Agronomía Mesoamericana

Scientific article
Volumen 35: Artículo 57558, 2024
e-ISSN 2215-3608, https://doi.org/10.15517/am.2024.57558

Impact evaluation combining ability of tomato hybrids and lines for production and fruit quality traits[*]

Evaluación del impacto de la habilidad combinatoria de híbridos y líneas de tomate para rasgos de producción y calidad del fruto

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[*] Reception: November 20th, 2023. Acceptance: May 9th, 2024. This work was part of a doctoral dissertation on the genetic analysis of colorful tomato strains and their hybrids, and the effect of jasmonic and salicylic acids on yield and its content of secondary compounds. There was no financial support for the research; all costs were covered by the researcher.
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Abstract

Introduction. The selection of pure lines followed by crosses to create superior hybrids is one of the oldest strategies in crop breeding. Combining ability studies provide reliable information for selection of parents for hybrid combination by revealing the nature and magnitude of gene actions involved in expression of quantitative traits. **Objective.** To estimate the general and specific combining ability (GCA and SCA) values for yield in cherry tomatoes and select F1 hybrids combining high yield and fruit quality traits. **Materials and methods.** The half-diallel design, following method 2 of Griffing was used to define the best breeding method. Five lines were crossed to produce ten hybrid combinations using a half diallel design involving the parents. Crosses and evaluations were conducted in a greenhouse in the Experimental Station at the University of Diyala, Baqubah, Iraq, in the winter of 2022-2023. **Results.** Based on GCA effects, lines LA353, LA3899 and IQ2 could be potential donor parents in breeding. Based on average performance, heterosis manifested and SCA effects, crosses IQ2×LA4013, LA3899×LA353 and IQ2×LA3899 were best in respect to yield and fruit quality. **Conclusion.** The general and specific combining ability values for most of the traits supported the material's great variety. The magnitude of heterosis was improved compared to parental lines. The high-yielding parent lines LA3899 and IQ2 could be used for breeding cherry tomatoes under greenhouse conditions.

Keywords: *Solanum lycopersicum*, anthocyanin content, breeding, diallel crosses, gene action, hybrid vigor.

Resumen

Introducción. La selección de líneas puras seguida de cruces para crear híbridos superiores es una de las estrategias más antiguas en el mejoramiento de cultivos. Los estudios de habilidad combinatoria proporcionan información confiable para la selección de padres orientada a la combinación híbrida al revelar la naturaleza y magnitud de las acciones genéticas involucradas en la expresión de rasgos cuantitativos. **Objetivo.** Estimar los valores de habilidad combinatoria general y específica (GCA y SCA) para el rendimiento en tomate *cherry* y seleccionar híbridos F1 que combinen un alto rendimiento y características de calidad de fruto. **Materiales y métodos.** Se utilizó el diseño semidialelo, siguiendo el método 2 de Griffing para definir el método de mejoramiento genético más apropiado. Se cruzaron cinco líneas para producir diez combinaciones híbridas utilizando un diseño medio dialélico que involucró a los padres. Los cruces y las evaluaciones se realizaron en un invernadero en la Estación Experimental de la Universidad de Diyala, Baqubah, Irak, en el invierno de 2022-2023. **Resultados.** Según los efectos de la GCA, las líneas 'LA353', 'LA3899' y 'IQ2' podrían ser posibles padres donantes en el proceso de reproducción. Según el rendimiento promedio, la heterosis manifestada y los efectos de SCA, los cruces IQ2×LA4013, LA3899×LA353 e IQ2×LA3899 fueron los mejores con respecto al rendimiento y la calidad de la fruta. **Conclusión.** Los valores de la habilidad de combinación general y específica respaldaron la gran diversidad del material. La magnitud de la heterosis mejoró en comparación con las líneas parentales. Las líneas parentales de alto rendimiento, LA3899 e IQ2, podrían ser utilizadas en el mejoramiento de tomates *cherry* a nivel de invernadero.

