

CRESCIMENTO DE MINI MELANCIA EM AMBIENTE PROTEGIDO UTILIZANDO SOLUÇÕES SALINIZADAS ENRIQUECIDAS COM POTÁSSIO E CÁLCIO ¹

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1 RESUMO

A adequada nutrição com potássio e cálcio pode reduzir o estresse salino nas plantas. Objetivou-se avaliar o efeito de concentrações de K e Ca como estratégia para a redução do estresse salino na cultura da mini melancia, cv. Sugar Baby. Utilizou-se o delineamento de blocos casualizados, com 6 tratamentos [S1 –solução nutritiva padrão, 0,5 dS m⁻¹ (SNP), S2 – SNP + NaCl (5,0 dS m⁻¹), S3 – S2 + 50% K, S4 – S2+ 100% K, S5 – S2 + 50% Ca e S6 – S2 + 100% Ca], com quatro repetições. Foram avaliadas as seguintes variáveis: altura de plantas, diâmetro do caule, número de folhas, área foliar, razão de área foliar, massas secas de folhas, caule, frutos e total, partição de massa seca e índice de redução de biomassa. A salinidade reduz o crescimento e o desenvolvimento da mini melancia. A suplementação de K em 50% (S3) reduziu o efeito do estresse salino sobre a área foliar e a massa seca de caule. A adição extra de Ca em 100% aliviou o estresse salino e aumenta a partição de fotoassimilados para frutos. Concentrações excessivas de K em solução nutritiva salinizada reduziu a tolerância da mini melancia, cv. Sugar Baby, ao estresse salino.

Keywords: *Citrullus lanatus*, fertirrigação, estresse salino, nutrição potássica, nutrição cálcica.

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**GROWTH OF MINI WATERMELON IN A PROTECTED ENVIRONMENT USING
SALINIZED SOLUTIONS ENRICHED WITH POTASSIUM AND CALCIUM**

2 ABSTRACT

Adequate nutrition with potassium and calcium can reduce salt stress in plants. The objective was to evaluate the effect of K and Ca concentrations as a strategy for reducing salt stress in mini watermelon, cv. Sugar Baby. A randomized block design was used, with 6 treatments [S1 – standard nutrient solution, 0.5 dS m⁻¹ (SNP), S2 – SNP + NaCl (5.0 dS m⁻¹), S3 – S2 + 50 %

K, S4 – S2+ 100% K, S5 – S2 + 50% Ca and S6 – S2 + 100% Ca], with four repetitions. The following variables were evaluated: plant height, stem diameter, number of leaves, leaf area, leaf area ratio, dry masses of leaves, stem, fruits and total, dry mass partition and biomass reduction index. Salinity reduces the growth and development of the mini watermelon. K supplementation at 50% (S3) reduced the effect of saline stress on leaf area and stem dry mass. The addition of 100% extra Ca alleviated salt stress and increased the partitioning of photoassimilated to fruits. Excessive concentrations of K in saline nutrient solution reduced the tolerance of mini watermelon, cv. Sugar Baby, to salt stress.

Keywords: *Citrullus lanatus*, fertigation, saline stress, potassium nutrition, calcium nutrition.

3 INTRODUCTION

Watermelon (*Citrullus lanatus*) is a vegetable crop belonging to the Cucurbitaceae family that originates from hot and dry regions of Africa. It is a tradition cultivated in the field in a creeping system, with large fruits ranging from 6 to 22 kg, and has great economic importance worldwide and in Brazil. With the reduction in the number of individuals per family, the market demand for smaller fruits, known as “ice boxes” or refrigerator watermelons, has increased, and their weight decreased, ranging from 1.5 to 4 kg, serving a demanding consumer market and high purchasing power. These mini watermelon hybrids can also provide greater productivity due to the possibility of greater density, in addition to cultivation in a vertical system (CAMPAGNOL; JUNQUEIRA; MELLO, 2012; SOUSA *et al.*, 2016; DIAS; SANTOS, 2019).

Mini watermelon can be grown in a substrate in a hydroponic system, as long as high-quality water is used for cultivation, especially with regard to distributed salt theories. Studies have reported the high sensitivity of mini watermelon cultivars to salinity, as this can cause disturbances in the metabolism and growth of the plant caused by a reduction in osmotic potential, which can cause nutritional imbalances, mainly regarding the absorption of potassium and calcium due to the antagonistic effects of

these nutrients on sodium (OLIVEIRA *et al.*, 2014; SILVA JUNIOR *et al.*, 2020).

The increase in K and Ca in the nutrient solution under saline conditions helps to mitigate the effects of salinity, as these nutrients interact antagonistically with toxic ions, such as Na⁺, which is beneficial for plant development. Its potential, among other functions, is that it is an enzymatic activator of several chemical reactions in addition to influencing the chemical and physical characteristics of the crop, and its adequate management during fertilization is essential for achieving high productivity (OLIVEIRA *et al.*, 2014; OLIVEIRA *et al.*, 2021a, 2021b). Taiz *et al.* (2017) reported that the availability of calcium is essential for maintaining functional ion levels in plant tissues, in addition to acting as an attenuator of the contractual effects of salinity on crops.

