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Production and post-harvest quality of mini-watermelon crop under irrigation management strategies and potassium fertilization[1]

Produção e qualidade pós-colheita de mini-melancieira sob estratégias de manejo de irrigação e adubação potássica

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HIGHLIGHTS:

Despite the deleterious effect of salinity on the diameter of mini-watermelon fruits, their appearance was not negatively affected.
Salt stress in the flowering and maturation stages does not compromise the production of mini-watermelon.
Water salinity of 4.0 dS m^{-1} reduces soluble solids and ascorbic acid in fruits when plants are fertilized with 150 mg K_2O kg^{-1} of soil.

ABSTRACT: The occurrence of water sources with a high concentration of salts stands out as a limiting factor for production in Northeast Brazil. Thus, the search for strategies that minimize the effect of salt stress on crops is of fundamental importance. In this context, this study was conducted with the objective of evaluating the production and post-harvest quality of Sugar Baby mini-watermelon fruits under different irrigation management strategies with saline water and potassium fertilization. The experiment was conducted in a greenhouse, using a randomized block design, in an 8 × 3 factorial scheme, with three replicates, corresponding to eight saline water irrigation management strategies (No stress throughout the crop cycle; irrigation with saline water in the vegetative, vegetative/flowering, flowering, flowering/fruiting, fruiting, fruiting/maturation and fruit maturation stages) and three doses of potassium (50, 100 and 150% of the recommended dose). The dose of 100% corresponded to 150 mg K_2O kg^{-1} of soil. Water with low and with high electrical conductivity (0.8 and 4.0 dS m^{-1}, respectively) was used. Irrigation with water of 4.0 dS m^{-1} in the flowering and fruit maturation stages is a promising strategy for the cultivation of mini-watermelon, as it does not compromise production. Fertilization with 50% of K_2O recommendation can be used in the cultivation of mini-watermelon without losses in yield. Mini-watermelon plants fertilized with 150% of K_2O recommendation and irrigated with water of high salt concentration continuously in the vegetative/flowering and fruiting stages reduced the contents of soluble solids and ascorbic acid in the fruits.

Key words: *Citrullus lanatus* L., salt stress, osmoregulator

RESUMO: A ocorrência de fontes hídricas com elevada concentração de sais se destaca como fator limitante para a produção no Nordeste brasileiro. Assim, é de fundamental importância a busca por estratégias que minimizem o efeito do estresse salino nas culturas. Neste contexto, desenvolveu-se esta pesquisa com o objetivo de avaliar a produção e a qualidade pós-colheita de frutos de mini-melancia Sugar Baby sob diferentes estratégias de manejo de irrigação com água salina e adubação potássica. O experimento foi conduzido em casa de vegetação, utilizando-se o delineamento de blocos casualizados, em esquema fatorial 8 × 3, com três repetições, sendo oito estratégias de manejo da irrigação com águas salinas (Sem estresse ao longo do ciclo da cultura; irrigação com água salina na fase vegetativa, vegetativa/floração, floração, floração/frutificação, frutificação, frutificação/maturação e maturação dos frutos) e três doses de potássio (50, 100 e 150% da dose recomendada). A dose de 100% correspondeu a 150 mg K_2O kg^{-1} de solo. Utilizou-se água com baixa e outra com alta condutividade elétrica (0,8 e 4,0 dS m^{-1}, respectivamente). A irrigação com água de 4,0 dS m^{-1} nas fases de floração e maturação dos frutos é uma estratégia promissora para o cultivo de mini-melancia, pois não compromete sua produção. Adubação com 50% da recomendação de K_2O pode ser utilizada no cultivo de mini-melancieira sem perda no rendimento. As plantas de mini-melancieira adubadas com 150% da recomendação de K_2O e irrigadas com água de elevada concentração de sais nas fases vegetativa/floração de forma continua e frutificação diminuíram os teores de sólidos solúveis e ácido ascórbico nos frutos.

Palavras-chave: *Citrullus lanatus* L., estresse salino, osmorregulador

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Introduction

Watermelon (*Citrullus lanatus* L.) stands out as one of the most produced fruits in Brazil. In 2019, Brazil produced 2,278,186 tons of watermelon in a planted area of 98,489 hectares, with the Northeast being the main producing region of this fruit, responsible for 775,324 tons in an area of 39,697 hectares (IBGE, 2021). However, in this region, more than 60% of the territory has a semi-arid climate (Medeiros et al., 2012), with high rates of evapotranspiration and low precipitation (Lima et al., 2018), so it is necessary to use irrigation to guarantee agricultural production.

