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ORIGINAL ARTICLE

Plant density and planting arrangement for tomato plants of determinate growth[1]

Densidade de plantas e arranjo de plantio para o tomateiro de crescimento determinado

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HIGHLIGHTS:
Higher plant density influences yields differently depending on the hybrid.
The single or double-row arrangement has little influence on tomato yield and quality variables.
Qualitative parameters of the fruits are not affected by planting densities.

ABSTRACT: Plant density and correct row spacing are fundamental factors for achieving profitable yield and fruit quality in crops. This study aimed to evaluate the yield of tomato plants of determinate growth and the physicochemical characteristics of the fruits in different planting arrangements and plant densities. Two experiments were conducted using the hybrids CVR-2909 (CVR Plant Breeding) and HMX 7885 (Agristar) in the first and second experiments, respectively. The experiments were conducted in a randomized block design with four replicates. Ten treatments were evaluated in a double factorial scheme (2 × 5). Two planting arrangements were evaluated in the first factor: single and double rows. The second factor comprised five plant densities: 15, 20, 25, 30, and 35 thousand plants ha^{-1}. For the CVR-2909 hybrid, single-row cultivation resulted in the highest yield, while higher planting densities gave the lowest yield and number of fruits per plant. For the HMX-7885 hybrid, it was found that higher densities gave higher yields but caused a decreasing effect on fruit production per plant, average fruit mass, and number of fruits per plant. For this hybrid, the planting arrangement provided a higher rate of green fruits.

Key words: *Solanum lycopersicum* L., cropping system, industrial tomatoes

RESUMO: A densidade de plantas e o espaçamento correto são fatores fundamentais para alcançar produtividade rentável e qualidade dos frutos em culturas agrícolas. Este estudo teve como objetivo avaliar a produtividade do tomateiro de crescimento determinado e as características físico-químicas dos frutos, em diferentes arranjos de plantio e densidades de plantas. Foram realizados dois experimentos, sendo que no primeiro experimento e no segundo experimento foram utilizados os híbridos CVR-2909 (CVR Plant Breeding) e HMX 7885 (Agristar), respectivamente. Os experimentos foram conduzidos em delineamento de blocos casualizados, com quatro repetições. Foram avaliados dez tratamentos em esquema fatorial duplo (2 × 5). No primeiro fator, foram avaliados dois arranjos de plantio: linhas simples e linhas duplas. No segundo fator, foram avaliadas cinco densidades de plantas: 15, 20, 25, 30 e 35 mil plantas ha^{-1}. Para o híbrido CVR-2909, o cultivo em linhas simples proporcionou maior produtividade, já as maiores densidades de plantas resultaram em menor produção e número de frutos por planta. Para o híbrido HMX-7885, maiores densidades de plantas proporcionaram maior produtividade, porém com menor produção por planta, massa média e número de frutos por planta. Para esse híbrido o arranjo de plantio proporcionou maior taxa de frutos verdes.

Palavras-chave: *Solanum lycopersicum* L., sistema de cultivo, tomate industrial

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Introduction

As an important agronomic technique, the planting arrangement determines, among other things, the vegetation area of the cultivated plants (Nkansah et al., 2021). This area must ensure the most efficient reception of soil and air factors, which is defined by the agroecological conditions of the growing micro-region, the biological traits of the plant (genotype), and the purpose of the crop. By defining the plant density (number of plants per unit area), i.e., the vegetation space of each plant, the aim is to allow maximum use of biofactors in the growing area and to achieve the yield potential of each genotype (Haque & Sakimin, 2022).

The ideal plant density optimizes using light, water, soil, and nutrients to achieve high yields and fruit quality in tomatoes for industrial processing (Patanè & Saita, 2015). Increasing planting density generally reduces vegetative growth, makes fruit ripen earlier, and increases fruit production per unit area despite reducing fruit production per plant and the size and quality of the fruit (Ismail & Mousa, 2014). According to Wamser et al. (2017), any changes in the planting system can cause economic impacts and increase or decrease production costs, mainly by influencing crop yield.

