

## ARTICLE / INVESTIGACIÓN

Study of genetic analysis of individual hybrids derived by the half-diallel cross of some *Lycopersicon esculantum* mill

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**Abstract:** The study was conducted for the first season of 2020 in the field of the College of Agriculture \ Diyala University which the seeds of the first generation F1 hybrids were produced for six strains that were selected according to the genetic distance among them and resulted in 15 hybrids by applying for the half diallel crossing program. In the second year, the seeds of individual hybrids were planted with their parents and a hybrid Commercial common boob cat for comparison within a field experiment to evaluate the field performance of these produced hybrids according to the design of complete randomized sectors and with three replications. The differences were tested according to the LSD test. The result showed that the highest hybrid strength compared with the highest parents for the trait of plant height 43.34 cm, number of fruits 48.20%, plant yield 77.27%, TSS ratio 41.83%, fruit content of vitamin C 33% and sugar content 25.86% for the above traits, respectively. As for the common commercial hybrid, Boob cat was 64.20%, 121.23%, 43.92%, 55%, 109.36% and 46.65%, respectively. As for the union ability, the father gave c.c. Orang (5) had the highest general combined ability for plant height which amounted to 3.972. For the number of fruits, plant yield and TSS, Father Rose (1) showed the highest general union ability, which amounted to 4.136, 0.358 and 0.095, respectively, while the vitamin C and sugars ratio were recorded by the fathers (5) Red P.t (2) and Amish Pa.(4). The highest general federating ability amounted to 1.937 and 0.975 respectively while the highest union ability for plant height in 1×5 hybrids reached 33.375 and for TSS and sugars the hybrid showed 1×3. The highest ability of a particular union was 1.60 and 1.77, respectively. Regarding the characteristics of fruit number and yield of a plant, the 1×2 hybrid was superior in a proportion of 16.71 and 1.11 for vitamin C, and the 3×4 hybrid was superior in a ratio of 8.06. As for the percentage of heritability was high compared to the strict sense, indicating the importance of non-host gene action of genes in the inheritance and manifestation of the trait. The mean of the degree of dominance was higher than one for all the mentioned traits, which evidences the participation of super dominance of genes in the manifestation of the trait.

**Key words:** Half-diallel, boob cat, genetic distance, *Lycopersicon esculantum*.

## Introduction

The tomato crop (*Lycopersicon esculantum* mill) family Solanaceae is one of the world's most essential and widespread vegetable crops because of its excellent nutritional value. The tomato contains calcium, iron, and vitamins A, B2, B6 and C. It also contains proteins, carbohydrates, amino acids and some pigments such as carotene. Lycopen and some phenolic compounds<sup>1</sup>. It grows in various environments, from dry regions to wet areas, as well as in different soils according to its original habitat. And genetic and even at the plant molecular level<sup>2</sup>. Because of the low production per unit area in the world and Iraq in particular, it has become imperative for plant breeders to search for means through which production can be increased and improved in quantity and quality, Which forms the basis of any crossbreeding program that aims to develop hybrid varieties as the genetic action of any trait is related to the amount of genetic variation and the ability to combine between the parental strains, and this is one of the necessary steps in developing and improving crops including the tomato crop. By testing them, the best genetically heterogeneous strains or varieties to obtain the phenomenon of hybrid vigor to produce hybrids that outperform the widely cultivated varieties in one or more traits<sup>3-5</sup>.

Cross-crossing is one of the most efficient breeding methods for selecting hybrids produced in the early stages or in later generations in breeding programs based on knowledge of the type of gene action that controls the inheritance of the trait<sup>6</sup>.

This mating design has been standard in many plant species regardless of whether self-pollinating or cross-pollinating, as it satisfies the breeder's desire to obtain distinctive hybrids by identifying the best parents familiar with each other. There are three mating designs in breeding studies: the plant is the diallel, partial dialled, and line x tester.

