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Research Article

Number of stems and plant density in mini watermelon grown in a protected environment[1]

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ABSTRACT

Watermelon farming has a high economic and social importance. In parallel, the consumers' demand for distinctive products has led to niche markets, where mini watermelons stand out. This study aimed to assess the agronomic performance and fruit quality of mini watermelon grown in coconut husk fiber, as a function of number of stems per plant and plant density. The Smile hybrid was used, as well as a randomized block design, in a 2 x 2 factorial scheme, with eight repetitions, being the first factor the number of stems per plant (1 or 2) and the second the number of plants per pot (1 or 2). Characteristics related to yield, physiological parameters and fruit quality were assessed. Interaction between number of stems and plant density was only observed for leaf area, average fruit fresh weight, total yield and percentage of large fruits. The factors were evaluated separately for the remaining traits. Two-stemmed training systems, at a density of one plant per pot, produce the highest yield, without compromising the quality of the fruits, being, in these conditions, the most suitable method for farmers.

KEYWORDS: *Citrullus lanatus*, coconut husk fiber, intraplant competition.

RESUMO

Número de hastes e densidade de plantas para o cultivo de minimelancia em ambiente protegido

A cultura da melancia apresenta grande importância econômica e social. Paralelamente, novos nichos de mercado são requeridos pelos consumidores, a fim de fornecer produtos diferenciados, dentre os quais destaca-se a minimelancia. Objetivou-se avaliar o desempenho agronômico e a qualidade de frutos de minimelancia cultivados em fibra de casca de coco, em função do número de hastes e densidade de planta. Utilizaram-se o híbrido Smile e delineamento experimental em blocos casualizados, em esquema fatorial 2 x 2, com oito repetições, sendo o primeiro fator constituído pelo número de hastes por planta (1 ou 2) e o segundo pelo número de plantas por vaso (1 ou 2). Foram avaliadas características relacionadas à produção, parâmetros fisiológicos da planta e qualidade de frutos. Houve interação entre o número de hastes e a densidade de plantas apenas para as características de área foliar, massa fresca média de frutos, produtividade total e percentual de frutos grandes, sendo que, para as demais características, os fatores foram avaliados separadamente. As plantas conduzidas com duas hastes, na densidade de uma planta por vaso, proporcionam maior produtividade, sem prejudicar a qualidade dos frutos, sendo, nessas condições, o método mais indicado para os produtores.

PALAVRAS-CHAVE: *Citrullus lanatus*, fibra de casca de coco, competição intraplanta.

INTRODUCTION

The *Citrullus lanatus* (Thunb.) Matsum & Nakai watermelon species originated in the dry regions of tropical Africa, with secondary diversification in southern Asia. It was domesticated in Central Africa, where it has been grown for more than 5,000 years (Viana et al. 2013).

Watermelon is traditionally a field crop, with trailing vine growth (Seabra Júnior et al. 2003). However, the demand for top quality in niche markets has prompted the search for new cultivars and modern production technologies, such as growing crops in protected environments and using alternative management practices.

Cultivation in protected environments using substrates and fertigation increases yield and fruit quality, because, in well-managed crops, the nutrient solution provides the plants the proper amount of nutrients for optimal development (Charlo 2011).

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Among the new cultivars are mini watermelons, compact and highly precocious hybrids, that allow a greater plant density (Guimarães et al. 2013). They are named for their small fruits (1-3 kg), also known as icebox watermelons, and cater to more demanding consumers with a high purchasing power (Gomes et al. 2017).

In addition to choosing the cultivar, managing the number of plants per area is a vital tool in obtaining the highest possible number of fruits in new hybrids (Kultur et al. 2001, Goreta et al. 2005). This is because the number of stems per plant and number of plants per pot directly affect the availability of water and nutrients and promote changes in the root architecture, associated with a larger root volume, better nutrient uptake and more vigorous plants (Viana et al. 2008).