Several studies have demonstrated that the side effects of salinity can be complemented with management strategies that enable plant growth and development. To define strategies to reduce the effects of salinity on plants, several authors have reported that Ca acts beneficially, limiting the impact of salinity on metabolism and the fruit ripening process (ATTARZADEH; AMINI, 2019).

Studies on potassium nutrition have shown that K affects the absorption of Na, significantly improving plant development (CHAKRABORTY *et al.*, 2016). Larbi *et al.* (2020), studying the mitigation of the effects of salinity on olive plants, highlighted that

Ca and K are recommended for use in supplementation to mitigate the counterbalancing effects of salinity.

Therefore, the objective of this research was to evaluate the efficiency of nutritional enrichment with K and Ca as a strategy to mitigate the harmful effects of salinity on the growth of mini watermelons in a protected environment.

4 MATERIAL AND METHODS

The experiment was carried out from July 31 to October 11, 2019, in a protected environment belonging to the Department of Agricultural and Forestry Sciences (DCAF) of the Universidade Federal Rural do Semi-Árido (UFERSA), in Mossoró, RN, whose geographic location is 5° 12' 04" south

latitude and 37° 19' 39" longitude west of Greenwich, with an average altitude of 18 m.

The design used was a randomized block design with 4 replications, in which each replication was composed of four plants. The treatments consisted of 6 nutrient solutions, one using low-salinity water (0.5 dS m⁻¹) and five using water supplemented with sodium chloride (5.0 dS m⁻¹): S1, the nonsalinized nutrient solution recommended by Campagnol, Junqueira and Mello (2012) for each development phase; S2, the nutrient solution S1 supplemented with NaCl; S3-S2 enriched with 50% K; S4-S2 enriched with 100% K; S5-S2 enriched with 50% Ca; and S6-S2 enriched with 100% K. After preparing the nutrient solutions, the following electrical conductivities are indicated: 2.6, 7.1, 8.0, 8.5, 7.3 and 7.9 dS m

Table 1. Nutrient concentration for preparing the nutrient solutions used in the experiment.

Nutrients (g 1000 L ⁻¹)	Phase I					
	S1*	S2	S3	S4	S5	S6
Nitrogen	130.6	130.6	130.6	130.6	130.6	130.6
Phosphor	74.4	74.4	74.4	74.4	74.4	74.4
Potassium	81.3	81.3	121.9	162.6	81.3	81.3
Calcium	94	94	94	94	141	188
Magnesium	21.9	21.9	21.9	21.9	21.9	21.9
Sulfur	27.6	27.6	27.6	27.6	27.6	27.6
	Phase II					
Nitrogen	130.6*	130.6	130.6	130.6	130.6	130.6
Phosphor	74.4	74.4	74.4	74.4	74.4	74.4
Potassium	122.3	122.3	183.4	244.6	122.3	122.3
Calcium	94	94	94	94	141	188
Magnesium	21.9	21.9	21.9	21.9	21.9	21.9
Sulfur	45.4	45.4	45.4	45.4	45.4	45.4
	Phase III					
Nitrogen	179.7*	179.7	179.7	179.7	179.7	179.7
Phosphor	55.5	55.5	55.5	55.5	55.5	55.5
Potassium	159.9	159.9	239.8	319.8	159.9	159.9
Calcium	80	80	80	80	120	160
Magnesium	44.2	44.2	44.2	44.2	44.2	44.2
Sulfur	55.8	55.8	55.8	55.8	55.8	55.8

* (CAMPAGNOL; JUNQUEIRA; MELLO, 2012).

Source: Authors (2024).

The water used to prepare the solutions was obtained from the UFERSA supply, and salinization was carried out by adding NaCl. Micronutrients were increased using Rexolin Q48 (Fe 6%) and Rexolin BRA micronutrients (11.6% potassium oxide, 1.28% sulfur, 0.86% magnesium, 2.1% boron, 2.66% iron, 0.36% copper, 2.48% manganese, 0.036% molybdenum, 3.38% zinc) according to the manufacturer's instructions; 30 g was added to 1,000 L of nutrient solution.

The sowing of mini watermelon, cv. Sugar Baby, was carried out directly, with five seeds placed in each pot. Ten days after emergence, thinning occurred, leaving more

vigorous seedlings in each pot. The pot has a capacity of 12 dm³, with dimensions of 0.33 m in height, 0.30 m in upper diameter and 0.20 m in lower diameter, and contains a substrate composed of coconut fiber and washed sand in a proportion of 1:1. A drainage system consisting of a 2.0 cm layer of gravel and a bidim blanket was placed at the bottom of the pot.

The spacing used was 0.45 m between plants and 1.20 m between rows of plants. Along each row of plants, wooden stakes and stainless steel wires were installed on the espaliers to support vertical branch development and assist with staking, which was accomplished with the help of

plastic ribbons. The plant was rushed with only one fruit per plant in the main rush, with thinning taking place throughout the cycle as needed.