The phenomenon of heterosis is one of the most critical agricultural phenomena that contributed to the development of agrarian production quantitatively and qualitatively. The phenomenon of hybrid vigor was first diagnosed by (7,8). The first scientists who noticed the strength of the hybrid in tomatoes were Hedrick, and Booth<sup>9</sup> was represented by an increase in yield and the number of fruits and then expanded to include yield components and qualitative characteristics<sup>10</sup>, and between Al-Shammari and Hamdi<sup>11</sup> Showed that the genetic divergence between the parents is a helpful indicator of the performance of the crosses. Heterozygosity is more influential than homozygosity, and many studies have confir-

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med a positive association between the genetic divergence of parents and the high performance of the crosses<sup>11-14</sup>.

To derive individual hybrids of tomato by cross-crossing and evaluate them in comparison with one of the hybrids approved in the environmental conditions of the region and the possibility of adopting it locally and estimating the genetic parameters and the strength of the hybrid and then choosing the best hybrids produced in quantity and quality that are well cultivated under the environmental conditions of the region and the possibility of adopting it locally.

## Materials and methods

### First season: production of individual hybrids (F1)

The seeds of these strains were planted inside cork dishes in one of the nurseries located within the Khan Bani Saad district of Baquba Center on 13/1/2020. After the seeds germinated and the plants had reached the seedling stage, they were transferred and planted in the open field at the research station of the Department of Horticulture and Landscaping for the College of Agriculture, Diyala University within the first season on 10/3/2020, All crop service work was carried out including watering, irrigation, fertilizing and removing the grasses as needed for producing unique hybrids (F1).

During this season, half dialele was conducted among these six strains according to the first method and the fixed model of Griffing<sup>15</sup> methods for the production of the first generation F1 hybrids, as shown in (Table 2) and resulted in 15 hybrids. The color of the flowers is cream. The bag was sacked after castration. The rest of the flowers were removed from the plant to ensure no cross-pollination.

### Studied traits

The measurements were taken from a random sample of five plants in the experimental unit, and for each replicate, the average was taken. The studied traits included the following:

Plant height (cm): It was measured at the end of the growing season from the surface of the soil to the top of the plant for five plants within the experimental unit, and the average was taken.

The number of fruits per plant (fruit plant<sup>-1</sup>).

The number of fruits in the experimental unit was calculated cumulatively from the beginning of the harvest until the end of the growing season and divided by the number of plants in the experimental unit.

### Plant yield (kg plant<sup>-1</sup>)

The cumulative yield was recorded from the beginning of harvest to the last pound for each experimental unit and then divided by the number of plants in one experimental unit.

The percentage of total dissolved solids (TSS %) was calculated using a Hand Refractometer.

The content of fruits of vitamin C (mg 100 g<sup>-1</sup>): It was estimated by smearing a specific volume of tomato juice with 2.6 Dichlorophenol indophenol dye and based on the mg unit of vitamin C per 100 g of fruit juice<sup>16</sup>.

### Estimation of total sugars in juice (%)

It was estimated by taking 1 ml of diluted juice and adding to it 1 ml of 5% phenol solution (5 g of phenol in 100 ml of distilled water) and 5 ml of concentrated sulfuric acid with continuous shaking; then the light absorption was read by a spectrophotometer at a wavelength of 550 nm And to calculate the sugar content of fruits by dropping the readings on the standard curve prepared using glucose.

### Statistical analysis

The standard statistical analysis was carried out according to the design of the entire random sectors with three replications, and data were entered (parents, single crosses, triple crosses and common commercial Bobcat crosses), and the averages were compared using the least significant difference (LSD) at the probability level of 5% and in the case of substantial differences between the treatments for the studied traits. The analysis is continued using the statistical method of this mating method by splitting the averages of the squares of the transactions into their components after collecting data for all the studied traits and populating using the Excel program; then, the data were statistically analyzed using the SAS program, and the data were compared according to the Tukey test at the probability level of 0.05, as the test was conducted regardless of the significance of F<sup>17</sup>.

