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Combining Ability and Heterosis for Earliness, Growth and Biological Yield of Some Flax Genotypes at Normal-irrigation and Water-Shortage Environments

Cross Mark

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ABSTRACT

Six parents and their 15 F_1 crosses were evaluated in 2019/2020 season under normal and drought-stress for earliness and its related traits of flax. A filed experiment was devoted for each normal and drought-stress), using RCBD with three replicates. Mean squares of general and specific combining abilities were highly significant for most traits, indicating the relative importance of both additive and non-additive influences of genes in the inheritance of these traits. δ^2GCA δ^2/SCA variances under normal-irrigation and drought-stress were greater than unity for days to maturity, plant height at harvest and stem diameter. P_1 was found to be the best combiner for earliness under both conditions. While, P_4 and P_5 were good combiner for plant height at flowering and at harvest and biological yield under drought conditions. The best heterosis (mid and better parent) for the earliest hybrids was recorded by hybrid No. 11 under normal and hybrid No. 7 under drought. Hybrids No. 6 over mid-parents and No. 11 over better-parents under drought for days to maturity shown the best heterosis. While, hybrids No. 8 and 10 recorded the best heterosis for plant height at flowering under both situations. But, the best heterosis were recorded by hybrids No. 2 and 8 for plant height at harvest and hybrids No.7 and 13 for technical stem length shown under normal irrigation conditions. The hybrids No. 4 and 9 for biological yield per plant showed the best heterosis over mid and better parents under normal and drought conditions, respectively.

Keywords: Flax; Combining ability; Heterosis; earliness; growth; biological yield

INTRODUCTION

Flax (*Linum usitatissimum* L.) considers the most important bast fiber crop in Egypt since several thousand years ago. Flax is cultivated in Egypt for dual 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. Selection of parents for crossing is deemed a vital step in any plant breeding program aimed at enhancing yield and its correlated components. Combining ability analysis is an essential tool for the choice of appropriate 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 imperative to precisely guess the greatness and relation quantity of the numerous components of genetic variance to escalate the primary type of gene action that gearshifts the trait of interest, for case, general combining ability variance is a quantity of additive effects of genes and of additive x additive epistatic interaction, while specific combining ability variance is a quantity of dominance and epistatic types of gene action. Several investigators investigated the combining ability in flax, Sedhom *et al.* (2016), El-Refaie, Amena and Hussein (2017), Kumar *et al.* (2017), Naik (2017) and Nirala *et al.* (2018) who noticed that additive genetic variance had more critical role in the inheritance of straw-yield, height of plant, technical length of stem and weight of 1000-seed.

Drought stress is one of the most essential environmental stresses limiting growth and production of plants. Drought can significantly affect plant presentation and survival and can lead to main constraints in plant operative, counting a series of morphological, physiological and metabolic changes (Nematallahi and Saeidi, 2011). Drought affects photosynthesis directly and indirectly and accordingly arid matter production, and its allocation to numerous plant organs (Kariuki *et al*., 2016). Drought stress also decreases leaf expansion and production, and stimulates senescence and abscission.

The commercial exploitation of heterosis led to the remarkable yield advances in numerous cross cross-fertilized crops. In self-pollinated crops, it is now well recognized that heterosis is very beneficial increasing production. The greatness of heterosis provides a basis for genetic diversity and guideline to the choice of desirable parents for increasing superior F1 hybrids so as to exploit hybrid vigor and for structure gene pool to be exploitation in population improvement. In the present studies heterosis (mid-parent and better parent) was estimated for seed yield and some important agronomic traits in F1 generation of linseed genotypes using diallel model suggested by Kempthorne (1961). Kandil *et al.* (2011) raported that parents vs crosses were significant for most characters, indicating the heterotic effects. Significant positive heterosis over mid-Parents, better parent and commercial cultivars were observed for seed yield/fed, number of apical branches/plant and number of capsules/plant. The crosses exhibited heterosis for seed yield also showed significant heterosis for most yield components characters.

Flax cultivars significantly varied in their agronomic characters (ElKady, Eman and Abd El-Fatah, 2009; El-Kady,

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Eman and Abo-Kaied, 2010; El-Refaie, Amena and Hussein, 2012 and Hussein *et al*., 2015). Significant necessary (negative or positive) heterosis evaluations over mid and better parent were detected in earliness, yield and yield components in numerous cross combinations of linseed (Pant and Mishra, 2008 and Reddy *et al*., 2013). Mohammadi *et al*. (2010) found that a significant heterosis was also detected for the calculated traits in some cross combinations and the maximum heterobeltiosis values of 64.1, 35.2, 21.6, 77.2 and 91.3% were found for numeral of capsules per plant, numeral of seeds per capsule, weight of 1000-seed, seed yield per plant and straw yield, respectively. Therefore, the major objectives of the present study were to: Estimate the amount of both general and specific combining ability, and the potentiality of heterosis expression under normal irrigation and drought stress conditions with a final aim of selecting suitable parents and the higher crosses.

MATERIALS AND METHODS

Six flax genotypes were chosen (as parents) based on their diversity in some agronomic traits to achieve this study, i.e. two local cultivars (Sakha 6 and Giza 11), one introduced cultivar (Southana) and three new strains (402/1, 402/21/19/10 and 806/75/9). Seeds of the genotypes were obtained from Fiber Crops Research Section, Field Crops Research Institute, Agriculture Research Center (ARC), and Giza. Genotype characteristics of the material used according to their names, type, pedigree and origin of the parental genotypes are obtainable in Table 1.

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

Name	Type	Pedigree	Origin
Sakha 6	Dual	Giza 8 x S. 2419/1	Local c.v.
Giza 11	Dual	Giza 8 x S. 2419/1	Local c.v.
Southana	Fiber	Introduced from France	France
402/1	Oil	Giza 5x I 235	USA
402/21/19/10	Dual	Giza 5 x I 235	USA
806/75/9	Fiber	S. 485/93/1016 x S. 533	ARC

In (2018/19) season, all possible diallel crosses (except reciprocals) were made among six parents, were sowing in two sowing dates, so seeds of 15 direct F1 crosses were obtained. Two field experiments were carried out in season in (2019/2020) at the AgriculturalExperiment and Research Station of the Faculty of Agriculture, Mansoura Univ., Mansoura. Each experiment included 21 genotypes (15 F1 crosses and their six parents). The first experiment was done under well irrigation by giving all required irrigations, but the second experiment was done under deficit irrigation. A randomized complete blocks design with three replications was used in each experiment.