Pollination was carried out manually, always in the early hours of the morning, considering that pollen grains have a reduced probability throughout the day (ABREU *et al.*, 2008). When fruit fixation was ensured in the desired position (between 8 and 14 internodes), thinning was performed, leaving only one fruit per plant. The fixed fruits, when they reached approximately 4.0 cm in diameter, were supported using nylon nets (bags), which were tied to the horizontal wires that followed above the planting line (CAMPAGNOL; JUNQUEIRA; MELLO, 2012).

Each nutrient solution was distributed by an independent control system consisting of a set of motor pumps (0.5 hp), polyethylene distribution lines (16 mm) and microtube-type emitters (spaghetti), with an average flow rate of 7.0 L h⁻¹.

Irrigation control was carried out using a digital timer, varying the frequency and duration of each irrigation event throughout the experiment. In the first phase of crop development, fertigation occurred 5 times a day for 1 minute. The second phase occurred 7 times a day, lasting 2 minutes, and the third phase of culture development occurred 4 times a day, lasting 1 minute.

Throughout the experiment, plant growth analyses were carried out in a nondestructive way at 30, 37, 44 and 51 days after sowing (DAS), where the following variables were evaluated: plant height, measured with a graduated tape at the main flush to the substrate up to the apical bud; stem diameter, measured with a digital caliper on the main stem 1.0 cm above the substrate; number of leaves, selected by successively counting all fully expanded leaves; and leaf area, estimated from a mathematical model using average values of length (L) and width (L), measuring three

leaves per plant, eq. 1 (SILVA JÚNIOR *et al.*, 2017).

$$AF = C \times L \times 0.75 \quad (1)$$

AF – leaf area, cm² plant⁻¹;
C – compimentoleaf blade, cm;
L – Largura of the leaf blade, cm.

At 75 DAS, the plants were harvested, and their parts were separated into leaves, stems and fruits and then weighed to determine their respective fresh masses.

BENICASA disc methodology (2004), eq. 2.

$$AF = \frac{(MSF \times AD)}{MSD} \quad (2)$$

where:

AF – leaf area, cm² plant⁻¹;
MSF – leaf dry mass, g plant⁻¹;
MSD – dry mass of disc, g;
AD – disco area, cm².

Leaf, stem and fruit samples were dried in an oven with forced air circulation at 65 °C until constant weight, and after dehydration, the dry masses of the leaves, stems, fruits and total plants were measured.

With the total dry matter production data, the percentages divided between the vegetative organs and the biomass production reduction index (IR) were calculated by comparing the data from the saline treatments with the control (S1) using Eq. 3 (FAGERIA; BALIGAR; JONES, 2010).

$$IR(\%) = \frac{(PBMTc - PBMTs)}{PBMTc} \times 100 \quad (3)$$

where:

PBMTc- biomass production from the control treatment;
PBMTs- biomass production from saline treatment.

The classification regarding salinity tolerance was given according to the

following ranges of relative reduction in total dry matter: tolerant, zero to 20%; moderately tolerant, 21 to 40%; and moderately susceptible, 41 to 60% and susceptible, above 60% (FAGERIA; BALIGAR; JONES, 2010).

The data obtained were subjected to analysis of variance, and the means were compared by the Tukey test at 5% using the SISVAR software (FERREIRA, 2014).

5 RESULTS AND DISCUSSION

Statistical analysis of the data revealed that there was a significant effect of nutrient solution (NS) on the variable height of plants at 44 DAS ($p < 0.05$) and 75 DAS ($p < 0.01$); for the other evaluations, there was no significant effect. The ceramic variables of the stem (75 DAS) and number of leaves (44 DAS) were affected by NS ($p < 0.05$). Leaf area showed a significant response to nutrient solutions in all the evaluations, at a significance level of 5% at 51 DAS and a 1% probability in the other evaluations (Table 2).

Table 2. Summary of analysis of variance (mean squares) for plant height, stem diameter, number of leaves and leaf area of mini watermelon plants grown in a protected environment and fertigated with saline nutrient solutions enriched with potassium and calcium.