In Cucurbitaceae, managing the number of stems per plant may be an important technique to consider and investigate in mini watermelon farming. Gualberto et al. (2001) studied different training systems in melon grown in a greenhouse and found that plants with two stems and two fruits per stem showed the highest yields, when compared with two stems containing only one fruit each. The same findings were reported by Maruyama et al. (2000) in net melons, whereby two-stemmed plants exhibited higher yields per plant than those with one.

In addition to these management techniques, it is also important to analyze their effect on fruit quality in mini watermelons. Campagnol et al. (2012) studied mini watermelons as a function of pruning height and plant density and reported that the latter affected soluble solids, titratable acidity and ascorbic acid. Gualberto et al. (2001) assessed the effect of spacing and number of stems in melon plants and observed differences for soluble solids, whereas Ramos et al. (2009) found no differences in mini watermelon quality traits as a function of plant density.

As such, with a view of enhancing and adopting beneficial management techniques for farmers interested in offering distinctive high-quality products, this study aimed to assess the agronomic performance and fruit quality of mini watermelons grown in coconut husk fiber, as a function of number of stems per plant and plant density.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse of the Universidade Estadual Paulista, in Jaboticabal, São Paulo state, Brazil (21º14’05”S, 48º17’09”W and altitude of 614 m), from February to April 2016. According to the Köppen’s classification, the climate is in the transition zone between Aw and Cwa.

The average temperatures and relative humidity in the greenhouse during the experiment were 36 ºC, 31 ºC and 30 ºC and 68 %, 55 % and 52 %, respectively, measured by a thermohygrometer installed in the greenhouse.

A randomized block design was used in a 2 x 2 factorial scheme, with four repetitions. The first factor was the number of stems per plant (1 or 2) and the second the number of plants per pot (1 or 2). Each plot consisted of 10 plants, with only the six center plants assessed.

The Smile hybrid was used, which typically exhibits four oval fruits, with bright red pulp, excellent flavor and soluble solid content of 12-13 ºBrix (Takii Seed 2015).

Seedlings were produced by indirect seeding, using Bioplant® substrate and 128-cell expanded polystyrene trays, with one seed per cell. After planting, the trays were placed in a greenhouse and watered from three to four times a day. When plants exhibited one fully expanded true leaf, they were transplanted into 13 dm^3 black plastic pots containing Golden Mix 98® commercial coconut fiber substrate, with a water retention capacity of 400 mL per liter of substrate, 95 % of total porosity and electrical conductivity of 0.9 sS m^{-1}. One or two seedlings were transplanted into each pot, according to the established treatments.

Drip fertigation was used, with spaghetti tubing and two drippers per pot, at a flow rate of 2 L h^{-1} each. The fertigation system consisted of five 1,500 L reservoirs activated by a motor and pump system. The pumps were controlled by timers that activated the system 10 times a day and left running until drainage onset was observed, lasting 10 min, on average.

The nutrient solution adopted is recommended by Furlani et al. (1999) for the entire growth cycle of fruiting vegetables, with the following formulation: potassium nitrate (1.6 mmol L^{-1} of N and 1.82 mmol L^{-1} of K); calcium nitrate (3.67 mmol L^{-1} of N and 2.09 mmol L^{-1} of Ca); monoammonium phosphate (1.01 mmol L^{-1} of N and 0.9 mmol L^{-1} of P); magnesium sulfate (0.61 mmol L^{-1} of Mg and 0.61 mmol L^{-1} of S); potassium chloride (2.07 mmol L^{-1} of K and 2.07 mmol L^{-1} of Cl); iron

(0.28 mg L^{-1}); manganese sulfate (0.79 mg L^{-1}); copper sulfate (0.42 mg L^{-1}); boric acid (0.37 mg L^{-1}); sodium molybdate (0.03 mg L^{-1}); and zinc sulfate (0.24 mg L^{-1}). The adjusted pH of the nutrient solution was 6.0 and the electrical conductivity approximately 2.2 dS m^{-1}.