Each experimental plot consisted of one row of 3 m lengthy move apart 20 cm. Single seeds were hand drilled at 5 cm spacing within row. All other cultural applies were applied as suggested for flax farming. At harvest, individual surrounded by plants were taken at random from each row; 10 plants from each parent and F_1 cross per replication for record the characters.

Studied traits:

Days to flowering (days), days to maturity (days), plant height at begging of flowering (cm), plant height at harvest (cm), Basle stem diameter (mm), stem diameter (mm), capsule diameter (mm), technical stem length (cm) and biological yield/plant (g).

Biometrical and Genetic Analyses:

Analysis of difference of the RCBD was achieved on the basis of single plot observation using Costat software program, Version 6.303 (2004). Least significant differences (LSD) values were calculated to test the significance of differences between means according to Steel and Torrie (1980). Diallel crosses were examined to achieve general (GCA) and specific (SCA) combining ability variances and effects for studied traits according to Griffing (1956) Model I (fixed effect) Method 2.

Heterosis estimates

Heterosis calculated as deviation of F_1 mean from each of the mid-parents and better parent values, and expressed in ratio according to the following formulae given by Bhatt (1971):

Mid-parents heterosis (%) = (F_1- M.P / M.P) x100

Better parent heterosis (Heterobltiosis) (%) = (F_1 – B.P / B.P) x100

Where:

F_1 = the mean of the F_1 hybrid, M.P. = the mean of the mid parents and B.P. = the mean of the better parent.

RESULTS AND DISCUSSION

1. Analysis of combining ability variances:

Estimates of variances due to general (GCA) and specific (SCA) combining ability of the diallel crosses of Flax for 6 parents under normal and drought stress conditions are obtainable in Table 2. Mean squares of general combining ability were statistically or highly statistically for most characters under normal and drought stress environments, as presented in Table 2. In this connection, general combining ability was significant or highly significant for all studied traits under normal conditions. Also, general combining ability were significant or highly significant for all studied traits under drought stress conditions, except days to maturity, plant tallness at flowering, technical stem length and stem diameter. The significance of GCA and SCA indicate the attendance of both additive and non-additive types of genes in the genetic system controlling these traits.

The available results reported that GCA was mean square were greater than those of SCA for some traits under the investigated as illustrated in Table 2. It could be noticed that the GCA mean square was higher than those of SCA for days to maturity, plant height at harvest, basle stem diameter, stem diameter, capsule diameter and biological yield at harvest. This means that these traits are mainly controlled by additive gene action. Therefore, it might be established that selection procedures based on the accumulation of additive effect would be more effective in the early segregated generation. These results are in general agreement with those reported by Mohamed, Magda (2004), Naik (2017) and Nirala *et* al. (2018). In contrast, the SCA mean square was higher than those of GCA for days to flowering, plant height at the begging of flowering and technical stem length Table 2 under normal conditions. The found results shown that the percentage of GCA/SCA were more than unity for days to maturity, plant height at harvest, biological yield. In this connection, the results showed that the ratio of GCA/SCA were more than unity for days to flowering, days to maturity, basle stem diameter and biological yield under drought stress conditions.

Table 2. Mean squares estimates of general combining ability (GCA) and specific combining ability (SCA) and their percentage for earliness characters under normal and drought stress conditions.

S.O.V	d.f	Mean squares					
		Normal	Drought	Normal	Drought	Normal	Drought
		Days to flowering		Days to maturity		Plant height at begging to flowering	
GCA	5	38.88**	65.25**	85.40**	2.62	23.72**	31.79
SCA	15	63.81**	56.49**	63.53**	2.63	44.97**	68.36**
Error	40	6.21	10.16	2.71	2.55	4.01	14.39
GCA/SCA	-	0.66	1.38	1.4	31.08	0.57	0.56
		Plant height at harvest		Effective length		Crown diameter(mm)	
GCA	5	57.72**	36.59**	12.68*	9.76	12.64**	10.26**
SCA	15	23.31**	88.44**	36.09**	54.68**	25.06**	11.45**
Error	40	9.17	13.62	5.01	8.71	2.19	3.77
GCA/SCA	-	4	0.47	0.39	0.19	4.33	1.28
		Stem diameter		Capsule diameter		Biological yield/plant	
GCA	5	0.33*	0.17	0.30**	0.28**	159.68 **	50.37**
SCA	15	0.31**	0.37**	0.18**	0.42**	68.61**	45.98**
Error	40	0.1	0.12	0.07	0.05	5.83	8.88
GCA/SCA	-	1.51	0.62	2.63	0.74	2.53	1.33

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

In this regard, El-Farouk *et al.* (1998) establish that the mean squares of variances due to general and specific combining ability were significant for straw yield, plant height and technical stem length. Khan *et al.* (1999), Popescu *et al*. (1999), Mohammadi *et al*. (2010), Abdel-Moneam (2014), Pali and Mehta (2014), Amein (2016), Kumar *et al.* (2016), Singh *et al*. (2016), Kumar *et al.* (2017) and Nirala *et al.* (2018) found that both general and specific combining ability variances were significant for all or some seed yield and its components in flax. On the other side, El-Farouk *et al.* (1998) showed that the higher magnitude of variance due to general combining ability for straw yield, plant tallness and technical stem length was predominantly influenced by additive gene effects. Khan *et al.* (1999) reported that the ratio of GCA/SCA effects obtained were higher than unity for seed yield per plant and plant height, while were less than unity for number of capsules per plant, number of seeds per capsule, and 1000-seed weight. Therefore, additive genetic variance was more important for seed yield per plant and plant height, whereas non-additive for others.

However, number of capsules/plant and number of seeds/ capsule were largely controlled by dominance genetic effects, whereas both additive and non-additive gene actions were important in genetic control of seed yield/plant. Abdel-Moneam (2014) stated that the GCA/SCA ratio was more than unity for plant height and technical stem length.

General combining ability (GCA) effects:

Earliness characters:

Estimates of general combining ability (GCA) effects of parental genotypes for days to flowering and days to maturity are recorded in Table 3. Results indicate that (P_1) Sakha 6 variety showed highly significant negative general combining ability values under normal and water stress conditions for both days to flowering and days to maturity, indicating that this parent P_1 (Sakha 6) was the best general combiners for earliness traits. Contrarily, the rest parents showed significant or highly significant positive (GCA) effects. Therefore, the parents behaved as the poor general combiners for days to flowering and days to maturity.