Source of variation	GL	Medium squares				
		30 DAS	37 °DAS	44 DAS	51 °DAS	75 DAS
Plant height						
Nutrient Solution	5	169.71ns	950.24ns	1450.15*	1586.05 ^{nos}	3076.25**
Repetition	3	39.77 ^{ns}	35.84ns	230.11ns	293.99 ^{nos}	494.11 ^{nos}
Error	15	190.02	356.98	683.47	346.71	541.19
CV (%)		12.13	9.67	11.21	7.79	8.68
Stem diameter						
Nutrient Solution	5	0.1391ns	0.2261ns	0.8160ns	1.2200 ^{ns}	4.6339*
Repetition	3	0.2438ns	0.1599ns	1.0061 ^{ns}	0.5458ns	0.2076ns
Error	15	0.3381	0.3621	0.9257	1.3486	1.2109
CV (%)		11.21	9.74	14.90	17.31	13.67
Number of sheets						
Nutrient Solution	5	1.8787 ^{ns}	9.1669 ^{ns}	53.1834*	23.8943 ^{nos}	26.3503ns
Repetition	3	2.0979 ^{ns}	4.3498ns	7.8835 ^{ns}	16.5406ns	18.2777 ^{ns}
Error	15	2.0998	5.1116	13.0461	11.4753	12.6489
CV (%)		8.27	8.32	9.56	7.45	7.45
Leaf area						
Nutrient Solution	5	606430.3**	2307023.3**	346131.9**	3924735.3*	6608890.2**
Repetition	3	47356.6ns	85395.7ns	142437.1ns	558010.2ns	134048.5ns
Error	15	82476.1	214718.9	759226.2	880706.7	316282.2
CV (%)		19.49	15.11	20.32	17.18	16.24

*- Significant at the 5% level, ** significant at the 1% level, ns not significant according to the F test.

Source: Authors (2024).

The height of the plants decreased with the addition of NaCl to the nutrient solution (S2) at 37 DAS. In this evaluation, the addition of additional K and Ca, regardless of the dose, prevented the effect of salinity. At 51 DAS, there was also a reduction in plant height in response to salinity; however, this effect decreased when 100% K (S4) and Ca (S5 and S6) were added to the saline nutrient solution. In the last evaluation period, the effect of salinity on plant height was more evident due to the greater accumulation of salts in the substrate.

In this case, the solutions enriched with K (S3 and S4) and 50% Ca (S5) were efficient at significantly reducing the effect of salt stress on this variable (Figure 1A).

A similar result was obtained by Martins *et al.* (2013), working with watermelon, cv. Congo, reported a 50% reduction in the height of the main rush hour under saline conditions. Sousa *et al.* (2016), who studied the initial development of mini watermelons under salinity, obtained similar results, in which salinity affected the qualities and length of mini watermelon

branches, which was also observed by Silva Júnior *et al.* (2020) working with salinity in the production of watermelon seedlings.

Taiz *et al.* (2017) reported that the reduction in this variable under conditions of saline stress is associated with both a reduction in the vertical growth of the stem and the death of axillary buds resulting from physiological, hormonal and nutritional disorders promoted by ions, including Na^+ .

Stem diameter was affected by salinity only in the last evaluation period, in which the addition of NaCl to the nutrient solution caused a 27% reduction (S2) compared to the stem diameter observed in plants fertigated with standard nutrient solution (S1). It was also found that the addition of additional K (S3 and S4) or Ca (S5 and S6) reduced the effect of salt stress on this variable, despite not significantly differing from the effect of the solution (S2) (Figure 1B).

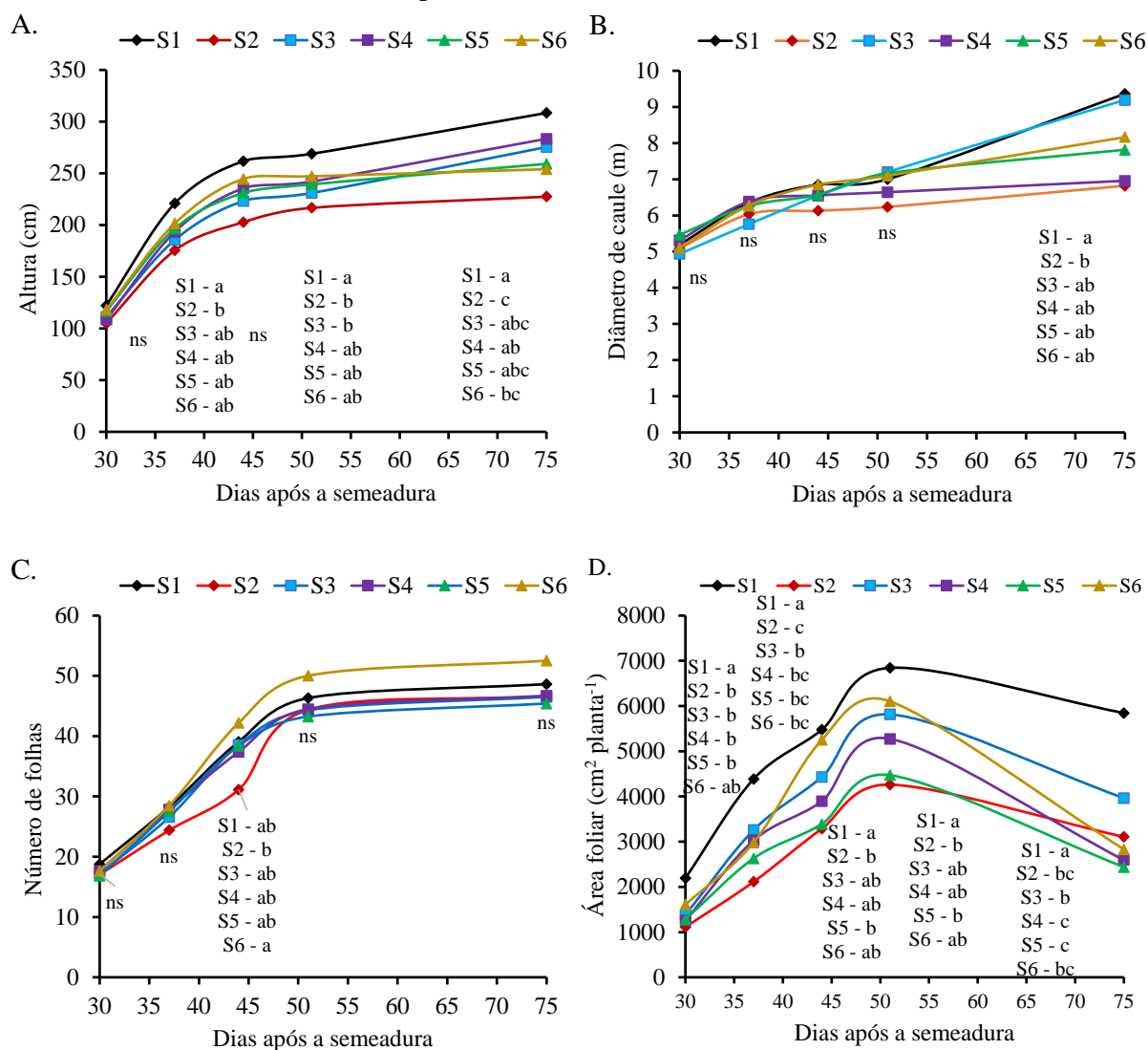
A reduction in stem diameter in watermelon in response to saline stress was also observed by Silva Júnior *et al.* (2020) working with watermelon changes. Albuquerque *et al.* (2016), working with cucumber cultivars, also reported that stem diameter was strongly affected by the salinity of the irrigation water.