The plants were grown in pots, spaced 0.5 m apart with 1.0 m between rows and a plant density of 0.5 plants m^{-2}, according to the established treatments. They were trained to a height of 2.2 m, using plastic twine and vine clips, and then pruned. Laterals were pruned up to the eighth leaf node and clips applied as needed. The remaining laterals that emerged were horizontally trained up to the third leaf and then pruned. In treatments with two-stemmed plants, the second stem was the first secondary branch that emerged at the base of the stem and was trained in the same manner as the primary stem. It is important to note that two fruits were maintained per plant, on the primary or secondary stem.

At the onset of flowering, beehives (*Melipona* sp.) were placed in the middle and at the end of the greenhouse to pollinate the flowers. The beehives were removed after the fruit emergence on the first and second stems, and pruning was performed to maintain only two fruits per plant. Treatments with two-stemmed plants and two plants per pot also considered two fruits on each. The watermelons were supported with nylon nets, when they reached a diameter of approximately 7 cm.

Fruits were harvested four times, at 58, 67, 74 and 79 days after transplanting (DAT). Harvesting was performed in accordance with Almeida (2006), when the fruits were at full size and the rind texture changed and turned into a dull green.

The growth and production traits assessed for the six center plants studied were: leaf area (cm^2 plant^{-1}), at the end of the growth cycle, using a LI-COR leaf area meter (LI 300); net photosynthesis (A), measured with an infrared gas analyzer (IRGA) at 44 DAT in the fully expanded terminal leaf; precocity (dats), obtained based on the difference in days between the planting date and harvesting of the first fruit; peak harvest time (days), calculated by the difference between the harvest dates of the first and second fruits; mean fruit fresh weight (g), obtained from the average weight of the fruits in the plot; and total yield (t ha^{-1}), estimated based on fruit weight, plant and row spacing.

The collected fruits were classified according to Campagnol (2009), as it follows: noncommercial (under 1.0 kg), small (1.0-1.5 kg), medium (1.5-2.0 kg), large (2.0-2.5 kg) and extra large (over 2.5 kg).

Qualitative characteristics were evaluated in a sample of six mini watermelons, as it follows: firmness, expressed in Newtons and determined based on the average of two readings taken in the middle of the rind, using an FT 327 penetrometer with an 8 mm tip; soluble solids (SS), measured in five fruits per plot with a digital refractometer, expressed in ºBrix and corrected at 20 ºC (AOAC 1997); titratable acidity (TA), determined by titration with 0.05 N NaOH, using 10 mL of homogenized pulp diluted in 10 mL of distilled water (AOAC 1997); soluble solids to titratable acidity ratio (SS/TA), used to assess the fruit flavor and ripeness (Chitarra & Chitarra 2005).

The data obtained were submitted to analysis of variance and compared using the Tukey test at 5 % of probability.

RESULTS AND DISCUSSION

The studied vegetative growth and yield traits showed significant interaction only for leaf area, average fruit fresh weight and total yield (Table 1). The factors were analyzed separately for the remaining characteristics.

Leaf area (Figure 1) showed a difference only for the treatment with one stem and one plant per pot, exhibiting a worse performance in relation to the other treatments. The treatment with single-stemmed plants and two plants per pot obtained the highest mean for leaf area (11,295.02 cm^2 plant^{-1}), but did

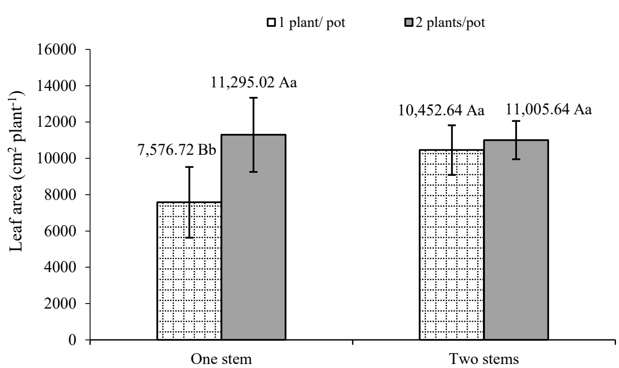

Figure 1. Leaf area per plant, as a function of number of stems and number of plants per pot, in Smile mini watermelons grown in a greenhouse. * Means followed by the same upper case letter compare the number of stems and the same lower case letter the number of plants per pot, and do not differ according to the Tukey test (p > 0.05).

