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DIALLEL CROSS ANALYSIS FOR STRAW, SEED YIELDS AND THEIR COMPONENTS IN FLAX

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ABSTRACT

The present investigation was designed to study combining ability and gene action for yield and yield components in flax under two plant distances. This was achieved via evaluating six parents; P_1 (Sakha 1), P_2 (Giza 7), P_3 (S.2419/1), P_4 (S.16), P_5 (S.22), P_6 (Sakha 3) and their 15 F_1,s progenies under two distances (5 and 10 cm) between plants in a randomized complete block design with three replications at Sakha Res. Station at Kafr El-Sheikh Governorate during 2008/2009 and 2009/2010 growing seasons.

The collected data indicated that the additive effects were more important than non-additive effects for eight characters under study, revealed that the inheritance of these traits were mainly controlled by additive effects of genes. On the other hand, non-additive genetic effects were much more influenced by the two distances between plants than additive effects in number of basal branches, 1000-seed weight and number of seeds per capsule. In contrast, additive genetic effects were more influenced by distances between plants than non-additive effects for straw weight, seed weight and number of capsules per plant. P_3 exhibited significantly positive GCA effects for straw weight, number of basal branches, seed weight, number of capsules per plant and 1000-seed weight. Therefore, using this parent in hybridization programs may result in isolating desirable segregates for these characters. For straw traits, two crosses involved high x high general combiner parents, one cross (P_1xP_2) for plant height and other cross (P_2xP_3) for technical stem length as well as P_3xP_6 (high x low general combiners) for straw weight per plant. For seed traits, two crosses, P_4xP_5 and P_4xP_6 exhibited high SCA effects for 1000-seed weight and included low x high general combiner parents. Therefore, it could be concluded that these crosses are suitable in breeding for increasing the above-mentioned traits.

Keywords: Flax, Diallel analysis, Combining ability, Gene action, plant distances.

INTRODUCTION

Flax (*Linum usitatissimum* L.) consider the most important bast fiber crop in Egypt since several thousand years ago. Flax is cultivated in Egypt for two purposes (seeds and fibers) as a winter annual crop. Linseed oil produced is used in paints and varnishes. Linseed cake or meal is used as feed for livestock. Flax fiber is spun into linen yarns which are used in threads and twines of various kinds.

Choice of parents for crossing is considered an important step in any plant breeding program aimed at improving yield and related attributes. Combining ability analysis is an important tool for the selection of desirable parents together with the information regarding nature and magnitude of gene effects controlling quantitative traits of economic importance. Moreover, such information is more reliable when drawn over various environments. It is important to accurately estimate the magnitude and relative proportion of the various components of genetic variance in order to understand the underlying type of gene action that controls the trait of interest, for example, general combining ability variance is a measure of additive effects of genes and of additive x additive epistatic interaction while specific combining ability variance is a measure of dominance and epistatic types of gene action. Many investigators studied the combining ability in flax, *i.e.* Patil, *et al.,* (1997), Foster *et al.,* (1998), Abo El-Zahab and Abo-Kaied (2000) and Abo-Kaied (2002), who found that additive genetic variance had more important role in the inheritance of straw yield, plant height, technical stem length and 1000-seed weight. ON the contrary, non-additive variance had an important role in the inheritance of No. of basal branches per plant, seed yield per plant and capsules per plant as reported by Shehata and Comstock (1971), Patil and Chopde (1981), Zahana (2006), Abo-Kaied *et al*. (2007) and El-Kady and Abo-Kaied (2009).

Therefore, the main objective of the present investigation was to study general and specific combining ability in six parental flax genotypes and their15 F_1 crosses under two distances (5 and 10 cm) between plants.

MATERIALS AND METHODS

The materials used for the present study consisted of 6 parents viz., P_1 (Sakha 1), P_2 (Giza 7), P_3 (S.2419/1), P_4 (S.16), P_5 (S.22) and P_6 (Sakha 3) and 15 F_1 crosses. Genotype characteristics of these parents and their pedigree, type (dual, oil and fiber types) and origin are presented in Table (1).

Table (1): Identification of parental genotypes used, pedigree, classification (dual, oil, fiber types) and origin.

Genotypes	Pedigree	Type	Origin
P1= Sakha 1	I. Bombay (U.S.A.) x I.1485 (U.S.A.)	Dual	Local variety
P2= Giza 7	Giza 5 (cv.) x I. New river (USA)	Dual	Local variety
P3=S.2419/1	Selected from I. Humpata (Hungarian)	Oil	Local strain
P4= S. 16	Giza 8 x S.2419/1	Oil	Local strain
P5=S. 22	I.370 x I.2561	Oil	Local strain
P6= Sakha 3	I. Belinka x I. 2569	Fiber	Local variety

In 2008/09 season, the six parents were crossed in a diallel mating design excluding reciprocals to obtain 15 F_1 crosses. In 2009/10 season, the parents and their crosses were evaluated under two distances (5 and 10 cm) between plants in the breeding nursery of the Sakha Res. Section, ARC at Kafr El-Sheikh Governorate.

The experiment was laid out in a randomized complete block design with three replications with restricted randomization where each plot consisted of two F_1 row guarded by one row of its parents. Rows were 2 m long, spaced 20 cm apart. Single seeds were hand drilled in two rows (one row 5 cm and the other row 10 cm spacing within row). At harvest, individual guarded plants were taken at random from each row; 10 plants from each parent and F_1 per replication. These plants were used for recording: straw weight(g)/plant, plant height (cm), technical stem length(cm), No. of basal branches, seed weight (g)/plant, 1000-seed weight (g), No. of capsules/plant, and No. of seeds/capsule.