There was no effect of the solutions on the number of leaves in most evaluation periods, except at 44 DAS, in which the addition of NaCl to the nutrient solution (S2) caused a reduction in NF, despite not significantly differing from the standard nutrient solution. There was a significant difference only between solutions S2 and S6, with the highest NF obtained in the saline solution enriched with 100% Ca (S6), which was significantly different from that in S2 and did not differ from that in the other solutions (Figure 1C).

According to Tester and Davenport (2003), plants use, as an adaptation strategy for stress conditions, the reduction of the number of leaves, considering the osmotic effect of salts in the root zone, thus resembling conditions of water scarcity, and the reduction in the number of leaves therefore reduces transpiration.

Negative effects on the number of mini watermelon leaves were observed by Sousa *et al.* (2016) working with the cultivar Smile. The authors found reductions in the number of leaves caused by salinity. Albuquerque *et al.* (2016) reported a linear reduction in the number of leaves present during the initial development of cucumber plants under conditions of saline stress, a behavior corroborated for cucurbits.

Figure 1. Plant height (A), stem diameter (B), number of leaves (C) and leaf area (D) of mini watermelon plants grown in a protected environment supplemented with saline solutions enriched with potassium and calcium.



(Standard nutrient solution (S1); saline nutrient solution (S2); saline nutrient solution + 50% K (S3); saline nutrient solution + 100% K (S4); saline nutrient solution + 50% Ca (S5) and saline nutrient solution + 100% Ca (S6)). *Averages followed by the same letter do not vary between each other according to the Tukey test at 5% probability in each evaluation period.

Source: Authors (2024).

In general, salinity did not affect the number of leaves in most evaluation periods. This may have occurred due to pruning throughout the cycle, preventing the plants from showing greater vegetative development.

The addition of NaCl to the nutrient solution (S2) reduced the leaf area of the mini watermelon plants at all evaluation

times, with reductions of 49, 52, 40, 38 and 47% at 30, 37, 44, 51 and 75 days after sowing, respectively (Figure 1D). Furthermore, the addition of extra K or Ca impairs the effect of salinity on the expansion of the leaf blade, showing that adequate nutrient availability can be a viable alternative to reduce salinity stress, helping to overcome toxicity of specific ions,

especially Na⁺ (GRATTAN; GRIEVE, 1999).

Despite nutritional supplementation, the concentration of salts in the solution harms the leaf development of the crop due to the osmotic potential, which is inversely related to the concentration of salts, so that as the salts are concentrated in the applied solution, the osmotic potential of the substrate becomes more negative, which reduces the flow of water to the plant, promoting the emergence of signs of water stress and maintaining water in the substrate (TAIZ *et al.*, 2017). Sousa *et al.* (2016), evaluating mini watermelon irrigated with saline water, reported a decrease of approximately 13.7% in the crop's leaf area when irrigated with water with a salinity greater than 1.5 dS m⁻¹.