Table 1. Average values for leaf area (LA), net photosynthesis (A), precocity (days), average fruit fresh weight (AFFW) and total yield (TY), as a function of number of stems per plant (NSP) and number of plants per pot (NPP), in Smile mini watermelons.

Number of stems (NSP)	LA	A	Precocity	AFFW	TY
	cm^2 $plant^{-1}$	µmol m^{-2} s^{-1}	days	kg	t ha^{-1}
One stem	9,431.07 a	13.26 a	78.00 b	2.36 b	56.12 b
Two stems	10,729.14 a	13.27 a	74.00 a	2.72 a	85.44 a
F-test	3.69^{ns}	0.00^{ns}	12.91**	50.00**	58.17**
Number of plants (NPP)					
One plant per pot	9,010.18 b	13.46 a	73.00 a	2.764 a	82.16 a
Two plants per pot	11,150.33 a	13.06 a	80.00 b	1.317 b	59.41 b
F-test	10.03**	1.10^{ns}	47.37**	79.93**	35.04**
LSD	1,405.29	0.78	2.13	0.10	7.99
NSP x NPP	5.52*	0.33^{ns}	3.56^{ns}	16.18**	15.23**
CV (%)	18.96	8.05	3.80	5.55	15.36

Means followed by the same letter do not differ according to the Tukey test at p < 0.05 (*) and p < 0.01(**); ns not significant; LSD: least significant difference; CV: coefficient of variation.

not differ from treatments consisting of two-stemmed plants with one and two plants per pot.

The large leaf area recorded in this treatment is due to the higher number of leaves, because there were more plants per pot. This is important, since a large leaf surface improves the plant capacity to intercept solar energy, thereby increasing photosynthesis, making it a useful trait in assessing the yield potential (Reis et al. 2013).

Similar results were reported by Campagnol et al. (2010), who found that training systems influenced the leaf area, with single-stemmed systems resulting in less leaf development (3,485.46 cm^2 $plant^{-1}$) than their two-stemmed counterparts (4,263.77 cm^2 $plant^{-1}$).

With respect to net photosynthesis (Table 1), there was no difference between the studied factors (mean of 13.26 µmol m^{-2} s^{-1}), indicating that it did not affect the photosynthetic efficiency, despite the heightened competition for growth factors such as water, light and nutrients resulting from the increase in the number of stems and plants per pot.

In terms of precocity (Table 1), significant differences were observed for number of stems per plant, with a greater precocity (74 days) for two-stemmed plants, in relation to their single-stemmed counterparts (78 days). In regard to number of plants per pot, the treatment with one plant per pot exhibited a greater precocity (73 days) than two plants per pot (80 days). This may have occurred due to fruit emergence on both the primary and secondary stems.

Unlike in the present study, Nogueira (2008) grew Smile mini watermelons in a protected environment and found that fruit emergence on the secondary stem delayed harvesting. The author also observed precocity in treatments with one plant per pot, likely in response to the reduced competition in these treatments.

Precocity is a desirable trait, because it provides shorter harvesting times and a faster return on investment (Ferreira et al. 2003), meaning it is also linked to supply and demand (Martins et al. 1998).

Figure 2 shows the results of the interaction number of stems per plant x number of plants per pot for average fruit fresh weight, indicating that two-stemmed plants and one plant per pot resulted in a higher average fruit fresh weight.

