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Humus contribution to the production and post-harvest quality of mini watermelon cultivars

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Abstract: The demand for quality fruit has driven producers to look for cultivars that are attractive to consumers. Thus, the aim of this study was to evaluate the effect of humus application on production and postharvest characteristics of fruits of mini watermelon cultivars. The experiment was carried out in a randomized blocks, in a factorial scheme 4 x 2, with five replicates. The treatments consisted of four mini watermelon cultivars (Champagne, E-48, Fancy and Serenade) cultivated with the application or not of humus associated with fertigation. The physical characteristics and post-harvest quality of the mini watermelon fruits were analyzed. Humus improved the morphological characteristics of the fruit, except for pulp yield and fruit shape index. The humus increased by 46.85, 22.10, 22.03 and 26.92%, respectively, the shoot dry mass and the fresh masses of fruit, pulp and rind, compared to plants grown without humus addition. Among the cultivars, the shoot dry mass of Serenade was 20.79% higher than the mean of Champagne and E-48 cultivars, which did not differ from each other. The highest pulp yields were obtained in Champagne and E-48 cultivars, while Fancy and E-48 showed the highest levels of total soluble solids. The addition of humus did not affect the sugar content in the studied cultivars, with an average of 10.9 °Brix and a maturity index of 48.65%. Thus, the presence of humus in the substrate improves the morphological characteristics of the fruits without affecting the total soluble solids content.

Keywords: *Citrullus lanatus* L., vermicompost, maturation index.

Contribuição do húmus na produção e qualidade pós-colheita de cultivares de minimelancia

Resumo: A demanda por frutas de qualidade tem impulsionado os produtores a busca por cultivares que sejam atrativas ao consumidor. Neste contexto, objetivou-se com este estudo avaliar o efeito do húmus na produção e características pós-colheita de cultivares de minimelancias. O experimento foi em blocos casualizados, em esquema fatorial 4 x 2, com cinco repetições. Os tratamentos foram quatro cultivares de minimelancias (Champagne, E-48, Fancy e Serenade) cultivadas com a aplicação ou não de húmus juntamente com a fertigação. Foram analisadas as características físicas e qualidade pós-colheita das minimelancia. O húmus melhorou as características morfológicas do fruto, com exceção de rendimento de polpa e índice de formato de fruto. O húmus aumentou em 46,85, 22,10, 22,03 e 26,92%, respectivamente, a massa seca da parte aérea e as massas frescas do fruto, da polpa e da casca, em relação às plantas cultivadas sem adição de húmus. Entre as cultivares, a massa seca da parte aérea da Serenade foi 20,79% maior que a média das cultivares Champagne e E-48, que não diferiram entre si. Os maiores rendimentos de polpa foram obtidos nas cultivares Champagne e E-48, enquanto na Fancy e a E-48 obtiveram os maiores teores de sólidos solúveis totais. A adição de húmus não afetou o teor de açúcar nas cultivares estudadas, com média 10,9 °Brix e um índice de maturação de 48,65%. Assim, a presença de húmus no substrato proporciona melhoria nas características morfológicas dos frutos sem afetar o teor de sólido solúveis totais.

Palavras-chave: *Citrullus lanatus* L., vermicompostos, índice de maturação.

Introduction

Watermelon (*Citrullus lanatus* L.) is an herbaceous plant belonging to the Cucurbitaceae family. It is a plant widely cultivated in the Northeast region of Brazil due to the favorable climate for its cultivation under irrigated conditions [9]. In 2019, Brazil produced 2,278,186 tons of watermelon and the Northeast region was the largest national producer, with 34.03% [19]. However, the soils used in its cultivation are characterized by low levels of organic matter, due to long periods of drought and high temperature [6].

Cultivation of plants in soils or substrates poor in organic matter and nutrients as well as inadequate soil management can cause reductions in yield [31]. In this scenario, it is necessary to use synthetic chemical fertilizers that add nutrients to the soil, for the proper development of crops, but they increase production costs [34]. Additionally, incorrect management of synthetic fertilizers can cause even more damage to the environment, so organic management strategies are needed [11].

