_1's and F_2's as well as seed yield/plant in only F_1's. P_3 (S. 954) showed significant positive for GCA effects. P_4 (S. 888/22) exhibited significant positive GCA effects for seed index in both F_1's and F_2's as well as seed yield/plant and plant height in only F_1's. Also, P_6 (Bombay) exhibited significant positive GCA effects for straw yield/plant, plant height and fiber percentage in F_1's generation.

In general, P_2 (S. 997) and P_5 (S. 103) exhibited significant positive GCA effects for most important characters (straw yield, plant height and fiber percentage), indicating that the use of these parents (P_2, P_5) in flax breeding programs could increase fiber yield. Concerning, seed yield/plant and oil percentage results indicated that the P_1 (Giza 8,) showed significant positive $\hat{g}_i$ values. Therefore, this parent appeared to be good combiner for seed yield and consequent increasing oil yield.

The simple correlation coefficient between GCA values and parental means for two traits (plant height and fiber percentage) only were significantly positive in both generations (F1's and F2's). These results indicated that the parents showing higher mean performance (Table 6) proved to be the highest general combiners for these traits. Therefore, selection of parental population for initiating any proposed breeding program could be practiced either on their respective mean performance or on the basis of ĝi effects. Such agreement might add another proof to the preponderance of additive genetic variance in these cases. Mishra *etal* (2013), Kumar *etal*(2013), Sahu (2013), Abdel-Moneam (2014), Pali and Mehta (2014) and Abd Al-Sadek, (2015).

Table 2. Mean Squares for 21 flax genotypes (6 parents and 15 crosses), general (GCA) and specific (SCA) combining ability for straw, seed yields and thier components.

S.O.V.	df	straw yield/ plant (g)		Plant height (cm)		Technical stem length (cm)		No. of basal branches		Fiber percentage		Seed yield/plant (g)		Number of capsules/plant		Number of seeds/capsules		Seed index (g)		Oil percentage	
		F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Reps	2	1.36ns	0.30ns	8.69*	9.30ns	7.68ns	1.96ns	1.36ns	0.30ns	0.05ns	0.10ns	0.33ns	0.10ns	110.46ns	11.25ns	0.49**	0.66ns	0.04ns	0.31ns	0.22ns	0.48ns
Genotypes	20	45.80**	8.16**	364.18**	162.11**	318.30**	314.93**	45.80**	8.16**	3.89**	4.30**	13.07**	1.90**	2,312.31**	412.97**	2.29**	0.66ns	2.56**	2.93**	2.23**	3.20**
Crosses (C)	14	49.46**	9.97**	468.50**	102.78**	157.23**	275.65**	49.46**	9.97**	4.72**	5.27**	8.85**	1.33**	924.68**	559.41**	2.43**	0.86*	1.30**	2.33**	2.46**	3.93**
Parents (P)	5	4.00**	4.00**	126.74**	126.74**	60.52**	60.52*	4.00**	4.00**	2.27**	2.27**	1.16**	1.16**	67.10ns	67.10*	0.15ns	0.15ns	4.28**	4.28**	1.80**	1.80**
P.*vs*.C	1	203.51**	3.64*	90.93**	1169.58**	3862.11**	2136.87**	203.51**	3.64*	0.28ns	0.85**	131.63**	13.63**	32965.27**	92.15*	11.09**	0.51ns	11.6**	4.61**	1.17**	0.15ns
GCA	5	6.39**	1.80**	186.96**	55.54**	83.51**	68.64**	6.39**	1.80**	3.51**	1.63**	1.32**	0.02ns	56.19*	33.18**	0.18**	0.31ns	0.81**	1.30**	1.76**	1.72**
SCA	15	18.22**	3.03**	99.54**	53.54**	113.63**	117.09**	18.22**	3.03**	0.56**	1.37**	5.37**	0.84**	1,008.96**	172.48**	0.96**	0.19ns	0.87**	0.87**	0.41**	0.85**
Error	40	0.25	0.20	0.79	4.26	1.12	6.06	0.25	0.20	0.02	0.03	0.07	0.04	22.57	6.91	0.03	0.14	0.02	0.04	0.05	0.07
GCA/SCA		0.35	0.59	1.88	1.04	0.73	0.59	0.35	0.59	6.30	1.19	0.24	0.03	0.06	0.19	0.19	1.64	0.93	1.49	4.33	2.02