Statistical Analysis

Plot means were used for statistical analysis. Data from each environment (5 and 10 cm spacing within row) were analyzed and Barteltt's test for heterogeneity of error variances across environments indicated that error terms were homogeneous. In the combined analysis across environmental effect was assumed to be fixed. Combining abilities, general (GCA) and specific (SCA) were calculated according to Griffing's method 2, model 1 (fixed effects). Forms of analysis for individual environments as given by Griffing (1956) and for combined analysis as suggested by Singh (1973).

RESULTS AND DISCUSSION

Straw weight per plant and its components:

Mean squares of ordinary and combining ability analysis for straw weight and its components in 21 genotypes (15 F_1 crosses and 6 parents) under two distances (5 and 10 cm) and their combined data are presented in Table 2. Mean square estimates for straw weight and its components, plant height, technical stem length and No. of basal branches/plant due to these genotypes under two distances (d) and their combined data were significant. Mean squares due to environments and genotypes were highly significant for straw weight and its components. This indicated the presence of true differences among the genotypes and the wide diversity between the parental materials used in the present study under two distances. The significant differences among parents and crosses observed for straw weight and its components at both distances and their combined analysis, indicated that sufficient genetic variability was existed in the population and increase the chance of isolating good new recombinations in the following generations. In this connection, significant differences between flax genotypes for straw weight and its attributes were detected by Abo El-Zahab and Abo-Kaied (2000), Abo-Kaied *et al.* (2007) and El-Kady Eman and Abo-Kaied (2009). Also, the parents *vs.* crosses mean squares, as an indication to average heterosis over all hybrids were significant, revealing that heterotic effect was pronounced for straw weight and its components at the two distances and in the combined analysis.

Mean squares due to general (GCA) and specific (SCA) combining ability were highly significant for straw weight and its components under two distances with exception of SCA variance for technical stem length at 10 cm distance was non significant. These results indicate that both additive and non-additive genetic effects were involved in the inheritance of straw weight and its components.

Whereas, the magnitude of mean squares due to GCA with that for SCA revealed that GCA/SCA ratio was more than unity for straw weight and its components. Therefore, effective selection could be possible within F_2 and subsequent generations of the involved crosses for straw weight/plant and its components. These results were similar to those obtained by Patil, *et al.* (1997); Foster *et al.* (1998); Abo El-Zahab and Abo-Kaied, (2000), Abo-Kaied, (2002) and Abo-Kaied *et al.* (2007).

Table (2): Mean squares of ordinary and combining ability analyses for straw weight and its components of 21 genotypes (6 parents and their 15 F1crosses) under two distances (5 and 10 cm) and their combined data (C.).

S.O.V	df S.	df C.	E1 (5 cm)	E2 (10 cm)	C.	E1 (5 cm)	E2 (10 cm)	C.
			Straw weight/plant (g)			Plant height/plant (cm)		
Distance (d)		1			280.240 **			29.167 **
Reps/ d		4			0.708 ns			11.241 ns
Genotypes(G)	20	20	6.930 **	16.249 **	18.180 **	126.090 **	170.181 **	268.191 **
Parents (P)	5	5	3.040 **	8.343 **	21.504 **	56.110 **	96.574 **	523.852 **
Crosses(C.)	14	14	10.430 **	17.930 **	7.346 **	237.150 **	299.394 **	117.092 **
P.vs.C	1	1	43.820 **	118.525 **	153.239 **	550.670 **	554.602 **	1105.267 **
G x d		20			17.117 **			206.878 **
P x d		5			21.194 **			361.922 **
C x d		14			4.038 **			35.588 **
P vs C x d		1			111.265 **			736.848 **
GCA	5	5	3.191 **	5.502 **	7.520 **	89.651 **	142.293 **	224.926 **
SCA	15	15	2.015 **	5.388 **	5.573 **	26.158 **	28.205 **	44.221 **
GCA x d		5			1.173 ns			7.017 ns
SCA x d		15			1.830 **			10.143 **
Error	40	80	0.410	1.469	0.627	5.830	4.800	3.542
GCA/SCA			1.58	1.02	1.35	3.43	5.04	5.09
S.O.V	S.	C.	Technical stem length/plant (cm)			Number of basal branches/plant		
Distance (d)		1			293.533 **			4.734 **
Reps/ d		4			20.196 **			0.028 *
Genotypes(G)	20	20	156.800 **	121.644 **	225.285 **	0.280 **	0.749 **	0.800 **
Parents (P)	5	5	84.920 **	80.430 **	429.068 **	0.130 ns	0.435 *	2.140 **
Crosses(C.)	14	14	199.740 **	240.697 **	108.665 **	0.650 **	1.721 **	0.329 **
P.vs.C	1	1	948.460 **	103.376 **	839.044 **	0.400 *	0.302 **	0.695 **
G x d		20			203.348 **			0.758 **
P x d		5			297.415 **			1.662 **
C x d		14			56.681 **			0.237 **
P vs C x d		1			772.154 **			0.467 **
GCA	5	5	61.667 **	118.734 **	158.990 **	0.105 **	0.520 **	0.502 **
SCA	15	15	49.133 **	14.486 ns	47.130 **	0.087 **	0.160 *	0.188 **
GCA x d		5			21.412 **			0.122 *
SCA x d		15			16.489 **			0.059 ns
Error	40	80	5.370	13.867	6.410	0.040	0.098	0.045
GCA/SCA			1.26	8.20	3.37	1.20	3.25	2.67

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

The interaction between each of genotypes, parents, crosses and parent *vs.* crosses with two distances was highly significant for all traits. Also, the mean squares of interaction between two distances and both types of combining ability (GCA, SCA) were highly significant for straw weight and its components, except GCA x d interaction was insignificant for straw weight and plant height as well as SCA x d for No. of basal branches/plant, revealing that the magnitude of both additive and non-additive types of gene action varied from one distance to another. This results indicated that non-additive genetic effects were much more influenced by the distances between plants than additive effects in No. of basal branches/plant. In contrast, additive genetic effects were more influenced by distances than non-additive effects for both straw weight and plant height. These results are more or less in harmony with those obtained by Abo-Kaied *et al.* (2007).

