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Evaluation of Triple Hybrids of Tomato Crop (*Lycopersicon esculantum*. Mill) Derived from Individual Hybrids and Some Pure line

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Abstract

The study was during which the seeds of triple hybrids were produced by deriving individual hybrids by introducing 6 strains into the half-diallel cross-breeding program, resulting 15 genotypes. In the second season the hybrid seeds were planted Individuals with two strains for the purpose of developing triple hybrids. During the third season, all 48 genotypes were planted according to the randomized complete block design with three replications, service operations were conducted for the crop from irrigation, fertilization, weeding and control whenever needed. The result showed that the triple hybrid (1×3)b was significantly superior to all genotypes for the plant height reached 140.66 cm, and for the number of leaves per plant, the triple hybrid (1×2)b had the highest number of leaves over all the genotypes, which scored 137.9 leaf^{-1}. For the number of fruits and plant yield, the triple hybrid (5×6)a showed significant superiority over all the genotypes within the experiment by recording 43.20 fruits of the plant^{-1} and 7.921 kg of the plant^{-1}, respectively and the superiority of the triple hybrids (2×6)b and (4×5)a significantly over the rest of the compounds with the highest percentage of carbohydrates amounting to 10.363% and 10.325%, respectively, while the hybrids (5×6)a, (2×3)a, (1×3)a and (4×5)a recorded the highest Significant values of sugars were 16.993%, 16.880%, 16.833% and 16.813%, respectively.

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Introduction

Tomato *Solanum Lycopersicon* L. is a common cultivated species that belongs to the family Solanaceae. It is a herbaceous plant with double chromosomal self-pollination (2n = 24). It is considered one of the most common vegetable crops in the world including Iraq, because of its high nutritional value as it is considered a main and protective food for its content of nutrients and antioxidants. Oxidation, vitamins such as C and E nutrients such as calcium and contains some pigments such as carotene, lycopene and some phenolic compounds (Al-Mfargy, 2017; Erika *et al*., 2020). The tomato is domestic to the regions of Ecuador, Peru, Bolivia, Colombia and Chile it grows in a variety of environments from dry areas to wet areas, as well as growing in different soils according to its original habitat. Plant molecular (Tasisa, *et al*., 2012). The low production per unit area in the world and in our country 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 traits as the number of fruits, total yield, hardness, carbohydrates and sugars. Any forms the basis of any breeding program that aims to develop hybrid varieties. Studies indicate that interest in research activity in the field of tomato breeding and its improvement to produce seeds of hybrid varieties began in 1944 and 1945, as Powers produced several hybrids of tomato with the aim of explaining the phenomenon of hybrid strength in it and then rolled Studies with the aim of obtaining superior hybrids since that date and to the present day, so we find that plant breeders have been interested in producing hybrids by testing the best genetically heterogeneous strains or varieties in order to obtain the phenomenon of hybrid vigor to produce hybrids that are superior to the widely cultivated varieties in one or more traits. (Kumar, 2015; Kulus, 2022).

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 (Kherwa, 2017). There are three mating designs in plant breeding studies: diallel, half diallel and line × tester (Al-Shammari and Hamdi, 2021). The genetic divergence between the parents is a useful indicator of the performance of the crosses. Heterozygosity is more influential than homozygosity and many studies have confirmed the existence of a positive association between the genetic divergence of the parents and the high performance of the crosses (Liu *et al.,* 2002). The aim of this study is to derive triple crosses by cross-crossing and evaluate them in comparison with one of the crosses adopted in the environmental conditions of the region and the possibility of adopting it locally, estimating the genetic parameters and the strength of the hybrid and then choosing the best crosses that can be adopted locally.

Materials and Methods

The study was conducted the Department of Horticulture and Landscape Design in the College of Agriculture, University of Diyala. The experiment included three seasons. All of the crop service work, including irrigation, irrigation, fertilizing and removing the bush, as needed Soil samples were taken and analyzed for the purpose of diagnosing the percentage of mineral elements in them as shown in Table 1, for the purpose of producing individual hybrids (F1) was carried out by the half dialle method between these parents according to Griffing methods (1956), which resulted in 15 crosses using each Cap strain and in one direction, after extracting the seeds individual hybrids from the hybrid fruits, a part of the seeds of each hybrid and the seeds of the two lines Fr and Marb were planted in the greenhouse of the Department of Horticulture and Landscaping in the college (the strain Fr was encoded with the symbol a and the strain Marb with the symbol b), as shown in Tables 2, 3. The width of each terrace is 2 m. The first terrace was planted with the seeds of the two lines (Fr and Marb) while the other three terraces were planted with individual hybrid seeds. The pollination was carried out as the two strains (lines) Fr and Marb were used as parents and individual hybrids as mothers.

