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THE FOLIAR APPLICATION OF SILICON ON THE PRODUCTION AGRICOLA OF MINI WATERMELON CV. SUGAR BABY CAUSE MITIGATING EFFECTS IN CULTIVATION UNDER OF WATER DEFICIT?

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ABSTRACT: The Plants in ambient conditions are subject to dealing with biotic and abiotic stresses. Water deficit, being an abiotic stress, causes changes in plants that make them respond in several ways, such as reduced growth, leaf senescence and lower fruit growth rate, production of Reactive Oxygen Species (ROS), caused by a deficiency in the dissipation of energy due to impaired photosynthesis. The application of silicon becomes an alternative to mitigate the effects of this stress on plants, being deposited in the cell wall, providing rigidity, and increasing the plant's defense enzymes. The study aimed to understand the morphological, physical, and post-harvest responses of mini watermelon according to different soil humidity associated with the foliar application of silicon. The study was conducted in a greenhouse using the mini watermelon cv. Sugar Baby. The experimental design was in randomized blocks, in a 3x2 factorial scheme, with three water tensions in the soil (-35 kPa without water deficit, -50 kPa moderate water deficit, and -65 KPa severe water deficit) and two doses of foliar Si (0 and 1.5 $g\ L^{-1}$), with four repetitions. The variables plant length, stem diameter and shoot dry mass, root dry mass, total soluble carbohydrates, proline, gas exchange, and post-harvest analyses were analyzed. There was a significant difference for the variables ($p>0.05$), but there was no interaction between tension and Si. Proline levels were not statistically significant. The water deficit promoted shorter plant length, aerial part dry mass, root dry mass and Si provided greater stem diameter. For biochemical variables, water deficit caused a higher carbohydrate content in the leaf and lower gas exchange rates. Si influenced skin thickness and average fruit weight. Thus, SI proves to be a strategy for cultivating mini watermelon in conditions of deficient water application.

KEYWORDS: sustainability, irrigation management, efficient use of water, plant nutrition, micronutrient

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INTRODUCTION

Plants under environmental conditions are subject to dealing with biotic and abiotic stress. Water deficit, being a possible abiotic stress, causes changes in plants that make them respond in several ways (SELEIMAN, et al., 2021). At a visual level, reduced growth, leaf senescence, and lower fruit growth rate (VOLSCHENK, 2021). And at the molecular level, where the plant produces Reactive Oxygen Species (ROS), caused by a deficiency in energy dissipation due to impaired photosynthesis (MILLER et al., 2010). Blum (2011) says that water deficit occurs when the water supply is less than the crop's demand. To mitigate the effects of water deficit on plants, an alternative is the use of silicon (Si), which, associated with water stress, provides a lower rate of transpiration, but at levels that do not affect cellular metabolism and rather help with the efficiency of water use. water through the plant (MAJUMDAR and PRAKASH, 2020). In addition to structural benefits such as deposition in the cell wall, providing rigidity, Si acts in conjunction with the antioxidant system, contributing to its increase and protecting the plant from oxidative stress (SHI et al., 2016).

The benefits of Si have been highlighted over the years, and despite not being considered essential, it has been recognized as a relevant nutrient for several crops, playing an important role in adverse situations that the plant may experience, such as biotic and abiotic stresses, which trigger morphological and physiological changes. Furthermore, another benefit is that nutrition with silicon can reduce the use of fungicides and pesticides (KOVÁCS et al., 2022). Epstein (1994) already said that Si is an anomalous element, due to its non-essentiality, however, when available to the plant, it presents advantages for it.

Watermelon *cv. Sugar Baby* (*Citrullus lanatus*) is a vegetable-fruit belonging to the cucurbitaceae family, which requires a large amount of water during its cycle. In the initial stages with 2 to 3 true leaves and when the first flowers and fruits appear, they consume around 170ml and 250ml of water per day, respectively in each phase (KHURRAMOVNA and OGLI, 2022). This vegetable-fruit is grown mainly in semi-arid regions around the world. Counting on the help of irrigation during times of greater water deficiency, its production is sustained (MELO et al., 2020). Thus, aiming to reduce the amount of water used and thinking about the scenario of water variations, this research aimed to understand the morphological, physical, and post-harvest responses of mini watermelon according to different soil humidity associated with the foliar application of silicon.

MATERIALS AND METHODS

The research was conducted in two cycles cultivating the watermelon *cv. Sugar Baby* (*Citrullus lanatus*) in a greenhouse located at (16º59'61"23 S e 49º27'99"06 W). The experimental unit consisted of cultivation in 3-liter pots, filled with soil samples with the following attributes: fertility;; pH= 5.3, P (Mehl)= 1.5 mg dm^{-3} , H + Al= 1.9 cmolc dm^{-3}, K= 77 mg dm^{-3}, Ca= 280 mg dm^{-3}, Mg= 60.75 mg dm^{-3}, matter organic: 1.2 , and cation exchange capacity (CEC)= 4.0 cmolc dm^{-3}; and physical composition of 43% sand, 15% de silt and 42% clay. After homogenizing the soil, sowing took place directly in the pots and the water deficit began when the plants reached the 3rd definitive leaf.