Tomatoes for industrial processing in Brazil are generally grown in single or double rows. The planting density generally used for all arrangements and hybrids is 30,000 plants per hectare (Jacinto et al., 2012).

The economic yield of most crops, especially tomatoes for industrial processing, increases with denser cultivation. In their study, Warner et al. (2002) showed that an approximate yield increase of 2 t ha^{-1} can compensate for the extra cost of increasing planting density in industrial processing tomatoes. Most qualitative traits of tomato fruit do not change with variations in planting density, and the effect of density in different growing seasons remains constant (Patanè & Saita, 2015).

Studies of phytotechnical aspects aim to characterize the agronomy of materials and their performance under different climatic conditions, in different regions, and during different growing seasons (Evangelista et al., 2022). This study aimed to evaluate the yield of tomato plants of determinate growth and the physicochemical characteristics of the fruits in different planting arrangements and plant densities.

Material and Methods

Two experiments were conducted in the experimental area located in Abadia de Goiás, Goiás state, Brazil, at 16° 45’ 26” S, 49° 26’ 15” W, and an average altitude of 898 m. According to the Koppen classification, the predominant climate of the region is Aw-type (tropical climate with a dry winter season).

The hybrids CVR-2909 (CVR Plant Breeding) and HMX 7885 (Agristar) were used in the first growing season (04/02/2021 to 08/04/2021) and in the second growing season (06/03/2021 to 09/29/2021), respectively. Both genotypes are commonly used by tomato producers for industrial processing (Evangelista et al., 2022). The seedlings were grown in a commercial nursery in an agricultural greenhouse in 450-cell trays filled with commercial coconut fiber substrate. During the experiments, an automatic weather station recorded the temperature and relative air humidity data (Figure 1).

The soil of the experimental area was classified as Oxisol with the following chemical characteristics at the 0-0.20 m layer: pH ($CaCl_2$) = 5.8 and 5.8, P = 30.0 and 92.0 mg dm^{-3}, K = 84.7 and 42 mg dm^{-3}, OM = 26 and 24 g dm^{-3}, Al = 0.0 and 0.0 cmol$_c$ dm^{-3}, Ca = 3.1 and 2.6 cmol$_c$ dm^{-3}, Mg = 1.2 and 1.1 cmol$_c$ dm^{-3}, base saturation (%) = 71.5 and 68.5, for each cultivation area of the hybrids CVR -2909 and HMX 7885, respectively.

Planting and topdressing fertilizations were conducted according to the soil analysis results, following the recommendations of Silva et al. (2012). Planting fertilization was conducted in the furrows by applying 1350 and 1523 kg ha^{-1} of single superphosphate + 450 and 388 kg ha^{-1} of granulated monoammonium phosphate (MAP) + 273 and 288 kg ha^{-1} of potassium chloride + 30 and 22 kg ha^{-1} of zinc sulfate. Topdressing was applied using ammonium nitrate (326 and 364 kg ha^{-1}), ammonium sulfate (210 and 138 kg ha^{-1}), potassium chloride (537 and 625 kg ha^{-1}), monoammonium phosphate (50 and 60 kg ha^{-1}), magnesium sulfate (241 and 329 kg ha^{-1}), and boric acid (40 and 35 kg ha^{-1}). The fertilizations were the same for the different plant densities and totaled 210 and 203 kg ha^{-1} of N, 548 and 558 kg ha^{-1} of P_2O_5, 486 and 548 kg ha^{-1} of K_2O, 210 and 222 kg ha^{-1} of S, 6 and 4 kg ha^{-1} Zn, 7.0 and 6.0 kg ha^{-1} of B and 22 and 30 kg ha^{-1} of Mg, for each cultivation area of the hybrids CVR -2909 and HMX 7885, respectively.

Irrigation was conducted via a conventional sprinkler system using sprinklers with a flow rate of 24.6 L min^{-1}. Reference evapotranspiration was determined using climatological data obtained from the Metos™ meteorological station. Kc values recommended by Marouelli et al. (2012) were used to estimate crop evapotranspiration. Pests and diseases were monitored and controlled according to the level of infestation, following the recommendations of integrated pest and disease management, following the recommendations of Clemente & Boiteux (2012).