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

Table 3. Estimation of general combining ability effects(ĝi) for straw, seed yields and their components in 6 flax genotypes

Characters	G.	Parents						r	LSD (gi-gi)	
		P1= Giza 8	P2=S. 997	P3=S. 945	P4=S.888/22	P5=S. 103	P6=Bombay		0.05	0.01
Straw yield/plant	F1	0.06ns	1.35**	-1.27**	0.03ns	0.44**	-0.60**	0.23	0.51	0.68
	F2	-0.76**	0.65**	0.16ns	0.20ns	-0.24ns	0.01ns	0.65	0.45	0.60
Plant height (cm)	F1	-7.31**	3.27**	-4.50**	2.84**	4.86**	0.84**	0.81	0.90	1.20
	F2	-4.63**	1.71*	0.78ns	1.06ns	2.55**	-1.47*	0.83	2.08	2.79
Technical stem length (cm)	F1	-6.15**	2.77**	-0.17ns	0.20ns	2.42**	0.93**	0.95	1.07	1.43
	F2	-2.69**	2.65**	3.51**	1.02ns	-0.62ns	-3.86**	0.52	2.49	3.33
No. of basal branches	F1	0.24**	0.11ns	-0.42**	0.10ns	-0.16**	0.13*	0.67	0.17	0.22
	F2	-0.10ns	-0.02ns	-0.16*	-0.11ns	0.21**	0.18*	-0.52	0.24	0.32
Fiber percentage	F1	-1.32**	0.04ns	0.23**	0.35**	0.26**	0.45**	0.99	0.16	0.21
	F2	-0.79**	0.24**	0.46**	-0.05ns	0.31**	-0.18**	0.77	0.16	0.22
Seed yield/plant	F1	0.47**	0.40**	-0.34**	0.21*	-0.42**	-0.32**	0.61	0.27	0.36
	F2	0.08ns	0.01ns	0.00ns	-0.07ns	-0.04ns	0.03ns	0.50	0.20	0.27
Capsules/plant	F1	0.77ns	2.82ns	-1.23ns	0.53ns	-4.65**	1.76ns	0.59	4.80	6.42
	F2	-0.84ns	-1.18ns	-1.76*	-0.97ns	1.09ns	3.66**	-0.66	2.66	3.55
No. of seeds /capsule	F1	0.13*	0.02ns	-0.21**	0.05ns	0.16**	-0.16**	0.21	0.17	0.23
	F2	0.07ns	-0.21ns	-0.06ns	-0.12ns	0.35**	-0.04ns	0.56	0.38	0.51
Seed index	F1	-0.12*	0.04ns	0.47**	0.21**	-0.15**	-0.45**	0.94	0.16	0.21
	F2	-0.03ns	-0.01ns	0.59**	0.30**	-0.31**	-0.53**	0.85	0.21	0.29
Oil percentage	F1	0.93**	-0.25**	-0.25**	0.03ns	-0.17*	-0.28**	0.91	0.23	0.31
	F2	0.83**	-0.21*	-0.53**	0.10ns	-0.24**	0.05ns	0.67	0.26	0.35

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

SCA effects:

Specific combining ability effects for straw yield/plant and its components are shown in Table 4a. For straw yield/plant, out of the 15 F_1 and F_2 crosses, only six crosses in F_1 and four crosses in F_2 showed significant positive SCA effects, while two crosses ($P_1\times P_2$ and $P_3\times P_4$) only exhibited significant positive SCA effects for both generations. Six crosses in F_1 and seven crosses in F_2 for plant height are shown significant positive SCA effects, in either three crosses ($P_1\times P_6$, $P_2\times P_4$ and $P_3\times P_4$) indicated significant and positive SCA effects for both generations. For technical stem length, two crosses F_1 and eight in F_2 exhibited significant and positive SCA effects, only one cross ($P_1\times P_5$) indicated highly significant and positive SCA effects for both generations. Also, one cross ($P_5\times P_6$) for No. of basal branches/plant only and one cross ($P_1\times P_5$) for fiber percentage exhibited desirable direction SCA effects.