The use of organic fertilization has been promising in Brazil in recent years [4], and earthworm humus or vermicompost is among the main organic composts. Vermicomposting is the process of transforming organic material into stabilized organic matter through the action of earthworms and microsymbionts [37].

Studies have shown that the use of vermicompost in fertilization has a positive influence, reducing the need for chemical fertilizers and increasing the availability of essential nutrients, soil porosity, shoot biomass and plant development [27, 18, 24]. On the other hand, organic fertilization can affect post-harvest quality, because the greater availability of nitrogen in the soil stimulates vegetative growth, which increases competition for photoassimilates between shoots and fruits [13]. In view of the above, this study aimed to evaluate the effect of humus on the production and post-harvest characteristics of fruits of four cultivars of mini watermelon.

Material and Methods

The experiment was conducted in a protected environment in the experimental area of the Nucleus of Water and Soil Engineering of the Federal University of Recôncavo da Bahia, located in the municipality of Cruz das Almas - BA, Brazil, from November to January 2019, for 92 days. The coordinates of the protected environment are 12° 40’ 39” South latitude and 39° 40’ 23” West longitude with altitude of 220 m. The climate of the region is classified as hot and humid tropical (Af) according to Köppen's classification [1], with relative air humidity and mean annual temperature of 80% and 24.5°C, respectively, and average annual rainfall of 1,224 mm.

The experimental design used was randomized blocks, in a 2 x 4 factorial scheme with five blocks, totaling 40 experimental units. The treatments used were without and with the addition of humus in the soil and four cultivars of mini watermelon: Champagne (CH), E-48, Fancy (FA) and Serenade (SE), whose seeds were supplied by the company Takii do Brasil Ltda. The humus was prepared by vermicomposting plant remains from tree pruning with bovine manure and its subsequent chemical characterization (Table 1) was performed according to methodologies recommended by Jones [20].

Sowing was carried out in 300 mL polyethylene containers with coconut fiber substrate, by planting one seed per cup. Holes were opened at the bottom of the cups for water drainage. The seeds were irrigated until 7 days after sowing (DAS) only with water from the local supply system, with electrical conductivity (ECw) of 0.33 dS m^{-1}. Transplanting of seedlings was performed 20 days after sowing. The experimental unit consisted of a container with a capacity of 10 dm^3 and height of 23 cm, which was filled with a 0.03 m thick layer of crushed stone and soil (Latossolo Amarelo Ditrocoeso típico - Oxisol) from the 0-0.20 m layer, which had been properly pounded to break up clods, homogenized and previously characterized (Table 1) according to methodologies recommended by Teixeira et al. [36]. The soil was collected from the experimental area of the Federal University of Recôncavo da Bahia and incubated with limestone for 60 days to raise base saturation to 70% [14]. The crushed stone layer and the soil were separated by a screen. A 16 mm diameter tube was installed at the bottom of each container for drainage.

The experimental unit of the treatments consisted of 9 kg of substrate, composed of humus and soil in the proportion of 1:2 (m/m). The experimental units in the absence of humus were filled with 9 kg of soil. The plants were vertically trained using wires supported by bamboo posts and fixed by polypropylene twine. The plants were grown with two stems, with one fruit on the main stem.

The lower shoots were eliminated soon after they emerged and, when the plants reached the upper wire (2.0 m high), apical pruning was performed. The fruits developed from the 5th internode of the main stem, and one fruit was produced per plant.

Pollination was carried out manually, by harvesting the male flower and taking it to the female flower. Pollination was performed with the flowers of their respective species, except for the cultivar Serenade as it is a triploid. Therefore, the pollens of the flowers of the cv. Serenade are unviable to produce fruit, so cross pollination was performed with the male flowers of the cv. Fancy. Pollination was carried out between 08:00 and 10:00 h, because it is during this period that the flowers open and pollen grains are viable [7].

The fruits were placed in protective nets when they reached the approximate size of 4 to 5 cm in diameter. One end was tied around the fruit peduncle and the other was tied to the lower wire (1.50 m high), with polypropylene twine.

