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Study of Combining Ability Analysis in Cherry Tomato (Solanum *lycopersicum var. cerasiforme*)

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Abstract

The study aimed to show the best effect of the general combining ability (GCA) and specific combining ability (SCA) for parents and their hybrids of the studied traits. The study included two main successive seasons. In the first season, cherry tomato pure lines were selected that were introduced from the Tomato Genetics Resource Center (TGRC) at University of California, Davis in USA, 5 pure lines were selected which were the most genetically Distant which are (LA4451, LA4753, LA3334, LA1221 and LA4689) and its code (1, 2, 3, 4 and 5) respectively and entered into Full Diallel crossing program to produce individual crosses. The second season included an experiment to compare genotypes (5 parents + 20 cross-hybrids. and its reciprocal hybrids) according to RCBD design with three replications. The results were as follows: parents 1 showed a general significant ability to combine in the desired direction in terms of fruit set percentage and fruit weight, while the superiority of parent 4 in terms of plant yield and total yield. The parent 5 was superior in the number of flowers in the inflorescence, the number of total flowers of the plant and the number of fruits, whereas the hybrid (5×1) showed superiority in the number of flowers in the inflorescence 35.667, number of total flowers 259.66, the percentage of the set 15.69 and the number of fruits 86.83. (1×4) appeared significant effect of (SCA) were shown significant and desirable in the traits average fruit weight 1.47, plant yield 0.55 and total yield 0.69.

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Introduction

Cherry tomato belongs to the pure line of small-fruited (cherry) tomato that came from the plant variety *Lycopersicon esculentum* var. cerasiforme, which belongs to the Solanaceae family. It is consumed fresh in salads or as a food supplement for outer space navigators in flight it was chosen as one of the vegetable crops for cultivation in outer space colonies due to its rapid growth and production (Murrand and Azoubel, 2002). Cherry tomato is characterized by its high yield, high quality and excellent acceptance by the consumer due to its high sweetness and distinctive taste better than regular tomatoes (Preczenhak *et al*., 2014). Knowing the genetic diversity of sources and the genetic relationships among them provides basic and essential information to plant breeders for their usefulness in designing genetic breeding and improvement programs, (Kumari *et al*., 2020 ; Erika *et al*., 2020).

The concept of a full diallel is the rearrangement and assembly of the genetic genes available or present in the parents involved in the breeding programs. It is also useful for predicting the best possible combinations between parents (Valerius *et al*., 2009; da Cruz Baldissera *et al*., 2012).

Sprague and Tatum (1942) were the first who define the ability to combine and divide the genetic action related to it into two parts, the general combining ability (GCA), which gives us an indication of the ability of a genotype (a variety or strain) to combine with as many varieties as possible, or the breeds included in the breeding program to achieve the highest yield and the best traits for its components, and the general allosteric ability is subject to the effect of the additive gene action of genes. Specific combining ability (SCA) is the amount of deviation of a given cross's value from the trait average for crosses of that breed or variety that is under the influence of non-additive gene action.

The genetic analysis showed that both additional and non-additional effects of genes are important in the heritability of most of the studied traits. Mahmoud and El-Eslamboly (2014) found through semi-reciprocal cross-crossing of 7×7 in cherry tomatoes that the effect of additional genetic action was clear in all the studied traits of the produced hybrids except for fruit hardness and ascorbic acid in fruits. The analyzes also showed a significant sign of the general and specific perishability of all the studied traits except for the hardness of fruits and ascorbic acid.

Al-Mfargy (2014) indicated when studying some genetic parameters of the tamarisk hybrids planted in greenhouses, the genetic variance and the degree of heritability in the broad sense were high for most of the studied traits. Therefore, the selection for the traits of the crop was effective, because the genetic variance constitutes the largest part of the phenotypic variance.

Al-Mfargy and Al-Douri (2015) explained through their study of six genotypes of cantaloupe, which showed a significant superiority for most of the a number of branches number of leaves and plant yield, and some of the genetic changes showed significant superiorities for some of the traits included in the experiment.