Estimates of GCA effects (g_i) for six parental genotypes as affected by distances as well as the combined for straw weight and its components are presented in Table 3. In both distances and combined analysis, P_3(S.2419/1) exhibited good general combining ability effects for straw weight and No. of basal branches/plant as well as P_1(Sakha 1) and P_2(Giza 7) for plant height. For technical stem length, both P_2 and P_3 exhibited significant positive GCA values at combined data as well as one distance only for either 10 or 5 cm, respectively.

Table (3): Estimates of general combining ability effects (ĝi) for straw weight and its components of six parental genotypes under two distances (5 and 10 cm) and combined data (C.)

Parents	E1	E2	C.	E1	E2	C.
	Straw weight/plant (g)			Plant height/plant (cm)		
P1	-0.201ns	-0.722*	-0.462*	2.514**	2.781**	2.647**
P2	0.032ns	-0.572ns	-0.270ns	2.272**	4.543**	3.408**
P3	1.177**	1.243**	1.210**	1.072ns	1.576**	1.324**
P4	-0.004ns	0.851*	0.423*	0.956ns	0.206ns	0.581Ns
P5	-0.324ns	-0.414ns	-0.369*	-6.511**	-7.432**	-6.972**
P6	-0.680**	-0.386ns	-0.533**	-0.303ns	-1.674**	-0.988*
LSD 5%	0.530	1.000	0.560	1.991	1.808	1.331
(gi-gj)1%	0.708	1.338	0.742	2.664	2.419	1.763
r	0.903**	0.830*	0.910**	0.977**	0.900**	0.960**
	Technical stem length/plant (cm)			Number of basal branches/plant		
P1	-0.328ns	1.874ns	0.773ns	-0.028ns	-0.149ns	-0.088Ns
P2	0.693ns	3.728**	2.210**	-0.019ns	-0.203*	-0.111*
P3	3.935**	1.565ns	2.750**	0.214**	0.501**	0.358**
P4	0.572ns	0.386ns	0.479ns	-0.103*	-0.015ns	-0.059Ns
P5	-4.703**	-7.360**	-6.031**	0.022ns	-0.090ns	-0.034Ns
P6	-0.169ns	-0.193ns	-0.181ns	-0.086ns	-0.044ns	-0.065Ns
LSD 5%	1.911	3.072	1.790	0.159	0.258	0.150
(gi-gj)1%	2.556	4.111	2.372	0.213	0.345	0.199
r	0.952**	0.980**	0.980**	0.953**	0.980**	0.990**

ns,*, non- significant, significant at 0.05 and 0.01 levels of probability, respectively..**
 # P_1 (Sakha 1), P_2 (Giza 7) , P_3 (S.2419/1), P_4 (S. 16), P_5 (S. 22) and P_6 (Sakha 3)

Also, the previous parents (P_3, P_1 and P_2) gave the highest mean values for the same characters, in addition to P_4 which achieved maximum estimates for straw weight and plant height/plant were more than the other parents (Table 8). Therefore, using these parents in hybridization programs may be resulted in isolating desirable segregates for the above-mentioned characters. The correlation coefficient (r) between mean performance (Table 8) of parents and their GCA values as shown in Table 3 was significant and positive at both distances and combined data for straw weight and its components. These results indicated that the parents showing higher mean performance proved to be the highest general combiners for these traits. Therefore, high mean performance of the parents could be transferred to crosses in such cases.

The specific combining ability effects (S_{ij}) for straw weight and its components at the two distances and their combined data are presented in Table 4. The results indicated that there was no cross combination which was consistently good for all traits under two distances. Out of the 15 F_1 crosses, three crosses (P_1 x P_6, P_2 x P_4 and P_2 x P_5) exhibited highly significant positive SCA effects for straw weight/plant under two distances and combined as well as two crosses (P_3 x P_5 and P_3 x P_6) at combined data in addition the distance 10 cm only. For plant height, one cross (P_5 x P_6) under the three cases (5, 10 cm and combined) as well as five crosses (P_1 x P_2, P_1 x P_5, P_1 x P_6, P_2 x P_4 and P_3 x P_6) under combined and one distance. Also, for technical stem length, one cross (P_1 x P_6) under the three cases as well as three crosses (P_1 x P_4, P_2 x P_3, and P_3 x P_5) under combined and one distance exhibited significant and positive SCA effects. For number of basal branches/plant, one cross (P_1 x P_6) exhibited significant positive SCA effects in the desirable direction under two distances and their combined data as well as one cross (P_2 x P_5) under combined and one distance (10 cm).

In general only two crosses involved high x high general combiner parents, one cross (P_1xP_2) for plant height and other cross (P_2xP_3) for technical stem length as well as P_3xP_6 (high x low general combiners) for straw weight/plant. While, the cross P_1 x P_6 involved low x low for straw weight/plant, Therefore, these crosses (P_1xP_2 and P_2xP_3) are likely to throw good segregates for these traits if the allelic genetic systems are present in good combination and epistatic effects present in the crosses act in the same direction to maximize the desirable characteristics. Therefore, these crosses (P_1xP_2 and P_2xP_3) may prove useful for simultaneous improvement of the above-mentioned traits. The correlation between cross means (Table 8) and their SCA values (Table 4) was significant and positive for all traits except plant height/plant indicating that high performing crosses were high specific combinations. Therefore, the choice of promising cross combinations would be based on SCA effects or mean performance of a cross.

Seed weight per plant and its components:

Ordinary and combining ability analysis of variance (Table 5) showed significant differences existed among 21 flax genotypes (6 parents and 15 F_1's crosses), parents and crosses for seed weight and its components viz., No. of capsules/plant, 1000-seed weight and No. of seeds/capsule in most cases.