For irrigation management, a tensiometer was installed in three replicates of each treatment at 0.15 m depth. The tensiometers were read daily and irrigation was performed based on the average of all tensiometers, in order to increase the soil moisture content to field capacity (0.45076 $cm^3\,cm^{-3}$ - 10 kPa) to meet the water needs of the crop.

The applied water depth was calculated according to the pot area (0.091 m), effective depth of the root system (0.20 m) and the soil water characteristic curve, previ-

Table 1: Chemical characteristics of the humus and physical and chemical characteristics of the soil used in the experiment.

Humus			
pH	N	P	K
	mmol g^{-1}		
6.43	1.536	0.118	0.08

Soil						
Sand	Silt	Clay	Texture	SD	ECse	pH
g kg^{-1}				kg dm^{-3}	dS m^{-1}	
682.5	202.2	115.3	Samdy loam	1.5	1.28	5.1

P	K	Ca	Mg	Al	H+Al	NA	SBs	CEC	V
mg dm^{-3}		$cmol_c$ dm^{-3}							%
1.3	48	1.0	0.5	0.2	3.0	0.04	1.66	4.66	35.6

pH - Hydrogen potential in water; N - Nitrogen; P - Phosphorus; K - Potassium; Ca - Calcium; Mg - Magnesium; Al - Aluminum; H + Al - Potential acidity; Na - sodium; SD - Soil density; ECse - Electrical conductivity of saturation extract; SBs - Sum of bases; CEC - Cation exchange capacity; V - Base saturation.

ously obtained according to the model of Genuchten [17], as shown in Eq. 1.

$$\theta = 0.101 + \left(\frac{0.468 + 0.101}{[1 + (0.056 \cdot |\Psi|)^{1.345}]^{0.256}} \right) \quad (1)$$

Where:
θ – soil moisture ($cm^3\,cm^{-3}$); and,
Ψ – matrix potential (kPa).

Fertigation was performed daily with the nutrient solution according to the recommendations of Campagnol et al. [8] until 57 DAS in all treatments (Table 2). After this period, the plants were irrigated twice a day, with nutrient solution in the morning and with water from the local supply system in the afternoon, to avoid salinization of the substrate.

The amounts of fertilizers were defined according to the development stage of the plant, similar to that used by Campagnol et al. [8] with minor adaptations (Table 2). Stage I comprised the period of seedling production (7 to 20 DAS), stage II corresponded to the period from seedling transplanting to the beginning of the development of the first fruits (20 to 35 DAS) and stage III corresponded to the period from the beginning of fruit development to harvest (35 to 63 DAS).

The harvest point was defined when the tendril adjacent to the fruit was dry. The variables analyzed were: fresh fruit mass (FM), fresh rind mass (RM), pulp mass (PM), pulp yield (PY), pulp diameter (PD), transverse circumference (TC) and longitudinal circumference (LC), total soluble solids (TSS), pH, total titratable acidity (TTA), maturity index (MI) and shoot dry mass (ShDM).

The FM, PM, RM and ShDM were determined using a semi-analytical digital scale (0.001 g), PD (red part of the pulp) was measured with a graduated ruler, and TC and LC were measured with a measuring tape.

The variables of post-harvest quality (TSS, pH and TTA) were determined as described by Zenebon et al. [38]. The pulp of one mini watermelon fruit was homogenized and used for the determination of total soluble solids (TSS) with a digital refractometer. Fruit pH was measured with a bench top pH meter and its total titratable acidity was determined by titration with 0.05 N NaOH solution up to pH ± 8.3, using phe-

Table 2: Concentration of fertilizers used in the preparation of the nutrient solution for fertigation in the different stages of development of mini watermelon plants.