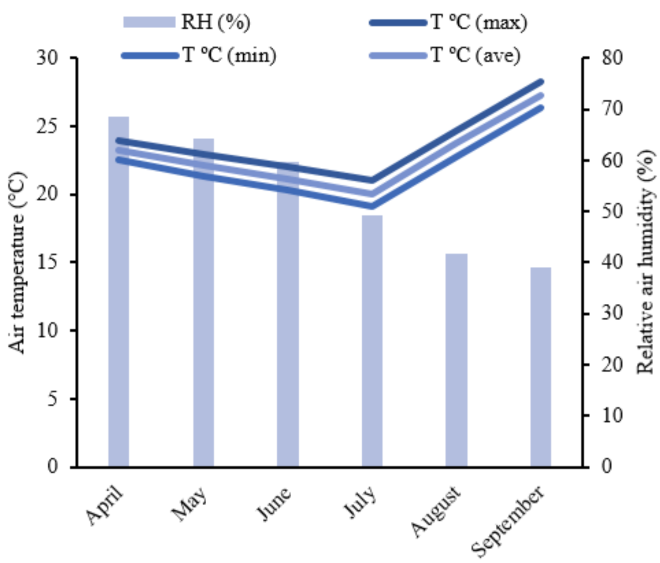

Figure 1. Climatological data on maximum (max), minimum (min), and average (ave) air temperature and average relative air humidity (RH) during the conduction of the experiments from April to September 2021

The two experiments were conducted in a randomized block design with four replicates. Ten treatments were evaluated in a double factorial scheme (2 × 5). The first factor evaluated two planting arrangements: single row (1.20 × 1.20 m) and double row (0.45 × 1.35 m). The second factor comprised five plant densities: 15, 20, 25, 30, and 35 thousand plants ha^{-1}. Each plot consisted of three planting rows, each 10 m long. Data was collected on ten sequential plants along the central row, totaling a useful plot area of 3.6 m².

Fruit harvest was conducted 124 and 118 days after planting for the hybrids CVR -2909 and HMX 7885, respectively. The fresh mass of the fruit was assessed to determine the fruit production per plant (kg per plant), total yield, and commercial yield (t ha^{-1}). The fresh mass of unripe, rotten, and burned fruit was obtained separately to calculate total and commercial yield, considering only ripe fruit. Unripe fruits were considered to be those with 100% of the surface-colored green.

Ten fruits per plot were used to conduct the biometric and physicochemical analysis, according to the methodology of Souza et al. (2022). The average fruit mass (g) was assessed using a digital scale with a precision of 0.001g. The longitudinal and transverse diameter (mm^{-1}) of the fruit was measured using a digital caliper. The pericarp thickness (mm^{-1}) was evaluated by cutting the fruit in the equatorial region and measured using a digital caliper. Fruit firmness (kgf cm^{-2}) was obtained by taking the reading with a digital penetrometer, Instrutherm™ PTR-300, with an 11 mm penetration tip in the equatorial region of the fruit. The soluble solids content was assessed from the pulp juice by refractometric reading, expressed in °Brix, at 20 °C, with a portable digital refractometer Brix-Refractive Index Reichert. Hydrogen potential (pH) was determined by potentiometry with a potentiometer model TEC-7 Tecnal™ benchtop digital pH meter.

Data were submitted to the analysis of variance (F-test). Once significant differences were detected ($p \leq 0.05$), regression analysis (linear and quadratic models) for plant density was applied. The data of green fruits, rotten fruits, burned fruits, production per plant, and number of fruits per plant were transformed ($(x + 0.5)^{0.5}$) to meet the assumptions of normality and homogeneity. Statistical analysis was performed using the software Sisvar 5.3.