Palabras clave: *Solanum lycopersicum*, contenido de antocianinas, mejoramiento, cruzamiento dialélico, acción genética, vigor híbrido.

Introduction

Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is widely cultivated for food worldwide and is a significant member of the Solanaceae. With an average yield of 36.85 t/ha, tomato output reached 189.13 Mt globally in 2021 from an expected 5.17 Mha of land (Food and Agriculture Organization of United Nations, n.d.). Due to tomato nutraceutical properties, its consumption has increased significantly. This rise is associated with the health benefits induced by its numerous bioactive molecules. It serves as an essential source of various nutrients, including vitamins and minerals, such as tetraterpenoids, polyphenols, ascorbic acid and phytosterols, crucial for human growth and development (Pinela et al., 2012, 2016, 2019). The nutritional importance of the tomato highlights there is need to formulate breeding program and to develop cultivars rich in lycopene, processing traits with high quality of fruit as well as yield. Recent studies indicate that lycopene that give the ripe tomato its bright red color is a very effective natural antioxidant and quencher of free radicals (Hamdi, 2017).

In comparison to other types of crops, 90-95 % of the land used for tomato production comprises hybrid varieties, which are preferred over pure line varieties due to their superiority in marketable yield and fruit quality, which are more resistant to biotic and abiotic challenges (Al-Shammari & Hamdi, 2021). The utilization of heterosis proves to be an efficient approach for improving tomatoes, as hybrid varieties exhibit high yield potential and have gained popularity among growers (Alwan & Mohammed, 2023). This is because they offer higher profits, even with the high seed costs (Al-Shammari & Hamdi, 2022). To meet the needs of both producers and consumers, breeders are increasingly focusing on the development of hybrids (Tamta & Singh, 2018).

Heterosis (hybrid vigor) refers to the phenomenon in which the progeny of diverse varieties of a species or crosses between species exhibit greater biomass, faster development and higher fertility than both parents. The division of heterotic groups and the determination of heterosis patterns, as indicated by many research results, demonstrate that for tomatoes and other crops there is significantly improved breeding efficiency, accelerating progress in breeding effects (Al-Obaidi, 2022). The phenomenon of heterosis in tomato hybrids has been examined, as it increases yield while improving other qualitative and quantitative properties (Schnable & Springer, 2013). Heterosis occurs when an F1 hybrid outperforms the average of its two parents (Conesa et al., 2020; Hamdi, 2022).

Utilizing heterosis for crop development depends on identifying superior heterotic pairings and proper inbred selection (Falconer & Mackay, 1996). The study of combining ability serves as a technique for determining the desired parent and a specific cross combination for future exploitation (Mukherjee et al., 2020; Semel et al., 2006).

A combining ability study provides a valuable perspective on the performance of resistant hybrids and how to select parents from diverse backgrounds (Sprague & Tatum, 1942). In addition to the absence of better combiners, the involvement of various types of gene effects to varying degrees in regulating quality traits, which are often quantitative in nature, has also limited the generation of resistant hybrids (Griffing, 1956). Evaluating combining ability and heterosis is the first step in breeding inbred lines to develop commercial hybrids. While the genetic bases of heterosis and combining ability remain unclear (Al-Shammari & Hamdi, 2022; Fortuny et al., 2023), this lack of clarity does not diminish the importance of heterosis and combining ability in crop breeding. In the utilization of heterosis, the level of combining ability serves as a crucial basis for selecting parental crosses and directly influences the quality of the hybrids. Combining ability is assessed through two genetic parameters, general combining ability (GCA) and specific combining ability (SCA), which are influenced by the additive genetic effects and non-allelic interactions of the parents, respectively (Hamdi, 2022).