Fertilizers	Stage 1	Stage 2	Stage 3
		$mg\,L^{-1}$	
Potassium nitrate	180.5	201.5	500.0
Calcium nitrate	380.0	426.0	300.0
Ammonium nitrate	50.0	100.0	0.0
Monoamonic phosphate	230.0	257.0	80.0
Magnesium sulfate	190.0	210.0	140.0
Potassium sulfate	192.0	192.0	381.0
'Dripsol' micro rexene balance*	10.0	15.0	15.0

*'Dripsol' (0.85% B; 0.5% Cu; 3.4% Fe; 3.2% Mn; 0.05% Mo; 4.2% Zn and 1.1% Mg). Stage 1: 7 to 20 days after sowing (DAS); Stage 2: 20 to 35 DAS (beginning of the development of the first fruits) and Stage 3: 35 to 63 DAS (period from the beginning of fruit development to harvest)

nolphthalein indicator.

The data were subjected to analysis of variance (ANOVA). In the case of significant effect in the F test, the means were subjected to Tukey test. The statistical analysis was performed with the statistical program SISVAR, version 5.6. [15].

Results and Discussion

According to the results of the F test (Table 3), there was no significant effect ($p>0.05$) of the interaction between cultivars and substrate on the morphological characterization of mini watermelons, that is, the cultivars showed a similar behavior with the addition of humus to the substrate. The isolated effect of substrate was significant for the fresh fruit mass (FM), pulp mass (PM) and transverse circumference (TC); for the cultivars, the effects were on pulp yield (PY) and fruit shape index (FSI), and both variation factors caused significant effects on rind mass (RM), pulp diameter (PD), longitudinal circumference (LC) and shoot dry mass (ShDM).

The variables fresh fruit mass (FM), fresh pulp mass (PM) and fresh rind mass (RM) were affected by the type of substrate (Table 3). It was observed that the substrate with addition of humus promoted increments of 22.10, 22.03 and 26.92% in the variables FM, PM and RM, respectively compared to the substrate without humus. Dutra et al. [12] found no difference in the production of watermelon cv. Sweet Crimson when evaluating organic sources humus, goat manure and bovine manure, but the production was within the range found for conventional cultivation, equal to 14.6, 19.15 and 17.75 kg per plant, respectively. However, Nascimento et al. [28], when evaluating watermelon production in soil fertilized with doses of bovine manure and potassium, observed that the addition of bovine manure increased fruit mass, hence reducing the need for potassium fertilizer.

The increase in fresh fruit, pulp and rind mass observed with the addition of humus can be attributed to its chemical constituents, which improve plant nutrition and moisture retention by the substrate. According to Liu et al. [24], the addition of vermicompost to the soil increases the proportion of macroaggregates and nutrients such as N, P and K, even in saline soils. Moreover, the increase in soil porosity through the incorporation of humus also increases the availability of water for the plant, due to the higher soil water retention capacity [35]. A study showed that the addition of 40% of vermicompost (volume basis) in soil

Table 3: Summary of the Fisher's test (F) and the mean observed for the morphological characteristics of the fruits and shoot dry mass (ShDM) of mini watermelon cultivars without and with the addition of humus in the substrate

					Test F					
FV	DF	FM	PM	RM	PY	PD	TC	LC	FSI	ShDM
Cultivars (C)	3	ns	ns	**	**	**	ns	*	**	**
Substrate (S)	1	**	**	**	ns	**	**	*	ns	**
Interaction (CxS)	3	ns	ns	ns	ns	ns	ns	ns	ns	ns
Block	4	ns	ns	ns	ns	ns	ns	ns	ns	ns
Error	28	ns	ns	ns	ns	ns	ns	ns	ns	ns
Residue	39	ns	ns	ns	ns	ns	ns	ns	ns	ns
Mean		0.955	0.658	0.297	69.09	11.20	39.27	39.29	1.00	29.66
					Substrate					
		kg			%	cm				g
Without humus		0.86b	0.59b	0.26b	69.74a	10.78b	38.26b	38.42b	1.00a	24.03b
With humus		1.05a	0.72a	0.33a	68.44a	11.62a	40.29a	40.16a	0.99a	35.29a
					Cultivars					
CH		0.93a	0.68a	0.25b	72.99a	10.77b	38.33a	39.50ab	1.03a	26.95b
E-48		0.91a	0.65a	0.27b	70.95a	11.88a	39.43a	37.66b	0.96b	27.03b
FA		0.92a	0.62a	0.29b	67.74b	11.19b	38.90a	39.40ab	1.01a	32.10ab
SE		1.07a	0.69a	0.38a	64.68b	10.96b	40.42a	40.62a	1.00a	32.60a
CV(%)		13.64	14.10	16.27	3.76	6.27	5.12	5.23	3.17	15.22

