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RESEARCH ARTICLE

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Performance, heterosis, and inbreeding depression of flax genotypes (*Linum usitatissimum* L.) of the factorial mating design.

Suhaib Hakim Issa Al-Ani[1] **Mohammed Ibrahim Mohammed[2]**
A. H. Noaman[3]
[1]Department of field crops, College of Agriculture, University of Kirkuk. Kirkuk. IRAQ.
[2]Department of medicinal and industrial plants, College of Agriculture – Al-Hawija, University of Kirkuk. Kirkuk. IRAQ.
[3]Department of field crops, College of Agriculture, University of Anbar. Anbar. IRAQ.
*Corresponding Author: suhaib.h.isa@uoanbar.edu.iq

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ABSTRACT

Seven genotypes of flax were used in this study, four of which were male parents (Sakha 1, Sakha 2, Sakha 3, and Sakha 5), three of which were female parents (Sakha 6, Giza 8, and Syrian), (12) hybrids from the second generation, and (12) hybrids from the third generation according to Factorial Mating Design. The results showed that parent (Giza8) superior to an increase in traits of No. of capsule, No. of seeds in capsule, and the biological yield, which amounted to (44.00, 8.00, 12.11), respectively. In the second generation, the (Sakha2*Syrian) hybrid excelled in the No. of seeds in a capsule and the biological yield, reaching (8.00, 12.13), respectively. In the third generation, the (Sakha2*Syrian) hybrid showed an increase in No traits. of seeds in capsule, seed yield, and biological yield, reaching (8.00, 2.73, 12.13), respectively. In the second generation, the hybrid heterosis was significant. It was calculated based on the mean deviation of the parents in the hybrid (Sakha1*Sakha6) in the second generation at a probability level of 1% in the No. of the capsule plant, the No. of seeds in capsule, seed yield and harvest index, and reached (0.50, 0.28, 0.11, 1.09), respectively, and the hybrid (Sakha5*Sakha6) in the No. of the capsule plant, the No. of seeds in capsule, seed yield and biological yield, and reached (1.00, 1.17, 0.17, 0.84), respectively, and in the third generation hybrid (Sakha2*Syrian) in the No. of the capsule plant, the No. of seeds in capsule, the weight of 1000 seeds, seed yield, biological yield and harvest index, and reached (2.00, 1.17, 0.28, 0.24, 0.65, 0.85), respectively. At the same time, no hybrid showed negative or positive significance for genetic deterioration by internal breeding.

***Keywords*:** Flax, Heterosis, Inbreeding Depression, Hybrids, Factorial mating design.

INTRODUCTION

The flax plant is considered one of the important crops as it is classified as a complementary food, as flax seeds are used as an important food grain and are used in traditional medicine by humans because of their many health benefits [1]. Plant breeders' search for new genetic combinations is a continuous and never-ending. Because of the large and increasing genetic variation due to hybridization and genetic mutations in flax and its complex heritability because it contains multiple genomes, there are great opportunities to interaction new genetic combinations with high environmental adaptation through breeding and re-selection of genes. Desirable superiority associated with the syndrome [2]. Various methods are used to develop new gene combinations with desirable characteristics. Hybridization is considered one of the main sources for forming new genetic combinations with important economic characteristics [3]. The hybridization program depends mainly on selecting genetic combinations that carry the required traits. Therefore, the first essential step in a hybridization program is to evaluate traits of the genetic combinations to be introduced. In the hybridization program to develop new genetic combinations that possess characteristics that plant breeders are keen to possess, the most important of which is grain yield and its components [4]. Selection is important in testing superior isolates in solitary generations [5]. The current study aims to evaluate the performance of all genotypes and estimate heterosis as well as Inbreeding depression.