Hybrid vigor of individual hybrids was estimated based on.

units	characteristics	Valuable soil	units	characteristics	Valuable soil
g kg <sup>-1</sup>	6.8	Organic matter	ds	6.5	Electrical EC <sub>1:1</sub> conductivity
	230	Caco3	--	7.55	pH1:1
	250	Sand	mg kg <sup>-1</sup>	53.0	N
	450	silt		39.0	P
	300	Clay		240.0	K
%	25	Weight moisture field capacity	Mg cm-3	1.36	Bulk density for depth 0.3-3m
			Silty loam	Soil texture	

**Table 1.** Some physical and chemical properties of field soil.

Breed number	Breed name	its source
1	Rose	Genetic Resource Center at the University of California, Davis, USA
2	Red P.t	
3	Nepal	
4	Amish Pa	
5	C. C. Orange	
6	T. 115	

**Table 2.** Breeds used in crossbreeding and their source.

Parents	Rose	Red P.t	Nepal	Amish Pa	c.c. Orang	T. 115
Rose	1	X	X	X	X	X
Red P..t		2	X	X	X	X
Nepal			3	X	X	X
Amish Pa.				4	X	X
c.c. Orang					5	X
T. 115						6

**Table 3.** Individual crosses are derived from pure strains according to the second Griffing method (1956).

## Results and discussion

Firstly: The mean deviation of the first generation  $\bar{F}_1(i)$  from the best parents BP according to the following equation:

$$H_{BP} = \bar{F}_{1(i)} - BP$$

Secondly. The mean deviation of the first generation  $\bar{F}_1(i)$  from the ordinary standard hybrid Boobcat according to the following equation

$$H_{CP} = \bar{F}_{1(i)} - \bar{CP}$$

$\bar{CP}$  = Commercial Hybrid

The degree of inheritance in the narrow and broad sense was estimated according to the following equation

$$h^2_{bs} = \frac{\sigma^2_G}{\sigma^2_P}$$

$$h^2_{ns} = \frac{\sigma^2_A}{\sigma^2_P}$$

Since:

$h^2_{bs}$ : degree of inheritance broadly

$h^2_{ns}$ : the degree of heritability in its narrow (limited) sense

$\sigma^2_A$ : the portion of the genetic variance due to the additional verb

$\sigma^2_G$ : genetic variance

$\sigma^2_P$ : phenotypic variance

The dominance degree rate was estimated from the following equations:

$$a = \sqrt{\frac{2 \bar{f}^2 D}{\bar{f}^2 A}} = \sqrt{\frac{8 \bar{f}^2 Sca}{4 \bar{f}^2 gca}} = \sqrt{\frac{2 \bar{f}^2 Sca}{\bar{f}^2 gca}}$$

From the values of  $a$ , we infer the following:

If  $a$  is zero, this indicates that there is no sovereignty

If it is zero  $> a > one$ , this shows a partial dominance

If  $a$  is equal to one, this suggests that there is complete dominance

If  $a < 1$ , this indicates that there is a super-dominance

studied traits. Most hybrids showed positive and positive hybrid vigor in the desired direction for the plant height trait. The highest was the hybrid 2×6 which scored 43.34 compared with the best parents. Compared with the commercial hybrid, the hybrid 1×5 showed the highest desirable hybrid vigor of 64.20% for the number of fruits. The hybrid 3×6 showed the highest rate of 48.20% compared with the highest parent, while the hybrid 1×2 recorded the highest hybrid strength compared with the standard hybrid, which amounted to 121.23%. It reached 77.27%, while the hybrid 1×2 recorded the highest significant and desirable hybrid strength compared with the standard hybrid, which amounted to 43.92%. As for TSS, the hybrid 1×3 showed positive and significant hybrid strength compared with the best parents, with a percentage of 41.83% compared to the commercial hybrid. The above hybrid had the highest hybrid strength of 55%. The highest hybrid strength distinguished the 2×5 hybrid compared to the best parents for vitamin C, which amounted to 33%. The hybrid 1×2 showed the highest significant and positive hybrid strength of 109.36% compared with the standard hybrid. As for sugars, the hybrid 1×3 was distinguished by the best hybrid strength compared to the highest hybrid, which amounted to 25.86%, while the hybrid 4×5 recorded the highest hybrid strength compared with the commercial hybrid 46.65%. The difference of hybrids in the above traits is mainly due to the variation