Results and Discussion

Significative results of interaction between the studied factors were not verified for the variables analyzed for the hybrid CVR-2909 (Tables 1 and 2). The arrangement of single

Table 1. Total (TY) and commercial (CY) fruit yield, green, rotten, and burned fruit rates, fruit production per plant (PP), number of fruits per plant (NFP), and average fruit mass (AFM) of the hybrid CVR-2909

Source of variation	TY	CY	Green fruits	Rotten fruits	Burned fruits	PP	NFP	AFM
	(t ha^{-1})			(%)		(kg per plant)		(g)
Planting arrangement (PA)								
Single row	158.10	142,99	5.31	1.09	3.18	6.82	120.79	54.42
Double row	147.72	133.45	5.22	1.04	3.38	6.44	115.59	53.87
'F' value	5.02*	5.20*	0.01^{ns}	0.07^{ns}	0.21^{ns}	3.41^{ns}	1.56^{ns}	0.39^{ns}
Plant density (PD)								
15,000	144.32	129.85	5.96	0.76	3.24	9.62	167.33	55.84
20,000	155.24	138.37	6.06	0.73	4.15	7.76	136.35	54.62
25,000	155.28	140.72	5.21	1.33	2.76	6.21	111.45	54.37
30,000	152.55	139.24	4.96	0.99	2.85	5.08	92.85	53.46
35,000	157.16	142.89	4.16	1.43	3.41	4.49	82.97	52.46
'F' value	0.96^{ns}	1.13^{ns}	0.63^{ns}	3.36**	1.21^{ns}	83.52**	54.06**	1.66^{ns}
Regression	-	-	-	L^{1}	-	L^{2}	L^{3}	-
Interaction PA × PD ('F' value)	0.74^{ns}	0.56^{ns}	0.87^{ns}	0.36^{ns}	0.89^{ns}	0.44^{ns}	1.02^{ns}	0.69^{ns}
CV (%)	9.58	9.56	23.30	51.38	17.12	4.43	11.12	5.13

CV - Coefficient of variation; ns – Non-significant by F-test; * - Significant at $p < 0.05$ by F-test; ** - Significant at $p < 0.01$ by F-test; L - Linear; L^{1} - $y = 0.000003^{**}x + 0.2425$, $R^2 = 62.4$; L^{2} - $y = -0.0003^{**}x + 13.102$, $R^2 = 96.37$; L^{3} - $y = -0.0042^{**}x + 224.3$, $R^2 = 96.39$

Table 2. Soluble solids (SS), pH, fruit firmness, longitudinal diameter (LD), transverse diameter (TD), and pericarp thickness (PT) of fruits of the hybrid CVR-2909

Source of variation	SS (°Brix)	pH	Fruit firmness (kgf cm^{-2})	LD	TD	PT
					(mm)	
Planting arrangement (PA)						
Single row	4.55	4.40	2.39	60.26	48.28	6.24
Double row	4.59	4.49	2.29	60.48	47.66	6.30
'F' value	0.23^{ns}	7.65*	2.83^{ns}	0.07^{ns}	1.46^{ns}	0.38^{ns}
Plant density (PD)						
15,000	4.47	4.47	2.25	60.59	47.71	6.18
20,000	4.56	4.46	2.33	59.73	47.69	6.07
25,000	4.53	4.46	2.36	60.25	47.22	6.22
30,000	4.67	4.43	2.44	60.52	48.23	6.58
35,000	4.61	4.43	2.32	60.77	48.49	6.30
'F' value	0.71^{ns}	0.34^{ns}	1.19^{ns}	0.17^{ns}	1.20^{ns}	4.21^{ns}
Regression	-	-	-	-	-	-
Interaction PA × PD ('F' value)	0.01^{ns}	0.49^{ns}	0.09^{ns}	0.63^{ns}	2.34^{ns}	5.21^{ns}
CV (%)	5.62	2.21	7.85	4.54	3.34	4.21

CV - Coefficient of variation; ns – Non-significant by F test; * - Significant at $p < 0.05$ by F-test and double rows influenced only the yield variables of the CVR-2909 hybrid (Table 1). Single-row cultivation increased by 7.02 and 7.15% in total and commercial yield, respectively, compared to double-row cultivation. Corroborating these results, studies conducted under Cerrado conditions of Central Brazil indicated that compared to double-row cultivation, planting in single rows provides around a 10% increase in fruit yield (Marouelli et al., 2012). In general, the fruit yield observed in this study was higher than the national average, around 70 t ha^{-1} (IBGE, 2024); Trento et al. (2021) observed a similar result evaluating the performance of cultivars of determinate growth. According to Quezado-Duval et al. (2014), the CVR-2909 hybrid is adaptable to the edaphoclimatic conditions of the Cerrado since it was developed in these conditions.