Individual hybrids, and fruits reached red maturity they were picked from each cross individually then their seeds were carefully extracted and placed inside paper wrappers on which all the requirements of the hybridization process were recorded. During the third season, the 30 hybrids were planted with their parents in addition to a hybrid BobcatIt is a local hybrid with good productivity and resistance to many diseases and environmental conditions within the country. After the seedlings reached the seedling stage. Parents (pure lines) were obtained from tomatoes by importing them from the Tomato Genetics Center at the University of California - Davis, USA (Tomato Genetics Resource Center {TGRC} at UCD). 6 genotypes were entered into the half cross-crossing program to produce single crosses and two were used as parents to derive triple crosses.

Table 1. Some physical and chemical properties of field soil

units	characteristics	Valuable soil		units	characteristics	Valuable soil	
g kg^{-1}	6.8	matter Organic		ds	6.5	conductivity$_{1:1}$Electrical EC	
	230	Caco3		--	7.55	pH1:1	
	250	Sand	Soil Separators	mg kg^{-1}	53.0	N	-Ready made Elements
	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	
	Soil texture	Silty loam		Silty loam	Soil texture		

acclimatization and hardening operations were carried out to relieve the shock of the seedling inside the open field then the seedlings were transferred and planted inside the field exposed on March 2020, 2021 as it was planted on terraces with a width of 1.20 m and a length of 4.8 m at a rate of 10 plants per experimental unit, and the distance between one plant and another is 40 cm. With three replications according to the design of the complete pedestrian sectors (RCBD). Tape tubes were used for the purpose of irrigation. All agricultural service operations for the tomato crop were carried out, including irrigation, weeding, and fertilization control whenever needed. Homogeneously for all experimental units.

Table 2. Breeds used in breeding for the production of camels

Pure Font Number	pure line	Name Usage
1	Rose	Half cross multiplication
2	Red P.t	Half cross multiplication
3	Nepal	Half cross multiplication
4	Amish Pa	Half cross multiplication
5	C. C. Orange	Half cross multiplication
6	T. 115	Half cross multiplication
7	Fr	Triple multiplication
8	Marb	Triple multiplication

Table 3. Triple crosses derived from individual crosses from pure lines

Breeds / parents	(a). Fr	Marb (b)
1×2	1×a2	1×b2
1×3	1×a3	1×b3
1×4	1×a4	1×b4
1×5	1×a5	1×b5
1×6	1×a6	1×b6
2×3	2×a3	2×b3
2×4	2×a4	2×b4
2×5	2×a5	2×b5
2×6	2×a6	2×b6
3×4	3×a4	3×b4
3×5	3×a5	3×b5
3×6	3×a6	3×b6
4×5	4×a5	4×b5
4×6	4×a6	4×b6
5×6	5×a6	5×b6

Studied traits

Measurements were taken on 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. (Ipgri, 1996).

Total number of leaves (leaf plant^{-1})
The total leaves of all experimental unit plants were counted at the end of the season and then the average was extracted (Ipgri, 1996).

Number of fruits per plant (fruit plant^{-1})
The number of fruits in the experimental unit was cumulatively calculated from the beginning of the harvest until the end of the growing season and divided by the number of plants in the experimental unit according to the following equation:

Number of fruits (fruit plant^{-1}) = Number of fruits / Number of plant
Plant yield (kg plant^{-1})
The cumulative yield was recorded from the beginning of the harvest until the last harvest for each experimental unit and then divided by the number of plants in one experimental unit.

Estimation of Carbohydrates and Total Sugars in Juice (%)
Concentration from the Standard Score x Concentration (Ranganna, 1977).

Carbohydrates and Total Sugars in Juice (%) = Concentration from standr curve*focus / the volume of juice taken * 10000

Statistical analysis
The method included the analysis of triple crosses according to the Randomized Complete Blocks Design (RCBD) in order to test the significance of the difference between the genotypes. Data (parents triple crosses and common standard cross Bobcat) were entered and the averages were compared using the least significant difference at the probability level of 0.05 and using the excel program, then the data were analyzed statistically using SAS program and the data were compared according to tukey test at a probability level of 0.05, as the test was conducted regardless of the significance of F. As shown in Table 4. (Dean *et al*. 2017).