Materials and methods

Seven genotypes of flax were used in this study, four of which were male parents (Sakha 1, Sakha 2, Sakha 3, and Sakha 5), three of which were female parents (Sakha 6, Giza 8, and Syrian), (12) hybrids from the second generation, and (12) hybrids from the third generation according to the Factorial Mating method. Design proposed by [6],
Seeds, genotypes, parents and hybrids were planted in flocks with a seed quantity of 40 kg ha^{-1} [7], according to the RCBD completely randomized block design for three blocks, each of which includes (31) experimental units in which the blocks are randomly distributed the genetics is shown above. Each experimental unit includes two lines of each genotype with a length 3 m^2, and the distance between one line and another line is 0.25m. Where field operations were carried out, which included preparing the land, plowing it well, leveling and smoothing operations, as well as carrying out agricultural operations to serve the crop, represented by irrigation, hoeing, and weeding whenever necessary. Phosphate fertilizer was added in the form of triple superphosphate (46% P_2O_5) at a rate of 50 kg P ha^{-1} in the form of

one batch Before planting, nitrogen fertilizer was added in the form of urea (%N 46) at a rate of 80 kg N ha^{-1} in two batches, the first after germination and the second a month after the first batch [8].
Statistical analysis of genotype data was performed using the program SAS. heterosis was also estimated on the basis of the deviation of the first generation from the mean of the two best parents as a ratio. The (t) test was used for the significance of heterosis for the genotypes at the probability level (1%, 5%), and the genetic deterioration of each hybrid for the second and third generations was calculated based on the mean deviation. The second and third generation hybrids differ from the expected mean of the first-generation hybrids, which was estimated according to the following equation [9]:

I.D = I.D = E $\underline{F1}$ – $\underline{F2}$

I.D = Inbreeding depression.

E $\underline{F1}$= Mean expected first generation hybrid.

$\underline{F2}$ = Mean hybrid of the second generation.

The equation for estimating the expected mean of the first generation:

The expected first-generation hybrid means E was calculated according to the following equation:

E $\underline{F1}2 = \underline{F2} - (1/2)\, \underline{P1} + (1/2)\, \underline{P2}$

So: $\underline{P1}$ and $\underline{P2}$ = Means of the parents included in the first-generation hybrid.

Results and discussion

Table (1) analysis of variance using the mating system method shows that (hybrid, male parents, female parent, and male × female) in the second and third generation showed significance at the 1% level in all studied traits (No. of capsule plant^{-1}, No. of seeds in capsule^{-1}, weight of 1000 seeds, seed yield, biological yield, and Harvest index). except for harvest index in second generation in male was not significant, these results were consistent with previous studies by [10, 11, 12, 13].

Table (1) analysis of variance by the method of the factorial mating system

S. o. V	D.F	No. of capsule plant^{-1}		No. of seeds in capsule^{-1}		Weight of 1000 seeds (g)		Seed yield (ton ha^{-1})		Biological yield (ton ha^{-1})		Harvest index (%)	
		F2	F3	F2	F3	F2	F3	F2	F3	F2	F3	F2	F3
Rep	2	12.00	15.02	0.08	0.08	0.12	0.09	0.01	0.06	0.00004	0.00008	0.37	0.19
Hybrids	11	27.52*	29.65**	1.88**	1.95**	1.45**	0.75**	0.02**	0.04**	0.47**	0.47**	1.23**	2.51**
Male	3	33.58	37.71*	2.30**	2.77**	0.74	2.15**	0.01*	0.03**	0.06**	0.06**	0.03	2.37**
Female	2	75.25	78.37	0.58	0.33	4.95*	0.34**	0.01**	0.06**	0.65**	0.65**	4.66**	0.99*
Male × Female	6	8.58*	10.66*	2.10**	2.07**	0.64*	0.19**	0.02**	0.04**	0.62**	0.62**	0.68**	3.08**
Error	22	0.00001	0.00003	0.05	0.05	0.09	0.00004	0.00007	0.00009	0.00007	0.00009	0.01	0.02

Tables (2) and (3) show means squares of the parents and the crosses of the second and third generations for all the studied traits in traits of No. of capsule plant^{-1} (capsule plant^{-1}), we note that parent 6 obtained the highest value among the parents, with a mean of 44.00 capsule plant^{-1}, while parent 6 obtained the highest Value in parents, with a mean of 44.00 capsule plant^{-1}, parent 5 had the lowest value in sires because he gave a mean of 31.00 capsule plant^{-1}, while the second generation (1×6) hybrids showed the highest values for this trait, reaching 45.00 capsule plant^{-1} compared to (3×5) hybrids which gave less. The hybrids were valuable, with an average of 34.00 capsule plant^{-1}, while the third generation (1×6) hybrids showed the highest values for this trait, reaching 46.00 capsule plant^{-1}, compared to the (3×5) hybrids, which were the least valuable hybrids, with a mean of 35.00 capsule plant^{-1}.