The experiment was designed in randomized blocks with treatments arranged in a 3 x 2 factorial scheme, corresponding to three water tensions in the soil: -35, -50 and -65 kPa and presence or absence of Si applied to the leaves: 0.0 (control) and 1.5 g L^{-1}. Irrigation was carried out by drip, starting when the soil water potential reached -35, -50 and -65 kPa and ending when the potential reached -15, -25 and -35 kPa respectively. Being maintained throughout the crop cycle.

Biometric analyzes were carried out based on the standardization of plants at the vegetative stage (30 Days After Emergence). Plant height was measured from the base of the plant to the apex of the main stem, using a tape measure, and the diameter of the stem was measured at the base of the plant using a manual caliper (BEZERRA, 2017). Other parameters such as dry mass of the aerial part (stem and leaves) and dry mass of the root were measured by collecting 3 plants from each plot, drying them in an oven at 65º C until constant mass (CAMPAGNOL et al., 2012).

The post-harvest analyzes carried out were number of fruits per plant (NFP); average fruit weight (AFW); shell thickness (ST); pulp thickness (PT); fruit length (FL) and diameter (FD), hydrogen potential (Ph) and Soluble Solids (BRIXº). The NFP was obtained by adding the number of fruits in each plot divided by the number of plants in the plot. The AFW was measured by weighing all the fruits individually on a digital scale, which were then added together and divided by the number of fruits harvested, Ribeiro (2015). The thickness of the peel comprises the region that goes from the epidermis to the transition zone of pulp color (white-red) and was measured with a manual caliper, as well as the thickness of the pulp from the transition zone (white-red) to the center of the fruit (SILVA, et al., 2017). The length and diameter were measured with a manual caliper, including measurements from the peduncle to the apex of the fruit and the middle part of the fruit (SILVA, et al., 2017). pH was measured following the Adolfo Lutz Institute methodology (1985). While Brix° was measured from watermelon juice in a digital refractometer (NRB-01, Next Instrumentos).

The data were subjected to Tukey mean test analysis at 5% probability using the AgroEstat® statistical software.

RESULTS AND DISCUSSION

Tables 1 and 2 present the results of the analysis of variance for the variables plant length, stem diameter, shoot dry mass (SDM) and root dry mass (RDM), respectively, for the first and second cycle. Table 3 presents the results of post-harvest analyses.

Tabela 1. ANOVA summary of the biometric variables of the first cycle, that is, plant length (m), stem diameter (mm), Shoot Dry Mass (SDM) and Root Dry Mass (MSR).

Treatment	Biometric Analyzes			
	Plant Lenght (m)	Stem Diameter (mm)	DM (g)	RDM (g)
Water tension in the soil (kPa)				
-35	2.32[a]	6.16[a]	73.91[a]	3.97[a]
-50	1.99[b]	5.86[a]	68.67[a]	2.92[b]
-65	2.00[b]	5.86[a]	38.98[b]	1.41[c]
F	6.94**	1.33ns	44.23**	38.41**
Doses of Si (g L $^{-1}$)				
0.0	1.86[b]	5.73[a]	56.45[b]	2.48[b]
1.5	2.35[a]	6.19[b]	64.59[a]	3.06[a]
F	33.96**	6.98*	6.20*	6.00**
Interaction kPa x Si				
F	1.43ns	2.28ns	3,49ns	0.26ns
Overall Average	2.10	5.96	60.52	2.77
CV	9.7	7.12	13.23	21.17

(*) Significant at 5% by F test; (**) significant at 1% by F test; (ns) not significant at 5% by F test. Values followed by different lowercase letters in the same column differ significantly at 0.05.

No significant effect was observed in the interaction of soil water tension and Si application on all biometric variables in both cultivation cycles. Length, shoot dry mass and root dry mass showed significant effects in the first cycle for water tension and Si demonstrated effects on all biometric parameters. In the second cycle, the analysis indicated significant effects of voltage variation on all biometric parameters, while the presence of silicon (Si) did not demonstrate any influence on these effects. It is observed that the growth in length was directly proportional to water availability. Furthermore, there was a significant increase in plant length when Si was applied, resulting in a percentage increase of 27.71% compared to plants without silicon.