The type and strength of gene activity governing the inheritance of yield and its contributing qualities determine the best breeding strategy and suitable parent selection (Chahal & Gosal, 2002). One way to obtain genetic information about tomato production and fruit quality attributes is through diallel analysis (Roa et al., 2016). To create a set of F1 progeny, a set of parents are mated in every feasible way using the diallel analysis mating design (Phan & Sim, 2017). The diallel cross techniques was investigated by many researchers such as Sprague and Tatum (1942), Griffing (1956) and Jinks et al. (1969), who discussed the theory of diallel crosses and gave the procedure for estimating certain genetic parameters in terms of gene models in varying degrees of complexity.

Some studies indicate that there is no fixed relationship between GCA and SCA (Kumar et al., 2013; Liu et al., 2021). Xiang et al. (2019) revealed a correlation between parental traits and GCA, but parental performance is not correlated with heterosis. Therefore, parental performance per se and GCA are not necessarily reliable predictors of heterosis. Many studies have shown that parental GCA may be a good predictor of hybrid performance (Hamdi, 2022; Ibirinde et al., 2022; Reddy et al., 2020). Using this approach can be helpful in finding genetic information that regulates the inheritance of traits being studied in early generations (Liu et al., 2021). It is the simplest way to understand how genetics influences inherited quantitative traits (Ene et al., 2023). Understanding how genes function makes it easier to decide whether to use heterosis breeding or recombination and selection (Singh et al., 2021). The objective of this study was to estimate the GCA and SCA values for yield in cherry tomatoes and select F1 hybrids combining high yield and fruit quality traits.

Materials and methods

Genotypes were made up of five lines of cherry tomatoes (*Solanum lycopersicum* var. *cerasiforme*) (pure line) indeterminate (LA4013, LA353, LA2921, LA3899, and IQ2) type arranged in a 5 × 5 half diallel mating design. These lines were sourced from the CM Rick Tomato Genetic Resources Centre (TGRC) at the University of California, USA, with the addition of IQ2, which came from the plant breeding department of the University of Baghdad, Iraq. These lines have the potential for high yielding and water stress tolerance. A greenhouse experiment was conducted from January to July 2022 at the experimental station of the Horticultural Crops Research Centre at the University of Diyala, Baqubah, Iraq, using 50 plants for each line. At the flowering stage, plant emasculation and pollination of tomato lines were done (Table 1). Pollinated flowers were covered with cellophane to prevent unintended pollination.

When the fruits reached physiological maturity, their seeds were extracted and dried using paper towels, resulting in ten F1 crosses using the method 2 by Griffing (1956).

For a second season, a total of 15 genotypes of cherry tomatoes were planted: five lines and ten F1 hybrids in greenhouse conditions. Seedlings with three to four true leaves and 25 cm height were planted in separate rows

ISSN 2215-3608 https://doi.org/10.15517/am.2024.57558

Table 1. Representation of the cross or hybrid combinations (10 in total) of cherry tomatoes (*Solanum lycopersicum* var. *cerasiforme*), developed as a result of the half-diallel cross design during spring crop cycle of 2022. University of Diyala, Baqubah, Iraq.

Cuadro 1. Representación de las combinaciones de cruzas o híbridos (10 en total) de tomate *cherry* (*Solanum lycopersicum* var. *cerasiforme*), desarrolladas como resultado del diseño del cruce medio dialélico durante el ciclo de cultivo de primavera de 2022. Universidad de Diyala, Baqubah, Irak.

	LA4013	**LA353**	**LA2921**	**LA3899**	**IQ2**
LA4013	LA4013	LA353×LA4013	LA2921×LA4013	LA3899×LA4013	IQ2×LA4013
LA353		LA353	LA2921×LA353	LA3899×LA353	IQ2×LA353
LA2921			LA2921	LA3899×LA2921	IQ2×LA2921
LA3899				LA3899	IQ2×LA3899
IQ2					IQ2

(1.20 m between rows and 0.50 m between the plants in each row). This experiment took place from November 8, 2022, to July 1, 2023, lasting 8 months. It was conducted using in a randomized complete block design with three replicates. Each plot for lines or F1 hybrids consisted of 15 plants. All standard agronomic practices for tomato genotypes were followed, as per Hamdi (2022).