Regarding the No. of seeds in capsule^{-1} (seed capsule^{-1}), we notice that the parents (1) and (6) had the highest value in paternalism, with an average of 8.00 seed capsule^{-1}, while the parent 4 had the lowest value in fatherhood because it gave a mean amount of 6.00 seed capsule^{-1}, while the second generation hybrids (1×5), (2×7), and (4×7) showed the highest values for this trait, amounting to 8.00 seed capsule^{-1}, compared to the hybrids (2×5), (5×3), and (3×7), which gave the lowest value of the hybrids, with a mean of 6.00 seed capsule^{-1}, while the third-generation hybrids, (1×5), (2×5), (2×7), and (3×6), showed the highest values for this trait, reaching 8.00 a mean, compared to the hybrids (4×6), (4×5), and (1×7), which were the least valuable hybrids, with a mean of 6.00 seed capsule^{-1}.

As for the weight of 1000 seeds (g), we note that the parent (5) had the highest value in fatherhood, with an average of 8.28 (g), while the parent (2) had the lowest value in fatherhood because he gave a mean of 6.36 (g), while the second generation hybrids showed (3×6) and (2×6) had the highest values for this trait, amounting to 8.25 and 8.30 (g) compared to the (2×7) hybrid, which gave the lowest value among the hybrids, with a mean of 6.28 (g), while the third-generation hybrids, (2×5) and (3×7), showed the highest values for this trait, amounting to 7.83 and 7.84 (g), compared to the (4×6) and (1×7) hybrids, which were the least valuable hybrids, with a mean of 6.56 and 6.52 (g).

Regarding the seed yield we note that the parent (3) had the highest value in the parent, with a mean of 2.62 ton ha^{-1}, while the parents (1), (2), (4), and (5) had the lowest value in the parents, it gave means of 2.41, 2.41, 2.44, and 2.43 ton h^{-1}, while the second-generation hybrid (3×5) showed the highest values for this trait, amounting to 2.68 ton ha^{-1}, compared to the hybrids (3×7) and (4×7), which gave the lowest value among the hybrids, with a means 2.42 and 2.45 ton h^{-1}, while the third-generation hybrids (4×5) and (2×7) showed the highest values for this trait, amounting to 2.74 and 2.73 ton h^{-1}, compared to the hybrids (4×6) and (1×6), which were the least valuable hybrids, with a means of 2.41 and 2.38 ton h^{-1}.

As for the biological yield trait we note that the parents (3) and (6) had the highest value in the fathers, with an average of 12.10 and 12.11 tons ha^{-1}, while the parents were (1), (2), and (4) the lowest value in the sires because they gave means of 11.17, 11.23, and 11.23 tons h^{-1}, while the second-generation crosses (4×5), (2×7), and (1×7) showed the highest values for this trait, amounting to 12.13, 12.13, and 12.12 ton h^{-1} compared to the hybrids (1×5), (1×6), (2×5), (3×6), (3×7), and (4×6) gave the lowest value of the hybrids, with a means of 11.18, 11.24, 11.24, 11.21, 11.25, and 11.25 ton h^{-1}, while the third generation hybrids (4×5), (2×7), and (1×7) showed the highest values for this trait, reaching 12.15, 12.14, and 12.13 ton h^{-1} compared to the (1×5), (1×6), (2×5), (3×6), (3×7), and (4×6) hybrids, which were the least valuable hybrids, with an average of 11.20, 11.25, 11.25, 11.22, 11.26, and 11.26 ton ha^{-1}.