Khalil and Mahmoud (2019) estimated the general coalescence viability of 5 parents and the specific union viability of 10 hybrids of tomato with the hemi-dialysis system, the parents MON-8 and MON-9 gave the highest overall combination ability for number of branches, number of leaves and plant yield. While the two hybrids, MON-8 × MON-9 and MON-9 × MON-15, gave the highest ability, especially for the number of fruits per plant, plant yield and fruit hardness. Mishra *et al*. (2020) also found, by evaluating 45 hybrids, including 10 producing parents from hemi-dialytic crosses, that the mean squares of general and specific destructiveness were significant for all studied traits. The study aimed to show the best effect of the (GCA) and (SCA) for parents and their hybrids of the studied traits.

Materials and Methods

The study was conducted at Baladruze city, Diyala Governorate, Iraq during the growing seasons 2021-2022. Seeds of the first generation F1 and seeds were stored until planting in the agricultural season 2021 - 2022. The soil of the plastic house of 45 × 9 and a height of 3.2 m dimensions .It was divided into three Blocks, each one containing three lines, and the distance between them was 75 cm. Drip irrigation tube distance of 40 cm, with three replications. Each repeater included 20 hybrids, with the pure lines, where the seeds of the genotypes that were produced in the first season were planted in dishes on (20/11/2021), and after germination and the formation of real leaves, they were transferred to the greenhouse in (5/1/2022) and were planted next to irrigation pipes. The length of the experimental unit was 4 m, and the distance between plants is 40 cm, with 10 plants per experimental unit, which represents one genotype to evaluate its field and production performance. The experiment was implemented within the Randomized Complete Block Design (RCBD). The results were analyzed according to the above-mentioned design. Arithmetic means were compared by using Duncan's test at a probability level of 0.05. (Al-Rawi and Khalafallah, 2000).

Reciprocal analysis

The reciprocal analysis of the studied traits was carried out when significant differences appeared between the genotypes and according to the F-test according to the (RCBD) to estimate the General Abilities of the Coalition (GCA).

General Combining Ability (SCA) Specific Combining Ability in cross- and cross-hybrids, so the number of genotypes included in the analysis is equal to P2, that is, twenty-five genotypes, according to the following mathematical model:

Yijk = µ + gi + gj + Sij + rij + eijk

Yijk = value of hybrid genotype i in repeat k

µ = general average of the adjective

gi = effect of the susceptibility of the general coalition to parent i

gj = effect of general coalescence susceptibility of dad j

sij = effect of combination susceptibility of single hybrid ij

rij = the effect of the combination susceptibility of the inverse single hybrid ij

eijk = effect of experimental error axis

Through the following equations, the averages of the expected variance EMS were calculated, which includes the variance of the general susceptibility of the coalition σ2Gca and the special 2Scaσ and the variance of the adverse effect 2rcaσ: (Griffing, 1956)

σ2Gca $=\frac{(Ms.gca-Mse)}{2P}$

σ2Sca $=(MS.Sca-Mse)$

σ2rca $=\frac{MS1rca-M.S.e}{2}$

Since: P (parents) = Number of parents

MSe = axis experimental error

He estimated the standard error of the difference between the effect of the general susceptibility to the coalition (g ii) for two parents, as in:

Standard Error (SE)(gi-g) $=\sqrt{\frac{Mse}{P}}$

The standard error of the difference between the effects of the special susceptibility to combination (Si j) between two commutative multiplications was estimated as follows:

SE (Sij – Sik) $=\sqrt{\frac{(P-1)MSe}{P}}$

Table 1 shows the results of the genetic statistical analysis and the division of the mean squares of the genotypes into components due to the general and specific capabilities of the union.