The water sources in the semi-arid region of the Northeast commonly have high concentrations of dissolved salts, which hamper crop production (Paiva et al., 2016). The excess of salts in water and/or in the soil causes changes in various physiological and metabolic processes of plants (Gupta & Huang, 2014), due to the excessive absorption of ions such as sodium (Na^+) and chloride (Cl^-). High concentrations of salts can also promote oxidative stress through the generation of reactive oxygen species (Isayenkov & Maathuis, 2019).

Several studies carried out with watermelons under conditions of salt stress highlighted the sensitive nature of the crop to the salinity of irrigation water (Sousa et al., 2016; Silva et al., 2020; Lima et al., 2020a). However, the effect of salt stress on plants may vary according to the stages of plant development, as well as fertilization management practices, irrigation and climatic conditions (Lemes et al., 2018). Among the strategies that can minimize the deleterious effects of salt stress on plants, the use of saline water only in the tolerant phenological stages stands out (Silva et al., 2020; Lima et al., 2020b).

Potassium fertilization should also be considered as an alternative capable of increasing plant tolerance to salinity, as K^+ is vital for various biological processes in cells, such as enzymatic activation, respiration, photosynthesis and improvement in water balance (Prazeres et al., 2015). Under salt stress, K^+ helps maintain ionic homeostasis and regulate osmotic balance. In addition, this macronutrient contributes to energy transfer and decreases the production of reactive oxygen species (ROS) in plants (Hasanuzzaman et al., 2018). Indeed, it is one of the nutrients most required by watermelon (Nogueira et al., 2014), being fundamental in increasing the size of the fruits, in the thickness of the rind and in the pulp acidity index (Anjos et al., 2015).

In this context, this study was conducted with the objective of evaluating the production and post-harvest quality of Sugar Baby mini-watermelon fruits under different irrigation management strategies with saline water and potassium fertilization.

Material and Methods

The experiment was carried out from October to December 2017, in an arched greenhouse, covered with low-density polyethylene (150 microns), at the Federal University of Campina Grande, in Campina Grande (7° 15' 18" S, 35° 52' 18" W and mean altitude of 550 m), in the state of Paraíba, Brazil.

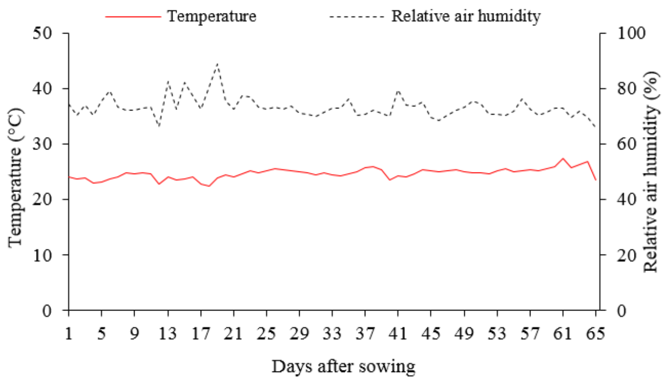


Figure 1. Temperature and relative air humidity observed during the conduction of the experiment inside the greenhouse

The temperature and relative air humidity data (Figure 1) were collected daily using a thermo-hygrometer. It is noteworthy that the temperature and relative air humidity observed in this study are within the range considered ideal for crop.

The experimental design was randomized blocks, in an 8 × 3 factorial scheme, with three replicates, with one plant per plot, testing eight water salinity management strategies - SMS [NS - no stress throughout the crop cycle; irrigation with saline water in the vegetative (VE), vegetative/flowering (VE/FL), flowering (FL), flowering/fruiting (FL/FR), fruiting (FR), fruiting/fruit maturation (FR/MAT) and fruit maturation stages (MAT)] associated with three potassium doses - KD (50, 100 and 150% of the recommendation of Novais et al. (1991), corresponding to 75, 150 and 225 mg of K_2O kg^{-1} of soil. Potassium chloride was used as a source of potassium, applied via fertigation in three equal portions, at 23, 37 and 46 days after sowing (DAS). It is important to highlight that potassium chloride is a fertilizer that has a high salt index (116.3) which, associated with water of high salinity, can intensify the effect of salt stress.

The water salinity management strategies consisted of two levels of electrical conductivity (ECw), one of low (0.8 dS m^{-1}) and the other of high (4.0 dS m^{-1}) salinity, varying according to the phenological stages of the plants: vegetative - period from emergence of the second true leaf to the appearance of the first female flower (14-34 DAS); flowering - from the first female flower to fertilization (35-43 DAS); fruiting - from fertilization to fruit filling (44-58 DAS) and maturation - from fruit filling to harvest (59-65 DAS). The levels of water salinity were established considering the levels of electrical conductivity frequently found in the waters used for irrigation in the semi-arid region of Northeast Brazil and the threshold level of salinity of the watermelon crop (3.0 dS m^{-1}), as indicated by Ayers & Westcot (1999).