Table 4. Analysis of variance of the genotypes (parents, haploid hybrids, triple crosses and standard cross Bobcat) for the studied traits

S.O.V	Replication	Genotype	Error
df / **traits**	**2**	**47**	**94**
plant height	448.0	454.6**	16.71
number of leaves	300.0	321.5**	5.65
number of fruits	245.0	0.445**	139.9
plant yield	2959.9	3209.5**	83.05
carbohydrates	0.145	8.783**	0.044
sugars	5.035	5.790**	0.186

(**) and (*) are significant at 0.01 and 0.05 probability levels, respectively.

Results and Discussion

The analysis of variance of data the genotypes (parents, single hybrids, triple crosses and common commercial Bobcat hybrids) for the studied traits and it is noted in table 5 that the mean of the squares of the genotypes was significant for all studied, that the differences between (genetic structures) are due to genetic differences between them, so it is necessary to continue studying her genetic behavior for the purpose of identifying the nature of the work of the genes that control the inheritance of the trait, and this is consistent with what was mentioned (Dharva *et al.*, 2018; Kande et al., 2019; Islam *et al*., 2022; Hamdi, 2022).

Plant Height (cm)

We note from the results presented in table 5 that the parents 1×3 and 2×6 were significantly superior in plant height by recording the best plant length of the two parents, which was 125.66 cm each, while the father 4×6 recorded the lowest plant height of 85.66 cm. As for the triple crosses, the hybrid (1×3)b And the hybrid (1×2)b were significantly superior to all the hybrids in plant height, they recorded 140.66 cm and 138.66 cm, respectively, while the lowest plant height was 90.66 cm for each of the two hybrids (2×5)a and (4×5)b.

Number of leaves (leaf^{-1})

It was noticed from table 5 that the (parent) 2×3 and the father 2×4 were significantly superior to the rest of the fathers in the number of leaves per plant, as they recorded 135.2 leaves $^{-1}$ for each, while the father Fr gave the lowest value of 90.00 leaves plant $^{-1}$, while the triple crosses showed the triple hybrid (1×2)b was significantly superior to all genotypes for the number of leaves per plant by recording a value of 137.9 leaf plant $^{-1}$, while the lowest value for this trait was 93.5 leaf plant^{-1} in hybrid (5×6)a.

Number of fruits (fruit plant^{-1})

Table no.5 shows that the parent 3×6 significantly outperformed all fathers for the number of fruits per plant, it reached 37.20 fruits. plant^{-1}, while this value decreased to 20.20 fruits. plant^{-1} when hybrid 2×6 and hybrid (5×6)a was significantly superior to the highest number of fruits per plant. On the rest of the hybrids, as well as the parents, as it reached 43.20 fruits. plant^{-1}, while the hybrid (5×6)b was considered the lowest hybrid for the number of fruits per plant, as it swallowed 21.90 fruits.plant^{-1}.

Plant yield (kg plant^{-1})

The data in Table 5 indicated that there were significant differences between the genotypes in the plant yield, as the parent 2×3 gave the highest yield of 5.747 kg plant^{-1}, while the parent 3×4 recorded the lowest yield among the parents amounting to 3.336 kg plant^{-1} and the triple hybrid superiority. (5×6) a was significantly on all genotypes of plant yield with a value of 7.921 kg plant^{-1}, while plant yield decreased to 3.021 kg plant^{-1} for triple hybrid (3×4)b.

Carbohydrate content of tomato juice (%)

Through table (5) it was found that the parent or hybrid or genotype 1×3 was significantly superior to the highest percentage of carbohydrates in the fruits, which amounted to 9.843%, while the parent Marb recorded the lowest concentration of carbohydrates among the two fathers, which amounted to 5.133%, in contrast to the superiority of the triple crosses (2×6)b and (5×6)a and (4×5)a had the highest concentration of carbohydrates in the fruits, which amounted to 10.363%, 10.255% and 10.325%, respectively, compared to the hybrid (2×3)a which gave the lowest value of 4.293%..