Growth characters:

Evaluations of general combining ability effects of all the parental genotypes for growth traits under normal and water stress conditions are obtainable in Tables 3. Data showed that the parents P_4 and P_6 exhibited was significant or highly significant and positive GCA effects for plant height at the begging of flowering under normal conditions indicating at these patents are the best general combiners for plant height (tallness). On the other side, P_1 and P_5 recorded highly significant and negative GCA effects under normal irrigation conditions, showing that these parents are the greatest general combiner for shortness of plant. Also, the parents P_2 and P_3 under normal and P_4 under drought showed significant or highly significant and positive GCA effects for plant height at harvest meaning that these parents are the best general combiner for tallness at harvest.

In this regard, significant positive GCA values would be the best combiner for technical stem length, basle stem diameter, stem diameter and capsule diameter. Data indicated that the parent P_6 (806\75\9) showed significant and positive GCA effects for technical stem length under normal conditions. While, parent P_5 (402\ 21\19\10) exhibited highly significant and positive GCA effects for basle stem diameter under normal conditions. On the other side, parent P_3 and P_6 showed significant or highly significant and positive GCA effects for stem diameter under normal conditions. Also, parent P_3 under drought and P_5 under both environments presented significant or highly significant and positive GCA effects for capsule diameter. Results also, indicate that parent P_5 (402\ 21\19\10) showed highly significant positive general combining ability effects for biological yield. These results are in general agreement with those recorded by Rastogi and Shukla (2019) and Wadikar *et al*. (2019).

Specific combining ability (SCA) effects:

Earliness characters:

The evaluations of specific combining ability effects of F_1 crosses were calculated for all traits under normal and water stress conditions are obtainable in Table 4. Significant negative SCA values would be the best for days to flowering and days to maturity. Results show that out of 15 crosses, there were 7 crosses under normal and 5 crosses under drought stresses showed significant or highly significant and negative SCA effects for days to flowering. Crosses namely P_1xP_2, P_1xP_5, P_2xP_4 and P_3xP_5 were the best crosses combinations under both conditions for days to flowering. With respected to days to maturity, results in Table 5 indicated that there were only four crosses under normal irrigation and three crosses under drought conditions exhibited negative and significant SCA effects. These crosses namely P_1xP_3, P_1xP_6, P_2xP_5 and P_5xP_6 under normal conditions, P_2xP_3, P_2xP_4 and P_3xP_5 under drought stresses, so these crosses are the best crosses combinations for days to maturity (earliness). These results are in good harmony with those of Kumar *et al.* (2016).

Growth characters:

The assessments of specific combining ability effects of F_1 crosses were calculated for all traits under normal and water stress conditions are obtainable in Tables 4. Significant or highly significant positive SCA values would be the finest for plant height at begging of flowering and plant height at harvest. Results indicate six and five crosses showed significant or highly significant positive specific combining ability values for plant height at begging of flowering under irrigation and stress conditions, respectively. The best crosses combinations for these traits were P_2xP_5, P_3xP_4 and P_4xP_5 under both conditions. Regarding plant height at harvest, results in Table 18 showed that five crosses under normal irrigation and four crosses under drought noted significant or highly significant and positive SCA effects for these traits, and the best crosses combinations were P_3xP_5 and P_4xP_6 under both combinations, P_1xP_3, P_1xP_6 and P_2xP_5 under normal irrigation, P_1xP_5 and P_3xP_4 under drought stresses conditions.

For technical stem length, out of 15 F1 crosses there were five crosses namely P_1xP_3, P_1xP_6, P_2xP_4, P_2xP_5 and P_4xP_5 under normal irrigation, and two crosses namely, P_1xP_2 and P_1xP_5 under drought revealed positive and significant or highly significant SCA effects, showing that these crosses are the best crosses combinations for increasing the effective length of flax plant, as shown in Table 4. With respected to basle stem diameter traits, results in Table 3 revealed that three or four crosses revealed positive and significant or highly significant SCA effects under irrigation or stress conditions, respectively. These crosses namely P_1xP_3, P_1xP_5 and P_1xP_6 under normal irrigation, P_2xP_3, P_2xP_5, P_3xP_5 and P_4xP_6 under drought stress conditions, indicating that these crosses are the best crosses combination for increasing the crown diameter of flax plant and there for increasing the resistance to lodging of plants.

The estimates of specific combining ability effects of F_1 crosses were computed for stem diameter under irrigation and stress conditions are presented in Table 4. Significant or highly significant positive SCA values would be the best for stem diameter. Results indicate three and five crosses showed significant or highly significant positive specific combining ability values for stem diameter under irrigation and stress conditions, respectively. The best crosses combinations for these traits were P_1xP_5, P_3xP_5 and P_3xP_6 under normal irrigation, and five crosses namely; P_1xP_2, P_1xP_3, P_1xP_4, P_1xP_5 and P_4xP_6 under drought conditions. In this connection to capsule diameter trait, results in Table 18 revealed that four crosses showed positive and significant or highly significant SCA effects under normal or drought conditions, respectively. These crosses namely P_1xP_6, P_2xP_5, P_3xP_4 and P_4xP_5 under normal irrigation, P_1xP_2, P_1xP_3, P_1xP_4 and P_1xP_5 under drought stress conditions, indicating that these crosses are the best crosses combination for increasing the capsule diameter of flax plant. The results of the present investigation are in trend with those obtained by Kariuki *et al*. (2016) and El-Refaie, Amany and Hussein (2017).

B- Heterosis estimates:

Matching to the phenomenon of inbreeding depression is its opposed, "hybrid vigor" or heterosis. When inbred lines are crossed, their progeny shows a rise of those traits that previously suffered a decrease from inbreeding. Or, in general terms, the ability which was missing by inbreeding depression can be restored by crossing. The quantity of heterosis is the variance between the crossbred and inbred means (Falconer *et al.*, 1996). Flax appearances hybrid vigor when hybridization occurs between pure varieties.