In general, $P_1\times P_2$ for straw yield/plant, $P_1\times P_6$ for plant height and $P_1\times P_5$ for both of technical stem length and fiber percentage which showed significant positive SCA effects involved high × low general combiner parents. It could be concluded that the three crosses are suitable in breeding for increasing the three above-mentioned characters.

For seed yield and its components (Table 4b), out of 15 F_1 and 15 F_2 crosses, nine crosses in F_1 and one cross in F_2 indicated significant positive SCA effect for seed yield/plant, ten crosses in F_1 and two crosses in F_2 for No. of capsules/plant, seven crosses in F_1 only for No. of seeds/capsule, three crosses in F_1 and five crosses in F_2 for seed index and four crosses in both generations for oil percentage showed significant positive SCA effects. On the other hand, three crosses only exhibited SCA effects for both generations ($P_1\times P_2$ for No. of capsules/plant, $P_4\times P_6$ for seed index and finally $P_5\times P_6$ for each of No. of capsules/plant, seed index and oil percentage). One cross ($P_5\times P_6$) involved high × low general combiner parents for No. of capsules/plant, indicated more evidence that this cross may yield transegressive segregates in later generations.

The correlation between cross means (Table 5) and their SCA values (Table 4b) indicated that the crosses showing higher mean performance proved to be the highest specific combining ability for these traits. Pali and Mehta (2014), Abdel-Moneam (2014), Abd Al-Sadek, (2015), Abd El-Haleem and Abd Al-Sadek (2015). Singh *etal* .(2016) and Ram *etal* (2018).

Table 4a. Estimation of specific combining ability (Ŝij) effects for straw, seed yields and their components in 15 F_1 flax crosses

Crosses	straw yield/ plant (g)	Plant height (cm)	Technical stem length (cm)	No. of basal branches	Fiber percentage	Seed yield/plant (g)	Number of capsules/plant	Number of seeds/capsules	Seed index (g)	Oil percentage
$P_1\times P_2$ \$	5.86**	-1.98*	-8.58**	1.35**	-0.78**	2.21**	12.05**	1.04**	0.86**	0.09ns
$P_1\times P_3$	0.02ns	-8.70**	-14.01**	0.89**	-1.30**	0.62*	24.83**	-0.04ns	0.07ns	0.42*
$P_1\times P_4$	-2.49**	-17.15**	-8.79**	0.29ns	-0.85**	0.05ns	-8.39ns	0.69**	0.13ns	0.61**
$P_1\times P_5$	-0.67ns	4.93**	2.62**	0.23ns	0.50**	-0.59*	0.42ns	-0.08ns	-0.38**	-0.53*
$P_1\times P_6$	4.52**	10.08**	-2.94**	0.81**	0.39**	2.87**	36.61**	0.29ns	-0.60**	-0.20ns
$P_2\times P_3$	-5.10**	0.26ns	5.67**	-1.29**	0.96**	-2.69**	-11.97**	0.65**	-0.84**	-0.94**
$P_2\times P_4$	-0.38ns	9.66**	-4.28**	2.14**	-0.38**	1.43**	22.50**	-1.63**	-0.30*	-0.03ns
$P_2\times P_5$	8.67**	5.95**	-4.13**	0.74**	0.51**	3.52**	44.93**	1.32**	-1.05**	-0.82**
$P_2\times P_6$	-0.53ns	-6.47**	-6.33**	1.02**	-0.55**	0.78**	10.80*	0.28ns	-0.52**	0.63**
$P_3\times P_4$	3.86**	7.33**	-4.67**	0.95**	0.24ns	2.78**	34.52**	0.53**	-1.66**	-0.12ns
$P_3\times P_5$	-2.89**	-20.42**	-14.00**	0.66**	-0.81**	0.44ns	-7.30ns	-1.33**	-0.35*	0.13ns
$P_3\times P_6$	2.77**	1.21ns	-1.98*	1.20**	0.77**	1.00**	20.13**	0.20ns	0.20ns	-1.10**
$P_4\times P_5$	3.60**	10.96**	-3.05**	0.75**	0.69**	1.33**	20.32**	1.50**	-0.96**	-0.27ns
$P_4\times P_6$	-0.23ns	-0.77ns	-5.68**	0.06ns	0.38**	0.31ns	6.88ns	0.52**	0.86**	-0.10ns
$P_5\times P_6$	0.05ns	-6.29**	-4.13**	1.44**	-0.42**	-0.36ns	10.68*	0.03ns	0.47**	0.93**
r #	0.97**	0.90**	0.86**	0.95**	0.81**	0.96**	0.98**	0.98**	0.85**	0.80**
LSD(Sij-Sii)										
5%	1.34	2.38	2.83	0.44	0.41	0.72	12.70	0.46	0.42	0.62
1%	1.79	3.19	3.78	0.59	0.55	0.96	17.00	0.61	0.56	0.82