The results indicated that the parental genotypes and F_1 crosses showed reasonable degree of variability for these traits. Significant differences were also noted for the component parents *vs*. crosses for seed weight and its components at two distances and combined except d_2 (10 cm) for No. of capsules/plant and No. of seeds/capsule. Also, both mean squares due to general (GCA) and specific (SCA) combining abilities were highly significant for all characters in both distances and combined except the SCA for d_1(5 cm) for seed weight and No. of capsules/plant, also for d_2 (10 cm) regarding No. of seeds/capsule. In general, the magnitude of mean squares due to GCA was greater than that due to SCA. High ratio of GCA/SCA was also detected.

These results revealed that additive played greater role than non-additive gene effects in the inheritance of seed weight/plant and its components. Similar results were reported by Shehata and Comstock (1971), Patil and Chopde (1981), Abo El-Zahab and Abo-Kaied (2000) and Abo-Kaied *et al*. (2007).

4

Table (5): Mean squares of ordinary and combining ability analyses for seed weight and its components of 21 genotypes (6 parents and their 15 F1crosses) under two distances (5 and 10 cm) and their combined data (C.).

S.O.V	Df		5 cm		10 cm		C.		E_1		E_2		C.	
	S.	C.	Seed weight/plant (g)						No. of capsules/plant					
Distance (d)		1					63.08	**					12504.50	**
Reps/ d		4					0.20	**					116.90	**
Genotypes(G)	20	20	0.76	**	23.31	**	14.32	**	257.30	**	1021.21	**	985.41	**
Parents (P)	5	5	0.44	ns	29.00	**	8.34	**	189.94	*	785.71	**	1713.62	**
Crosses(C.)	14	14	1.63	**	8.48	**	16.52	**	460.28	**	1883.70	**	786.54	**
P.vs.C	1	1	0.91	**	17.89	**	13.42	**	185.33	*	5.87	ns	128.58	*
G x d		20					19.30	**					950.04	**
P x d		5					7.33	**					1772.77	**
C x d		14					12.92	**					189.11	**
P vs C x d		1					14.32	**					148.34	*
GCA	5	5	0.58	**	9.17	**	6.44	**	268.50	**	967.30	**	1011.63	**
SCA	15	15	0.15	ns	7.31	**	4.22	**	24.85	ns	131.44	**	100.75	**
GCA x d		5					3.30	**					224.18	**
SCA x d		15					3.24	**					55.54	*
Error	40	80	0.14		0.98		0.37		39.54		47.64		29.06	
GCA/SCA			3.94		1.25		1.53		10.80		7.36		10.04	
S.O.V	S.	C.	1000-seed weight (g)						No. of seeds/capsule					
Distance (d)		1					1.15	**					1.45	**
Reps/ d		4					0.29	ns					0.37	Ns
Genotypes(G)	20	20	3.64	**	3.68	**	7.11	**	1.02	**	0.93	*	1.68	**
Parents (P)	5	5	3.16	**	2.78	**	11.10	**	0.49	*	0.69	ns	3.72	**
Crosses(C.)	14	14	4.91	**	6.67	**	5.83	**	2.49	**	1.75	**	0.99	**
P.vs.C	1	1	4.07	**	1.35	**	5.05	**	1.11	*	0.22	ns	1.17	**
G x d		20					4.96	**					1.39	**
P x d		5					7.89	**					2.99	**
C x d		14					0.11	ns					0.19	Ns
P vs C x d		1					3.73	**					0.94	**
GCA	5	5	3.18	**	3.58	**	6.64	**	0.57	**	0.64	**	1.14	**
SCA	15	15	0.56	**	0.44	**	0.94	**	0.27	**	0.20	ns	0.37	**
GCA x d		5					0.12	ns					0.07	Ns
SCA x d		15					0.06	ns					0.10	Ns
Error	40	80	0.18		0.13		0.10		0.12		0.21		0.11	
GCA/SCA			5.69		8.07		7.04		2.14		3.22		3.12	

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

The interaction between each of genotypes, parents, crosses and parent vs. crosses with two distances was significant for seed weight and its components except crosses x d interaction for 1000-seed weight and No. of seeds/capsule revealing inconsistent responses for these sources of variations from two distances. Also, (GCA x d) and (SCA x d) mean squares were highly significant or significant for seed weight and No. of capsules/plant and insignificant for 1000-seed weight and No. of seeds/capsule. These results are in harmony with those reported by Patil and Chopde (1981) and Abo El-Zahab and Abo-Kaied (2000) and Abo-Kaied *et al*. (2007).

Estimates of GCA effects (g_i) for seed weight and its components for studied parents in both distances as well as combined data are presented in Table (6). P_3(S.2419/1) showed significant positive (g_i) effects for seed weight, No. of capsules/plant and 1000-seed weight in both two distances as well as the combined data. Also, this parent (S.2419/1) gave the highest mean performance than the other parents for the same previous traits (Table 9). P_5(S.22) expressed significant positive (g_i) effects for No. of capsules/plant, P_4(S.16) for 1000-seed weight and P_6(Sakha 3) for No. of seeds/capsule in both distances as well as combined. Therefore, the parent P_3(S.2419/1) could be considered as an excellent parents in breeding programs towards releasing flax varieties characterized by high value for the three above-mentioned traits. The simple correlation between GCA values (Table 6) and parental means (Table 9) for seed weight/plant and all its components were significant and positive in both distances as well as combined data. These results indicated that the parents showing high mean performance proved to be the high general combiners for these traits under two distances. In general, using the promising strain 2419/1 in hybridization programs may be resulted in isolating desirable segregates for both straw and seed weights (producing dual purpose type of flax).

Table (6): Estimates of general combining ability effects (ĝi) for seed weight and its components of six parental genotypes under two distances (5 and 10 cm) and combined data (C.)