The crop used was the mini-watermelon Sugar Baby. Plants were grown in plastic containers of 20 L capacity adapted as drainage lysimeters. At the base, a 3-cm-thick layer of crushed stone was placed, covered by a geotextile to prevent clogging of the drainage system. A transparent 4-mm-diameter tube was connected to its base to facilitate drainage and to a plastic container for collecting drained water.

The containers received 24 kg of an Entisol of sandy-loam texture from a cultivated area of the municipality of Lagoa Seca, PB, whose physical and chemical attributes were determined according to Teixeira et al. (2017): Ca^{2+} = 2.60 $cmol_c$ kg^{-1}; Mg^{2+}

= 3.66 $cmol_c\ kg^{-1}$; Na^+ = 0.16 $cmol_c\ kg^{-1}$; K^+ = 0.22 $cmol_c\ kg^{-1}$; $H^+ + Al^{3+}$ = 1.93 $cmol_c\ kg^{-1}$; CEC = 8.57 $cmol_c\ kg^{-1}$; organic matter = 1.36 dag kg^{-1}; P = 6.8 mg kg^{-1}; pH in water (1:2.5) = 5.90; electrical conductivity of soil saturation extract = 0.19 dS m^{-1}; sand = 732.9 g kg^{-1}; silt = 142.1 g kg^{-1}; clay = 125 g kg^{-1}; moisture at 33.42 kPa = 11.98 dag kg^{-1}; moisture at 1519.5 kPa = 4.32 dag kg^{-1}.

Phosphorus and nitrogen fertilizations were performed according to the recommendation contained in Novais et al. (1991), applying 300 and 100 mg kg^{-1} of soil of P_2O_5 and N, respectively, in the form of single superphosphate (crushed to facilitate its solubilization) and calcium nitrate. The dose of P_2O_5 and $Ca(NO_3)_2$ was applied as top-dressing, split into three equal applications at 15, 32 and 42 DAS for P, while N was applied at 19, 35 and 44 DAS. Micronutrient applications were performed at 27, 34, and 46 DAS, using a sprayer with Ubyfol® solution at a concentration of 1.5 g L^{-1} [(N (15%); P_2O_5 (15%); K_2O (15%); Ca (1%); Mg (1.4%); S (2.7%); Zn (0.5%); B (0.05%); Fe (0.5%); Mn (0.05%); Cu (0.5%); Mo (0.02%)] on the adaxial and abaxial sides of the leaves.

Sowing was performed with four seeds per lysimeter, planted at 3 cm depth and distributed equidistantly. Prior to sowing, the soil moisture content was elevated to the level corresponding to the maximum water retention capacity, using low-salinity water (0.8 dS m^{-1}).

After sowing, irrigations were carried out daily, at 5 p.m., applying in each container the volume corresponding to the water needs of the plants, determined by the water balance. The water volume to be applied to the plants was determined by Eq. 1:

$$VI = \frac{(Vp - Vd)}{(1 - LF)} \quad (1)$$

where:

VI - volume of water to be applied in the irrigation event (mL);

Vp - volume of water applied in the previous irrigation event (mL);

Vd - volume of water drained (mL); and,

LF - leaching fraction of 0.2.

At 14 DAS, the application of water of different levels of salinity began, according to the treatments established. The water used in the irrigation of low salinity level (0.8 dS m^{-1}) was obtained by diluting water from the public supply system of Campina Grande, Paraíba, Brazil (ECw = 1.21 dS m^{-1}), with rainwater (ECw = 0.02 dS m^{-1}); the level corresponding to ECw of 4.0 dS m^{-1} was prepared by adding salts in the form of Na, Ca, Mg chloride in the equivalent ratio of 7:2:1, respectively, which is the predominant ratio found in sources of water used for irrigation in small properties in Northeastern Brazil. The water was prepared considering the relationship between ECw and salt concentration ($mmol_c\ L^{-1}$ = 10 x ECw in dS m^{-1}) according to Richards (1954). The measurement of the electrical conductivity of the water was performed at each water preparation, in accordance with the treatments.

Plants were vertically trained, and only the main branch and three lateral branches per plant were left to grow. Pollination was carried out manually, with a cotton swab, by collecting pollen and taking it to the stigma, always between 06:00 and 07:00 a.m. During the formation of fruits, thinning was performed, leaving only one fruit per plant. Fruit thinning was carried out as suggested by Campagnol et al. (2012) in vertical cultivation of mini-watermelons in order to increase the quality and fruit production.

At the time of harvest (65 DAS), the following production variables were analyzed: fresh fruit mass (FFM), determined on a scale with precision of 0.01 g; polar diameter (PD) and equatorial diameter (ED) of mini-watermelon fruits, obtained with a measuring tape and expressed in centimeters.