The weight of all the fruits harvested from each plant (kg/plant) and the overall yield were used to calculate the yield. Total soluble solids (TSS) were determined in triplicate using an Atago PR-100 digital refractometer, and the results were expressed in ºBrix. Titratable acidity (TA in %), vitamin C (VC in mg/100 g), lycopene content (LPC in mg/100 g) and anthocyanin content (ANC in mg/100 g) were analyzed in fresh tomato fruits collected from healthy, non-infected plants of each genotype, following the estimation methods of Ranganna (1986). Where appropriate data were subjected to analysis of variance (ANOVA) in SAS (ver. 9.4, SAS Institute, Cary, NC). Means were separated using Tukey's test.

Combining ability variances and effects were determined according to Griffing's (1956) model 1 and method 2; the latter method is applicable to the study as parents and one set of non-reciprocal F1s were included. Model 1 assumes that variety and block effects are constant, and the experimental material is the population about which inferences are to be made. Parent heterosis was calculated using the Narayanam and Singh (2009) method and the equation 1. In the case of hybrids, better or higher parent heterosis was assessed by comparing the mean performance of the hybrids against the better parent, and the value was expressed as a percentage.

$$Better - parent\ heterosis = \frac{\text{F1-HP}}{\text{HP}} \times 100 \qquad (1)$$

Where:

F1 = Mean performance value of F1 hybrid.

HP = Mean performance value to better parent of the specific cross.

Results

Variances due to general combining ability (GCA) effects were significant for all traits (Table 2). Among the lines, the good combiners were IQ2 and LA3899 for most yield and fruit quality traits. The line IQ2 was the best combiner for yield per plant (0.31 kg/plant), total yield (0.41 t/ha) and titratable acidity (0.023 %). The line LA4013 was the best combiner for TSS (0.48 %) and lycopene content (0.63 mg/100 mL). The line LA353 had significant

ISSN 2215-3608 https://doi.org/10.15517/am.2024.57558

positive GCA values for vitamin C and anthocyanin content (0.73 and 10.91 mg/100 mL, respectively) compared to other lines.

Table 2. Estimates of general combining ability effects of parents for yield per plant, total yield, total soluble solids, titratable acidity, vitamin C, lycopene content, and anthocyanin content characters of cherry tomatoes (*Solanum lycopersicum* var. *cerasiforme*). University of Diyala, Baqubah, Iraq, from November 8, 2022, to July 2023.

Cuadro 2. Estimaciones de los efectos generales de la capacidad combinatoria de los padres para el rendimiento de la planta, el rendimiento total, los sólidos solubles totales, la acidez titulable, la vitamina C, el contenido de licopeno y el contenido de antocianinas del tomate cherry (*Solanum lycopersicum* var. *cerasiforme*). Universidad de Diyala, Baqubah, Iraq, del 8 de noviembre de 2022 a julio de 2023.

Parent	Plant yield (kg/plant)	Total yield (t/ha)	TSS (%)	TA (%)	VC	LPC	ANC
					mg/100 mL		
LA4013	-0.08	-0.14	0.48*	-0.031*	0.30*	0.63*	2.62*
LA353	0.03	0.06	-0.20*	-0.013*	0.73*	0.05	10.91*
LA2921	-0.48*	-0.61*	-0.08	0.002	-0.50*	-0.18*	-1.23*
LA3899	0.22*	0.27*	-0.10	0.017*	-0.93*	-0.22*	-5.55*
IQ2	0.31*	0.41*	-0.09	0.023*	0.38*	-0.28*	-6.74*
SE(ĝi)	***0.18***	***0.24***	***0.18***	***0.01***	***0.26***	***0.13***	***0.41***

* Significance. / * Significancia.
TSS: Total soluble solid. TA: Titratable acidity. VC: Vitamin C. LPC: Lycopene content. ANC: Anthocyanin content. / TSS: Sólido soluble total. TA: Acidez titulable. VC: Vitamina C. LPC: Contenido de licopeno. ANC: Contenido de antocianinas.