Table 5. The average values of parents and triple crosses for growth traits and tomato yield

Genotypes	plant height cm	Number of leaf per plant	number of fruits fruit plant^{-1}	Plant Yield or	Carbohydrates %	Sugars %
Fr (a)	115.66^{f}	^{m}92.0	^{wxy}22.40	^{s}3.763	^{rs}5.683	^{s}12.413
Marb (b)	110.63^{g}	^{j}101.0	^{wx}23.20	^{no}4.176	^{tu}5.133	$^{q-n}$13.433
1×2	92.66^{p}	^{l}122.8	^{b}34.20	^{ig}5.080	^{e}9.426	$^{n-j}$14.083
1×3	125.66^{d}	^{d}113.7	^{ig}32.10	^{no}4.354	^{b}9.843	^{bc}15.913
1×4	115.64^{f}	^{h}126.7	^{g}31.80	^{hi}5.173	^{lmn}6.463	^{cde}15.613
1×5	110.66^{g}	^{h}111.0	^{yz}21.70	^{s}3.818	^{lm}6.523	$^{n-k}$13.943
1×6	90.66^{q}	^{g}112.4	^{ts}25.70	^{mn}4.446	^{pqr}5.853	$^{g-k}$14.573

2×3	100.67[l]	[e]135.20	[ts]25.10	[d]5.747	[cd]9.143	[l-i]14.343
2×4	105.66[j]	[e]135.2	[no]29.00	[mn]4.437	[st]5.413	[ab]16.503
5×2	102.66[k]	[w]118.0	[gk]31.40	[ij]5.055	[J]7.163	[i-g]14.723
2×6	125.66[d]	[s]119.4	[-a]20.20	[pqr]4.141	[i]7.943	[rs]12.503
3×4	100.65[l]	[l]122.8	[-e]24.90	[uv]3.336	[ef]8.743	[h-d]15.053
3×5	90.67[q]	[a]115.3	[uv]24.30	[st]3.693	[c]9.473	[n-k]13.943
3×6	120.66[e]	[c]114.0	[g]37.20	[g]5.431	[jk]6.883	[bc]16.023
4×5	108.67[h]	[m]122.8	[wxy]22.80	[jk]4.902	[ghi]8.203	[a]16.723
4×6	85.66[r]	[r]119.7	[rs]26.20	[lm]4.585	[hi]8.023	[i-e]14.943
5×6	98.66[m]	[n]121.9	[no]29.00	[jk]4.814	[hi]8.053	[f-c]15.503
1×2a	100.66[l]	[k]125.3	[c]41.10	[jk]4.912	[kl]6.713	[h-d]15.043
1×2b	138.66[a]	[a]137.9	[gkl]31.10	[pr]4.162	[opq]6.073	[p-m]13.513
1×3a	105.6[j]	[o]121.7	[fg]38.00	[nop]4.315	[ef]8.703	[a]16.833
1×3b	140.66[a]	[J]125.8	[opq]27.20	[s]3.829	[mno]6.243	[m-j]14.170
1×4a	100.66[l]	[g]127.1	[no]29.0	[v]3.290	[tu]5.133	[rs]12.723
1×4b	105.66[j]	[c]133.2	[lmn]30.10	[st]3.663	[opq]6.103	[s-p]12.943
1×5a	110.63[g]	[n]121.9	[wx]23.10	[n]4.433	[gh]8.303	[i-e]14.943
1×5b	97.66[n]	[q]120.4	[klm]30.40	[l]4.620	[lm]6.523	[n-k]14.003
1×6a	125.66[d]	[z]115.4	[mn]29.60	[opq]4.224	[kl]6.693	[i-f]14.833
1×6b	115.66[f]	[u]118.6	[klm]30.40	[c]6.314	[r-o]5.993	[a]17.113
2×3a	95.62[o]	[p]120.6	[h]34.80	[t]3.640	[w]4.293	[a]16.880
2×3b	97.66[n]	[t]118.9	[rs]26.18	[s]3.820	[c]9.263	[bc]15.953
2×4a	110.64[g]	[f]112.7	[fe]38.90	[c]6.224	[de]8.913	[q-n]13.39
2×4b	108.66[h]	[y]116.8	[i]33.10	[ij]5.052	[rs]5.713	[n-k]13.943
2×5a	90.66[q]	[i]126.5	[cd]40.10	[fg]5.515	[qr]5.803	[r-o]13.11
2×5b	105.6[j]	[n]121.9	[h]35.60	[jk]4.934	[kl]6.743	[bc]16.053
2×6a	99.66[q]	[b]134.2	[g]37.30	[b]7.01	[t]5.323	[qrs]12.833
2×6b	110.62[g]	[d]131.5	[ts]25.80	[d]5.800	[a]10.363	[lmn]13.813
3×4a	120.66[e]	[r]119.7	[o]28.40	[ef]5.644	[ghi]8.193	[f-c]15.453
3×4b	95.62[o]	[x]117.3	[-a]20.0	[w]3.021	[cd]9.143	[p-m]13.513
3×5a	106.66[i]	[v]118.5	[-a]25.80	[no]4.355	[fg]8.443	[ab]16.463
3×5b	108.6[h]	[y]116.8	[o]29.60	[fg]5.497	[b]9.803	[cd]15.723
3×6a	127.66[c]	[n]121.9	[y]27.0	[k]4.800	[b]9.973	[f-c]15.513
3×6b	128.66[b]	[f]128.5	[g]31.90	[fg]5.518	[v]4.773	[h-d]15.053
4×5a	95.61[o]	[g]127.1	[vw]23.40	[de]5.754	[a]10.325	[a]16.813
4×5b	90.65[q]	[e]112.8	[stu]25.20	[h]5.288	[nop]6.163	[lmn]18.553
4×6a	108.6[h]	[k]99.6	[de]39.50	[fg]5.490	[rs]5.713	[l-h]14.403
4×6b	105.62[j]	[i]101.3	[uv]24.40	[v]3.315	[jk]6.993	[o-l]13.743
5×6a	100.66[l]	[l]93.5	[a]43.20	[a]7.921	10.255[a]	[a]16.963
5×6b	105.66[j]	[e]112.8	[xyz]21.90	[k]4.861	[ef]8.713	[g-d]15.223
Bobcat	85.66[r]	[n]90.9	[wxy]22.60	[r]4.022	[uv]4.853	[t]11.403