Table 3. Evaluations of general combining ability (GCA) effects for parent genotypes for all studied traits under irrigation and water stress conditions

	Normal	Drought	Normal	Drought	Normal	Drought
	Days to flowering		Days to maturity		Plant height at flowering	
P_1 (Sakha 6)	-3.21**	-3.78**	-2.31 **	-2.55*	-3.38 **	0.53
P2 (Giza 11)	-1.06	-1.65	1.23	-1.18	0.63	0.53
P3 (Southana)	-0.19	1.18	-0.38	0.85	-0.63	0.44
P4 (402\1)	1.94 *	-1.74	-1.66 *	-1.28	5.25 **	-0.22
P5 (402\ 21\19\10)	-0.46	2.14*	1.85 **	2.76*	-3.38 **	-0.56
P6 (806\75\9)	2.98 **	3.85 *	1.28	1.41	1.50 **	-0.72
S.E. GCA (j)	0.80	1.03	0.65	1.22	0.13	0. 52
Parents	Plant height at harvest		Technical stem length		Basle stem **diameter**	
P_1 (Sakha 6)	**3.94-	-3.06*	-0.56	-1.64	-0.25	-2.04**
P2 (Giza 11)	2.07 *	-0.70	1.16	-0.21	-0.44	0.05
P3 (Southana)	2.43 *	1.15	-1.73 *	-0.28	0.16	0.84
P4 (402\1)	-2.76 **	3.37**	-0.82	0.36	-0.56	0.92
P5 (402\ 21\19\10)	0.72	-0.32	0.38	1.78	2.38**	-0.46
P6 (806\75\9)	1.48	-0.45	1.56**	-0.02	-1.28**	0.70
S.E. GCA (j)	0.98	1.19	0.72	0.95	0.48	0.63
Parents	Stem diameter		Capsule diameter		Biological yield at harvest	
P_1 (Sakha 6)	- 0.01	- 0.06	0.06	-0.31**	-0.57	-2.34*
P2 (Giza 11)	- 0.13	-0.15	-0.04	-0.02	-2.63**	0.19
P3 (Southana)	0.36**	- 0.15	0.16	0.22**	-3.23**	2.95**
P4 (402\1)	- 0.09	0.21	- 0.01	-0.03	-3.24**	3.01**
P5 (402\ 21\19\10)	0.09	0.11	0.18*	0.17*	8.36**	-1.20
P6 (806\75\9)	0.21*	0.04	-0.35**	- 0.02	1.31	-2.60**
S.E. GCA (j)	0.10	0.11	0.09	0.07	0.78	0.96

Table 4. Evaluations of specific combining ability (SCA) effects for F_1 crosses for earliness characters under irrigation and stress conditions.

	Normal	Drought	Normal	Drought	Normal	Drought
	Days to flowering		Days to maturity (days)		Plant height at begging to flowering (cm)	
P_1XP_2	-3.51 **	6.79- **	-1.25	0.17-	-3.07 **	2.76-
P_1XP_3	-4.06 **	2.62-	-6.00 **	0.08-	2.13 *	0.55
P_1XP_4	-6.18 **	4.29 **	8.13 **	0.58	-1.42	5.85 **
P_1XP_5	-9.95 **	2.92- *	4.75 **	0.92	-4.60 **	5.64 **
P_1xP_6	-0.22	4.04**	-3.13**	-0.92	3.89**	-11.18
P_2XP_3	1.8	12.58 **	10.00 **	2.08- **	-1.75 *	3.49- *
P_2xP_4	-11.66**	-12.17**	4.13**	-1.42*	-9.47**	-11.45**
P_2XP_5	7.74 **	4.29 **	-2.25 **	1.08-	12.32 **	7.60 **
P_2XP_6	-0.37	4.75 -**	7.88 **	0.92-	-7.49 **	6.97- **
P_3XP_4	12.13 **	6.67 **	5.38 **	1.33-	9.39 **	7.78 **
P_3XP_5	-10.81 **	11.87- **	-1	-1.67*	-4.45 **	8.26- **
P_3XP_6	-2.91 **	9.08 **	9.13 **	0.83-	-6.93 **	1.38-
P_4XP_5	5.40 **	2.04	8.13 **	0.33-	2.24 *	6.30- **
P_4XP_6	7.63 **	2.67	3.25 **	0.17-	9.74 **	9.3
P_5xP_6	7.03**	2.12	-3.13	2.17**	-2.8	9.99**
S.E. SCA $_{(ij)}$	1.0531	1.3468	0.6955	0.6754	0.8467	1.6032
	Plant height at harvest		Technical stem length (cm)		Basle stem diameter (mm)	
P_1XP_2	5.31- **	1.41-	-1.88	7.03**	5.23- **	3.71- **
P_1XP_3	8.08 **	0.49	3.93 **	0.94	1.66 *	0.4
P_1XP_4	2.19	0.85	-1.23	4.71- **	9.70- **	1.64-
P_1XP_5	2.04-	14.54 **	-7.52 **	5.13 **	4.03 **	1.75-
P_1xP_6	4.62**	-9.99**	4.47 **	4.49 -**	4.22 **	0.57
P_2XP_3	0.15	3.04-	1.3	1.49-	4.54- **	2.57**
P_2xP_4	-0.25	-0.84	3.97 **	4.30- **	1.82- **	1.71- *
P_2XP_5	9.44 **	0.68	3.60 **	5.38- **	2.02- **	5.96 **
P_2XP_6	1.21-	1.48	-8.81 **	8.75- **	0.35	3.08- **
P_3XP_4	4.13- **	5.97 **	-2.34 *	1.06-	5.36- **	4.01- **
P_3XP_5	3.17 *	5.05 **	-6.43 **	0.89-	0.49	2.43 **
P_3XP_6	2.47	3.70- *	-8.86 **	2.84- *	0.91-	2.42- **
P_4XP_5	0.12-	2.31- **	7.41 **	0.79	0.08-	0.28
P_4XP_6	2.62 *	3.32 *	0.14	1.68	1.08	4.71 **
P_5xP_6	-7.21**	-24.40**	-3.97 **	14.90 -**	4.98- **	5.29- **
S.E. SCA $_{(ij)}$	0.9772	1.5597	0.9458	1.2472	0.626	0.8208
	Stem diameter (mm)		Capsule diameter (mm)		Biological yield plant $^{-1}$ at harvest (g)	
P_1XP_2	0.40- **	0.49 **	0.03	0.91 **	1.90-	4.84 **
P_1XP_3	0.26	0.54 **	0.24- *	0.55 **	6.62 **	4.50- **
P_1XP_4	0.03-	1.08 **	0.18-	0.30 **	0.41	10.52 **
P_1XP_5	0.86 **	0.48 **	0.21	1.11 **	3.21 **	10.98 **
P_1xP_6	0.14-	0.23-	0.48 **	0.07	2.09 *	-4.87 **
P_2XP_3	0.26	0.06	0.09	-0.46**	0.24-	-4.53**
P_2xP_4	0.30- *	0.03-	0.44- **	0.52- **	0.23	1.01-
P_2XP_5	0.09	0.32 *	0.42**	0.1	2.11 *	7.95 **
P_2XP_6	0.05-	0.53 **	0.07-	0.14-	14.83 **	2.3
P_3XP_4	0.44- **	0.13-	0.55 **	0.06	16.65- **	1.68-
P_3XP_5	0.77 **	0.22-	0.13	0.52- **	5.02 **	3.44- **
P_3XP_6	0.36 *	0.03-	0.92- **	0.34- **	2.77 **	5.23 **
P_4XP_5	0.04-	0.16-	0.41 **	0.14	3.98 **	-6.70**
P_4XP_6	0.16-	0.61 **	0.13	0.34- **	7.42 **	3.37 *
P_5xP_6	1.19- **	-0.53**	0.51- **	0.35- **	15.35- **	8.98- **
S.E. SCA $_{(ij)}$	0.1335	0.1433	0.1138	0.0939	1.0201	1.2593