Other studies have shown that leaf area is the variable most affected by saline stress in several crops (MART *et al.*, 2013; SILVA JUNIOR *et al.*, 2020; LIME *et al.*, 2020). A reduction in leaf area constitutes

one of the plant's initial responses to salt stress and has been attributed to decreased cell division and expansion of the leaf surface. This response is an adaptive mechanism of plants grown in saline conditions, as the reduction in transpiration and, consequently, the reduction in the absorption of Na and Cl result in water conservation in vegetable crops (TAIZ *et al.*, 2017).

Considering that the leaf area of a plant directly depends on the number and size of the leaves, it was found in the present study that the effect of the applied treatments was more evident in the expansion of the leaf blade than in the emission of new leaves.

The nutrient solutions significantly affected the variables leaf dry mass (MSF), stem dry mass (MSC), fruit dry mass (MSFR) and total dry mass (MST) at the 1% probability level, with no significant response occurring ($p > 0.05$) for the leaf area ratio (RAF) (Table 3).

Table 3. Summary of analysis of variance (mean squares) leaf area ratio (RAF), leaf dry mass (MSF), stem dry mass (MSC), fruit dry mass (MSFR) and total dry mass (MST) of mini watermelon plants grown in a protected environment and fertigated with saline solutions enriched with potassium and calcium.

Source of variation	GL	Medium squares				
		MSF	MSC	MSFR	MST	RAF
Solution	5	97.0042**	47.5598**	1307.133**	2,304,964**	237.8229 ^{ns}
Repetition	3	3.6559 ^{ns}	2.0117 ^{ns}	7.3819 ^{nos}	26.9692 ^{ns}	21.7408 ^{ns}
Error	15	5.6657	4.5504	57.9251	74.2275	111.3201
CV (%)		14.28	22.16	14.19	10.78	24.09

** -Significant at the 1% level; ns - not significant according to the F test.

Source: Authors (2024).

The addition of NaCl to the nutrient solution (S2) caused a 33% reduction in the dry mass of leaves compared to the values obtained in the standard nutrient solution (S1). Furthermore, we found that the extra additions of K (S3 and S4) and Ca (S5 and S6) did not promote greater tolerance of the culture to saline stress (Figure 2A).

On the other hand, the addition of Ca at 50% (S5) enhanced the effect of salt stress, causing a 56% reduction compared to that in the S1 solution. Water deficit caused by salinity can limit not only growth but also the number of leaves and their growth (Figure 2A).

Martins *et al.* (2013), studying the initial development of watermelon cultivars

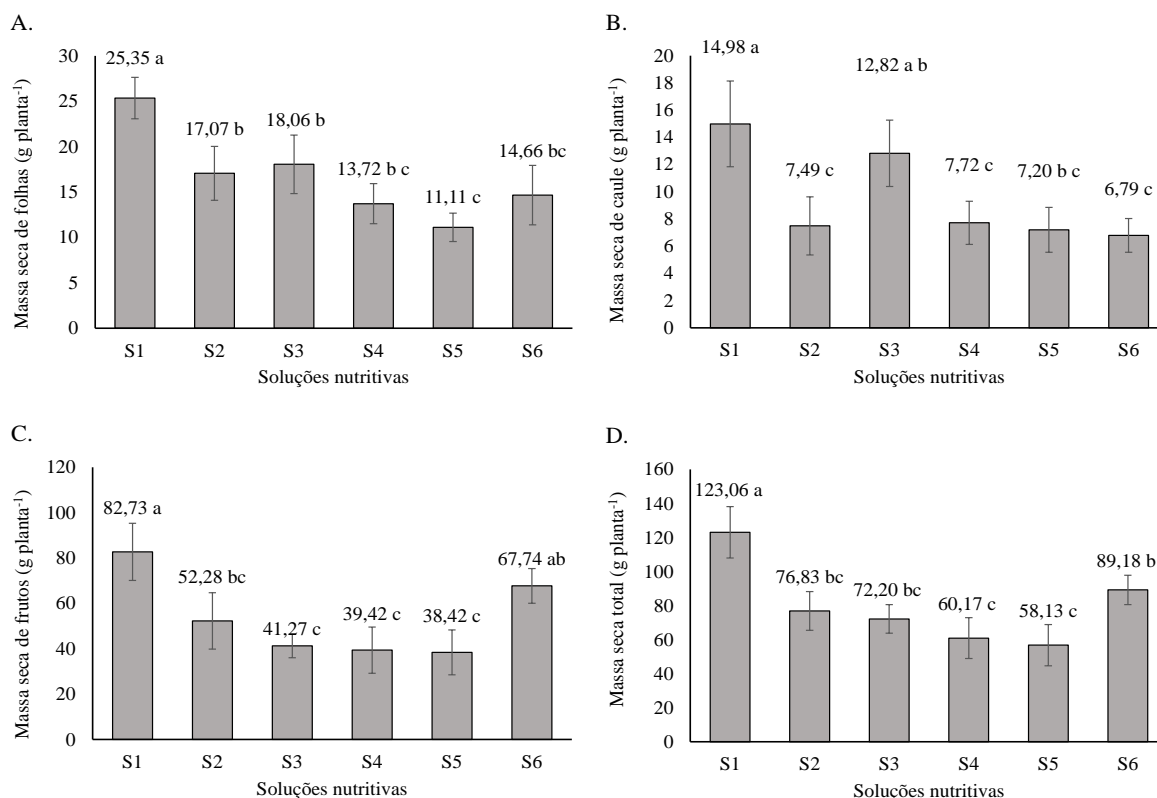
under saline stress, reported negative effects of salinity on leaf dry mass, with reductions of approximately 74.1% in the Crimson Sweet cultivar. Other authors have reported a reduction in the dry mass of leaves caused by salinity in species from the Cucurbitaceae family (OLIVEIRA *et al.*, 2014; ALBUQUERQUE *et al.*, 2016; ARAÚJO *et al.*).).2016).