FM - fresh fruit mass (kg), PM - pulp mass (kg), RM - rind mass (kg), PY - pulp yield (%), PD - pulp diameter (cm), TC - transverse circumference (cm), LC - longitudinal circumference (cm), FSI - fruit shape index and ShDM - shoot dry mass (g). ns - not significant ($p>0.05$) by Test F; * and ** significant at $p<0.05$ and $p<0.01$, respectively, the means followed by different letters show significant differences at the 0.05 level of probability by the Tukey test

increased water retention in the substrate and water absorption by Limonium sinuatum Mill plants when compared to the pot with only soil [2].

Regarding the influence of cultivars on rind mass, it was observed that the RM of Serenade (SE) was 40.74% higher than the mean of the other cultivars, which did not differ from each other. Usually, the rind represents the part of the fruit that is not consumed, so higher rind production is an undesirable characteristic for the consumer. On the other hand, it is favorable for packaging/transport, because fruits with very thin rind require special care until the moment of consumption by the consumer [32]. Thus, among the cultivars studied, Serenade is more resistant to transport because it has higher RM. In addition, watermelon rind can be used in the preparation of pickles [14], in the manufacture of flour to be introduced in the bakery industry [21] and cupcake industry [10], and in animal feed [16].

The cultivars Champagne, E-48 and Fancy, for having lower RM and not showing significant differences ($p>0.05\%$) between cultivars in FM and PM, are the ones with potential to satisfy the consumer as they have higher pulp mass. Therefore, pulp yield can better express the relationship between these variables and the consumer.

Pulp yield (PY) is a variable of great importance for the consumer, because it represents the edible part of fresh watermelon, and improvements in this characteristic can make the fruit more attractive to the consumer [29]. PY was influenced by the cultivars, with the highest values observed in the cultivars Champagne and E-48, with a mean of 71.97%, approximately 5.76% higher compared to the mean of the cultivars Serenade and Fancy (66.21%).

Pulp diameter (PD) and longitudinal circumference (LC) of the fruits were influenced by both the substrate and the cultivars of mini watermelon. The substrate with humus increased pulp diameter (11.62 cm) compared to the substrate without the addition of humus (10.78 cm), which represents an increase of 7.79%. In relation to cultivars, the PD of E-48 was 8.26% higher than those of the other cultivars, which did not differ from each other. For the longitudinal circumference (LC) of the fruits, the highest means (40.16 cm) were observed with the addition of humus, representing an increase of 4.53%. Regarding cultivars, the highest LC was observed in cv. Serenade (40.62 cm) and the lowest LC was observed in the cv. E-48 (37.66 cm). In a comparison between these two cultivars, the LC of Serenade was 7.86% higher than that of E-48.

The transverse circumference (TC) of the fruits was influenced only by the type of substrate, with a mean of 40.29 cm in the treatment with humus, representing an increase of 5.30% in comparison to the fruit cultivated in the substrate without humus.

The morphological characteristics PD, LC and TC of the fruit are important quality attributes, because a high values indicate greater acceptance by the consumer, due to the increase in the edible mass of the fruit, as observed in the present study.

The fruit shape index (FSI) did not vary with the addition of humus in the substrate, but the cv. E-48 (FSI = 0.96) showed a reduction of 4.95% compared to the mean of the other cultivars (FSI = 1.01), which did not differ from each other. However, all cultivars showed small and spherical fruits which, according to Oliveira et al. [30], facilitates storage in boxes for transportation.