Table (2) means squares of parents (males and females) for the studied traits.

traits / Parents	No. of capsule plant^{-1}	No. of seeds in capsule^{-1}	Weight of 1000 seeds (g)	Seed yield (ton ha^{-1})	Biological yield (ton ha^{-1})	Harvest index (%)
1	42.00	8.00	6.74	2.41	11.17	21.55
2	37.00	7.00	6.36	2.41	11.23	21.49
3	33.00	6.33	6.85	2.62	12.10	21.61
4	37.00	6.00	6.77	2.44	11.23	21.72
5	31.00	7.00	8.28	2.43	11.35	21.40
6	44.00	8.00	7.42	2.58	12.11	21.26
7	37.00	6.67	7.78	2.55	11.76	21.72
L.S.D.	0.001	0.525	0.506	0.013	0.017	0.095

Regarding the harvest index (%), we note that parents (4) and (7) obtained the highest parents value, with a means of 21.72 and 21.72 (%), while parent (6) obtained the lowest parents it gave an average of 21.26 (%). The second generation (4×6) hybrid showed the highest value for this trait, amounting to 23.05 (%), compared to the (1×7) hybrid, which gave the lowest value with a mean of 21.15 (%), while the third generation (3×6) hybrid showed the highest value. For this trait, it amounts to 23.95 (%) compared to the (1×6) hybrid, which was the lowest average hybrid value of 21.12 (%). these results agreed with [14, 15,16, 17].

Table (3) means squares of hybrids of the second and third generation of the studied traits.

Hybrids	No. of capsule plant^{-1}		No. of seeds in capsule^{-1}		Weight of 1000 seeds (g)		Seed yield (ton h^{-1})		Biological yield (ton h^{-1})		Harvest index (%)	
	F2	F3	F2	F3	F2	F3	F2	F3	F2	F3	F2	F3
1×5	38.0	39.0	8.00	8.00	6.63	7.28	2.52	2.56	11.1	11.2	22.5	22.9
1×6	45.0	46.0	6.33	7.00	7.73	6.75	2.54	2.38	11.2	11.2	22.6	21.1
1×7	39.0	40.0	7.00	6.00	7.44	6.52	2.56	2.59	12.1	12.1	21.1	21.3
2×5	35.0	36.0	6.00	8.00	6.55	7.83	2.51	2.67	11.2	11.2	22.3	23.7
2×6	40.0	41.0	7.00	6.67	8.30	7.14	2.57	2.53	11.4	11.4	22.6	22.3
2×7	38.0	39.0	8.00	8.00	6.28	7.34	2.61	2.73	12.1	12.1	21.5	22.4
3×5	34.0	35.0	6.00	7.00	6.84	7.54	2.68	2.55	11.8	11.8	22.7	21.6
3×6	36.0	37.0	7.00	8.00	8.25	7.66	2.50	2.69	11.2	11.2	22.3	23.9
3×7	38.0	39.0	6.00	7.33	6.76	7.84	2.42	2.57	11.2	11.2	21.4	22.8
4×5	35.0	36.0	7.67	6.00	7.52	6.73	2.60	2.74	12.1	12.1	21.4	22.6
4×6	41.0	42.0	7.00	6.00	7.99	6.56	2.60	2.41	11.2	11.2	23.0	21.4
4×7	38.0	39.0	8.00	7.00	7.68	6.63	2.45	2.55	11.4	11.4	21.6	22.4
L.S.D.	0.001	0.001	0.389	0.389	0.497	0.046	0.015	0.026	0.012	0.012	0.119	0.247

Heterosis due to the deviation of the second and third generations from mean of the parents as a ratio.

Table (4) shows that the hybrids showed positive and negative heterosis due to the deviation of the generations from the means of the parents for the studied traits. As for No. of capsule plant^{-1} (%), eight hybrids of the second generation showed desirable heterosis in the positive direction for the trait number of capsules. In the plant capsule plant^{-1}at the probability level of 1%, which are consecutively, in the third generation, ten hybrids showed significant heterosis in the desired positive direction for the same trait and at the 1% probability level, amounted 12.00, 0.50, 2.00, 4.00, 2.00, 1.50, and 2.00 (%), respectively.