\$ = Number refer to parent codes, Table 2.

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

r #: Simple correlation coefficients between SAC values and means of crosses.

Table 4b. Estimation of specific combining ability (Ŝij) effects for straw, seed yields and their components in 15 F_2 flax crosses.

Crosses	straw yield/ plant (g)	Plant height (cm)	Technical stem length (cm)	No. of basal branches	Fiber percentage	Seed yield/plant (g)	Number of capsules/plant	Number of seeds/capsules	Seed index (g)	Oil percentage
$P_1\times P_2$ \$	2.63**	-0.28ns	0.30ns	0.12ns	-1.30**	-0.38*	5.50*	0.47ns	0.81**	1.58**
$P_1\times P_3$	-2.55**	5.29**	4.76*	-0.77**	0.17ns	-0.40*	-4.99*	-0.31ns	0.77**	-0.14ns
$P_1\times P_4$	-0.53ns	2.18ns	4.65*	-0.24ns	-0.05ns	-0.06ns	-0.08ns	0.52ns	0.59**	-0.43ns
$P_1\times P_5$	-0.82*	1.05ns	7.34**	-0.65**	1.13**	-0.66**	-8.56**	0.06ns	-0.56**	-0.96**
$P_1\times P_6$	-1.22**	7.11**	8.24**	-0.73**	0.01ns	-0.94**	-8.96**	-0.10ns	-0.68**	0.22ns
$P_2\times P_3$	0.87*	-0.38ns	0.03ns	0.54*	0.10ns	-0.43*	2.99ns	-0.20ns	-1.35**	-0.78**
$P_2\times P_4$	-2.32**	9.87**	11.54**	0.04ns	1.28**	-0.72**	-5.61*	-0.99**	0.26ns	-0.77**
$P_2\times P_5$	-0.86*	3.45ns	1.39ns	-0.46*	-0.65**	-0.35ns	-4.77*	0.31ns	-1.22**	-0.17ns
$P_2\times P_6$	-1.03*	5.94**	11.79**	-1.23**	1.00**	-0.52**	-11.98**	0.10ns	-0.06ns	-0.45ns
$P_3\times P_4$	0.82*	4.60*	4.81*	0.27ns	0.52**	-0.28ns	-0.57ns	-0.32ns	-1.35**	-0.59*
$P_3\times P_5$	-1.92**	9.31**	18.06**	-0.95**	1.69**	-0.81**	-9.76**	0.16ns	0.09ns	-1.21**
$P_3\times P_6$	0.72ns	-0.58ns	1.23ns	-0.11ns	-1.81**	-0.60**	-5.73*	0.25ns	0.24ns	0.28ns
$P_4\times P_5$	-0.16ns	-0.13ns	-0.59ns	-0.31ns	-1.91**	-0.31ns	-2.16ns	0.39ns	-1.21**	1.27**
$P_4\times P_6$	0.74ns	3.82*	-0.42ns	-0.87**	-1.51**	0.11ns	2.08ns	0.26ns	0.64**	1.17**
$P_5\times P_6$	3.35**	-10.37**	-17.89**	3.24**	0.24ns	1.93**	41.12**	0.24ns	0.46*	0.53*
r #	0.95	0.84	0.94	0.99	0.91	1.00	0.99	0.92	0.84	0.89
LSD(Sij-Sii)										
5%	1.18	5.52	6.58	0.64	0.43	0.53	7.03	1.01	0.56	0.69
1%	1.58	7.38	8.80	0.85	0.58	0.71	9.40	1.35	0.76	0.92

\$ = Number refer to parent codes, Table 2.