Similar results were reported by Campagnol et al. (2010), in trained Smile mini watermelons, whereby the highest average fruit fresh weight values were recorded in two-stemmed systems with fruit on the main stem. The same trend was observed by

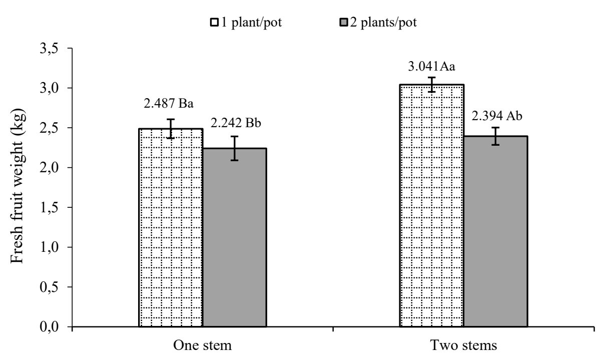

Figure 2. Average fresh fruit weight, as a function of number of stems and number of plants per pot, in Smile mini watermelons. * Means followed by the same upper case letter compare the number of stems and the same lower case letter the number of plants per pot, and do not differ according to the Tukey test (p > 0.05).

Barni et al. (2003), who obtained the highest average fruit fresh weight (1.025 kg) in treatments with two stems per plant.

As such, the greater fruit weight in two-stemmed plant systems with one plant per pot may be the result of the large leaf area in this treatment, generating a greater photoassimilate production for fruit development.

There was a significant interaction of number of stems per plant x number of plants per pot for total yield (Figure 3), with two-stemmed plants displaying higher yields than their single-stemmed counterparts, regardless of the number of plants per pot. The one-plant-per-pot treatment exhibited higher yields than two plants only for two-stemmed watermelons, with no difference between the number of plants per pot for the single-stemmed treatment.

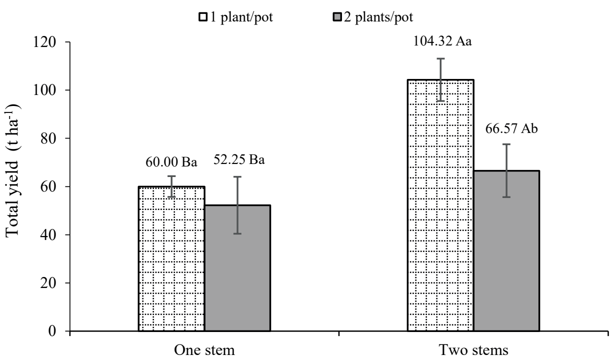

Figure 3. Total yield, as a function of number of stems and number of plants per pot, in Smile mini watermelons. * Means followed by the same upper case letter compare the number of stems and the same lower case letter the number of plants per pot, and do not differ according to the Tukey test ($p > 0.05$).

Campagnol et al. (2010) and Barni et al. (2003) also found higher yields in two-stemmed mini watermelon and melon plants, respectively.

Thus, the total yield results obtained here reflect the effects of competition between treatments with greater stem and plant density, resulting in larger leaf areas in the two-stemmed system with one plant per pot and a higher final production.

Fruit classification (Table 2) exhibited a significant interaction only for the percentage of large fruits (2.0-2.5 kg). The factors were analyzed separately for the remaining classes. It is important to underscore that no noncommercial fruits (under 1.0 kg) were produced, meaning that the total yield was in line with commercial standards. Additionally, small watermelons (1.0-1.5 kg) were not considered in the statistical analysis, since none was obtained.

Differences were observed between both the factors assessed, in terms of percentage of medium-sized fruits. For number of stems per plant, the highest percentage (16.87 %) was recorded in the one-stemmed treatment, whereas the two-plants-per-pot system produced the largest percentage (17.66 %) for number of plants per pot. This may be because the plant density did not cause strong competition for light, water and nutrients, and two-stemmed plants require more photoassimilates for growth, what may compromise the fruit development on the primary stem.

Similar results were reported by Campagnol (2009), who studied training systems and plant

Table 2. Average values for percentage of medium, large and extra large Smile mini watermelons, as a function of number of stems per plant (NSP) and number of plants per pot (NPP).