The postharvest quality of mini-watermelon fruits was assessed based on: hydrogen potential - pH, determined directly in the pulp immediately after harvesting, with a digital meter previously calibrated at pH 7.0 with a buffer solution; soluble solids - SS, measured by direct reading in digital refractometer, expressed in °Brix; anthocyanins - ANT, obtained by spectrophotometer reading, expressed in mg per 100 g of pulp; and ascorbic acid content - AA, determined by titration, expressed in mg per 100 g of pulp. These parameters were determined according to the methodologies of IAL (2008), except for anthocyanins, whose evaluation was performed based on the methodology recommended by Francis (1982).

The data obtained were evaluated by analysis of variance by the F test. In the cases of significance, the Scott-Knott means grouping test ($p \leq 0.05$) was performed for the water salinity management strategies, while Tukey's test ($p \leq 0.05$) was applied for potassium doses, using the software program Sisvar (Ferreira, 2014).

Results and Discussion

Water salinity management strategies significantly influenced ($p \leq 0.01$) fruit variables for fresh fruit mass, polar and equatorial diameters, hydrogen potential, and anthocyanin and ascorbic acid contents (Table 1). Potassium doses significantly affected ($p \leq 0.01$) fresh fruit mass, equatorial diameter, hydrogen potential, anthocyanin and ascorbic acid ($p \leq 0.05$). The interaction between the factors (SMS × KD) caused a significant effect ($p \leq 0.01$) only on the postharvest quality variables of Sugar Baby mini-watermelon, at 65 days after sowing.

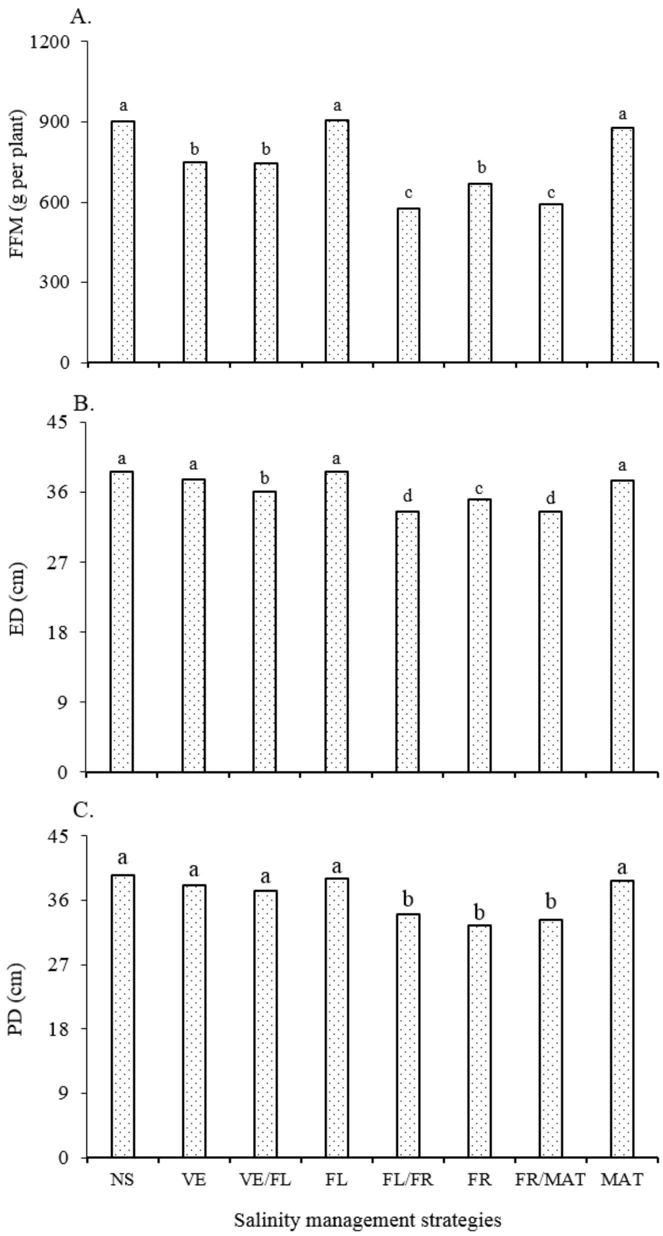
For fresh fruit mass (Figure 2A), plants irrigated with low-ECw water throughout the cycle (NS) and subjected to salt stress in the flowering (FL) and maturation (MAT) stages obtained the highest values (901.11, 907.77 and 876.66 g per plant, respectively), differing significantly from plants under salt stress in the other strategies. Among the SMS tested, irrigation with high-salinity water in the FL and MAT stages stands out as promising strategy, since it led to results similar to that obtained in NS.