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

r #: Simple correlation coefficients between SAC values and means of crosses.

Mean performance:

Parent mean performance:

Increasing the yield of oil per unit area and improving its quality for cooking purpose are among the major breeding objectives of linseed research in Egypt. The first objective, *i.e.* the increasing the oil yield per unit area, could be achieved by increasing both the seed yield per unit area and oil content of the seed. Oil content can be increased by decreasing the proportions of seed coat and protein, since there is an inverse relationship between oil, protein and fiber contents (Knowles, 1983 and Nagvi *et al* 1987). For oil percent, P_1 (Giza 8) exhibited the highest number of capsules, oil percentage and the highest mean performance (Table 5). Parent P_5 (S. 103) of fiber type exhibited maximum values for plant height and technical stem length. Also, exhibited the highest mean performance in number of seeds/capsule. The finding that the fiber type P_5 (S. 103) revealed the maximum number of seeds/capsule is apparently not explainable, but in fact this may be expected on the basis of its small size expressed as seed weight. Identification of more valuable crosses in the F_1 and F_2 generations would result in more efficient breeding programs (Smith and Lambert, 1968). Significant variations due to cross combinations, some cross combinations reached the best high parent and in some cases significantly exceeded the mean performance of the best parent for all traits studied in F_1 except technical stem length and seed index. However, such phenomina, in F_2 generation were recorded for some crosses in only four traits viz: plant height, number of basal branches/plant, number of capsules/plant and oil percent (Table 5). Similar findings were found by Shehata and Comstock, (1971) in nine parents diallel cross in flax, where average of four F_2 populations exceeded the high yielding parent by 15 to 19%. One F_2 population, Russian × C.L.1664, exceeded by 5.5 % the yield of Marine as the highest yielding cultivar. It is evident from data presented on Table (5) that in F_2, out of fifteen cross combinations, one cross ($P_2 \times P_5$) for straw yield/plant, and two crosses ($P_1 \times P_6$) and ($P_2 \times P_5$) for seed yield/plant, and for two crosses ($P_1 \times P_2$ and $P_4 \times P_6$) for number of capsules/plant, for one cross ($P_1 \times P_2$) for 1000 seed weight, for three crosses ($P_1 \times P_2$, $P_1 \times P_3$ and $P_1 \times P_4$) for oil percentage, recorded superiority over the best parent. However, in F_2 this superiority was detected in one cross ($P_4 \times P_5$), ($P_2 \times P_4$) and ($P_2 \times P_5$) for plant height, all crosses for number of capsules/plant and two crosses ($P_1 \times P_3$ and $P_1 \times P_4$) for oil percentage (Singh *et al*, 2016)

Table 5. Mean performances of 21 flax genotypes(6 parents,15 F1's and 15 F2'scrosses) for straw, seed yield and their components.