Parents	E1		E2		C.		E1		E2		C.	
	Seed weight/plant (g)						**No. of capsules/plant**					
P1	-0.261	*	-1.014	**	-0.638	**	-6.307	**	-12.269	**	-9.288	**
P2	-0.039	ns	-1.029	**	-0.534	**	-1.090	ns	-10.540	**	-5.815	**
P3	0.374	**	1.817	**	1.095	**	4.685	**	16.526	**	10.606	**
P4	-0.110	ns	0.520	ns	0.205	ns	-2.169	ns	-1.453	ns	-1.811	ns
P5	0.282	**	-0.032	ns	0.125	ns	9.085	**	8.214	**	8.649	**
P6	-0.245	*	-0.262	ns	-0.253	ns	-4.203	*	-0.478	ns	-2.340	ns
LSD 5%	0.309		0.816		0.431		5.188		5.695		3.812	
(gi-gj)1%	0.413		1.091		0.572		6.941		7.620		5.051	
r	0.897	**	0.780	*	0.800	*	0.983	*	0.920	**	0.940	**
	1000-seed weight (g)						No. of seeds/capsule					
P1	-0.068	ns	0.220	*	0.076	ns	0.110	ns	0.349	**	0.229	**
P2	0.121	ns	0.198	*	0.160	*	0.033	ns	0.045	ns	0.039	ns
P3	0.683	**	0.716	**	0.699	**	-0.084	ns	-0.138	ns	-0.111	ns
P4	0.630	**	0.457	**	0.543	**	-0.348	**	-0.391	**	-0.369	**
P5	-0.385	**	-0.513	**	-0.449	**	-0.149	ns	-0.154	ns	-0.151	*
P6	-0.979	**	-1.079	**	-1.029	**	0.438	**	0.289	*	0.363	**
LSD 5%	0.348		0.298		0.227		0.280		0.379		0.233	
(gi-gj)1%	0.466		0.399		0.300		0.375		0.507		0.309	
R	0.916	**	0.930	**	0.930	**	0.865	**	0.830	*	0.850	**

ns,*, non- significant, significant at 0.05 and 0.01 levels of probability, respectively.**
 # P_1 (Sakha 1), P_2 (Giza 7) , P_3 (S.2419/1), P_4 (S. 16), P_5 (S. 22) and P_6 (Sakha 3)

SCA effects for seed weight/plant and its components for 15 F_1 crosses as affected by two distances as well as combined data are given in Table (7). Out of the 15 F_1 crosses, one cross (P_5 x P_6) for seed weight/plant and two crosses (P_4xP_5 and P_4xP_6) for 1000-seed weight exhibited significant positive SCA effects at the two distances and combined.

Whereas, P_3xP_4 for seed weight and P_2xP_5 for No. of capsules/plant as well as three crosses (P_1 x P_3, P_1 x P_5 and P_3 x P_6) for 1000-seed weight gave significant and positive SCA effects at the combined data and one distance only.

In general, the specific combining ability estimates indicated that there was no cross combination which was consistently good for all characters. Out of the previous crosses, the cross P_5xP_6 showed high SCA effects for seed weight as well as their two parents were low x low general combiner.

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Whereas, the two crosses, P_4xP_5 and P_4xP_6 exhibited high SCA effects for 1000-seed weight and included low x high general combiner parents. Therefore, it could be concluded that the two crosses are suitable in breeding for increasing 1000-seed weight. The simple correlation between cross means (Table 9) and their SCA values (Table 7) was significantly positive for all traits under the two distances and combined, indicate that high performing crosses were high specific combinations parents.

Table (9): Mean performance for seed weight and its components of 21 genotypes (6 parents and 15 F_1 crosses) under two distances (5 and 10 cm) and combined data (C.)

genotype	E1	E2	C.	E1	E2	C.	E1	E2	C.	E1	E2	C.
Parents	Seed weight/plant (g)			No. of capsules/plant			1000-seed weight (g)			No. of seeds/capsule		
P1	1.84	3.55	2.69	31.07	60.67	45.87	7.44	8.92	8.18	6.71	7.00	6.85
P2	2.02	3.10	2.56	39.93	55.73	47.83	8.39	9.24	8.81	6.52	5.74	6.13
P3	3.10	7.08	5.09	53.10	125.87	89.48	9.52	9.83	9.67	6.03	5.63	5.83
P4	1.83	3.13	2.48	35.93	75.67	55.80	8.01	8.27	8.14	4.73	4.66	4.70
P5	2.54	3.92	3.23	59.87	80.07	69.97	6.78	6.68	6.73	6.71	6.15	6.43
P6	0.92	2.25	1.59	29.13	71.47	50.30	5.86	6.06	5.96	7.42	6.01	6.72
Mean	2.04	3.84	2.94	41.51	78.24	59.88	7.67	8.17	7.92	6.35	5.87	6.11
Crosses												
P1xP2	1.97	3.93	2.95	35.80	70.20	53.00	8.49	8.84	8.67	6.25	5.99	6.12
P1xP3	1.95	3.99	2.97	37.73	60.47	49.10	9.45	9.67	9.56	6.04	5.61	5.83
P1xP4	1.88	3.19	2.54	35.00	59.20	47.10	8.93	9.38	9.16	6.25	5.78	6.02
P1xP5	2.47	3.66	3.07	50.33	75.93	63.13	8.27	8.40	8.34	5.98	5.94	5.96
P1xP6	1.57	2.78	2.18	38.07	65.80	51.93	5.92	6.41	6.16	5.95	5.87	5.91
P2xP3	2.18	3.25	2.72	42.07	65.00	53.53	8.15	8.57	8.36	6.09	5.80	5.95
P2xP4	2.25	3.76	3.00	41.17	62.17	51.67	8.97	9.12	9.05	6.29	5.57	5.93
P2xP5	2.53	3.76	3.15	61.20	82.67	71.93	7.66	7.79	7.73	5.34	5.36	5.35
P2xP6	2.33	3.63	2.98	40.70	75.27	57.98	7.39	7.57	7.48	6.26	6.55	6.40
P3xP4	2.57	14.86	8.71	54.73	99.17	76.95	9.35	9.29	9.32	6.25	5.26	5.76
P3xP5	2.71	4.07	3.39	56.80	111.27	84.03	7.75	8.65	8.20	5.41	4.79	5.10
P3xP6	3.00	6.99	4.99	49.47	95.67	72.57	8.19	8.69	8.44	6.48	6.56	6.52
P4xP5	2.26	4.63	3.45	47.07	93.40	70.23	9.48	9.61	9.55	5.32	5.21	5.27
P4xP6	2.11	4.23	3.17	42.33	74.20	58.27	8.76	8.49	8.63	6.64	6.14	6.39
P5xP6	2.81	8.53	5.67	47.07	93.40	70.23	6.67	6.87	6.77	6.34	5.57	5.96
Mean	2.31	5.02	3.66	45.30	78.92	62.11	8.23	8.49	8.36	6.06	5.73	5.90
LSD5%=	0.49	1.30	0.99	8.30	9.11	8.71	0.56	0.48	0.52	0.45	0.60	0.53