Number of stems (NSP)	Medium (1.5-2.0 kg)	Large (2.0-2.5 kg)	Extra large (> 2.5 kg)
		%	
One stem	16.87 a	54.58 a	28.24 b
Two stems	5.71 b	41.02 a	52.34 a
F-test	4.69*	4.20^{ns}	17.93**
LSD	10.71	13.76	11.84
Number of plants (NPP)			
One plant per pot	4.92 b	31.92 b	61.93 a
Two plants per pot	17.66 a	63.68 a	18.65 b
F-test	6.12*	23.03**	57.83**
LSD	10.71	13.76	11.84
NSP x NPP	0.63^{ns}	5.37*	3.47^{ns}
CV (%)	129.11	39.15	39.95

Means followed by the same letter do not differ according to the Tukey test at $p < 0.05$ (*) and $p < 0.01$(**); ^{ns} not significant; LSD: least significant difference; CV: coefficient of variation.

densities in mini watermelons and found that single-stemmed plants produced a higher percentage of medium-sized fruits. According to the author, this is beneficial, because it results in higher percentages of large and extra large fruits.

In relation to the percentage of large watermelons, there was a significant interaction between the factors assessed (Figure 4), indicating that single-stemmed systems with one and two plants per pot performed better, albeit with no difference from the two-stemmed treatment with two plants per pot.

A different behavior was observed by Campagnol (2009), who found no differences in large fruit percentages for single and two-stemmed training systems, as a function of plant density.

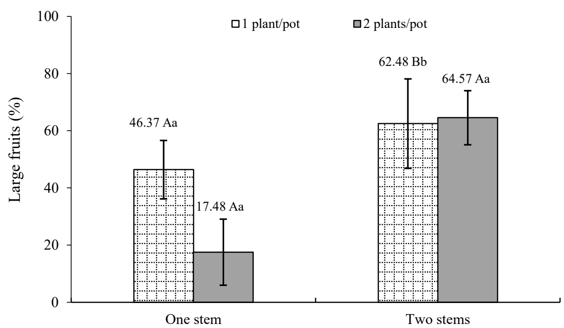

Figure 4. Percentage of large fruits, as a function of number of stems and number of plants per pot, in Smile mini watermelons. * Means followed by the same upper case letter compare the number of stems and the same lower case letter the number of plants per pot, and do not differ according to the Tukey test ($p > 0.05$).

There were significant differences between the two factors for the percentage of extra large fruits (Table 2), with average values of 52.34 % and 61.93 %, respectively for the two-stemmed and one-plant-per-pot systems.

Campagnol (2009) also recorded higher extra large fruit percentages for plants with two stems, which were more productive and resulted in commercial quality fruits.

Thus, the high large and extra large fruit percentages obtained here may have contributed to raising the total yield in the two-stemmed training system, in addition to increasing the leaf area and photoassimilate production.

With respect to fruit quality (Table 3), the factors were analyzed separately and showed no significant interaction.

For fruit firmness (Table 3), differences were observed only for number of plants per pot, whereby treatments with one plant differed from the others, obtaining an average of 11.45 N.

Campagnol (2009) also reported that training systems do not influence mini watermelon firmness. However, management practices, cultivars and production regions may affect fruit firmness (Semmelmeyer 2006). In the present study, one plant per pot likely resulted in firmer fruits because there was less competition for growth factors, such as water.

There were no significant differences in vitamin C content (Table 3), with an average of 12.90 mg of ascorbic acid 100 g^{-1} of pulp.

Table 3. Average values for fruit firmness (FF), vitamin C, titratable acidity (TA), soluble solids (SS) and maturity index (MI), as a function of number of stems per plant (NSP) and number of plants per pot (NPP), in Smile mini watermelons grown in a greenhouse.