of their genetic composition, which in turn affects the physiological ability and its efficiency in converting the products of photosynthesis in favor of the growth and elongation of stem cells and then the increase in plant height and number of branches which is reflected on other vegetative growth indicators. In other words, the trait Vegetativeness is mainly determined by genetic factors and shares with them the response of hybrids to the influence of environmental factors affecting their growth, including agricultural service operations<sup>5,14,18,19</sup>.

As shown in Table (5) the results of the statistical genetic analysis and the splitting of the mean squares of the genotypes into components that belong to the general and specific abilities of the union according to the second method of the first model (Fixed Model) proposed by Griffing (1956).

The analysis of variance of the genotypes data (parents + individual hybrids + common commercial Bobcat hybrid) for all traits shows that the mean of squares was significant for all the traits that were under study. The general ability to combine was highly significant for most traits except for TSS, which did not reach the significance limit as the results presented in Table 5 showed a highly effective effect of the mean squares of genotypes and their interactions for all studied traits and identifying the nature of the work of the genes that control the inheritance of the studied traits. These results are consistent with what was found by a group of researchers including<sup>14,20-22</sup>.

adjectives	plant height		number of fruits		plant yield		TSS		VC		sugars	
genetics	BPH	SCH	BPH	SCH	BPH	SCH	BPH	SCH	SCH	BPH	SCH	BPH
2×1	2.20	8.17	51	121.23	38	43.92	13.77	35.71	109.36	16.90	23.50	11.38
3×1	4.73	29.18	-3	42	3	7.94	41.83	55.00	77.02	-1.15	39.55	25.86
4×1	27.57	35	-3.92	40.70	23	28.29	1.34	7.86	42.49	-20.43	36.92	4.48
5×1	39.73	64.20	-34.44	-3.98	-9.52	-5.71	26.95	27.86	89.18	5.63	22.27	10.28
6×1	0	5.83	-22.35	13.71	6.42	10.92	-3.68	12.14	79.21	0	27.80	-1
3×2	-4.73	17.50	-7.37	-11	-31.5	-32.01	-7.78	10.00	103.04	22	25.78	14.96
4×2	23.34	23.34	-0.68	28.31	9	10.42	1.19	20.71	37.14	-12.69	44.72	10.43
5×2	1.98	19.84	35.34	38.93	27	26.05	-2.39	16.43	108.92	33	29.11	22.96
6×2	43.34	46.69	-19.52	-10.61	3.75	2.98	-1.19	17.86	99.64	18.98	9.65	-15
4×3	-4.73	17.50	-14.72	10.17	-17.48	-16.87	10.45	20.71	102.80	21.93	32.01	0.73
5×3	-14.19	5.83	4.74	7.524	24.16	-8.19	2.61	12.14	20.60	-27.48	22.27	11.75
6×3	14.19	40.85	48.20	64.60	77.27	35.48	-1.84	14.29	23.02	-26.67	40.51	8.82
5×4	7.94	26.84	-21.91	0.88	10.83	11.66	25.50	33.57	51.00	6.97	46.65	11.91
6×4	-2.28	0	-10.27	15.92	-2.95	-2.23	1.22	17.86	86.26	11	31.04	0
6×5	-1.98	15.17	-16.73	-7.52	66.55	27.30	0	16.43	81.40	8.11	35.95	5.29

**Table 4.** Shows the strength of the hybrid (%) based on the deviation of the first generation from the highest parent and the commercial hybrid (Bobcat).