Mini-watermelon plants subjected to VE/FL, FL/FR, FR and FR/MAT strategies produced fruits with smaller equatorial diameters (Figure 2B), when compared to the other water salinity management strategies (NS, VE, FL and MAT). A similar situation occurred for the polar diameter (Figure 2C), except for plants grown under the VE/FL strategy, which did

Table 1. Summary of the analysis of variance for fresh fruit mass (FFM, g per plant), polar diameter (PD, cm) and equatorial diameter (ED, cm), hydrogen potential (pH), soluble solids (SS, °Brix), anthocyanins (ANT, mg 100g^{-1} of pulp) and ascorbic acid (AA, mg 100g^{-1} of pulp) of fruits of Sugar Baby mini-watermelon grown under different water salinity management strategies (SMS) and potassium doses (KD) at 65 days after sowing

Sources of variation	DF	Mean squares						
		FFM	PD	ED	pH	TSS	ANT	AA
Water salinity management strategies (SMS)	7	162298.41**	18.25**	9.99**	0.2276**	1.6729^{ns}	0.2260**	1.3363**
Potassium doses (KD)	2	57679.16*	0.43^{ns}	2.31**	0.0459**	1.7759^{ns}	0.0111**	3.1957**
Interaction (SMS × KD)	14	16372.81^{ns}	2.56^{ns}	0.22^{ns}	0.0773**	2.9512**	0.1273**	1.2415**
Blocks	2	21554.16^{ns}	2.44^{ns}	1.13^{ns}	0.0012^{ns}	0.0138^{ns}	0.0005^{ns}	0.0022^{ns}
Residual	46	11448.36	3.47	0.38	0.0009	1.0138	0.0005	0.0532
Mean		751.66	18.27	18.15	5.27	9.2180	0.9213	4.5236
CV (%)		14.23	10.20	3.42	0.57	10.92	2.60	5.10

DF - Degrees of freedom; CV (%) - Coefficient of variation; *,** - Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively; ^{ns} - Not significant



Bars with the same letters do not differ significantly from each other by the Scott-Knott test ($p \leq 0.05$). NS - No stress throughout the crop cycle; VE- Irrigation with saline water in the vegetative; VE/FL - Vegetative/flowering; FL -Flowering; FL/FR - Flowering/fruiting; FR - Fruiting; FR/MAT - Fruiting/fruit maturation; MAT - Fruit maturation stages

Figure 2. Fresh fruit mass - FFM (A), equatorial diameter - ED (B) and polar diameter - PD (C) of Sugar Baby mini-watermelon, as a function of water salinity management strategies, at 65 days after sowing

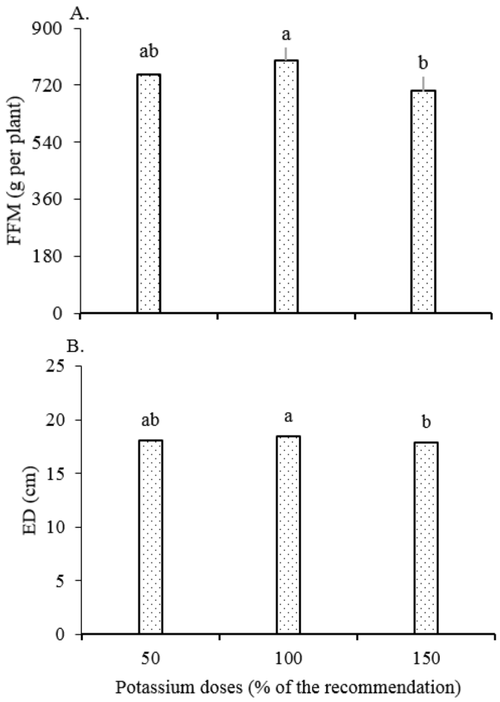
not significantly differ from those irrigated with low-ECw water (NS) and high-ECw water in the VE, FL and MAT stages.

It is worth pointing out that, despite the harmful effect of salinity on fruit diameter, there was a correspondence between PD and ED so that the PD/ED ratio was always close to 1, giving a spherical shape to the fruits, so their shape/appearance was not compromised by salinity.

The reduction in production and its components (FFM, PD and ED) may be related to energy diversion due to the decrease in the osmotic potential of the soil solution, causing a reduction in the absorption of water and nutrients, and even cell injury, caused by oxidative stress in the plant. In addition, salt stress affects the fruit yield of crops because it causes changes in plant physiology in response to factors such as osmotic stress, ionic toxicity and nutritional imbalance (Negrão et al., 2017).

Do Ó et al. (2020), in a study evaluating the effect of pulse and drip irrigation management and water salinity levels (ECsol ranging from 2.5 to 6.5 dS m^{-1}), on the productive and postharvest characteristics of Sugar Baby mini-watermelons, obtained fresh mass of 1,193 g of fruits in the plants cultivated under ECsol of 6.5, that is, a value higher than that used in the present study. It is worth mentioning that Do Ó et al. (2020) used as substrate mixture of coconut fiber and bovine manure in the proportion of 3:1 (volume basis), which might have mitigated the action of the matric potential on the availability of water for the plants.