 # P1 (Sakha 1), P2 (Giza 7) , P3 (S.2419/1), P4 (S. 16), P5 (S. 22) and P6 (Sakha 3)

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تحليل الهجن التبادلية لمحصولي القش والبذور ومكوناتهما في الكتان

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أجريت هذه الدراسة بهدف تقدير القدرة علي الائتلاف والفعل الجيني لمحصولي القش والبذرة للنبات ومكوناتهما في الكتان تحت مسافتي زراعة (٥, ١٠ سم) من خلال تقييم ١٥ هجين ناتجة من التهجين بين ستة أباء (١= سخا١، ٢= جيزة ٧، ٣= س١/٢٤١٩، ٤=س١٦ ، ٥ = س٢٢، ٦= سخا٣) باستعمال نظام الهجن التبادلية. في موسم ٢٠٠٩ /٢٠١٠ تم تقييم الـ٦ آباء مع ١٥ هجين في الجيل الأول في تجربة قطاعات كاملة العشوائية ذات ثلاثة مكررات.

وتشير النتائج إلى أن تأثير العوامل الوراثية المضيفة كان أكثر أهمية من غير المضيفة في توريث الثماني صفات تحت الدراسة مما يعكس أن المتحكم في توريث هذه الصفات فعل الجين المضيف. بينما كان تأثر فعل الجين الغير المضيف بمسافتي الزراعة أكثر من المضيف لصفات عدد الأفرع القاعدية ووزن الألف بذرة وعدد البذور بالكبسولة. وعلى العكس من ذلك فعل الجين المضيف تأثر بمسافتي الزراعة عن غير المضيف لصفات وزن القش ووزن البذور وعدد الكبسولات بالنبات.

أظهرت السلالة ١/٢٤١٩ معنوية موجبة لتأثير القدرة العامة على الائتلاف لصفات وزن القش وعدد الأفرع القاعدية ووزن البذور وعدد الكبسولات بالنبات ووزن الألف بذرة. لذلك إدخال تلك السلالة في برنامج التهجينات يمكن أن ينتج منه فيما بعد انعزالات مرغوبة لتلك الصفات.

بالنسبة لصفات القش أظهر هجينا ن تفوقًا في القدرة الخاصة على الائتلاف وكان أبويهما (عالي × عالي) بالنسبة للقدرة العامة على الائتلاف، الهجين الأول (سخا١ × جيزة ٧) لصفة الطول الكلي والهجين الثاني (جيزة٧ × س١/٢٤١٩) لصفة الطول الفعال. أيضًا الهجين س١/٢٤١٩ × سخا٣ (عالي × منخفض) تفوق في القدرة الخاصة على الائتلاف لصفة وزن القش للنبات. أما بالنسبة لصفات محصول البذور تفوق الهجينان (س١٦ × س٢٢)، (س١٦ × سخا٣) في القدرة الخاصة على الائتلاف في صفة وزن الألف بذرة وكانت آباؤهم (عالي × منخفض) بالنسبة للقدرة العامة على الائتلاف. لذلك تعتبر الهجن السابقة واعدة في برامج التربية لزيادة وتحسين الصفات سالفة الذكر.

قام بتحكيم البحث

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Table (4): Estimates of specific combining ability (ŝij) for straw weight and its components of 15 F1 crosses under two distances (5 and 10 cm) and combined data (C.)