Genotypes	Straw yield and its components										Seed yield and its components									
	straw yield/plant		Plant height (cm)		Technical length (cm)		No. of basal branche		Fiber percentage		Seed yield /plant (g)		No. of capsules /plant		seed index		No. of seeds/capsule		Oil percentage	
Parents																				
Giza 8	7.31		94.07		69.83		1.99		16.75		2.89		34.76		8.45		6.49		40.14	
S. 997	9.24		105.10		80.63		1.53		18.57		2.73		32.47		9.74		6.39		38.51	
S. 945	8.94		103.43		80.43		1.25		18.90		2.78		33.40		10.96		6.76		38.79	
S.888/22	8.70		102.95		79.90		1.41		19.05		2.01		29.12		10.11		6.49		38.49	
S. 103	7.31		114.44		82.45		1.06		18.67		1.53		22.15		9.57		6.79		38.41	
Bombay	6.33		105.09		78.66		1.29		18.98		1.59		26.95		7.63		6.21		37.83	
Crosses																				
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
$P_1 \times P_2$	18.08	10.10	96.25	107.80	54.31	88.12	5.00	1.06	16.32	16.46	7.62	1.22	81.62	31.37	9.51	9.75	8.38	7.00	39.25	40.82
$P_1 \times P_3$	9.62	4.43	81.77	112.43	45.95	93.43	4.02	0.03	15.98	18.15	5.29	1.20	90.35	20.30	9.15	10.30	7.07	6.37	39.59	38.78
$P_1 \times P_4$	8.41	6.49	80.66	109.61	51.54	90.84	3.94	0.61	16.57	17.42	5.27	1.47	58.88	26.00	8.95	9.83	8.06	7.14	40.05	39.12
$P_1 \times P_5$	10.64	5.76	104.77	109.96	65.16	91.89	3.61	0.52	17.83	18.96	4.00	0.89	62.51	19.59	8.08	8.08	7.39	7.15	38.70	38.24
$P_1 \times P_6$	14.79	5.62	105.89	112.00	58.12	89.54	4.49	0.42	17.90	17.35	7.55	0.68	105.12	21.75	7.56	7.74	7.45	6.60	38.93	39.72
$P_2 \times P_3$	5.79	9.26	101.31	113.10	74.54	94.05	1.70	1.43	19.61	19.10	1.91	1.10	55.60	27.95	8.41	8.21	7.65	6.19	37.04	37.11
$P_2 \times P_4$	11.81	6.11	118.05	123.63	64.96	103.06	5.65	0.97	18.39	19.78	6.59	0.74	91.83	20.13	8.68	9.53	5.63	5.34	38.23	37.74
$P_2 \times P_5$	21.28	7.14	116.37	118.70	67.33	91.28	3.98	0.79	19.19	18.20	8.05	1.13	109.08	23.04	7.58	7.44	8.69	7.11	37.23	38.00
$P_2 \times P_6$	11.03	7.22	99.92	117.17	63.64	98.43	4.55	0.00	18.32	19.36	5.40	1.04	81.37	18.40	7.80	8.39	7.33	6.52	38.58	38.01
$P_3 \times P_4$	13.43	8.77	107.95	117.44	61.64	97.20	3.93	1.07	19.20	19.24	7.20	1.17	99.79	24.59	7.75	8.51	7.56	6.17	38.15	37.60
$P_3 \times P_5$	7.10	5.58	82.23	123.63	54.52	108.80	3.38	0.17	18.06	20.77	4.22	0.67	52.80	17.47	8.70	9.35	5.81	7.12	38.19	36.64
$P_3 \times P_6$	11.71	8.47	99.83	109.71	65.05	88.74	4.21	0.98	19.83	16.77	4.88	0.95	86.64	24.07	8.95	9.29	7.02	6.82	36.85	38.42
$P_4 \times P_5$	14.88	7.39	120.94	114.48	65.84	87.67	3.99	0.85	19.69	16.65	5.66	1.10	82.17	25.86	7.83	7.75	8.90	7.29	38.06	39.74
$P_4 \times P_6$	10.01	8.54	105.19	114.40	61.72	84.60	3.59	0.27	19.56	16.56	4.74	1.59	75.15	32.67	9.35	9.39	7.60	6.77	38.12	39.93
$P_5 \times P_6$	10.71	10.15	101.70	100.62	65.49	65.84	4.71	4.62	18.67	17.91	3.44	3.40	75.15	73.77	8.60	8.41	7.22	7.18	38.95	38.55
G. Means																				
L.S.D 5%	1.34	1.18	2.38	5.52	2.83	6.58	0.44	0.64	0.41	0.43	0.72	0.53	12.70	7.03	0.46	1.01	0.42	0.56	0.62	0.69
1%	1.79	1.58	3.19	7.38	3.78	8.80	0.59	0.85	0.55	0.58	0.96	0.71	17.00	9.40	0.61	1.35	0.56	0.76	0.82	0.92

REFERENCES

A.O.A.C. (2000). Official Methods of Analysis, 17th Ed., Association of Official Agricultural Chemists, Washington, D.C., USA

Abd Al-Sadek, Maysa S. (2015). Diallel cross analysis for yield and its components in six Flax genotypes. J. Plant. Production. Mansoura Univ, 6(11): 1877-1886.