Total sugars in tomato juice (%)

parent 1×3 showed significant superiority in the percentage of sugars in tomato fruits, as it recorded a value of 15.913%, while father Fr gave the lowest values with a percentage of 12.413%, and for triple crosses excelled with the highest values for sugars in fruits amounting to 16.993%, 16.880% and 16.833% and 16.813% for each of the hybrid (5×6)a (2×3)a, (1×3)a and (4×5)a, respectively, while this percentage reached its lowest value in the hybrid (1×4)a it amounted to 12.723%.

The results of table 5 showed that there were differences between the genotypes (parents, single crosses, triple crosses and standard hybrids (Bobcat) in growth and yield traits. This variance is mainly due to the variation and difference of their genotypes, which has an effect on their physiological ability and efficiency in converting the output of photosynthesis in favor of cell growth Its elongation and division, and the vegetative and flowering growth indicators are almost directly governed by genetic factors and the influence of environmental factors that have an impact on the growth indicators of these genotypes (Alwan and Mazher 2015; Anuradha *et al*., 2021; Sinha *et al*., 2021; El-Sappah *et al.,* 2022).

It was also noted that there were significant differences between the genotypes (parents, single crosses, triple crosses and standard hybrid Bobcat) for the traits that were under study and that these differences were mainly caused by the difference in their genetic content since each combination of them expresses the trait to a significant degree in addition to the environmental impact. Which directly or indirectly affects these structures in ways that differ from one structure to another. These results agree with results (Murariu *et al*., 2021; Akhter *et al*., 2021; Athinodorou *et al*., 2021).

Conclusion

This study concludes from the previous results that most of the triple hybrids have outperformed the parents and the standard hybrid Bobcat for all the studied traits, as the triple hybrid (1×2)b for the number of leaves outperformed all the genotypes, and for sugars, the hybrid (1×3)a outperformed. Hybrid (5×6)a in terms of a number of fruit plant yield and percentage of sugars in fruit and hybrid (1×3)a showed superiority over all combinations for plant height trait, and sugars hybrid (2×3)a, reached the highest values for it either Hybrids (2×4)a, (2×6)a, (4×5)a, (1×4)a and (2×6)b were distinguished by the highest significant values for the characteristics of the proportion of carbohydrates in the fruit.

Conflict of interest

The authors declare that they have no competing interests.

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