Earliness characters:

Days to flowering:

The estimations of heterosis over mid and better parents for earliness traits under irrigated and stress conditions are obtainable in Table 5. There were six crosses out of the studied 15 crosses showed negative (desirable) significant or highly significant heterosis over both mid and better parents under normal conditions for days to flowering. The highest crosses were cross No. 4 (P_1xP_5) followed by No. 11(P_3xP_5), No. 7 (P_2xP_4), No. 1 (P_1xP_2) and No. 2 ($_{P1xP3}$) for earliness. On the other side, significant or highly significant positive heterosis values over both mid and better parents were found from crosses No. 10 (P_3xP_4), No. 14 (P_4xP_6) and No. 15 (P_5xP_6) for earliness at normal conditions. However, under drought stress conditions three crosses recorded negative significant or highly significant hetreosis over both mid and better parents. These crosses were No. 7 (P_2xP_4), 11 (P_3xP_5) and No. 1 (P_1xP_2). While, the crosses No. 12 ($P_3 \times P_6$) followed by No. 6 (P_2xP_3) and No. 10 (P_3xP_4) had significant positive heterosis values over their mid and better parents at drought conditions. These results are in good harmony with those of Kumar *et al* (2017).

Days to maturity

Results obtainable in Table 5 obviously show that the cross No. 6 (P2xP3) had significant negative heterosis values over their mid parents at stress conditions for days to maturity. Also, the cross No. 11 (P_3xP_5) had significant negative heterosis values over their better parents at stress condition for days to maturity. Vice-versa, most crosses recorded highly significant positive heterosis over both mid and better parents under normal conditions. The results also showed that the cross No, 6 (P_2xP_3) was the worst cross under normal condition followed by No. 10 (P_3xP_4), No. 12 (P_3xP_6), No. 13 (P_4xP_5) and No. 9 (P_2xP_6) over both mid and better parents compared with other crosses. These results are in agreement with those obtained by Pali and Mehta (2014) they recorded a few number of significant and highly significant negative heterosis values over mid parents under stress conditions.

Growth characters:

Plant height at the begging of flowering:

Estimates of heterosis over mid and better parents for plant height at the begging of flowering are presented in Table 6 reveal that No.8 (P2xP5) followed by No.10 (P3xP4) crosses showed positive and highly significant heterotic effects over both mid and better parents under normal conditions. On the other side, F1 hybrid No. 5 (P1xP6) followed by No. 7 (P2xP4), No. 9 (P2xP6) and No.15 (P5xP6) crosses showed negative and greatly significant heterotic effects over mid and better parents, respectively under stress conditions. On the contrary, no crosses showed significant positive heterosis values over their mid and better parents drought stresses conditions. These results are in overall arrangement with those noted by Kandil *et al*. (2011).

Plant height at harvest

The results in Table 6 showed that plant height at harvest had a extremely significant positive heterosis over mid and better parents for the crosses P_2xP_5 at irrigation conditions. For now, significant positive heterosis over mid better parents was achieved by the crossP_1xP_2 at water stress conditions. Vice-versa, significant or highly significant positive heterosis values over mid and better parents were found for the crosses P_1xP_3 at irrigated conditions. However, crosses No. 5 (P_1xP_6), No. 12 (P_3xP_6) and No. 15 (P_5xP_6) noted significant or highly significant negative heterosis over their mid and better parents under stress conditions, with reached from – 8.61% to 27.0% over mid parents and from -14.02% to 30.59 % over better patents. El-Sweify, Amena (2002) found that heterosis better parent values ranging from-24.3% to 10% for plant height. Results are in arrangement with those described by Mohammadi *et al*. (2010), Kalinina and Lyakh (2011), Kandil *et al*. (2011), Kumar *et al*. (2016a) and Kumar *et al*. (2017) found that negative heterosis is useful regarding plant height with ranged from -7.53 to 27.17% over mid parent and -22.67 to 8.89% over the better parent.

Technical stem length:

The results in Table 6 indication that non-significant positive heterosis values over mid and better parents at irrigation and stress conditions for technical stem length trait. Vice – versa, there were seven or nine crosses showed negative undesirable significant or highly significant heterosis over both mid and better parents under irrigation and stress conditions for technical stem length character. There are one cross newly P4xP5 gave highly significant positive heterosis over mid parents (11.06%). Also, there were three crosses (No. 1, 2 and 4) showed positive heterosis over their mid parents under drought stress conditions, but not reached to significant level. Also, there were three crosses (No. 7, 8 and 13)gave positive heterosis over better parents, but not reached to significant level and normal conditions. Similar results found by El-Farouk *et al.* (1998), El-Sweify, Amena (2002) and Kandil *et al.* (2011) found positive as well as negative values of heterosis for technical stem length.