Ferreira et al. (2017) also found no significant effect on fruit yield in an evaluation of industrial tomato plants in dense cultivation, and for the different spacings evaluated, the average fruit yield was 97.7 t ha^{-1}. Evaluating the density and planting arrangement of stacked tomato plants, Wamser et al. (2017) found different behavior; they found that larger fruits were obtained in double-row cultivation, contributing significantly to a higher average fruit yield of 155 t ha^{-1}, according to the authors which is likely to be due to the larger in-row spacing in double-row cultivation concerning single-row cultivation.

For the plant density of the CVR-2909 hybrid, a linear regression adjustment was verified for the rate of rotten fruit (Table 1). This result may be related to the fact that the plants tend to protect the fruit more in denser plantings due to the greater proportion of leaves per area (Patanè & Saita, 2015). However, this increase in biomass can favor the incidence of rotten fruits due to the formation of a microclimate with greater humidity that provides greater chances of attack by pests and diseases (Schwarz et al., 2013). A high value of the coefficient of variation was verified for the rate of rotten fruit (Table 1), even after data transformation. Therefore, there was greater variability, indicating a more heterogeneous data group.

There was no influence of plant density on yield. For the variables fruit production per plant and number of fruits per plant, there was a negative linear effect for higher plant density (Table 1). There was a difference of 46.67 and 49.39% for fruit production and number of fruits per plant, respectively, when comparing the plant density of 15,000 and 35,000 plants per hectare. These results align with those found by Dinh & Dang (2022), who found that at low planting density, fruit size increased, and the number of fruits per plant decreased compared to high planting density. According to Tóth et al. (2019), fruit mass and fruit production per plant are the important parameters for achieving profitable yields, for the author, the main objective is to achieve a yield of 100 t ha^{-1}. Increasing planting density generally reduces vegetative growth, makes fruit ripen earlier, and increases fruit production per unit area despite reducing fruit production per plant (Ismail & Mousa, 2014). Despite the significant effect of plant density on production and the number of fruits per plant, plant density did not influence average fruit mass (Table 1). According to CVR Plant Breeding Ltd., the CVR-2909 hybrid has an average weight between 60 and 70 g, values higher than those found in this study. It is expected that the average fresh mass of fruits decreases with increasing plant density (Matos et al., 2012).

For the CVR-2909 hybrid, there was an influence of planting arrangement on the pH value (Table 2). In the double-row cultivation, there was a higher average pH, but in the single-row cultivation, even though the average was lower, the pH was still within the right range. The pH of the fruit is fundamental when choosing which technique to use to preserve the tomato by product. According to pH, foods can be classified as low acid foods (pH above 4.5), acid foods (pH between 4.0 and 4.5), and very acid foods (pH below 4.0) (Franco & Landgraf, 2005). Foods with low acidity are the most prone to yeast and mold multiplication (Barth et al., 2009).

It was observed that the plant density did not influence the physical and chemical traits of the fruit (Table 2), corroborating the results of Wamser et al. (2012), who observed that tomato plant densification could increase fruit yield without compromising fruit quality and phytosanitary control.

For hybrid HMX-7885, the interaction between the factors studied was not verified for the variables analyzed (Tables 3 and 4). The planting arrangement significantly influenced only the rate of green fruits, whereas plant density influenced yield and fruit production (Table 3). Processing tomato varieties were developed for a single harvest when 95-100% of the fruits are mature red. The ripening concentration is influenced by climatic conditions, soil water content, and when irrigation is stopped or reduced (Soares & Rangel, 2012). A positive linear regression was found for total and commercial fruit yield (Table 3). Using a density of 35,000 plants per hectare, it was possible to obtain an increase of 39.32 and 54.63% in total and commercial yield, respectively, compared to the density of 15,000 plants per hectare. Therefore, densities greater than 35,000 plants ha^{-1} should be evaluated, as obtaining the maximum yield points was impossible. After comparing the harvesting of high plant density with the traditional plant density, Wamser et al. (2012) reported a higher yield for high plant-density tomatoes. Benetti et al. (2018) also observed that different spacings significantly modified tomato yields, with the highest yields obtained when the tomato plants were planted with reduced spacing. According to Carvalho et al. (2019), more plants per area compensate for competition between plants in dense planting.