Table 1. Means of squares for the components of genetic variance for the studied traits

S.O.V	R	T	GCA	SCA	Error
df	2	24	4	10	48
Number of flowers in the inflorescence	2.973	2891.09**	11808.42**	488.365**	1.001
Total number of flowers/plant	178.97	136938.6**	588447.56**	18935.43**	1045.88
Fruits set percentage	1.274	690.75**	2971.90**	163.727**	19.386
Number of fruits per plant	1.333	13907.58**	48936.42**	413.1**	0.875
Fruit weight	0.269	20.318**	65.038**	2.473**	0.271

Plant yield	0.029	2.028**	6.807**	0.393**	0.038
Total yield	0.046	3.161**	10.59**	0.614**	0.059

Results and Discussion

Effect of General Combining Ability

Table 2 shows the effect of the General Combining Ability (GCA) on the union of the studied traits. Where Parent 1 showed a general, significant, and positive ability to unite in the desired direction in terms of the percentage of fruits setting and fruit weight. The number of total fruits of the plant, while Parent 4 was superior in general ability to recombine, positive and significant, with plant yield and total yield. Parent 5 was distinguished by a general ability to unite, positive and desirable, in terms of the number of flowers in the inflorescence, the number of total flowers, and the number of total fruits of the plant. the high values of the general coalition effect of a particular parent mean a high host variance for this parent, which allows the possibility of transferring the trait from him to many of his crosses, and the low value indicates the weakness of his host variance and thus it is possible to transfer the trait to him from other parents. These results are in agreement with what was found by Mahmoud and EL- Eslamboly (2014); Saval and Patel (2017); Hamdi (2022) in their study on the tomato plant.

Table 2. estimations the effect of (GCA) for each parent of the traits studied

studied traits	Parents					SE (gi)
	1	2	3	4	5	
number of flowers ininflorescence	-11.89*	-4.46*	-12.19*	-6.42*	34.97*	0.163
Total number of flowers/plant	-111.80*	-37.90*	-83.10*	-7.10*	239.92*	5.281
Fruits set percentage	7.57*	2.33*	5.11*	2.34*	-17.37*	0.719
Number of fruits per plant	-41.03*	-15.60*	-24.30*	21.33*	59.60*	0.153
Fruit weight	1.73*	0.60*	-0.98*	0.62*	-1.98*	0.085
plant yield	0.40*	0.18*	-0.46*	0.42*	-0.55*	0.032
Total yield	0.50*	0.22*	-0.57*	0.53*	-0.69*	0.040

The effect of the special ability on the union is shown in Table 3 the effect of the special ability on the union of individual crosses for all the traits studied. The differences shown by the parents in the values of general combining ability had an effect on the behavior of their individual crosses resulting from crossing between them as follows:

Number of flowers in the inflorescence

Eleven crosses with a positive and significant ability to combine, the highest reached 35.66 in the hybrid (5×1), and the rest of the crosses showed negative or positive values that reach the level of significance, the lowest amounted to -4.707 in the hybrid (2×4).

Number of total flowers/plant

Fourteen hybrids showed a positive and significant ability to combine, the best of which was 259.66 in the hybrid (5×1), and the other hybrids showed significant negative values, the lowest reached -50.66 in the hybrid (5×2).

Fruits setting percentage

Ten crosses showed a positive and significant special ability to combine, which reached a maximum of 15.69 in the hybrid

(5×1), and the other crosses gave negative values reach the significant, the least of which was - 11.24 in the hybrid (5×3).

Number of fruits

Sixteen of the hybrids were distinguished by a positive and significant special ability to combine, the highest of fruits which was 86.83 in the hybrid (5×1), and the other hybrids showed significant negative values, the lowest of which was -4.50 in the hybrid (3×2).

Fruit weight

Seven crosses gave a positive and significant special ability to combine, the highest of which was 1.47 in the hybrid (1×4), while the other hybrids gave negative values that reach the significance and the lowest amounted to 3.43 in the hybrid (4×1).

Plant yield

The superiority of eight hybrids with a positive and significant special ability to combine in the desired direction, the best of which was 0.55 in the hybrid (1×4), and the other hybrids gave significant negative values, the lowest of which was -0.84 in the hybrid (4×1).