Basle stem diameter

The results in Table 6 show that significant positive heterosis values over mid and better parents at stress conditions were obtained by P_2xP_5 for basle stem diameter. Two crosses (P_1xP_5 and P_1xP_6) recorded positive heterosis over their mid and better parents under normal conditions, but not reached to significance level. In contrast, significant or highly significant negative heterosis values over their mid and better parents were detected by the crosses P_5xP_6, P_2xP_5, P_1xP_2 and P_2xP_6, respectively at stress conditions for basle stem diameter. Also, significant or highly significant negative heterosis values over their mid and better parents were detected by the crosses P_1xP_4, P_3xP_4, P_1xP_2, P_2xP_3, P_5xP_6, P_2xP_4 and P_4xP_6 at normal conditions. Similar results found by Al-Kaddoussi and Moawad (2001), Kandil *et al.* (2011) and Kumar *et al.* (2017).

Stem diameter:

The assessments of heterosis over mid and better parents for stem diameter at irrigation and stress conditions are obtainable in Table 6. There were two (P_1xP_5 and P_3xP_5) crosses out of the studied 15 crosses indicated positive necessary significant or highly significant heterosis over both mid and better parents under irrigation conditions for stem diameter. In contrast, highly significant negative heterosis values over both mid and better parents were obtained from crosses No. 15 (P_5xP_6) at normal conditions. Six namely crosses were cross No. 3 (P_1xP_4), No. 1 (P_1xP_2), No. 2 (P_1xP_3), No. 4 (P_1xP_5), No. 9 (P_2xP_6) and No. 14 (P_4xP_6) recorded significant or highly significant and positive heterosis over their mid parents. Also, there were two crosses (No1 and No. 3) revealed significant and positive heterosis over better parants under drought conditions.

Capsule diameter:

Estimates of heterosis as percentage relative to mid and better parents in the F1 hybrids recorded in Table 6 reveal that crosses No. 4,1, 2 and 3 crosses exhibited highly significant positive heterosis which gave values of 29.52% for the cross (P_1xP_5), 24.36 % for the cross (P_1xP_2), 15.83% for the cross (P_1xP_3) and 14.08% for the cross (P_1xP_4) relative to mid parents, respectively, and 11.30 for the cross (P_1xP_5) relative to better parent, respectively under drought conditions for capsule diameter. Also, crosses No.13 showed significant positive heterosis which gave values of 9.52% for the cross (P_4xP_5) relative to mid at normal conditions. In contrast, highly significant negative heterosis values over both mid and better parents were achieved from crosses No. 6 (P_2xP_3), No. 7 (P_2xP_4), No. 9 (P_2xP_6), No. 11 (P_3xP_5), No. 12 (P_3xP_6) and No. 14 (P_4xP_6) at stress conditions. Meanwhile, significant or highly significant negative heterosis values over both mid and better parents were obtained from crosses No. 12 (P_3xP_6) and No. 13 (P_4xP_5) at irrigation conditions.

Biological yield plant^{-1}:

The results in Table 6 showed that significant or highly significant positive heterosis over mid and better parents were achieved from the crosses No. 2 (P_1xP_3) No. 9 (P_2xP_6) and No. 14 (P_4xP6) with ranged from 13.93% to 36.14% over mid parents and from 12.88% to 26.08% over better parents at normal conditions, No. 4 (29.73% and 17.26%) and No. 8 (18.56% and 16.37%) at drought conditions for biological yield. While, significant or highly significant negative heterosis values over their mid and better parents were noticed by crosses; No.10 (P_3xP_4) and No. 15 (P_5xP_6) at normal conditions; No.6 (P2xP3), No. 11 (P_3xP_5), No. 13 (P_4xP_5) and No. 15 (P_5xP_6) at water stress conditions. El-Sweify, Amena (2002) stated that only one cross significantly exceeded the better parent (33.19%) and mean heterosis resulted in negative value of -8.55% for seed yield, Mohammadi *et al.* (2010) establish that heterosis observed for seed yield/plant in some cross combinations and the maximum heterobeltiosis value of 77.2%. Some of these results could be established by the results of Kandil *et al.* (2011) and Kumar *et al*. (2017).

Table 5. Heterosis percentage over mid (MP) and better (BP) parents for earliness characters under normal and drought stress conditions.

Treatments	Days to flowering (days)				Days to maturity (days)			
	Normal		Drought		Normal		Drought	
Genotypes	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**
P1xP2 (1)	-10.54**	-8.50**	-9.61*	-12.14**	2.63	2.63	-0.98	-1.94
P1xP3 (2)	-10.51 **	-8.47**	-0.17	-0.69	-0.66	0.00	-0.98	-1.94
P1xP4 (3)	-9.94 **	-7.26**	4.33	4.15	10.39 **	11.84**	0.00	0.00
P1xP5 (4)	-15.73 **	-13.37**	-5.37	-11.01**	4.64 **	5.33**	0.66	0.00
P1xP6 (5)	-3.51	-1.30	6.38	2.92	0.65	1.97	-0.66	-1.32
P2xP3 (6)	-0.65	-0.32	14.43 **	11.80**	12.58 **	13.33**	-3.23 *	-3.23
P2xP4 (7)	-11.15 **	-10.86**	-13.13 **	-15.41**	10.39 **	11.84**	-2.28	-3.23
P2xP5 (8)	5.75	6.27**	0.95	-2.45	2.65	3.33	-1.64	-3.23
P2xP6 (9)	0.65	0.66	-3.10	-3.57	10.39 **	13.33**	-1.64	-3.23
P3xP4 (10)	12.75 **	13.49**	11.38 **	11.00**	11.11 **	13.33**	-2.28	-3.23
P3xP5 (11)	-11.95 **	-11.22**	-9.71 *	-14.68**	3.33 *	3.33	-2.08	-3.87**
P3xP6 (12)	-1.30	-0.98	15.86 **	12.66**	11.11 **	13.33**	-1.64	-3.23
P4xP5 (13)	6.75 *	6.93**	1.30	-4.59	11.11 **	13.33**	-0.66	-1.32
P4xP6 (14)	11.80 **	12.18**	6.87	3.56	8.97 **	8.97**	-0.66	-1.32
P5xP6 (15)	8.05 *	8.58**	3.62	0.61	1.31	3.33	1.33	1.33
LSD 5%	6.17	5.34	7.88	6.83	4.07	3.53	3.95	3.42
LSD 1%	6.38	5.52	8.16	7.07	4.21	3.65	4.09	3.54

Table 5. Continued.