Regarding the effects of potassium doses on production per plant (Figure 3A) and equatorial diameter (Figure 3B), it was observed that plants fertilized with 100% of the recommendation of K_2O had statistically higher FFM and ED than those that received 150% of K_2O; however, they did not differ significantly from plants grown under 50% of K_2O recommendation. Potassium is a macronutrient that acts in the filling of fruits, due to its functions in the transport of photoassimilates from leaves to fruits, in the synthesis of starch and in cell expansion (Marschner, 2012). However, excessive doses of K can affect the absorption of Ca^{2+} and Mg^{2+} and induce changes in fruit weight with deleterious effects also on fruit quality (Andriolo et al., 2010). Another factor that may have contributed to the reduction of FFM, PD and ED was the source of potassio used in this study (KCl), which has a high salt index (116.3) and, when associated with water salinity, may induce a reduction of water availability to plants due to the decrease in the osmotic potential of the soil solution (Dias et al., 2019).



Bars with the same letters do not differ significantly from each other by Tukey test ($p \leq 0.05$)

Figure 3. Fresh fruit mass - FFM (A) and equatorial diameter - ED (B) of Sugar Baby mini-watermelon, as a function of potassium doses

For the hydrogen potential of mini-watermelon fruits (Table 2), it is verified that plants fertilized with 50 and 100% of the K_2O recommendation and subjected to the NS strategy, obtained fruits with the highest pH values (5.46 and 5.41, respectively), differing significantly from the other water salinity management strategies. On the other hand, plants fertilized with 150% of K_2O and under the strategies NS, FL, FR and MAT reached the highest pH values in mini-watermelon fruits (5.45; 5.45, 5.46 and 5.46, respectively), which were statistically higher than those of plants subjected to the strategies FL/FR, FR/MAT, VE/FL and VE.

The reduction in fruit pH shows that the salt stress imposed on mini-watermelon increased the acidic character of the pulp. It is worth mentioning that only the fruits obtained in plants irrigated under the VE and MAT strategies (fertilized with 50% of K_2O), FR (fertilized with 100% of K_2O), and FL, FR and MAT (fertilized with 150% of K_2O) are within the ideal range recommended by Normative Instruction No. 37, of October 1, 2018 of the Ministry of Agriculture Livestock and Food Supply, for the quality of watermelon juice, which requires a pH of at least 5.4. Sousa et al. (2016), in a greenhouse experiment with mini-watermelon cv. Smile irrigated with saline water (ECw ranging from 1.0 to 5.0 dS m^{-1}), also found that irrigation water salinity reduced the pH of watermelon fruits.

The fruit pH of plants fertilized with 150% of the K_2O recommendation and irrigated with high-salinity water in the FL, FR and MAT stages (Table 2) did not differ significantly in comparison with those of plants cultivated under the NS strategy, which is extremely relevant. According to Silva et al. (2005), the increase in fruit pH may be associated with the consumption of organic acids during ripening due to respiratory activity of cells.

In the analysis of K_2O doses considering each salinity management strategy for hydrogen potential (Table 2), there were significant differences in all strategies adopted. Plants grown under the strategies VE and VE/FL and fertilized with 50% of the K_2O recommendation obtained higher pH values, differing significantly from those fertilized with doses of 100 and 150%.

Plants grown under the NS and FR/MAT strategies and with 100% of K_2O had the highest pH values in the fruits. On the other hand, in plants subjected to FL, FL/FR, FR and MAT strategies, the highest dose of K_2O (150%) promoted higher pH values in watermelon fruits. The increase in K_2O doses resulted in an increase in the pH of fruits of mini-watermelon plants irrigated under the strategies NS, FL, FL/FR, FR, FR/MAT and MAT (Table 2); however, for plants grown under the VE and VE/FL strategies, the increase in K_2O doses reduced fruit pH.

For the contents of soluble solids (Table 2), there was a significant difference only for plants under 150% of the K_2O recommendation, and the lowest values of SS (8 and 6 °Brix) of the fruits were obtained with the VE and FL/FR strategies. In the analysis of K_2O doses considering each water salinity management strategy for total soluble solids (Table 2), significant difference was found only for plants subjected to the FL/FR strategy, highlighting reduction in the SS content of plants subjected to the dose of 150% of the K_2O recommendation. Salt stress can cause an increase in the SS content of fruits, because plants increase the synthesis of metabolites to acclimatize to the saline condition (El-Mogy et al., 2018).