Abd El-Haleem, R.A., and Abd Al-Sadek, Maysa S. (2015). Estimation of combining ability for eight flax genotypes under sandy soil condition. J. Plant. Production Mansoura Univ., 6(3)323:335.

Abdel-Moneam A.M. (2014). Diallel cross analysis for yield and its related traits in some genotypes of flax (*Linum usitatissimum* L.). Int J. Plant Breed Genet. (8):153-163.

Abo El Zahab, A.A., Abo-Kaied, H.M.H, Amein, M.M.M and Abd Al-Sadek, Maysa. S. (2010). Breeding dual purpose flax for marginal and sub marginal soils. 1- variability and combining ability of some flax crosses. .J.Plant. Breed Cairo Univ, 14(1) 229:259.

Abo El-Zahab, A.A., Mourad, N. K. and Abo-Kaied, H. M. H. (1994). Genotype-Environment Interaction and Evaluation of Flax Genotypes. Proc. 6th Conf. Agron., Al-Azhar Univ., Cairo, Egypt. 1: 129-152.

Abo-Kaied H. M. H. and El-Refaie, Amany, M. M. (2008). Genetic studies on yield and its attributes in some flax hybrids under different environmental conditions. J. Agri. Sci. Mansoura Univ., 33 (7): 4697-4715.

Abo-Kaied, H. M. H., Abd El-Dayem, M. A. and Zahana, Afaf, E. A. (2006). Variability and covariability of some agronomic and technological flax characters. Egypt. J. Agric. Res., 84 (4): 1117-1132.

Abo-Kaied, H.M.H. (2006). Line × tester analysis for combining ability in some flax genotypes. Egypt. J. Agric. Res., 84(4): 1133-1146

Betran, F.J., Beek, D., Banziger, M. and Edmeades, G.O. (2003). Genetic analysis of inbred and hybrid grain yield under stress and nonstress environments in tropical maize. Crop Sci., 43:807-817.

Bhullar, G. S., Gill, K. S. and Khehra, A. S. (1979). Combining ability analysis over F_1-F_5 generations in diallel crosses of bread wheat. Theor. Appl. Genet., 55:77-80.

De Haan, H. (1952). Flax breeding and flax varieties in the Netherlands. Euphytica., 1: 212-218.

Foster, R., Pooni, H. S. and Mackay, I. J. (1998). Quantitative analysis of *Linum usitatissimum* crosses for dual-purpose traits. J. Agricultural Sci. Cambridge., 131: 285-292.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci., 9: 436-493.

Knowles, P. F. (1983). Genetics and Breeding of Oilseed Crops. Economic Botany, 37(4): 423-433.

Kumar S, Kerkhi S.A, Kumar, A. and Singh, S.D. (2013). Combining ability and heterosis analysis in linseed (*Linum usitatissimum* L). Ann Agric Res New Series. (34):197-204.

Mishra, R.K, Marker, S., Bhatnagar, V and Mahto, D. (2013). Combining ability and heterosis for seed yield and its component in linseed (*Linum usitatissimum* L.). Adv. Plant Sci. 2(1):44-47.

Nagvi, H. A., Rai, M. and Vasishtha, A. K. (1987). Association of different components of seed oil in linseed. Indian J. Agric. Sci., 57: 230-236. (C.F.P1. Breed. Abst.,1987, 57: 9077).

Pali, V. and Mehta, N. (2014) Combining ability and heterosis for seed yield and its attributes in linseed (*Linum usitatissimum* L.). The Bioscan. 9(2):701-706.

Patil, V. D. I. and Chopde, P. R. (1981). Combining Ability Analysis over Environments in Diallel Crosses of Linseed (*Linum usitatissimum* L.).Theor. Appl. Genet, 60: 339-343.