Regarding the No. of seeds in capsule^{-1} (%), four hybrids from the second generation showed desirable heterosis in the positive direction for No. of seeds in capsule^{-1} (%) at the 1% probability level, which are (1×5), (2×7), (4×5), and (4×7), which amounted to 0.50, 1.17, 1.17, and 1.67 seed capsule^{-1}, respectively. In the third generation, six hybrids showed significant heterosis in the desired positive direction for the same trait at a 1% probability level, they are (1×5), (2×5), (2×7), (3×6), (3×7), and (4×7) which was 0.50, 1.00, 1.17, 0.83, 0.83, and 0.67 seed capsule^{-1} respectively.

As for the trait weight of 1000 seeds, four hybrids from the second generation showed a desirable heterosis in the positive direction for the trait weight of 1000 seeds at the 1% probability level, which are (1×6), (2×6), (3×6), and (4×6), reached 0.65, 1.41, 1.12, and 0.90 (%) respectively. In the third generation six hybrids showed significant heterosis in the desired positive direction for the same trait and at the 1% probability level, amounted (2×5), (2×6), (2×7), (3×6), and (3×7), which were 0.51, 0.25, 0.28, 0.52 and 0.53 (%) respectively.

Regarding the seed yield trait, nine hybrids from the second generation showed desirable heterosis in the positive direction for the seed yield trait at a probability level of 1%, amounted (1×5), (1×6), (1×7), (2×5), (2×6), (2×7), (3×5), (4×5), and (4×6) reached 0.11, 0.05, 0.08, 0.09, 0.08, 0.12, 0.15, 0.17, and 0.09 (%), respectively. In the third generation, eight hybrids showed significant heterosis in the desired positive direction for the same trait and at the 1% probability level, which is (1×5), (1×7), (2×5), (2×6), (2×7), (3×6), (4×5) and (4×7) amounted to 0.14, 0.10, 0.25, 0.04, 0.24, 0.09, 0.31 and 0.06 (%) respectively, while the (3×5) hybrid showed significant heterosis at a 5% probability level of 0.03 (%).

As for the trait, as for the biological yield trait, four hybrids from the second generation showed a desirable heterosis in the positive direction for the biological yield trait at a probability level of 1%, which are (1×7), (2×7), (3×5), and (4×5), and it amounted to 0.66. and 0.64, 0.06, 0.84, and 0.86 (%), respectively. In the third generation, four hybrids showed significant heterosis in the desired positive direction for the same trait and at the 1% probability level, which is (1×7), (2×7), (3×5), and (4×5) amounted to 0.67, 0.65, 0.07, and 0.86 (%), respectively.

Regarding the harvest index trait (%), seven hybrids from the second generation showed a desirable heterosis in the positive direction for the harvest index trait at a probability level of 1%, which is (1×5), (1×5), (1×6), (2×5), (2×6), (3×5), (3×6), and (4×6) amounted to 1.09, 1.19, 0.85, 1.26, 1.20, 0.83, and 1.56 (%), respectively.

In the third generation, eight hybrids showed significant heterosis in the desired positive direction for the same trait and at the 1% probability level, which is (1×5), (2×5), (2×6), (2×7), (3×6), (3×7), (4×5), and (4×7) amounted to 1.41, 2.31, 0.90, 0.85, 2.52, 1.12, 1.02, and 0.71 (%), respectively, these results agreed with [17, 18].

Table (4) heterosis in the second and third generations depends mean of the parents for seed yield and its components.