SOV	replication	genotype	parents	crosses	P V c	gca	aca	error	Total
df	2	20	5	14	1	5	15	40	82
plant height	**213.06	**711.17	**356.88	**666.28	**311.11	**88.85	**286.46	0.39	28889.1
number of fruits	85.2**	139.6**	65.3**	167.6**	118.9**	52.2**	44.6**	1.2	5804.58
plant yield	17**	2.19**	1.07**	2.07**	9.53**	0.58**	0.78**	1.14	120.0055
TSS	**12.35	1.02**	0.41**	0.99**	4.40**	0.06	0.43**	0.16	72.752
Vitamin C	94.2**	75.7**	35.6**	86.5**	125.1**	20.5**	26.7**	0.03	3219.37
sugars	**2.78	**6.48	**6.06	**3.79	**46.27	**2.48	**2.05	0.22	273.857

**Table 5.** Results of the analysis of variance for the genotypes (parents + individual hybrids + common commercial Bobcat hybrid), fathers and individual crosses for the studied traits.

Parents	Rose	Red P.t	Nepal	Amish Pa.	c.c. Orang	T.115	SE
plant height	-1.777*	3.972*	-2.902*	2.972*	-4.027*	1.763*	0.117
number of fruits	-1.418*	-3.363*	-0.163*	-0.568*	1.377*	4.136*	0.207
plant yield	0.023*	-0.126*	0.051*	-0.445*	0.137*	0.358*	1.99
TSS	-0.070*	-0.1*	-0.058*	0.041*	0.091*	0.095*	0.075
Vitamin C	0.490*	-1.775*	-1.729*	-0.499*	1.937*	1.575*	0.033
sugars	0.259*	-0.357*	0.975*	-0.086*	-0.602*	-0.188*	0.087

**Table 6.** Estimating the effect of the general ability of the parents to combine on the indicators of vegetative growth, flowering and yield of tomato plants.



Table (6) shows the effect of the general ability to combine for all the traits under study that were estimated and their results are shown in the above table in which it is noted that Father 1 showed a general desirable and significant ability to combine for the characteristic of plant height, number of fruits, yield of one plant, TSS and vitamin C. As for Father 2. It showed a desirable and moral effect of the general ability for the characteristics of the number of fruits, plant yield, TSS and vitamin C to combine, while Father 3 showed a broad ability of positive and significant for the trait of plant height and TSS to combine and father 4 showed a general effect on the combination significantly and in the desired direction for the trait of the yield of the plant only and the percentage of sugars. Father 5 was characterized by a general ability of significance and the desired direction for the characteristic of plant height only to combine. At the same time, father 6 showed a generally desirable and important combining ability for vitamin C traits.

Table (7) shows the effect of the special ability on the union of individual hybrids for all the studied traits, and it is noted that the plants shown by the parents due to the variation in the general ability to combine have an effect on the behavior of the resulting hybrids through the crossing tip between them. The height of the plant 9 crosses showed the power to destroy, especially for the significant and positive union. The highest reached 33.37 for the hybrid 1×5. For the number of fruits, 4 of the hybrids achieved a positive and significant unique ability to destroy the difference in the special ability to combine, reached a maximum of 16.71 for the hybrid 1×2, and 9 genotypes for the trait of the plant yield showed a special ability to combine positive and significant in the direction.

The desired one was the best of the hybrid 3×6 scoring 1.73 while 4 crosses were distinguished for TSS and showed positive and desirable values that have special ability to combine. The maximum was the hybrid 1×3, scoring 1.60.

As for the content of the fruits of vitamin C, 10 crosses showed the highest positive and significant special to combine ability in the desirable direction. The highest hybrid was 3×4, which scored 8.06. For the percentage of sugars, 9 combinations were distinguished. They gave positive, significant and desirable values for the unique ability to combine, which reached the highest rate in the 1×3 hybrid, which scored 1.77.