From the above, it was noted that the benefits promoted by humus in some morphological characteristics may be due to the supply of nutrients and because it acts as a conditioner that improves the physical attributes of the substrate. Nadai et al. [27] emphasize that the application of vermicompost in soil cultivated with tomato generates benefits such as availability of essential nutrients, reduction of the need for fertilizers and improvement in soil porosity. The application of vermicompost enriched with rock powder improved soil fertility (pH, Ca, Mg, K, P and cation exchange capacity), favoring the production components of radish [37].

The substrate and the cultivars caused significant isolated effects on ShDM (Table 3). The addition of humus increased ShDM by 46.85% in comparison to plants cultivated without the addition of humus, consequently increasing fruit production. Moreira et al. [26] report that the addition of organic fertilization with 75% of bovine manure in the substrate promoted increments of 125.71 and 13.80%, respectively, in shoot dry mass and root dry mass of lettuce plants when irrigated with water from the local supply system (electrical conductivity of 0.27 dS m^{-1}) compared to those grown in substrate without addition of bovine manure.

In relation to the cultivars, it was observed that Serenade and Fancy did not differ from each other in relation to ShDM, with a mean of 32.33 g. However, the ShDM of Serenade was 20.79% higher than the means of the cultivars Champagne and E-48, which did not differ from each other.

According to Santos et al. [33], in the absence of humus the root system of plants does not develop properly compared to the substrate with the addition of humus, probably because of nutritional restriction. Gomes Júnior et al. [18] observed that the addition of humic acids extracted from vermicompost (humus) promoted increments in the absorption of different nutrients (N, P, K, Ca, Mg, S, Fe, Zn, Cu and Mn) and chlorophyll a and b contents, favoring the development of mangosteen plants. For the production of umbu rootstock, the addition of different organic residues in the substrate, including humus, promoted better plant development as it increased substrate fertility and the development of microbial populations [25]. Thus, it is observed that the addition of humus increases the biomass production of the mini watermelon cultivars used in the present study, probably for improving soil fertility, promoting an increase in fruit production.

Table 4 shows that there was no significant effect ($p>0.05$) of the interaction between cultivars and humus on the post-harvest quality of mini watermelon, indicating that the cultivars behaved in a similar way in different substrates. For pH, there was no significant effect ($p>0.05$) of the treatments. In contrast, total soluble solids (TSS) contents were influenced by cultivars, total titratable acidity (TTA) by substrate and maturity index (MI) by both substrate and cultivars.

The pH values averaged 5.43 (Table 4). Although no significant effects of the factors were verified, the pH values are within the expected pH range for mini watermelon (5.2 to 5.5), as emphasized by Ó et al. [29]. Similar values were also obtained by Dutra et al. [12], who found pH values of 5.65, 5.66 and 5.85 when using humus, bovine manure and goat manure, respectively in watermelon cv. Crimson Sweet.

The sugar content of the fruit is directly related to the TSS content, which is a variable of great commercial interest, as it is an indicator of sweetness. In this study, it was observed that the cultivars E-48 and Fancy had higher values: 11.3 and 12.0 °Brix, respectively (Table 4). Therefore, it is important to mention that the TSS contents of the cultivars E-48 and Fancy were, on average, 14.06% higher than those of the other cultivars (Serenade and Champagne). However, these values are within acceptable limits for the commercialization of watermelon. According to Lima Neto et al. [22], an acceptable value must be equal to or greater than 10 °Brix. However, according to Dutra et al. [12], in the most commercialized watermelon cultivars, the TSS levels range from 11 to 13 °Brix.

Acidity is a very important quality component for fruits and vegetables, but the low acidity in watermelon attracts several consumers [3]. In the present study, TTA was influenced by the type of substrate and the addition of humus increased the acidity of mini watermelons by 21.05% (Table 4). The type of fertilization may have led to a change in fruit acidity. Generally, the presence of a nitrogen-rich fertilization favors vegetative growth, thereby reducing the transport of assimilates to the fruit [13].