Hybrids	No. of capsule plant $^{-1}$		No. of seeds in capsule^{-1}		Weight of 1000 seeds (g)		Seed yield (ton ha^{-1})		Biological yield (ton ha^{-1})		Harvest index (%)	
	F2	F3	F2	F3	F2	F3	F2	F3	F2	F3	F2	F3
1×5	1.50 **	2.50 **	0.50 **	0.50 **	-0.88 **	-0.23 **	0.11 **	0.14 **	-0.07 **	-0.06 **	1.09 **	1.41 **
1×6	2.00 **	3.00 **	-1.67 **	-1.00 **	0.65 **	-0.33 **	0.05 **	-0.11 **	-0.39 **	-0.39 **	1.19 **	-0.29 *
1×7	-0.50	0.50 **	-0.33	-1.33 **	0.19	-0.74 **	0.08 **	0.10 **	0.66 **	0.67 **	-0.49 **	-0.33 **
2×5	1.00 **	2.00 **	-1.00 **	1.00 **	-0.77 **	0.51 **	0.09 **	0.25 **	-0.05 **	-0.03 **	0.85 **	2.31 **
2×6	-0.50 **	0.50 **	-0.50 **	-0.83 **	1.41 **	0.25 **	0.08 **	0.04 **	-0.30 **	-0.30 **	1.26 **	0.90 **
2×7	1.00 **	2.00 **	1.17 **	1.17 **	-0.79 **	0.28 **	0.12 **	0.24 **	0.64 **	0.65 **	-0.13 *	0.85 **
3×5	2.00 **	3.00	-0.67 **	0.33	-0.72 **	-0.03	0.15 **	0.03 *	0.06 **	0.07 **	1.20 **	0.10
3×6	-2.50	-1.50 **	-0.17	0.83 **	1.12 **	0.52 **	-0.10 **	0.09 **	-0.90 **	-0.89 **	0.83 **	2.52 **
3×7	3.00 **	4.00 **	-0.50 **	0.83 **	-0.55 *	0.53 **	-0.17 **	-0.02	-0.68 **	-0.67 **	-0.20 **	1.12 **
4×5	1.00 **	2.00 **	1.17 **	-0.50 **	-0.01	-0.80 **	0.17 **	0.31 **	0.84 **	0.86 **	-0.13 *	1.02 **
4×6	0.50	1.50 **	0.01	-1.00 **	0.90 **	-0.54 **	0.09 **	-0.10 **	-0.42 **	-0.41 **	1.56 **	-0.12
4×7	1.00 **	2.00 **	1.67 **	0.67 **	0.41	-0.64 **	-0.04 **	0.06 **	-0.12 **	-0.11 **	-0.14 **	0.71 **

Inbreeding depression of the second and third generations:

It is clear from the results of the statistical and genetic analysis, as shown in Table No. (5), that the inbreeding depression the second and third generations indicates that there are no significant differences in all the studied traits, which are No. of capsule plant^{-1}, No. of seeds in capsule^{-1}, weight of 1000 seed, Seed yield, biological yield, and Harvest index

Table (5) genetic inbreeding depression of the second and third generations for seed yield, and its components studied traits.

traits	No. of capsule plant $^{-1}$		No. of seeds in capsule^{-1}		Weight of 1000 seeds(G)		Seed yield (ton h^{-1})		Biological yield (ton h^{-1})		Harvest index (%)	
Hybrids	F2	F3	F2	F3	F2	F3	F2	F3	F2	F3	F2	F3

1×5	1.50	2.50	0.50	0.50	-0.90	-0.22	0.11	0.15	-0.07	-0.06	1.09	1.42
1×6	2.00	3.00	-1.33	-1.00	0.65	-0.33	0.05	-0.10	-0.39	-0. 40	1.18	-0.17
1×7	-0.50	0.50	-0.33	-1.33	0.19	-0.76	0.09	0.13	0.66	0.67	-0.47	-0.13
2×5	1.00	2.00	-1.00	1.00	-0.73	0.53	0.09	0.25	-0.04	-0.03	0.86	2.31
2×6	-0.50	0.50	-0.50	-1.17	1.38	0.27	0.08	0.04	-0.30	-0.31	1.26	0.89
2×7	1.00	2.00	1.17	1.17	-0.79	0.30	0.12	0.24	0.64	0.65	-0.15	0.85
3×5	2.00	3.00	-0.67	0.33	-0.69	-0.02	0.16	0.03	0.06	0.07	1.21	0.10
3×6	-2.50	-1.50	-0.17	0.83	1.11	0.54	-0.10	0.09	-0.89	-0.90	0.82	2.53
3×7	3.00	4.00	-0.50	1.17	-0.57	0.51	-0.17	-0.02	-0.67	-0.68	-0.23	1.10
4×5	1.00	2.00	0.83	-0.50	-0.07	-0.82	0.15	0.31	0.86	0.87	-0.29	1.02
4×6	0.50	1.50	0.02	-1.00	0.47	-0.56	0.08	-0.08	-0.41	-0.42	1.51	0.09
4×7	1.00	2.00	1.67	0.67	0.83	-0.63	-0.04	0.05	-0.12	-0.11	-0.14	0.68
SE (ij)	13.00	13.00	3.21	3.22	2.82	2.69	0.30	0.34	1.62	1.62	2.49	2.73