Total yield (ton)

Eight hybrids showed a positive and significant special ability to combine, the highest of which was 0.69 in the hybrid (1×4), and the other crosses showed negative and positive significant values, the lowest of which was -1.05 in the hybrid (4×1). It was found through the results that the hybrids with a special general coalition effect (in the desired direction) resulted either from two parents who have a good general coalition effect, or from two parents, one of whom is good in the general coalition and the other is weak, or from two weak parents in the general coalition, and this indicates the possibility of benefiting from the pure lines of all tomatoes with its effects Different general coalitions to produce distinct hybrids. These results are in agreement with what was found by Al-Mfargy and Al-Douri (2015), Mishra et al. (2020), and Hamdi (2022).

Table 3. Estimates the effects of specific combining ability (SCA) of individual and their reciprocal hybrids for the studied traits

Individual hybrids	studied traits						
	Number of flowers in the inflorescence	Total number of flowers	Fruits set percentage (%)	number of fruits in the plant	Fruit weight (gm)	Yield per plant (kg)	Total yield (tons)
(1X2)	-2.90*	-9.32	0.31*	1.40*	-0.09	-0.02	-0.02
(1X3)	3.32*	17.37*	-0.49	1.26*	0.14	0.06	0.08
(1X4)	2.39*	10.20	0.65	6.80*	1.47*	0.55*	0.69*
(1X5)	-4.84*	-40.49	3.07*	-3.13*	-0.27*	-0.08*	-0.10*
(2X3)	-1.10*	-7.86	-0.86	-3.33*	0.22*	0.07*	0.08
(2X4)	-4.70*	-21.52*	1.42	2.53*	0.01	0.02	0.02
(2X5)	20.56*	129.27*	-10.97*	12.60*	-0.11	0.02	0.02
(3X4)	0.36*	2.84	0.10	-0.43*	-0.21*	-0.08*	-0.10*
(3X5)	-4.20*	-24.86*	2.33*	8.96*	0.09	0.04	0.05

(4X5)	6.86*	38.30*	-4.60*	1.16*	0.06	0.08*	0.10*
SE(Sij)	0.337	10.887	1.482	0.315	0.175	0.065	0.082
(2X1)	-0.83*	16.33*	-0.31	13.50*	-0.41*	-0.03	-0.04
(3X1)	-0.33	23.16*	-2.81*	10.33*	-2.09*	-0.65*	-0.81*
(3X2)	0.	4.83	-2.04*	-4.50*	-1.41*	-0.55*	-0.69*
(4X1)	-1.16*	86.00*	-5.20*	53.16*	-3.43*	-0.84*	-1.05*
(4X2)	0.16*	43.50*	1.18	42.66*	-1.31*	-0.23*	-0.29*
(4X3)	2.5*	59.33*	-0.49	48.66*	0.48*	0.46*	0.58*
(5X1)	35.66*	259.66*	15.69*	86.83*	-2.56*	-0.60*	-0.76*
(5X2)	7.83*	-50.66*	9.22*	54.66*	-2.16*	-0.75*	-0.94*
(5X3)	34.00*	200.66*	-11.24*	61.33*	-0.84*	-0.18*	-0.23*
(5X4)	19.50*	0.83	3.18*	26.50*	-1.23*	-0.48*	-0.59*
SE(rij)	0.408	13.203	1.797	0.382	0.213	0.079	0.099

Conclusion

The general and specific combining ability of five strains of cherry tomato and their F1 hybrids were estimated by full diallel crossing. parent 1, 4 and 5 showed significant superiority in the general ability of the coalition and the possibility of using them as a parent in the breeding programs for the production of hybrids in the future. The hybrids (1 × 5), (1 × 4) showed the best effects of ability (SCA) on the rest of the crosses for the studied traits.

Conflict of Interest

There is no affiliation with other bodies or institutions in the research, and there is no difference in the sequence of researchers' names**.**

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References

AL-Hamdany, S. Y. (2014). Genetic Variability and Determine of Some Genetic Parameters for Yield and Its Components in Peas (Pisum sativum L.). *Diyala Agricultural Sciences Journal*, *6*(1), 129-139.

Al-Mfargy, O. K. A. (2014). Evaluation and Estimation of Some Genetic Parameters for Tomato Hybrids Grown in the Green House. *Egyptian Journal of Agricultural Sciences*, *65*(4), 489-497.