Treatments	Plant height at the begging of flowering (cm)				Plant height at harvest (cm)			
	Normal		Drought		Normal		Drought	
Genotypes	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**
P_1xP_2 (1)	-.6.12*	-10.66**	-7.51	-12.05*	-2.35	-8.07*	-0.94	-4.51
P_1xP_3 (2)	0.98	-0.61	-1.14	-5.10	10.85 **	5.48	2.47	-1.13
P_1xP_4 (3)	0.46	-2.40	7.07	6.51	3.72	1.02	3.22	-1.72
P_1xP_5 (4)	-4.75	-7.31 *	2.28	-4.84	0.57	-4.24	12.21**	7.12
P_1xP_6 (5)	2.23	-1.45	-16.18 **	-22.58 **	5.90	-0.14	-14.13**	-21.87 **
P_2xP_3 (6)	-4.39	-7.60 **	-8.61	-9.52	2.71^{ns}	1.56 ^{ns}	-2.22	-2.33
P_2xP_4 (7)	-9.35 **	-16.07 **	-14.50 **	-19.11 **	0.46	-2.98	0.10	-1.17
P_2xP_5 (8)	10.24 **	7.73 **	0.46	-1.82	9.02**	7.73*	-1.43	-2.42
P_2xP_6 (9)	-10.25 **	-11.44 **	-15.02 **	-17.59**	-0.15	-0.32	-6.05	-11.53
P_3xP_4 (10)	12.24 **	7.37 *	8.01	3.16	-1.37	-3.70	7.46	5.98
P_3xP_5 (11)	-4.17	-5.25	-11.54 *	-14.38 **	5.34	5.27	3.89	2.74
P_3xP_6 (12)	-8.13 **	-10.04 **	-7.11	-10.78 *	4.30	3.31	-8.61 *	-14.02**
P_4xP_5 (13)	5.77 *	0.08	-7.69	-14.53 **	0.66	-1.65	-1.79	-2.06
P_4xP_6 (14)	11.81 **	4.83	5.39	-3.13	2.55	-0.79	-2.55	-7.10
P_5xP_6 (15)	-2.95	-3.89	-16.11 **	-16.77 **	-5.02	-5.99	-27.00**	-30.59 **
LSD 5%	4.96	4.29	9.39	8.13	7.49	6.49	9.13	7.91
LSD 1%	5.13	4.44	9.71	8.41	7.75	6.71	9.45	8.18

Table 5. Continued.

Treatments	Technical stem length (cm)				Basle stem **diameter (mm)**			
	Normal		Drought		Normal		Drought	
Genotypes	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**
P1xP2 (1)	-4.03	-6.14	6.97	-1.12	-23.77 **	-27.06 **	-14.92 *	-16.24 *
P1xP3 (2)	0.39	-1.49	0.87	-4.38	-4.34	-7.32	-3.84	-7.93
P1xP4 (3)	0.29	-3.73	-8.28	-14.42 *	-35.73 **	-39.22 **	-10.30	-15.01 *
P1xP5 (4)	-13.59 **	-16.05 **	3.21	-7.44	5.14	0.28	-8.41	-9.36
P1xP6 (5)	-0.46	-7.55	-14.84 **	-25.03**	7.80	1.68	-6.32	-12.43
P2xP3 (6)	-3.08	-3.41	-8.35	-10.76	-23.55 **	-24.52 **	6.32	3.36
P2xP4 (7)	7.99	1.48	-12.80 *	-13.68 *	-20.84 **	-21.81 **	-6.18	-9.75
P2xP5 (8)	1.92	1.23	-16.14 **	-18.87 **	-13.81 **	-14.10 **	18.36 *	15.33
P2xP6 (9)	-17.45 **	-21.70 **	-24.54 **	-28.44 **	-7.74	-16.50 **	-11.82	-16.34 *
P3xP4 (10)	-5.03	-10.47 *	-5.99	-7.55	-26.66 **	-28.47 **	-12.74 *	-13.68
P3xP5 (11)	-15.31 **	-16.16 **	-8.06	-13.31 *	-5.42	-6.93	7.21	1.63
P3xP6 (12)	-20.99 **	-25.31 **	-15.00 **	-21.41 **	-8.14	-15.89 **	-10.48	-12.70
P4xP5 (13)	11.06 **	3.70	-6.46	-10.38	-10.70 *	-11.50 *	0.25	-5.94
P4xP6 (14)	-2.91	-13.16 **	-9.68 *	-15.18 **	-7.45	-17.16 **	6.99	5.47
P5xP6 (15)	-12.77 **	-16.73 **	-32.07 **	-33.47 **	-14.50 **	-22.86 **	-17.05 *	-23.21 **
LSD 5%	5.54	4.80	7.30	6.32	3.66	3.17	4.81	4.16
LSD 1%	5.73	4.96	7.55	6.54	3.79	3.28	4.97	4.31

Table 5. Continued.

Treatments	Stem diameter (mm)				Capsule diameter (mm)			
	Normal		Drought		Normal		Drought	
Genotypes	MP	BP	MP	BP	MP	BP	MP	BP
P1xP2 (1)	-9.05	-11.50	48.31 **	40.69 *	1.57	1.18	24.36 **	7.39
P1xP3 (2)	16.99	11.57	36.49 **	20.00	-3.49	-6.83	15.83 **	-3.83
P1xP4 (3)	-3.24	-9.66	60.66 **	38.87 **	0.16	-1.45	14.08 **	-2.06
P1xP5 (4)	27.68 **	24.34 *	29.20 *	5.96	6.09	5.66	29.52 **	11.30 **
P1xP6 (5)	-7.27	-12.11	13.24	-3.91	4.63	2.90	7.71	9.35 *
P2xP3 (6)	10.91	8.64	13.59	4.80	-0.02	-3.84	-8.15 *	-12.36 **
P2xP4 (7)	-14.89	-18.44	18.91	7.74	-4.39	-5.57	-8.24 *	-8.87 *
P2xP5 (8)	2.58 ns	2.49	16.99	0.23	8.00	7.15	2.53	1.93
P2xP6 (9)	-10.49	-12.87	27.06 *	12.90	-3.89	-5.11	-5.64	-8.49 *
P3xP4 (10)	-8.75	-10.77	7.23	5.13	7.65	2.32	-2.47	-6.32
P3xP5 (11)	28.18 **	25.46 *	4.81	-12.22	2.61	-0.55	-7.02 *	-10.78 **
P3xP6 (12)	8.32	7.62	3.08	-1.08	-16.40 **	-20.58 **	-9.47 **	-10.98 **
P4xP5 (13)	-3.74	-7.82	3.70	-2.60	9.52 *	7.33	2.17	2.06
P4xP6 (14)	-15.70	-17.04	26.53 *	23.79	0.47	0.42	-8.82 *	-10.98 **
P5xP6 (15)	-32.03 **	-33.89 **	-11.19	-14.82	-7.73	-9.62	-6.30	-8.62 *
LSD 5%	0.78	0.68	0.84	0.73	0.67	0.58	0.55	0.48
LSD 1%	0.81	0.70	0.87	0.75	0.69	0.60	0.57	0.49

Table 5: Continued.