The specific combining ability (SCA) effects for hybrids related to traits varied (Table 3). The cross IQ2×LA4013 exhibited significant SCA effects in the desired direction for fruit yield per plant (1.10 kg/plant), the highest total yield (1.39 t/ha) and vitamin C (1.69 mg/100 mL). Cross IQ2×LA3899 showed highly significant SCA effects in the desired direction for the TSS trait, with a value of 0.34 %. The highest average performance for the titratable acidity trait was observed in cross LA2921×LA353, with a value of 0.07 %. Cross LA2921×LA4013 exhibited significant SCA effects in the desired direction for vitamin C and anthocyanin content (1.08 and 11.34 mg/100 mL, respectively). The highest average performance for lycopene content was observed in cross LA3899×LA4013, with a value of 0.99 mg/100 mL, compared to other crosses (Table 3).

Heterosis estimates compared to the better parent for yield per plant, total yield, total soluble solids, titratable acidity, vitamin C, lycopene content and anthocyanin content varied (Table 4). For each trait, there was a significant amount of heterosis in several crosses, either positive or negative. The hybrid from the LA2921×LA353 cross exhibited significantly high positive standard heterosis values for yield per plant (25.51 kg), total yield (25.61 t/ha) and lycopene content (33.99 mg/100 mL). The highest positive standard heterosis for TSS, at 32.51 %, was recorded by the hybrid from the IQ2×LA3899 cross. For titratable acidity, the highest positive standard heterosis was recorded by the hybrid from the LA3899×LA353 cross, which was 4.83 %. The highest positive standard heterosis for vitamin C was recorded by the hybrid from the LA2921×LA4013 cross, at 1.71 mg/100 mL. As for anthocyanin content, the highest positive standard heterosis was recorded by the hybrid from the IQ2×LA2921 cross, at 64.50 mg/100 mL, compared to other hybrids.

Table 3. Estimates of specific combining ability effects of hybrids for yield per plant, total yield, total soluble solids, titratable acidity, ascorbic acid, lycopene content and anthocyanin content characters of cherry tomatoes (*Solanum lycopersicum* var. *cerasiforme*). University of Diyala, Baqubah, Iraq, from November 8, 2022, to July 2023.

Cuadro 3. Estimaciones de los efectos específicos de la habilidad combinatoria de híbridos para el rendimiento de la planta, el rendimiento total, los sólidos solubles totales, la acidez titulable, el ácido ascórbico, el contenido de licopeno y el contenido de antocianinas del tomate *cherry* (*Solanum lycopersicum* var. *cerasiforme*). Universidad de Diyala, Baqubah, Iraq, del 8 de noviembre de 2022 a julio de 2023.

Crosses	Plant yield (kg/plant)	Total yield (t/ha)	TSS (%)	TA (%)	VC	LPC	ANC
					(mg/100 mL)		
LA353×LA4013	0.15*	0.23*	0.23*	-0.03*	-1.31*	-0.67*	3.92*
LA2921×LA4013	0.70*	0.95*	-0.17*	0.01*	1.08*	-0.007	11.34*
LA3899×LA4013	0.03	0.10	-0.08*	0.03*	0.99*	0.99*	-3.38*
IQ2×LA4013	1.10*	1.39*	0.04	0.06*	1.69*	0.57*	-15.61*
LA2921×LA353	0.14*	0.18*	-0.40*	0.07*	0.64*	0.19*	-7.17*
LA3899×LA353	0.32*	0.23*	0.18*	-0.06*	-1.09*	0.28*	5.29*
IQ2×LA353	-0.87*	-1.16*	-0.10*	-0.005	-0.44*	0.06*	-7.71*
LA3899×LA2921	-1.32*	-1.69*	0.01	-0.04*	-0.59*	0.07*	1.84*
IQ2×LA2921	-1.55*	-1.89*	0.06	-0.02*	-1.26*	-0.51*	4.42*
IQ2×LA3899	0.12*	0.21*	0.34*	-0.04*	-0.17*	-0.75*	5.67*
SE(ŝij)	***0.06***	***0.09***	***0.07***	***0.007***	***0.10***	***0.05***	***0.15***

* Significance. / * Significancia.