According to Normative Instruction No. 49, of September 26, 2018, from the Ministry of Agriculture, Livestock and Food Supply (Brasil, 2018), the minimum content of soluble solids

Table 2. Analysis of the interaction between water salinity management strategies (SMS) and potassium doses (KD) for hydrogen potential (pH) and soluble solids (SS, °Brix) of fruits of Sugar Baby mini-watermelon, at 65 days after sowing

SMS	pH			SS (°Brix)		
	KD 50%	KD 100%	KD 150%	KD 50%	KD 100%	KD 150%
NS	5.46 aAB	5.51 aA	5.45 aB	9.00 aA	9.20 aA	10.00 aA
VE	5.42 bA	5.09 dB	4.84 eC	9.00 aA	8.50 aA	8.00 bA
VE/FL	5.36 cA	5.09 dB	5.05 dB	10.00 aA	9.00 aA	9.00 aA
FL	5.38 bB	5.38 bB	5.45 aA	9.33 aA	9.00 aA	10.40 aA
FL/FR	5.04 fB	4.80 eC	5.29 bA	9.80 aA	10.00 aA	6.00 cB
FR	5.29 dC	5.40 bB	5.46 aA	9.00 aA	10.00 aA	9.00 aA
FR/MAT	5.15 eB	5.26 cA	5.16 cB	9.00 aA	10.00 aA	9.00 aA
MAT	5.41 bA	5.28 cB	5.46 aA	9.00 aA	10.00 aA	10.00 aA

Same lowercase letter in the column and uppercase letter in the row indicate no significant difference between management strategies (Scott-Knott, $p \leq 0.05$) and potassium doses (Tukey, $p \leq 0.05$), respectively. NS - No stress throughout the crop cycle; VE - Irrigation with saline water in the vegetative; VE/FL - Vegetative/flowering; FL - Flowering; FL/FR - Flowering/fruiting; FR - Fruiting; FR/MAT - Fruiting/fruit maturation; MAT - Fruit maturation stages established for commercialization as watermelon juice is 8 °Brix; thus, the levels of soluble solids achieved in this study (on average 9.21 °Brix) are in accordance with the technical regulation for setting the identity and quality standards for watermelon juice.

However, in this study there was a reduction in SS under the VE and FL/FR strategies, possibly due to the use of sugars in fruit respiration (Pelayo et al., 2003). In addition, high levels of Na^+ and Cl^- in the leaf tissues cause ionic imbalance, physiological disorders such as decreased photosynthetic activity and stomatal opening and oxidative damage in various cellular components, such as proteins, lipids and DNA, interrupting vital cellular functions (Gupta & Huang, 2014).

For the ascorbic acid content of the fruits (Table 3), it was verified that plants subjected to fertilization with 50% recommendation of K_2O and the strategies NS, VE/FL, FL/FR, FR and MAT stood out with the highest values of AA, equal to 4.65, 4.80, 4.67, 4.79 and 4.49 mg 100g^{-1} of pulp, respectively. On the other hand, plants fertilized with 100% recommendation of K_2O and subjected to the NS and MAT strategies obtained ascorbic acid contents (Table 3) statistically higher than those obtained with the other strategies (VE, VE/FL, FL, FL/FR, FR and FR/MAT).

Plants fertilized with 150% recommendation of K_2O and subjected to NS and FL strategies had a higher ascorbic acid content than plants cultivated under irrigation with high-ECw water in the VE, VE/FL, FL/FR, FR, FR/MAT and MAT stages. The reduction in ascorbic acid content may be related to the decrease in SS contents, because it is associated with the sugars present in fruit juice, where ascorbic acid is usually synthesized from hexose sugars, originally D-glucose or D-galactose (Raimundo et al., 2009).

Regarding the analysis of K_2O doses considering each salinity management strategy for ascorbic acid (Table 3), there was a significant difference in all water salinity management strategies, except for the FR stage. For plants subjected to NS, VE and MAT strategies, the dose of 100% of the K_2O recommendation promoted the highest levels of AA (5.87, 4.92 and 5.95 mg 100g^{-1} of pulp, respectively), significantly differing from those that received K_2O doses of 50 and 150% and under NS, VE and MAT. Mini-watermelon plants fertilized with 150% of the K_2O recommendation and subjected to NS and FL strategies stood out with the highest AA contents in fruits (5.16 and 5.19 mg 100g^{-1} of pulp, respectively). Plants subjected to VE and FL/FR strategies and K_2O dose of 150% of recommendation had the lowest AA contents in the fruits, 3.56 and 3.57 mg 100g^{-1} of pulp, respectively.