Conclusion:

It is clear from the above that it is possible to benefit from the heterosis and continue it segregations generations, specific in the (Sakha2*Syrian), (Sakha1*Sakha6), (Sakha5*Sakha6) hybrid, which excelled in most of the traits studied in the second generation, and in the (Sakha2*Syrian) hybrid excelled in all the traits studied in the third generation, which did not show any genetic deterioration by inbreeding dispersion.

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الأداء وقوة الهجين والتدهور الوراثي للتربية الداخلية لتراكيب وراثية من الكتان (Linum usitatissimum L.) وفق التصميم التزاوجي العاملي.

صهيب حكيم عيسى العاني[1] محمد إبراهيم محمد [2] عبد الصمد هاشم نعمان[3]

[1]قسم المحاصيل الحقلية، كلية الزراعة، جامعة كركوك، كركوك، العراق

[2] قسم النباتات الطبية والصناعية، كلية الزراعة–الحويجة، جامعة كركوك، كركوك، العراق.

[3]قسم المحاصيل الحقلية، كلية الزراعة، جامعة الانبار، الانبار، العراق.

الخلاصة

تم استخدام سبعة تراكيب وراثية من الكتان في هذه الدراسة، أربعة منها كانت من الآباء الذكور (سخا 1، سخا 2، سخا 3، سخا 5)، وثلاثة منهم إناث (سخا 6، جيزة 8، وسورية)، و(12) هجين من الجيل الثاني و (12) هجين من الجيل الثالث حسب تصميم التزاوج العاملي. أظهرت النتائج تفوق الأب (جيزة8) في زيادة عدد العلب الثمرية، وعدد البذور في العلبة الثمرية، والحاصل البيولوجي الذي بلغ (44.00 ، 8.00 ، 12.11)، على التوالي. وفي الجيل الثاني تفوق الهجين (سخا2*سوري) من حيث عدد البذور في العلبة الثمرية والحاصل البيولوجي حيث بلغ (8.00 ، 12.13) على التوالي. وفي الجيل الثالث أظهر الهجين (سخا2*سوري) زيادة في صفات عدد البذور في الكبسولة وحاصل البذور والحاصل البيولوجي حيث بلغ (8.00 ، 2.73 ، 12.13)، على التوالي. كانت قوة الهجين معنوية ومحسوبة على أساس انحراف متوسط الابوين في الهجين (سخا1*سخا6) في الجيل الثاني عند مستوى احتمال 1% في عدد العلبة الثمرية في النبات وعدد البذور في العلبة الثمرية وحاصل البذور ودليل الحصاد وبلغت على التوالي(0.50 ، 0.28 ، 0.11 ، 1.09)، والهجين (سخا5*سخا6) في عدد العلبة الثمرية في النبات وعدد البذور في العلبة الثمرية وحاصل البذور والحاصل البيولوجي وبلغت على التوالي (1.00 ، 1.17 ، 0.17 ، 0.84)، وفي الجيل الثالث الهجين (سخا2*سوري) في عدد العلبة الثمرية في النبات وعدد البذور في العلبة الثمرية ووزن 1000 بذرة وحاصل البذور والحاصل البيولوجي ودليل الحصاد وبلغت على التوالي (2.00 ، 1.17 ، 0.28 ، 0.24 ، 0.65 ، 0.85). بينما لم يظهر أي هجين معنوية سالبة أو موجبة للتدهور الوراثي بالتربية الداخلية.

الكلمات المفتاحية: المساءلة التنازلية، المساءلة التصاعدية، جودة الخدمة، التقويم، الارشاد الزراعي.