Parents	E1	E2	C.	E1	E2	C.	E1	E2	C.	E1	E2	C.
	Straw weight/plant (g)			Plant height/plant (cm)			Technical stem length/plant (cm)			Number of basal branches/plant		
P1xP2	0.042 ns	1.171 ns	0.607 ns	1.906 ns	4.235 **	3.071 *	3.489 *	-2.393 ns	0.548 ns	-0.194 ns	0.039 ns	-0.078 ns
P1xP3	1.510 **	0.952 ns	1.231 *	-0.227 ns	1.868 ns	0.821 ns	-1.820 ns	-1.164 ns	-1.492 ns	-0.294 *	-0.665 **	-0.480 **
P1xP4	-0.368 ns	-1.575 *	-0.971 ns	-1.711 ns	-5.294 **	-3.502 **	5.010 **	2.948 ns	3.979 *	0.023 ns	-0.215 ns	-0.096 ns
P1xP5	1.431 **	0.217 ns	0.824 ns	2.156 ns	3.877 **	3.016 *	-0.449 ns	1.494 ns	0.523 ns	0.098 ns	-0.007 ns	0.045 ns
P1xP6	2.481 **	2.852 **	2.666 **	1.748 ns	7.185 **	4.466 **	3.285 *	6.061 **	4.673 **	0.473 **	0.614 **	0.543 **
P2xP3	0.307 ns	-0.468 ns	-0.081 ns	0.548 ns	2.373 ns	1.460 ns	2.760 ns	5.848 *	4.304 *	-0.036 ns	-0.678 **	-0.357 *
P2xP4	1.109 **	2.154 **	1.632 **	5.798 **	0.177 ns	2.987 *	0.689 ns	0.527 ns	0.608 ns	0.348 **	0.105 ns	0.226 ns
P2xP5	0.901 *	1.756 *	1.329 *	-0.002 ns	3.314 *	1.656 ns	1.664 ns	0.440 ns	1.052 ns	0.089 ns	0.647 **	0.368 *
P2xP6	0.981 *	0.841 ns	0.911 ns	-1.877 ns	4.956 **	1.539 ns	2.730 ns	1.940 ns	2.335 ns	-0.069 ns	-0.299 ns	-0.184 ns
P3xP4	-0.093 ns	-0.057 ns	-0.075 ns	-0.269 ns	-0.857 ns	-0.563 ns	-6.553 **	-4.743 *	-5.648 **	-0.486 **	0.135 ns	-0.176 ns
P3xP5	-1.051 **	3.758 **	1.354 *	0.931 ns	2.081 ns	1.506 ns	17.889 **	2.536 ns	10.212 **	-0.344 **	-0.124 ns	-0.234 ns
P3xP6	0.476 ns	2.302 **	1.389 *	7.923 **	1.923 ns	4.923 **	0.022 ns	-3.164 ns	-1.571 ns	-0.036 ns	0.097 ns	0.031 ns
P4xP5	-0.046 ns	-0.566 ns	-0.306 ns	2.181 ns	1.785 ns	1.983 ns	2.118 ns	4.382 ns	3.250 ns	-0.094 ns	-0.074 ns	-0.084 ns
P4xP6	0.674 ns	-0.995 ns	-0.160 ns	-1.161 ns	-3.307 ns	-2.234 ns	2.785 ns	-3.852 ns	-0.534 ns	-0.119 ns	-0.186 ns	-0.153 ns
P5xP6	-0.444 ns	0.670 ns	0.113 ns	10.106 **	3.831 **	6.968 **	3.193 *	1.294 ns	2.243 ns	-0.111 ns	-0.045 ns	-0.078 ns
LSD 5%	1.059	2.001	1.371	3.983	3.614	3.260	3.821	6.144	4.385	0.318	0.517	0.367
(Sij-Sik)1%	1.417	2.677	1.817	5.329	4.835	4.319	5.113	8.220	5.810	0.426	0.692	0.487
r	0.694 **	0.810 **	0.690 **	0.493 *	0.470	0.280	0.798 **	0.490 *	0.550 *	0.831 **	0.670 **	0.650 **

 # P1 (Sakha 1), P2 (Giza 7) , P3 (S.2419/1), P4 (S. 16), P5 (S. 22) and P6 (Sakha 3)
ns,*, non- significant, significant at 0.05 and 0.01 levels of probability, respectively..**
r #: Simple correlation coefficients between SCA values and means of crosses.

Table (7): Estimates of specific combining ability (ŝij) for seed weight and its components of 15 F1 crosses under two distances (5 and 10 cm) and combined data (C.)

Parents	E1	E2	C.	E1	E2	C.	E1	E2	C.	E1	E2	C.
	Seed weight/plant (g)			No. of capsules/plant			1000-seed weight (g)			No. of seeds/capsule		
P1xP2	0.044 ns	1.295 *	0.670 ns	-1.020 ns	14.283 **	6.631 ns	0.368 ns	0.027 ns	0.197 ns	-0.036 ns	-0.179 ns	-0.107 ns
P1xP3	-0.395 ns	-1.498 *	-0.946 *	-4.862 ns	-22.517 **	-13.690 **	0.766 **	0.333 ns	0.549 *	-0.126 ns	-0.369 ns	-0.248 ns
P1xP4	0.022 ns	-0.997 ns	-0.488 ns	-0.741 ns	-5.805 ns	-3.273 ns	0.299 ns	0.309 ns	0.304 ns	0.344 ns	0.053 ns	0.199 ns
P1xP5	0.223 ns	0.029 ns	0.126 ns	3.338 ns	1.262 ns	2.300 ns	0.657 *	0.299 ns	0.478 *	-0.125 ns	-0.024 ns	-0.074 ns
P1xP6	-0.154 ns	-0.622 ns	-0.388 ns	4.359 ns	-0.180 ns	2.090 ns	-1.103 **	-1.132 **	-1.117 **	-0.744 **	-0.543 ns	-0.644 **
P2xP3	-0.384 ns	-2.216 **	-1.300 **	-5.745 ns	-19.713 **	-12.729 **	-0.717 **	-0.745 **	-0.731 **	-0.006 ns	0.125 ns	0.060 ns
P2xP4	0.166 ns	-0.415 ns	-0.124 ns	0.209 ns	-4.567 ns	-2.179 ns	0.153 ns	0.070 ns	0.112 ns	0.465 *	0.148 ns	0.306 ns
P2xP5	0.058 ns	0.144 ns	0.101 ns	8.988 *	6.266 ns	7.627 *	-0.145 ns	-0.289 ns	-0.217 ns	-0.684 **	-0.300 ns	-0.492 *
P2xP6	0.384 ns	0.237 ns	0.311 ns	1.776 ns	7.558 ns	4.667 ns	0.178 ns	0.053 ns	0.116 ns	-0.354 ns	0.441 ns	0.044 ns
P3xP4	0.074 ns	7.839 **	3.956 **	8.001 *	5.366 ns	6.683 ns	-0.025 ns	-0.284 ns	-0.155 ns	0.541 *	0.014 ns	0.277 ns
P3xP5	-0.175 ns	-2.399 **	-1.287 **	-1.187 ns	7.799 ns	3.306 ns	-0.617 *	0.046 ns	-0.285 ns	-0.505 *	-0.687 *	-0.596 **
P3xP6	0.641 **	0.751 ns	0.696 ns	4.767 ns	0.891 ns	2.829 ns	0.417 ns	0.655 **	0.536 *	-0.018 ns	0.641 *	0.312 ns
P4xP5	-0.141 ns	-0.535 ns	-0.338 ns	-4.066 ns	7.912 ns	1.923 ns	1.169 **	1.269 **	1.219 **	-0.324 ns	-0.021 ns	-0.172 ns
P4xP6	0.232 ns	-0.705 ns	-0.237 ns	4.488 ns	-2.596 ns	0.946 ns	1.043 **	0.714 **	0.878 **	0.403 ns	0.467 ns	0.435 ns
P5xP6	0.543 *	4.147 **	2.345 **	-2.033 ns	6.937 ns	2.452 ns	-0.032 ns	0.064 ns	0.016 ns	-0.089 ns	-0.334 ns	-0.212 ns
LSD 5%	0.618	1.633	1.057	10.376	11.390	9.337	0.696	0.598	0.555	0.560	0.756	0.571
(Sij-Sik)1%	0.827	2.185	1.400	13.882	15.240	12.372	0.931	0.800	0.736	0.749	1.011	0.756
r	0.586 *	0.910 **	0.890 **	0.497 *	0.590 *	0.560 *	0.682 **	0.560 *	0.620 **	0.687 **	0.710 **	0.650 **