Regarding anthocyanin contents (Table 3), it was verified that plants fertilized with 50% recommendation of K_2O and under the NS strategy stood out with the highest ANT content, differing statistically from those under the other strategies (VE, VE/FL, FL, FL/FR, FR, FR/MAT and MAT). Plants fertilized with 100% of the K_2O recommendation and cultivated under the VE/FL strategy obtained higher ANT content (1.39 mg 100g^{-1} of pulp), differing statistically from those under the other strategies. On the other hand, for mini-watermelon plants fertilized with 150% of K_2O recommendation, the NS and FR/MAT strategies promoted the highest ANT contents in the fruits, being higher than those found in plants subjected to the VE, VE/FL, FL, FL/FR, FR and MAT strategies. Salt stress can cause changes in water potential, nutritional imbalance and ionic toxicity, because of the excessive accumulation of ions in plant tissue (Farooq et al., 2017), which may cause negative effects on the chemical characteristics of the fruits.

Plants fertilized with 100 and 150% of K_2O recommendation and grown under the VE/FL and FR/MAT strategies, respectively, obtained fruits with higher ANT contents and similar to that of plants cultivated under NS strategy (irrigated with lower ECw throughout the cycle). Anthocyanins are the most important group of flavonoids in plants, which act to alleviate oxidative damage (Tena et al., 2020), caused by ionic imbalance, which results in ionic toxicity, osmotic stress and generation of reactive oxygen species in plants (Chawla et al., 2013).

In the analysis of K_2O doses considering each water salinity management strategy for anthocyanin (Table 3), there were differences between all strategies adopted. In plants subjected to the VE and FR strategies, the dose of 50% of the K_2O recommendation promoted higher levels of ANT, equal to 1.02 and 0.93 g 100g^{-1} of pulp, respectively. Plants subjected to NS, VE/FL and FL/FR strategies and 100% dose of K_2O recommendation obtained the highest contents of ANT, 1.26, 1.39 and 0.93 mg 100g^{-1} of pulp, respectively. Under irrigation with high-salinity water in the FL, FR/MAT and MAT stages and K_2O dose equivalent to 150% of recommendation, mini-watermelon plants reached the highest levels of ANT, 1.02, 1.12 and 1.00 mg 100g^{-1} of pulp, respectively. The decrease in anthocyanin levels with the increase in K_2O doses may have occurred due to the potassium source used in this study (KCl), which has a high salt index (116.3), and the increase in K_2O doses may have caused physiological and/or metabolic

Table 3. Analysis of the interaction between water salinity management strategies (SMS) and potassium doses (KD) for ascorbic acid (AA) and anthocyanins (ANT) of fruits of Sugar Baby mini-watermelon, at 65 days after sowing

SMS	AA (mg 100 g^{-1} of pulp)			ANT (mg 100 g^{-1} of pulp)		
	KD 50%	KD 100%	KD 150%	KD 50%	KD 100%	KD 150%
NS	4.65 aC	5.87 aA	5.16 aB	1.18 aB	1.26 bA	1.14 aB
VE	4.06 bB	4.92 bA	3.56 dC	1.02 cA	0.47 gC	0.59 fB
VE/FL	4.80 aA	4.49 bA	3.00 eB	1.12 bB	1.39 aA	0.66 eC
FL	4.18 bB	4.48 bB	5.19 aA	0.71 gB	0.73 fB	1.02 bA
FL/FR	4.67 aA	4.50 bA	3.57 dB	0.78 fB	0.93 dA	0.80 dB
FR	4.79 aA	4.63 bA	4.62 bA	0.93 dA	0.80 eB	0.84 cB
FR/MAT	3.45 cB	4.62 bA	4.82 bA	0.88 eC	1.03 cB	1.12 aA
MAT	4.49 aB	5.95 aA	4.02 cC	0.72 gC	0.90 dB	1.00 bA

Same lowercase letter in the column and uppercase letter in the row indicate no significant difference between management strategies (Scott-Knott, p ≤ 0.05) and potassium doses (Tukey, p ≤ 0.05), respectively. NS - No stress throughout the crop cycle; VE - Irrigation with saline water in the vegetative; VE/FL - Vegetative/flowering; FL - Flowering; FL/FR - Flowering/fruiting; FR - Fruiting; FR/MAT - Fruiting/fruit maturation; MAT - Fruit maturation stages disorders in the plants (Prazeres et al., 2015; Dias et al., 2019), which reduce growth, causing effects on production and post-harvest quality.

Conclusions

1. Irrigation using water with electrical conductivity of 4.0 dS m^{-1} in the flowering and fruit maturation stages is a promising strategy for the cultivation of Sugar Baby mini-watermelon, because it does not compromise its production.

2. Fertilization with 50% recommendation of K_2O can be used in the cultivation of Sugar Baby mini-watermelon without losses in yield.

3. Mini-watermelon plants fertilized with 150% recommendation of K_2O and irrigated with water of high salt concentration continuously in the vegetative/flowering and fruiting stages reduce the contents of soluble solids and ascorbic acid in their fruits.

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