Treatments	Biological yield plant $^{-1}$ at harvest (g)			
	Normal		Drought	
Genotypes	MP	BP	MP	BP
P1xP2 (1)	7.71	2.07	22.93 **	13.02
P1xP3 (2)	13.93 **	12.88 *	-4.33	-20.60 **
P1xP4 (3)	2.99	1.21	29.37 **	11.85
P1xP5 (4)	7.62	-7.35	29.73 **	17.26 *
P1xP6 (5)	12.16 *	9.46	-2.70	-11.04
P2xP3 (6)	4.95	-1.42	-7.08	-16.99 **
P2xP4 (7)	4.81	-2.30	4.27	-2.53
P2xP5 (8)	8.04	-11.07 **	18.56 **	16.37 *
P2xP6 (9)	36.14 **	26.08 **	7.20	6.55
P3xP4 (10)	-29.30 **	-29.87 **	-4.24	-8.80
P3xP5 (11)	5.63	-8.35 *	-9.10	-17.42 **
P3xP6 (12)	8.03	6.39	3.64	-6.91
P4xP5 (13)	3.47	-9.59 *	-9.45	-13.85 *
P4xP6 (14)	14.42 **	13.60 *	6.37	0.00
P5xP6 (15)	-16.98 **	-27.01 **	-17.50 *	-18.54 *
LSD 5%	5.97	5.17	7.37	6.39
LSD 1%	6.18	5.35	7.63	6.61

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القدرة على التآلف وقوه الهجين لصفات التبكير والنمو والمحصول البيولوجى لبعض التراكيب الوراثية للكتان تحت ظروف الري الطبيعي وظروف نقص مياه الري

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أجريت هذه الدراسة بالمزرعة البحثية لقسم المحاصيل – كلية الزراعة – جامعة المنصورة – مصر خلال موسمي 2019/2018 و 2020/2019 باستخدام ست تراكيب وراثية من الكتان كآباء تم زراعتهم في الموسم الزراعي الأول واجراء جميع التهجينات الممكنة بينها عن طريق نظام التزاوج نصف الدائري للحصول علي خمسة عشر هجين وتم تقييم جميع الهجن الناتجة بالاضافة للآباء فى تجربتن منفصلتين إحداهما للرى العادى (4 ريات طول الموسم) والأخرى للرى المنخفض وظروف الإجهاد (ريتين فقط طول الموسم) لمعرفة مدي استجابتها لنقص الماء وتحديد أفضلها، وقد استخدم في تنفيذ هذه التجارب تصميم القطاعات الكاملة العشوائية في ثلاث مكررات. أظهر تحليل التباين لقدرتي التآلف العامة والخاصة معنوية عالية في معظم الصفات تحت الدراسة مما يوضح الأهمية النسبية لكلاً من التأثيرات المضيفة وغير المضيفة للجينات في وراثة هذه الصفات. سجلت النسبة بين تباين القدرة العامة والخاصة علي التآلف (GCA/SCA) تحت ظروف الري والجفاف قيماً أعلي من الواحد الصحيح لعدد من الصفات منها صفه عدد الأيام حتي النضج، وطول النبات عند الحصاد. سجل الأب P_1 (سخا 6) قدرة عامة علي التآلف في تحسين صفة عدد الأيام حتي الإزهار وعدد الأيام حتي النضج تحت ظروف الري والجفاف. وسجل الأب P_4 (402/1) قدرة عامة علي التآلف لتحسين صفات طول النبات عند الحصاد والمحصول البيولوجي تحت ظروف الجفاف. أظهرت نتائج تأثيرات القدرة الخاصة على التآلف وجود اختلافات عالية المعنوية لبعض الهجن تحت الدراسة. أظهر الهجين P_2xP_4 وجود قدرة خاصة علي التآلف بالنسبة لصفتي عدد الأيام حتي الإزهار وعدد الأيام حتي الحصاد تحت ظروف الري والجفاف . أشارت نتائج تقديرات قوة الهجين إلي أن أفضل الهجن الأبكر لعدد الأيام حتي الإزهار بالنسبه لمتوسط وأفضل الآباء هو الهجين رقم 11 (P3xP5) تحت ظروف الري العادي والهجين رقم7 (P2xP4) تحت ظروف الجفاف. بالنسبة لعدد الأيام حتى النضج كان أفضل الهجن هو الهجين رقم 6 (P2xP3) بالنسبة لمتوسط الآباء والهجين رقم 11(P3xP5) بالنسبة لأفضل الآباء تحت ظروف الجفاف. فيما يتعلق بارتفاع النبات عند التزهير، كانت أفضل أنواع الهجن هي رقم 10(P_3xP_4) ورقم 14 (P_4xP_6) ورقم 8 (P_2xP_5) لمتوسط الاباء تحت ظروف الري ، والهجين رقم 8 (P_2xP_5) والهجين رقم 10(P_3xP_4) في ظل ظروف الجفاف لمتوسط وافضل الاباء. أما بالنسبة لارتفاع النبات عند الحصاد، فإن أفضل أنواع الهجن كانت رقم 2 (P_1xP_3) ورقم 8(P_2xP_5) لمتوسط وأفضل الاباء تحت ظروف الري. أما بالنسبة للمحصول البيولوجي فإن أفضل الهجن كان رقم 9(P_2xP_6) ورقم 4 (P_1xP_5) لمتوسط وأفضل الاباء تحت ظروف الري والجفاف على التوالي. نستخلص من هذه الدراسة أن الآباء P3 (Southana) و P4 (402/1) سجلا قدرة عامة على التآلف بالنسبة للمحصول البيولوجي تحت ظروف الجفاف وسجلت P_1xP_5, P1xP4, P3xP6 قدرة خاصة على التآلف موجبة وعالية المعنوي لصفة المحصول البيولوجي تحت ظروف الجفاف لذلك يمكن التوصية بإدخال هذه الهجن في برامج تربية الكتان لتحمل الجفاف