Studies have shown that the reduction in stem development in cucurbits can be attributed to the toxic effects of Na^+ ions, which in turn triggers a series of morphophysiological changes and, in response, delays plant development. As an effect of saline stress, plants tend to

accumulate toxic salts in the stem, which impairs their development, to preserve sensitive regions such as leaves (ALBUQUERQUE *et al.*, 2016; MARTINS *et al.*, 2013).

The deleterious effects of salinity were observed by Martins *et al.* (2013), where the authors observed reductions of 68.2 and 40% in the dry mass of the stem of watermelon cultivars Crimson Sweet and Charleston, respectively. With melon cultivars, Araújo *et al.* (2016) reported an average reduction of 37% in the accumulation of dry mass in the aerial part of the crop.

Figure 2. Dry mass of leaves (A), dry mass of stems (B), dry mass of fruits (C), total dry mass (D) and leaf area ratio (E) of watermelon plants grown in a protected environment supplemented with saline solutions enriched with potassium and calcium



(Standard nutrient solution (S1); saline nutrient solution (S2); saline nutrient solution + 50% K (S3); saline nutrient solution + 100% K (S4); saline nutrient solution + 50% Ca (S5) and saline nutrient solution + 100% Ca (S6)). *Averages followed by the same letter do not vary between each other according to the Tukey test at 5% probability in each evaluation period.

Source: Authors (2024).

For the variable dry mass of fruits (MSFR), the salinity of the nutrient solution in S2 caused a 37% reduction compared to the MSFR obtained in the standard nutrient solution (S1). Furthermore, the addition of K (S3 and S4) and 50% Ca (S5) increased the deleterious effect of salt stress on MSFR. However, the addition of 100% Ca (S6) resulted in a 29% increase in MSFR compared to that in S2 and therefore did not differ from that in S1. In this way, the addition of 100% Ca reduced the deleterious effect of salt stress (Figure 2C).

This positive response to the addition of Ca to the saline solution on the MFFR is, in part, due to the important functions of this nutrient in plants. Among other functions, calcium acts as a structural element, protecting membranes and cell walls, as well as signaling responses to biotic or abiotic stress conditions. Studies by Manishakar *et al.* (2018) reported the importance of this nutrient for protecting crops and its role in biochemical reactions that mitigate the effect of salinity.

On the other hand, the addition of extra K did not efficiently reduce the effect of salt stress on MSFR. These results corroborate, in part, those presented by Silva *et al.* (2020), who used the same genotype used in this work but were grown in soil, did not verify the effect of the interaction of potassium fertilization with salinity stress on plant development. Oliveira *et al.* studied melon trees. Moreover, the efficiency of potassium nutrition in alleviating salinity stress was not verified in 2021b.

Evaluating the total dry mass (MST), it was observed that saline stress (S2) caused a 37% reduction in this variable and that the extra addition of K by 100% (S4) and Ca by 50% (S5) accentuated the effects of salinity. It was also found that, as observed for MSFR, the addition of 100% Ca (S6) prevented the effect of salinity, despite not

differing from that of the S2 solution. In general, it is clear that the responses of the MST and MSFR variables are similar, which can be explained by the fact that fruits are the preferred drains of photoassimilates in watermelon crops, representing approximately 60% of the total mass of the plant. (Figure 2D).

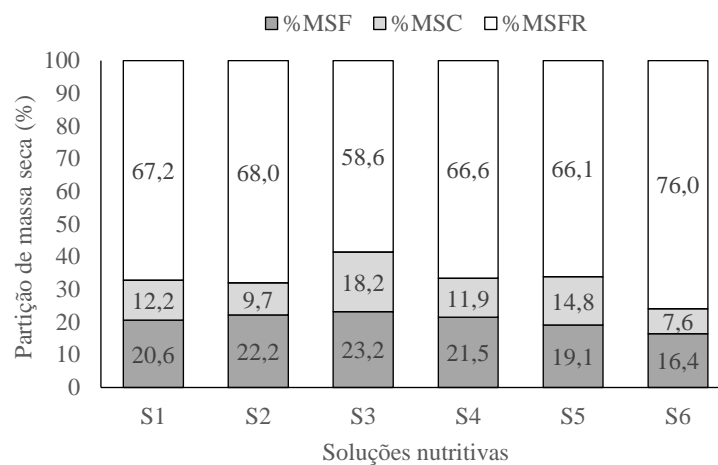
Therefore, the portion of assimilated photos observed in the present study is similar to that verified by other authors, in which fruits are the preferred drains. for watermelon and other authors evaluating cucurbits (SANTOS *et al.*, 2021; STRASSBURGER *et al.*, 2011; VIDIGAL; PUIATTI; SEDIYAMA, 2021).