Number of stems (NSP)	FF (N)	Vitamin C (mg ascorbic acid 100 g^{-1})	TA (mg citric acid 100^{-1} g pulp)	SS (ºBrix)	MI
One stem	11.11 a	12.21 a	4.00 a	10.96 a	430.45 a
Two stems	10.22 a	13.59 a	4.00 a	10.84 a	355.24 a
F-test	2.33^{ns}	1.67^{ns}	4.24^{ns}	0.35^{ns}	4.17^{ns}
LSD	1.21	2.22	1.00	0.43	76.56
Number of plants (NPP)					
One plant per pot	11.45 a	13.02 a	4.00 a	10.89 a	374.55 a
Two plants per pot	9.88 b	12.78 a	4.00 a	10.91 a	411.15 a
F-test	7.21*	0.05^{ns}	2.03^{ns}	0.01^{ns}	0.99^{ns}
LSD	1.21	2.22	1.00	0.43	76.56
NSP x NPP	1.48^{ns}	3.98^{ns}	3.04^{ns}	0.58^{ns}	3.55^{ns}
CV (%)	15.46	23.43	28.12	5.34	26.51

Means followed by the same letter do not differ according to the Tukey test at $p < 0.05$ (*) and $p < 0.01$(**); ^{ns} not significant; LSD: least significant difference; CV: coefficient of variation.

According to Chitarra & Chitarra (2005), the average concentration for watermelons is above 9 mg 100 g^{-1} of pulp, corroborating our data.

No significant differences were observed for titratable acidity (Table 3), with 0.04 % of citric acid, on average. Similar results were obtained by Campagnol et al. (2016) in mini watermelons under one and two-stem training systems.

Soluble solids and maturity index (Table 3) exhibited no differences for either of the factors assessed. Unlike in the present study, Campagnol et al. (2016) found that the number of stems influenced soluble solids, whereby single-stemmed systems showed higher concentrations than their two-stemmed counterparts, with average values of 11 ºBrix. In regard to the maturity index, the management practices adopted here did not influence the fruit flavor.

It is important to note that flavor is the balance between sweet and acidic components, expressed by the SS/TA ratio. As such, ripening generally leads to higher sugar levels and reduced acidity (Chitarra & Chitarra 2005).

CONCLUSION

Considering mini watermelons grown in coconut husk fiber in a greenhouse, two-stemmed training systems with one plant per pot produces the highest yields, without compromising the fruit quality, making them the most suitable for farmers.

REFERENCES

ALMEIDA, D. *Manual de cultural hortícola*. Lisboa: Presença, 2006.

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS (AOAC). *Official methods of analysis of the Association of Official Analytical Chemists*. 16. ed. Washington, DC: AOAC, 1997.

BARNI, V.; BARNI, N. A.; SILVEIRA, J. R. P. Meloeiro em estufa: duas hastes é o melhor sistema de condução. *Ciência Rural*, v. 33, n. 6, p. 1039-1043, 2003.

CAMPAGNOL, R.; MELLO, S. C.; BARBOSA, J. C. Vertical growth of mini watermelon according to the training height and plant density. *Horticultura Brasileira*, v. 30, n. 4, p. 726-732, 2012.

CAMPAGNOL, R. et al. Sistemas de condução e densidade de plantas no rendimento de minimelancia em ambiente protegido. *Horticultura Brasileira*, v. 28, n. 2, p. 336-342, 2010.

CAMPAGNOL, R. *Sistemas de condução de minimelancia cultivada em ambiente protegido*. 2009. 80 f. Dissertação (Mestrado em Fitotecnia) - Escola Superior de Agricultura "Luiz de Queiroz", Piracicaba, 2009.

CAMPAGNOL, R.; MATSUZAKI, R. T.; MELLO, S. C. Condução vertical e densidade de plantas de minimelancia em ambiente protegido. *Horticultura Brasileira*, v. 34, n. 1, p. 137-143, 2016.

CHARLO, H. C. O. et al. Growth analysis of sweet pepper cultivated in coconut fiber in a greenhouse. *Horticultura Brasileira*, v. 29, n. 3, p. 316-323, 2011.