For the yield-related variables, a negative linear regression was fitted for fruit production per plant and average fruit mass, while a quadratic regression was fitted for the number of fruits per plant (Table 3). Therefore, for the HMX-7885 hybrid, at higher densities of up to 35,000 plants per hectare, despite producing lower mass and number of fruits per plant, and these fruits being smaller, it is still possible to achieve higher yields. These results align with reports by Falodun & Emede (2019), who stated that commercial tomato yield decreased with high plant density, but total yield increased.

According to Clemente & Boiteux (2012), in industrial tomato growing, the aim is to obtain many productive plants and stems per hectare, resulting in higher yields. Therefore, in this crop, the greater the number of fruits harvested, the smaller their size. On the other hand, when the aim is to produce fruit for fresh consumption (for table), it is necessary to adjust the number of plants, stems, and fruit per hectare to obtain fruits of the required size and quality (Seleguini et al., 2006).

Table 3. Total (TY) and commercial (CY) fruit yield, green, rotten, and burned fruit rate, fruit production per plant (PP), number of fruits per plant (NFP), and average fruit mass (AFM) of the hybrid HMX-7885

Source of variation	TY	CY	Green fruits	Rotten fruits	Burned fruits	PP	NFP	AFM
	($t\ ha^{-1}$)		(%)			(kg per plant)		(g^{-1})
Planting arrangement (PA)								
Single row	110.43	91.28	6.24	3.72	7.80	4.64	68.46	67.71
Double row	115.56	94.54	8.54	3.13	6.55	4.90	70.69	69.09
'F' value	1.90^{ns}	0.99^{ns}	3.08^{*}	1.85^{ns}	2.37^{ns}	2.08^{ns}	0.86^{ns}	0.79^{ns}
Plant density (PD)								
15,000	93.17	71.57	9.89	4.74	8.73	6.21	87.64	70.71
20,000	108.28	90.39	6.83	2.41	7.10	5.41	77.58	69.65
25,000	112.39	92.65	6.45	3.53	7.65	4.49	64.69	69.84
30,000	121.31	99.29	8.62	3.26	6.00	4.04	59.49	67.84
35,000	129.81	110.67	5.14	3.16	6.39	3.71	58.48	63.96
'F' value	11.14^{**}	15.28^{**}	2.05^{ns}	3.04^{ns}	1.42^{ns}	25.38^{**}	22.29^{*}	7.93^{*}
Regression	L^1	L^2	-	-	-	L^3	Q^4	L^5
Interaction PA x PD ('F' value)	0.57^{ns}	0.95^{ns}	0.77^{ns}	0.98^{ns}	1.10^{ns}	0.54^{ns}	0.50^{ns}	0.74^{ns}
CV (%)	10.39	11.14	24.77	16.55	17.42	5.32	5.31	7.11

CV - Coefficient of variation; ns – Non-significant by F test; * - Significant at $p < 0.05$ by F-test; ** - Significant at $p < 0.01$ by F-test; L - Linear; Q - Quadratic; L^1 - $y = 0.0017^{**}x + 69.837$, $R^2 = 97.06$; L^2 - $y = 0.0017^{**}x + 49.364$, $R^2 = 92.75$; L^3 - $y = -0.0001^{**}x + 7.957$, $R^2 = 96.2$; Q^4 - $y = 7^{-8*}x2 - 0.0052x + 150.15$, $R^2 = 98.79$; L^5 - $y = -0.0003^{*}x + 76.055$, $R^2 = 80.83$

Studies on the effect of plant density on the yield of determinate-growth tomato plants indicate that cultivation under high planting densities provides a high total yield per area, decreases the number of fruits per plant, and reduces the average fruit size. Several studies have attributed the reduced number of fruits under high plant density to the development of fewer inflorescences and flowers and a lower fruiting rate (Ohta et al., 2018).