TSS: Total soluble solid. TA: Titratable acidity. VC: Vitamin C. LPC: Lycopene content. ANC: Anthocyanin content. / TSS: Sólido soluble total. TA: Acidez titulable. VC: Vitamina C. LPC: Contenido de licopeno. ANC: Contenido de antocianinas.

Table 4. Magnitude of heterosis (%) compared to the better parent in cherry tomato hybrids for plant yield, total yield, total soluble solids, titratable acidity, ascorbic acid, lycopene content and anthocyanin content traits of cherry tomatoes (*Solanum lycopersicum* var. *cerasiforme*). Conducted at the Research Station of the Department of Horticulture and Landscape Gardening, University of Diyala, Baqubah, Iraq, from January 1 to July 2023.

Cuadro 4. Magnitud de la heterosis (%) en comparación con el mejor progenitor en híbridos de tomate cherry para el rendimiento de la planta, rendimiento total, sólidos solubles totales, acidez titulable, ácido ascórbico, contenido de licopeno y contenido de antocianina en tomates cherry (*Solanum lycopersicum* var. *cerasiforme*). Realizado en la Estación de Investigación del Departamento de Horticultura y Jardinería Paisajística de la Universidad de Diyala, Baqubah, Irak, desde el 1 de enero hasta julio de 2023.

Crosses	Plant yield (kg/plant)	Total yield (t/ha)	TSS (%)	TA (%)	VC	LPC	ANC
					(mg 100 ml^{-1})		
LA353×LA4013	0.68	-81.00	-10.71	-1.96	-11.75	-19.21	-35.28
LA2921×LA4013	0.37	18.09	-20.35	-11.29	1.71*	-13.05	55.97*
LA3899×LA4013	11.19*	11.27*	-19.28	-3.22	-2.29	13.30*	-31.66
IQ2×LA4013	-54.15	-54.27	-20.35	-14.70	-5.68	-3.20	-39.09
LA2921×LA353	25.51*	25.61*	-16.25	0.00	1.26*	33.99*	-76.10
LA3899×LA353	9.52*	9.80*	-28.83	4.83*	-6.97	9.90	-69.77
IQ2×LA353	-58.89	-58.86	-8.13	-11.76	-2.56	14.19*	-83.86
LA3899×LA2921	4.33*	4.33*	-1.47	-14.51	-10.95	23.57*	44.38*
IQ2×LA2921	-36.83	-63.92	-4.92	-16.17	-12.95	1.62	64.50*
IQ2×LA3899	-15.21	-15.18	32.51*	-17.64	-11.31	13.27*	56.79*

* Significance. / * Significancia.

TSS: Total soluble solid. TA: Titratable acidity. VC: Vitamin C. LPC: Lycopene content. ANC: Anthocyanin content. / TSS: Sólido soluble total. TA: Acidez titulable. VC: Vitamina C. LPC: Contenido de licopeno. ANC: Contenido de antocianinas.

ISSN 2215-3608 https://doi.org/10.15517/am.2024.57558

Discussion

In this study, different parents exhibited varying GCA values for individual traits, while the SCA values of different parental crosses also differed, indicating fundamental distinctions between additive and nonadditive genetic effects. It was found that, for all traits, the GCA of the parents and the SCA of the crosses were statistically significant. Combining ability is an effective tool that provides useful genetic information for the selection of parents in terms of performance of their hybrids, offering valuable insights for improving yield and quality traits in tomatoes (Hamdi, 2022). A low value indicates weak host variation (Solieman et al., 2013), which is inconsistent with the results of this study. These results imply that both additive and non-additive gene effects work together to impact characteristics, with the additive effects of genes playing a dominant role in trait inheritance (Soresa et al., 2020). In Griffing's method 2, variances due to GCA and SCA effects were significant for all traits. Combining ability analysis is used in selection of parents in formulations of a crossing plan. The diallel study provided evidence for the existence of significant additive variation through high GCA values. The GCA of a parental clone provides an assessment of its breeding value, as judged by mean performance of its lines from crosses with other clones (El-Gabry et al., 2014).