CHITARRA, M. I. F.; CHITARRA, A. B. *Pós-colheita de frutas e hortaliças*: fisiologia e manuseio. 2. ed. Lavras: Ed. UFLa, 2005.

FERREIRA, M. A. J. F. et al. Correlações genotípicas, fenotípicas e de ambiente entre dez caracteres de melancia e suas implicações para o melhoramento genético. *Horticultura Brasileira*, v. 21, n. 3, p. 438-442, 2003.

FURLANI, P. R. et al. *Cultivo hidropônico de plantas*. Campinas: Instituto Agronômico, 1999.

GOMES, R. F. et al. Effect of spacing on mini watermelon hybrids grown in a protected environment. *Australian Journal of Crop Science*, v. 11, n. 5, p. 522-527, 2017.

GORETA, S. et al. Growth and yield of watermelon on polyethylene mulch with different spacings and nitrogen rates. *Hortscience*, v. 40, n. 2, p. 366-369, 2005.

GUALBERTO, R.; RESENDE, F. V.; LOSASSO, P. H. L. Produtividade e qualidade do melão rendilhado em ambiente protegido, em função do espaçamento e sistema de condução. *Horticultura Brasileira*, v. 19, n. 3, p. 240-243, 2001.

GUIMARÃES, M. A. et al. Principais cultivares. In: GUIMARÃES, M. A. (Ed.). *Produção de melancia*. Viçosa: Ed. UFV, 2013. p. 52-57.

KULTUR, F.; HARRISON, H. C.; STAUB, J. E. Spacing and genotype affect fruit sugar concentration, yield, and fruit size of muskmelon. *Hortscience*, v. 36, n. 2, p. 274-278, 2001.

MARTINS, S. R. et al. Produção de melão em função de diferentes sistemas de condução de plantas em ambiente protegido. *Horticultura Brasileira*, v. 16, n. 1, p. 24-30, 1998.

MARUYAMA, W. I.; BRAZ, L. T.; CECÍLIO FILHO, A. B. Condução de melão rendilhado sob cultivo protegido. *Horticultura Brasileira*, v. 18, n. 3, p. 175-178, 2000.

NOGUEIRA, C. C. P. *Fertirrigação em minimelancia (Citrullus lanatus) tutorada em ambiente protegido*. 2008. 74 f. Tese (Doutorado em Fitotecnia) - Escola Superior de Agricultura “Luiz de Queiroz”, Piracicaba, 2008.

RAMOS, A. R. P.; DIAS, R. C. S.; ARAGÃO, C. A. Densidades de plantio na produtividade e qualidade de frutos de melancia. *Horticultura Brasileira*, v. 27, n. 4, p. 560-564, 2009.

REIS, L. S. et al. Índice de área foliar e produtividade do tomate sob condições de ambiente protegido. *Engenharia Agrícola e Ambiental*, v. 17, n. 4, p. 386-391, 2013.

SEABRA JÚNIOR, S. et al. Avaliação do número e posição de frutos de melancia produzidos em ambiente protegido. *Horticultura Brasileira*, v. 21, n. 4, p. 708-711, 2003.

SEMMELMEYER, E. OECD guidance on objective testing to determine the ripeness of fruit. *Journal of Fruit and Ornamental Plant Research*, v. 14, n. 2, p. 101-112, 2006.

TAKII SEED. *Melancia*. 2015. Available at: <http://www.takii.com.br/melancia.html>. Access on: 19 Sep. 2015.

VIANA, C. S.; MOURA, T. N.; GUIMARÃES, M. A. Descrição e classificação botânica. In: GUIMARÃES, M. A. (Ed.). *Produção de melancia*. Viçosa: Ed. UFV, 2013. p. 44-51.

VIANA, T. V. A. et al. Densidade de plantas e número de drenos influenciando a produtividade de roseiras cultivadas em vaso. *Horticultura Brasileira*, v. 26, n. 4, p. 528-532, 2008.