 # P1 (Sakha 1), P2 (Giza 7) , P3 (S.2419/1), P4 (S. 16), P5 (S. 22) and P6 (Sakha 3)
ns,*, non- significant, significant at 0.05 and 0.01 levels of probability, respectively..**
r #: Simple correlation coefficients between SCA values and means of crosses.

Table 8: Mean performance for straw weight and its components of 21 genotypes (6 parents and their 15 F_1 crosses) under two distances (5 and 10 cm) and combined data (C.)

genotype	E1	E2	C.	E1	E2	C.	E1	E2	C.	E1	E2	C.
Parents	**Straw weight/plant (g)**			**Plant height/plant (cm)**			**Technical stem length/plant (cm)**			**Number of basal branches/plant**		
P1	4.70	9.57	7.14	108.07	102.93	105.50	73.93	74.33	74.13	1.67	2.27	1.97
P2	6.05	8.95	7.50	106.33	104.87	105.60	75.07	78.33	76.70	1.67	2.13	1.90
P3	9.43	12.06	10.75	102.67	102.77	102.72	81.07	77.53	79.30	2.80	4.07	3.43
P4	7.01	15.04	11.02	104.47	107.47	105.97	78.47	75.20	76.83	1.73	2.53	2.13
P5	6.61	9.07	7.84	84.27	81.00	82.63	57.73	54.27	56.00	2.00	2.07	2.03
P6	4.21	9.21	6.71	96.00	92.67	94.33	73.00	72.53	72.77	1.53	2.27	1.90
Mean	6.34	10.65	8.49	100.30	98.62	99.46	73.21	72.03	72.62	1.90	2.56	2.23
Crosses												
P1xP2	7.53	12.70	10.11	111.67	114.87	113.27	83.20	77.27	80.23	1.53	2.13	1.83
P1xP3	10.14	14.29	12.22	108.33	109.53	108.93	81.13	76.33	78.73	1.67	2.13	1.90
P1xP4	7.08	11.37	9.23	106.73	101.00	103.87	84.60	79.27	81.93	1.67	2.07	1.87
P1xP5	8.56	11.90	10.23	103.13	102.53	102.83	73.87	70.07	71.97	1.87	2.20	2.03
P1xP6	9.25	14.56	11.91	108.93	111.60	110.27	82.13	81.80	81.97	2.13	2.87	2.50
P2xP3	9.17	13.02	11.10	108.87	111.80	110.33	86.73	85.20	85.97	1.93	2.07	2.00
P2xP4	8.79	15.25	12.02	114.00	108.23	111.12	81.30	78.70	80.00	2.00	2.33	2.17
P2xP5	8.26	13.59	10.93	100.73	103.73	102.23	77.00	70.87	73.93	1.87	2.80	2.33
P2xP6	7.99	12.70	10.35	105.07	111.13	108.10	82.60	79.53	81.07	1.60	1.90	1.75
P3xP4	8.73	14.86	11.80	106.73	104.23	105.48	77.30	71.27	74.28	1.40	3.07	2.23
P3xP5	7.46	17.41	12.43	100.47	99.53	100.00	96.47	70.80	83.63	1.67	2.73	2.20
P3xP6	8.63	15.98	12.30	113.67	105.13	109.40	83.13	72.27	77.70	1.87	3.00	2.43
P4xP5	7.28	12.69	9.99	101.60	97.87	99.73	77.33	71.47	74.40	1.60	2.27	1.93
P4xP6	7.64	12.29	9.97	104.47	98.53	101.50	82.53	70.40	76.47	1.47	2.20	1.83
P5xP6	6.21	12.69	9.45	108.27	98.03	103.15	77.67	67.80	72.73	1.60	2.27	1.93
Mean	**8.18**	**13.69**	**10.93**	**106.84**	**105.18**	**106.01**	**81.80**	**74.87**	**78.33**	**1.72**	**2.40**	**2.06**
LSD5%=	**0.85**	**1.60**	**1.28**	**3.19**	**2.89**	**3.04**	**3.06**	**4.92**	**4.09**	**0.26**	**0.41**	**0.34**

 # P1 (Sakha 1), P2 (Giza 7) , P3 (S.2419/1), P4 (S. 16), P5 (S. 22) and P6 (Sakha 3)