Alwan, O. K., & Omer, Z. A. (2015). The Effect of The Genotype and Method of Agriculture in the Yield and Its components and estimate of some genetic parameters muskmelon (Cucumis melon L.) growth in gypsum soils. *Diyala Agricultural Sciences Journal*, *7*(2), 153-167.

Al-Rawi, Khasha'a Mahmoud and Abdel-Aziz Khalafallah (2000). Design and analysis of agricultural experiments. Ministry of Higher Education and Scientific Research, University of Mosul.

da Cruz Baldissera, J. N., Valentini, G., Coan, M. M. D., de Almeida, C. B., Guidolin, A. F., & Coimbra, J. L. M. (2012). Combining ability and reciprocal effect on agronomical traits of bean. *Semina: Ciências Agrárias*, *33*(2), 471-480.

Erika, C., Griebel, S., Naumann, M., & Pawelzik, E. (2020). Biodiversity in tomatoes: Is it reflected in nutrient density and nutritional yields under organic outdoor production?. *Frontiers in plant science*, *11*, 589692.

Griffing, B. R. U. C. E. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. *Australian journal of biological sciences*, *9*(4), 463-493.

Hamdi, Gh. J. (2022). Estimation of the genetic dimension and genetic parameters of growth and yield traits of tomato by Full Diallel crossing under the influence of water stress. College of Agriculture, University of Diyala.

Khalil, M. R., & Mahmoud, M. I. (2019). Genetic analysis and heterosis for some quantitative traits in tomato (*Solanum Lycopersicum* L.). *Menoufia Journal of Plant Production*, *4*(4), 287-302.

Kumari, K., Akhtar, S., Kumari, S., Kumar, M., Kumari, K., Singh, N. K., & Ranjan, A. (2020). Genetic variability and heritability studies in diverse tomato genotypes. *Journal of Pharmacognosy and Phytochemistry*, *9*(3), 1011-1014.

Lone, S., Hussain, K., Malik, A., Masoodi, K. Z., Narayan, S., Dar, Z. A., & Rashid, M. (2021). Heterosis studies in cherry tomato for various quality traits in open and protected environment.

Mahmoud, A. M. A., & El-Eslamboly, A. A. S. A. (2014). Genetic analysis to find suitable parents for development of cherry tomato hybrids under green house conditions. *Egypt. J. Plant Breed*, *19*(1), 55-70.

Mishra, A., Nandi, A., Sahu, G. S., Das, S., Mohanty, I. C., Pattanayak, S. K., & Tripathy, P. (2020). Studies of combining ability in tomato (Solanum lycopersicum L.) for vegetative growth, yield and quality traits. *Journal of Pharmacognosy and Phytochemistry*, *9*(1), 466-473.

Murrand F.E.X.and Azoubel P.M (2002) .Transport phenomena in food processing. Chapter 9. Effect of pretreatment on the Drying Kinetics of cherry tomato (Solanum lycopersicum L. Var. Cerasiforme), *print ISBN. 41*,137–149.

Preczenhak, A. P., Resende, J. T., Chagas, R. R., Silva, P. R., Schwarz, K., & Morales, R. G. (2014). Agronomic characterization of minitomato genotypes. *Horticultura Brasileira*, *32*, 348-356.

Savale, S. V., & Patel, A. I. (2017). Combining ability analysis for fruit yield and quality traits across environments in tomato (Solanum lycopersicum L.). *Int. J. Chem. Stud*, *5*(5), 1611-1615.

Sprague, G. F., & Tatum, L. A. (1942). General vs. specific combining ability in single crosses of corn. *Journal of the American Society of Agronomy*.

Valerius, I.P, F.I Oak , A.C Oliveira, C. Lorencetti, V.Q Souza, , J. Silva, I. Harwing, A.M.Schmidt, I.Bertan and G.Ribeiro. (2009). Production stability and of the ability to combine different oat populations. Semina: *Agricultural Sciences, Londrina*. *30*(2), 331-346.