RAF was not significantly affected by salt stress or by the addition of extra potassium or calcium to the saline solution (Figure 2). Considering that the RAF is obtained by the ratio between the leaf area and the total biomass production of a plant and that both variables are reduced by salinity, these results may indicate that salinity did not affect photosynthetic efficiency since, under these conditions, there was no change in the use of photosynthetic leaf area for the production of dry matter (BRIGHENTI *et al.*, 1993).

Porto Filho *et al.* (2006), working with melon cultivation, and Oliveira *et al.* (2014), working with pumpkin and strawberry cultivars, reported a reduction in the leaf area ratio in response to saline stress.

The differences in biomass among the different parts of the plant were not affected by the treatments applied; on average, considering the treatments with saline solution (S2, S3, S4, S5 and S6), the dry mass distribution was 20.49% for the leaf, 12.44% for the stem and 67.06% for the fruit. These results are close to the biomass distribution observed in the standard nutrient solution (S1) (Figure 3).

Figure 3. Partition of dry mass in mini watermelon grown in a protected environment using saline solutions enriched with potassium and calcium.



MSF – dry mass of leaves, MSC – dry mass of stem, MSFR – dry mass of fruits

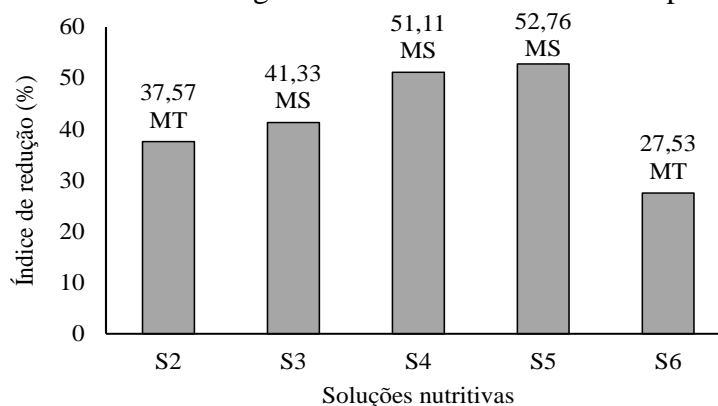
Source: Authors (2024).

This percentage of photos assimilated in the fruits is close to those seen by other authors working with mini watermelon (MARQUES *et al.*, 2016), who observed 72%, as well as in conventional watermelon (BRAGA *et al.*, 2011), in which they obtained approximately 65% of assimilated photos exported to the fruits.

By analyzing the tolerance index of mini watermelon, we found that it was moderately tolerant (MT) to a salinity of 5.0

dS m^{-1} of the water used to prepare the nutrient solution (7.1 dS m^{-1} of the nutrient solution). The addition of K at 50% (S3) and 100% (S4), as well as the addition of Ca at 50% (S5), increased the deleterious effect of salinity, so that the culture was moderately sensitive to salinity (IN). On the other hand, the addition of 100% Ca (S6) did not promote an increase in the effect of salinity, which is equivalent to S2 (Figure 4).

Figure 4. Relative reduction index of dry mass production in mini watermelon grown in a protected environment using saline solutions enriched with potassium and calcium.



MT – moderate-stage tolerance, MS – moderate-stage sensitivity

Source: Authors (2024).

The increase in the effect of salt stress shown in solutions S3 and S4 can be attributed to the K source used (KCl), which has a high salt content. With this, the increase in KCl dose increased the EC of the nutrient solutions to 8.0 and 8.5 dS m in solutions S3 and S4, respectively. In solution S6, despite an increase in EC with the maximum dose of Ca (7.9 dS m⁻¹), there was no increase in the effect of salinity, probably due to an antagonistic interaction between Ca an²⁺ and Na⁺ ions. . In a study carried out with the peanut crop, Freitas *et al.* (2021) also reported that increasing the dose of K potentiated the effect of salinity.

6 CONCLUSION

The use of saline water harms the growth and development of mini watermelon in a protected environment.

K supplementation at 50% (S3) impaired the deleterious effect of salt stress on leaf area and stem dry mass.

The addition of 100% extra Ca alleviated salt stress and increased the fraction of photoassimilates for mini watermelon fruits.

Excessive K concentrations in saline nutrient solution modified the tolerance of

mini watermelon, cv. Sugar Baby, to salt stress.

7 ACKNOWLEDGMENTS

A PhD scholarship was awarded to the first author of CAPES, the Research Group on Irrigation and Plant Nutrition (IRRIGANUTRI) and the Postgraduate Program in Soil and Water Management at UFRSA for assistance in financing the research.

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