Ram, B. P. N., Neha, R., Shivasankar A., Ramanuj. V., Tushar, R., Bishun, D. P., and Awadhesh, K. P. (2018). Combining ability analysis for grain yield and its component traits in linseed (*Linum usitatissimum* L.) Current J. of Appl Sci and Technology.31 (4): 1-12

SAFRR, (2004). Saskatchewan Agriculture, Food and Rural Revitalization. Oilseed Flax Straw Management, March, Canada.

Sahu V., Singh, S.K, Sharma, Amita and Bhati, P.K. (2013). Combining ability analysis for yield and yield traits using 'wa' cytoplasm in rice (*Oryza sativa* L.). The Bioscan. 8(3):871-874.

Shehata, A. H. and Comstock, V. E. (1971). Heterosis and combining ability estimates in F_2 flax populations as influenced by plant density. Crop Sci., 11: 534-536

Singh, N., Chandrawati, Kumar R., Kumar, S. and Yadav, H.K. (2016). Study on genetic combining ability estimates for yield and related traits in linseed (*Linum usitatssimum* L.). Australian Journal of Crop Science. 10(11):1594-1600.

Smith, L. E. and Lambert, W. J. (1968). Evaluation of early generation testing in spring barley. Crop Sci, 8: 490-493.

تحليل القدرة علي التالف للجيل الاول و الثاني في هجن التلقيح الدائري للكتان

دعاء إسماعيل محمود، مايسة سعيد عبد الصادق وطه أحمد عمر

قسم بحوث محاصيل الالياف، معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، مصر

تم تهجين ستة تراكيب وراثية ابوية من الكتان في جميع التوليفات الممكنة باستثناء العكسية في 2019/2018 لانتاج 15 هجين في الجيل الاول و 15 هجين في الجيل الثاني 2019/2018. لتقدير القدرة على التالف والفعل الجيني لمحصولي القش والبذور ومكوناتهما في الكتان ، في 2019/2018 ، 2020/2019 تم تقييم الآباء الستة وأنسالهم 15 هجين في الجيل الاول و 15 هجين في الجيل الثاني ، في تصميم قطاعات كاملة العشوائية باستخدام ثلاث مكررات بمحطة بحوث الجيزة، محافظة الجيزة ، مصر. أظهر P2 (S. 997) و P5 (S.103) تأثيرات إيجابية و معنوية للقدرة العامة علي التالف لأهم الصفات (محصول القش ، ارتفاع النبات ونسبة الألياف) ، مما يشير إلى أن استخدام هذه الآباء(P2 ، P5)في برامج تربية الكتان يزيد من محصول الألياف. فيما يتعلق بمحصول البذور / النبات والنسبة المئوية للزيت أوضحت النتائج أن P1 (جيزة 8) أظهرت قيم ĝi موجبة معنوية. لذلك ، يبدو أن هذا الأب ذو قدرة جيدة لمحصول البذور وما يترتب على ذلك من زيادة محصول الزيت. و أشار الارتباط الموجب بين قيم القدرة العامة علي التالف والمتوسطات الابوية إلى أن اختيار الهجن الابوية في برنامج تربية الكتان يمكن أن يعتمد على متوسط الأداء الأعلى لهذه الصفات. لتأثير القدرة الخاصة علي التالفP1× P2 لمحصول القش / نبات ، P1× P6 لارتفاع النبات و P1× P5 لكل من طول الساق التكنولوجي ونسبة الألياف التي أظهرت تأثيرات إيجابية و معنوية للقدرة الخاصة علي التالف المتضمنة آباء ذات قدرة عالية علي التالف × منخفضة. يمكن الاستنتاج أن الهجن الثلاثة مناسبة للتربية لزيادة الصفات الثلاثة المذكورة أعلاه. يشير الارتباط بين متوسطات الهجن وقيمهم الخاصة علي التالف إلى أن الهجن التي أظهرت أداء متوسط عالي أثبتت أنها ذات قدرة خاصة علي التالف عالية لهذه الصفات.