Among the chemical traits, the planting arrangement only influenced the pH of the pulp of the HMX-7885 hybrid, with the highest average observed for planting in double rows (Table 4). According to the classification of Franco & Landgraf (2005), for both arrangements evaluated, the acidity value is considered low (pH greater than 4.5).

As for the longitudinal diameter, it was found that the single-row cultivation resulted in a 3.4% increase in fruit diameter (Table 4). Possibly, this result is related to the lower number of fruits per plant, due to less competition, the plants have free growth and so do not need to compensate for densification, producing a greater number of branches and consequently more fruit.

It was observed that the plant density did not influence the physical and chemical traits of the fruit (Table 4). Similar results were observed by Benetti et al. (2018), evaluating the influence of different planting densities on the growth and yield of tomato plants. According to Patanè & Saita (2015), most qualitative traits of tomato fruit do not change with variations in planting density.

A negative linear regression model was fitted for pericarp thickness (Table 4). It was clear that as the plant density increased to 35,000 plants per hectare, there was a decrease in pericarp thickness (Table 4). The results obtained were similar to those found by Schwarz et al. (2013), who, working with ten cultivars of determinate growth tomato in two years of cultivation in the region of Pinhão, PR, Brazil, obtained average pericarp thicknesses between 5.0 and 8.3 mm. However, they were lower than Trento et al. (2021) observed, between 9.4 and 10.4 mm.

The pulp thickness determines the shape and firmness of the fruit. This is probably due to the detour of photoassimilates from the formation of the locule walls to the formation of the pericarp, increasing the firmness of the fruit. Fruit firmness is correlated with fruit quality parameters (color, shape, and appearance) (Mukherjee et al., 2020). Genotypes with firm fruit generally have a longer shelf life due to their thicker pericarp (Prema et al., 2011).

Table 4. Soluble solids (SS), pH, fruit firmness, longitudinal diameter (LD), transverse diameter (TD), and pericarp thickness (PT) of fruits of the hybrid HMX-7885

Source of variation	SS (°Brix)	pH	Fruit firmness (kgf cm²)	LD	TD	PT
					(mm)	
Planting arrangement (PA)						
Single row	4.33	4.59	2.91	83.80	48.73	6.60
Double row	4.18	4.70	2.85	81.04	48.73	6.60
'F' value	2.46^{ns}	17.80^{**}	1.07^{ns}	8.54^{**}	0.00^{ns}	0.00^{ns}
Plant density (PD)						
15,000	4.15	4.66	2.86	83.10	48.92	6.91
20,000	4.35	4.65	2.96	84.02	49.16	6.62
25,000	4.18	4.62	2.91	83.29	49.53	6.71
30,000	4.30	4.69	2.77	81.47	48.18	6.55
35,000	4.29	4.63	2.91	80.23	47.85	6.23
'F' value	0.56^{ns}	1.06^{ns}	1.34^{ns}	2.11^{ns}	0.98^{ns}	5.62^{**}
Regression	-	-	-	-	-	L^1
Interaction PA × PD ('F' value)	2.08^{ns}	0.76^{ns}	1.70^{ns}	0.32^{ns}	0.00^{ns}	0.00^{ns}
CV (%)	7.50	1.68	5.91	3.62	4.09	2.10

CV - Coefficient of variation; ns – Non-significant by F test; **Significant at $p < 0.01$ by F-test; L = Linear; L^1 - $y = -3^{-5**}x + 7.319$, $R^2 = 82.48$

Conclusions

1. For the CVR-2909 hybrid, single-row cultivation provides higher yields, while higher plant densities provide lower fruit production and number of fruits per plant. Furthermore, it does not affect commercial fruit yield, suggesting lower seedling cost.

2. For the HMX-7885 hybrid, it was found that higher densities provide greater yield. However, there was a decreasing effect on fruit production per plant, average fruit mass, and number of fruits per plant.

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