The maturity index (MI) is the ratio between TSS content and TTA, being the variable that best expresses the degree of fruit maturity [23], a high MI indicates that the fruits are sweet, so this characteristic is desirable for mini watermelons. According to Oliveira et al. [30], the MI is related to the amounts of sugars and acids present in the fruits, providing a notion of the balance between TSS and TTA. In the present study, it was observed that the addition of humus in the substrate reduced the MI by 22.56% in comparison to the treatment without humus, showing values around 48:1 (with humus) and 63:1 (without humus). It was notorious that the substrate with humus led to less ripe fruits, due to the higher acidity in their pulp. However, both substrates promoted mini watermelons with MI suitable for commercialization. According to Campagnol et al. [7], fruit acidity may be related to the fruit development period, because watermelon flowers pollinated with a difference of 8 days showed fruits with lower TTA, which induced an increase in MI. In the present study, humus promoted higher ShDM production, showing that the photoassimilates were also destined to the plant structure, delaying the formation and mat-

Table 4: Summary of Fisher's test (F) and the mean observed for the post-harvest characteristics of the fruits of cultivars of mini watermelon without and with the addition of humus in the substrate.

		Test F			
FV	DF	pH	TSS	TTA	MI
Cultivars (C)	3	ns	**	ns	*
Substrate (S)	1	ns	ns	**	**
Interaction (CxS)	3	ns	ns	ns	ns
Block	4	ns	ns	ns	ns
Error	28	ns	ns	ns	ns
Residue	39				
Mean		5.43	10.93	0.21	56.09
		Substrate			
Without humus		5.48a	11.08a	0.19b	63.21a
With humus		5.37a	10.79a	0.23a	48.95b
		Cultivars			
CH		5.33a	9.58b	0.23a	42.14b
E-48		5.53a	11.30a	0.19a	65.46a
FA		5.38a	12.00a	0.22a	58.45ab
SE		5.47a	10.85ab	0.20a	58.28ab
CV (%)		3.49	11.82	20.89	27.39

TSS - total titratable acidity (°Brix), pH - Hydrogen potential, TTA - total titratable acidity (% citric acid), MI - maturity index (%). ns - not significant ($p>0.05$) by Test F; * and ** significant at $p<0.05$ and $p<0.01$, respectively, the means followed by different letters show significant differences at the 0.05 level of probability by the Tukey test

uration of the fruits, despite the increase in FM. Therefore, it can be inferred that plants grown without the addition of humus were induced to early fruit maturation probably due to nutritional reduction and lower quality of the physical attributes of the substrate, confirmed by the lower production of ShDM and FM (Table 3).

It was also observed that the cultivar E-48 showed the best results compared to the others, with an MI value of 65:1 (Table 3). Oliveira et al. [30] also found differences between the watermelon hybrids Boston and Quetzali in commercial cultivation, with values of 86.24 and 63.72, respectively. In Sugar Baby mini watermelons using coconut fiber as substrate, Ó et al. [29] observed MI around 38:1 to 58:1.

The post-harvest quality of watermelon fruits evaluated in the present study does not depend on the addition or not of humus in the substrate, and the cultivars are within the characteristics of watermelon juice of Normative No. 37, of October 1, 2018, which establishes minimum values of TSS of 8 °Brix, total acidity expressed in citric acid of 2 g $100g^{-1}$ and pH of 5.4 [5].

The offer of new cultivars by specialized companies is of great importance for the production of foods with quality and variability in organoleptic characteristics. Thus, it can observe the importance of evaluating the cultivars of the present study by public institutions, through trials of competition, providing the growers with choices of cultivars that have good potential for production and commercialization in the region.

Conclusions

Application of humus in the cultivation of mini watermelon in protected environment with fertigation improves the morphological characteristics of the fruits, including fresh mass.

The presence of humus in the substrate does not improve the post-harvest quality of mini watermelon fruits.

The cultivars Serenade, Champagne, E-48 and Fancy respond similarly to the addition of humus in the substrate regarding morphological characteristics and post-harvest quality of the fruits.

Considering the set of variables analyzed, Champagne and E-48 had slightly better morphological characteristics, while E-48 has slightly more desirable results regarding post-harvest quality.

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