For the hybrids, SCA values were statistically significant for most traits, except in the cases of plant yield and total yield in the LA3899×LA4013 cross, the TSS trait in the IQ2×LA4013 and IQ2×LA2921 crosses, the AT trait in the IQ2×LA353 cross, and the LPC trait in the LA2921×LA4013 cross. Heterosis is mainly caused by dominance effects and non-allelic interactions. Therefore, SCA is highly important for heterosis. SCA can be used to predict the better parent, and this conclusion is also supported by previous studies (Al-Mfargy & Al-Juwari, 2023).

The results indicate that F1 heterosis may not directly correlate with parental performance. Heterosis depends on the nature of genetic variation (Al-Shammari & Hamdi, 2021). However, heterosis may depend on the sum of the parents' GCA and SCA. In a large-scale analysis of combining ability and heterosis in a hybrid tomato population, Solieman et al. (2013) found that the sum of parental GCAs was either negatively correlated or not correlated with heterosis. This finding contrasts with the conclusion of the present study, which found a highly significant positive correlation between the sum of parental GCA values and heterosis for some traits.

The significant effect of the specific combining ability of hybrids serves to enhance the outcomes of crosses compared to the averages of their parents, while the opposite is observed in hybrids that showed negative effects. Hybrids that exhibited positive and significant values for specific combining ability were the result of either parents with a positive overall effect on general combining ability, i.e., good parents such as the hybrids LA3899×LA4013, LA2921×LA353 and LA3899×LA353, or a combination of two parents, one of whom has at least a positive overall combining ability influence. This implies that plant breeders can leverage the various general combining abilities of all parents to produce hybrids with specific and favorable combining effects in the desired direction. These results align with what was discovered by Ene et al. (2023).

Most tomato traits exhibit significant heterosis, and a combination of high yield and quality can be achieved through hybridization (Singh et al., 2021). This result is consistent with findings from the present study, where the plant yield, total yield, lycopene content and anthocyanin content of most crosses showed a positive better parent effect, while the TSS, TA and VC were low for most crosses, except in the cases of crosses IQ2×LA3899, LA3899×LA353 and LA2921×LA4013. These traits are important indicators of productivity and quality in tomatoes (Liu et al., 2021). Plant yield and quality traits are crucial, as they can significantly increase economic efficiency. Therefore, the LA3899×LA4013 and LA2921×LA353 crosses, exhibiting heterosis for plant yield and total yield, are likely to be more valuable for production than the IQ2×LA353 cross, which shows heterosis for lycopene content.

Conclusions

Based on the results obtained in this experiment, developing and evaluating tomato lines that perform well in the greenhouse can produce distinctive hybrids with high combining ability, high yield and fruit quality traits. This was exemplified by the fact that the best-performing hybrids were from crosses 4×1, 3×2 and 4×2, which were superior in productivity and quality of cherry tomatoes in the greenhouse. Lines LA3899 and IQ2 are proposed for high-yield hybrid production, and their next-generation hybrids are suitable for releasing new high-yielding lines. The general combining ability values for most of the traits supported the material's great variety. This was exemplified because the best-performing hybrids were from 5×1 and 3×1, which were superior in productivity and quality. This demonstrated how important the additive and non-additive effects were for the inheritance of the characteristics under consideration. All things considered, this data will be helpful in designing and developing breeding programs that seek to increase yield while maintaining a reasonable balance of critical cherry tomato qualities.

Interests conflict

The authors declare no conflict of interest related to this study.

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