Table (8) shows the components of the phenotypic variance for the traits studied, and we note that the environmental conflict differed from zero for all the traits studied. In contrast, the additional genetic variance differed from zero for the characteristics under study except for the TSS percentage while the sovereign genetic variance differed from zero.

For all studied traits, the values of dominance genetic variance were greater than those of additional genetic variance. The table above shows that the importance of gene variance is greater than the environmental variance values for all the studied traits except for TSS. Accordingly, these traits can be genetically improved. These results agree with what was found by (14,23,24) in their studies on tomato plants. Shown in the table (8) are the values of heritability, the rate of the degree of dominance and the expected genetic improvement of the traits studied; it is noted that the importance of heritability in the broad sense was high and close in all the traits studied, while the values of heritability in the narrow mind for all the traits studied for TSS were low.

## Conclusions

The low values heritability in the narrow sense has appeared in the characteristics of plant height. TSS this decrease is due to the decline in the value of additional genetic variance and the increase in the value of the dominant genetic variance. As for the average degree of dominance, it was more significant than one for all the traits under study, which indicates the presence of super-dominance at some genetic sites that control the inheritance of all the traits studied. These results are consistent with what was found<sup>25</sup>.

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adjectives	plant height	number of fruits	plant yield	TSS	VC	sugars
genetics	-6.625*	16.71*	1.11*	0.65*	3.45*	0.45*
2×1	4.375*	0.75*	0.24*	1.60*	0.32*	1.77*
3×1	15.25*	0.05	0.57*	-0.49*	-4.39*	0.40*
4×1	33.375*	-6.84*	-0.35*	0.48*	3.69*	0.07
5×1	-10.875*	-4.79*	-9.09*	-0.28*	-0.28*	0.08
6×1	0.166*	0.18	-1.10*	-0.49*	4.44*	0.61*
3×2	11.041*	0.01	0.11*	0.10	-5.68*	0.71*
4×2	1.166*	5.61*	0.88*	-0.04	6.73*	1.26*
5×2	29.916*	-4.86*	-0.16*	-0.01	2.86*	-1.57*
6×2	-0.958*	-2.14*	-0.40*	0.15	8.06*	-0.25*
4×3	-17.833*	0.45	0.08*	-0.19	-6.04*	-0.03
5×3	17.916*	11.41*	1.73*	-0.12	-7.89*	1.43*
6×3	6.041*	-1.44*	0.38*	0.90*	0.42*	1.68*
5×4	-11.208*	0.00	-0.28*	0.13	4.23*	-0.70*
6×4	-5.083*	-2.09*	1.04*	0.11	3.43*	1.18*
6×5	0.322	0.57	0.05	0.20	0.09	0.24

**Table 7.** Estimates of the effects of special ability on the union of individual crosses for all studied traits.

Variations Adjectives	$\sigma^2 E$	$\sigma^2 A$	$\sigma^2 D$	$h^2_{n.s}$	$h^2_{b.s}$	$\bar{a}$	GA	GA %
plant height	0.13* ± 0.03	7.393* ± 4	95.443* ± 32.75	0.071	0.998	5.081	1.282	1.260
number of fruits	0.41* ± 0.08	2.073* ± 1.12	14.736* ± 5.10	0.120	0.976	3.770	0.879	3.229
plant yield	0.004* ± 0.0008	0.050* ± 0.02	0.252* ± 0.08	0.164	0.986	3.159	0.160	3.859
TSS	0.05* ± 0.01	0.000 ± 0.002	0.126* ± 0.04	0.014	0.718	17.435	0.003	0.063
Vitamin C	0.01* ± 0.002	1.715* ± 0.91	8.926* ± 3.06	0.161	0.999	3.226	0.924	3.178
sugars	0.07* ± 0.01	0.200* ± 0.01	0.66* ± 0.23	0.215	0.924	2.563	0.366	2.540

**Table 8.** Estimates of the components of phenotypic variance, standard error, heritability, mean degree of dominance, and expected genetic improvement for the studied traits.

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