For stem diameter, the significant effect was expressed in the treatment with Si application, in the first cycle, obtaining an increase of 8.02% in relation to the treatment without

Si application. In the second cycle, the variable that affected the increase in diameter was tension, with the -65 kPa tension being the one that resulted in the smallest diameter of the stem. That is, the presence of Si in the second cycle, possibly due to the accumulation of phytoliths along the cell wall, reduced the effect of water deficit. This fact was evidenced by Yan et al. (2021) and Lux et al., (2020) who confirmed the deposition of Si throughout the endodermis of the rice root, consequently the water deficit led to the accumulation of Si in the endodermis and cell wall as a response to the stress suffered by the plant.

Tabela 2. ANOVA summary of the biometric variables of the first cycle, that is, plant length (m), stem diameter (mm), Shoot Dry Mass (SDM) and Root Dry Mass (MSR).

Treatment	Biometric Analyzes			
	Plant Lenght (m)	Stem Diameter (mm)	DM (g)	RDM (g)
Water tension in the soil (kPa)				
-35	1.44^{a}	5.85^{a}	54.39^{a}	1.20^{a}
-50	1.29^{a}	5.47^{a}	51.35^{a}	1.00
-65	0.95^{b}	4.18^{b}	27.11^{b}	0.81
F	11.50**	47.08**	38.81**	5.41*
Doses of Si (g L $^{-1}$)				
0.0	1.14^{a}	5.02^{a}	41.51^{a}	1.04^{a}
1.5	1.31^{a}	5.31^{a}	47.06^{a}	0.97^{a}
F	4.21^{ns}	3.59^{ns}	4.01^{ns}	0.54^{ns}
Interaction kPa x Si				
F	0.11^{ns}	1.09^{ns}	0.72^{ns}	1,60
Overall Average	1.22	5.17	44.29	1,00
CV	17.03	6.95	15.32	23,64^{ns}

(*) Significant at 5% by F test; (**) significant at 1% by F test; (ns) not significant at 5% by F test. Values followed by different lowercase letters in the same column differ significantly at 0.05.

Tabela 3. ANOVA summary of the postharvest parameters, number of fruits per plant (NFP), average fruit weight (AFW), shell thickness (ST); pulp thickness (PT); fruit length (FL) and diameter (FD), hydrogen potential (Ph) and Soluble Solids (BRIXº) and e texture (Text).

Treatment	Postharvest Parameters								
	NFP	PMF	EC	EP	CF	DF	pH	Brixº	Text
Water tension in the soil (kPa)									
-35	2.25^{a}	0.40^{a}	6.20^{a}	41.08^{a}	94.50^{a}	99.67^{a}	6.88^{a}	6.81^{a}	12.14^{a}
-50	2.25^{a}	0.21^{b}	4.45^{b}	31.84^{b}	69.58^{b}	76.09^{b}	6.56^{ab}	6.20^{a}	9.87^{a}
-65	2.12^{a}	0.15^{c}	5.62^{ab}	30.09^{b}	68.67^{b}	77.92^{b}	6.33^{b}	4.96^{b}	10.92^{a}
F	0.05^{ns}	82.79**	4.77*	9.27**	53.92**	21.18**	5.37*	19.39**	2.99^{ns}
Doses of Si (g L $^{-1}$)									
0.0	2.33^{a}	0.23^{b}	4.80^{b}	33.83^{a}	76.27^{a}	84.02^{a}	6.55^{a}	6.06^{a}	11.17^{a}
1.5	2.08^{a}	0.28^{a}	6.04^{a}	35.38^{a}	78.89^{a}	85.10^{a}	6.53^{a}	5.92^{a}	10.78^{a}
F	0.41^{ns}	10.85**	6.80*	0.53^{ns}	1.29^{ns}	0.11^{ns}	0.88^{ns}	0.34^{ns}	0.25^{ns}
Interaction kPa x Si									
F	0.14^{ns}	0.03^{ns}	5.26*	0.16^{ns}	1.74^{ns}	0.19^{ns}	0.25^{ns}	3.37 ^{ns}	0.08^{ns}
Overall Average	2.20	0.25	5.42	34.60	77.58	84.56	6.59	5.99	10.98
CV (%)	43.42	15.70	18.47	13.07	7.27	9.53	4.41	8.74	16.91

CV (%) 43.42 15.70 18.47 13.07 7.27 9.53 4.41 8.74 16.91

(*) Significant at 5% by F test; (**) significant at 1% by F test; (ns) not significant at 5% by F test. Values followed by different lowercase letters in the same column differ significantly at 0.05.

The dry weight of the shoot was influenced by tension, showing that the increase in water deficit resulted in a reduction in the dry weight of the shoot. Plants with the application of silicon (Si) had a significant increase of 14.40% in dry weight, compared to plants without Si, in the first cycle. Si treatments were shown to significantly attenuate the reduction in MSPA and MSR loss in response to the increase in water deficit.

Average fruit weight reduced significantly in response to the deficit, compared to the control treatment (-35 kPa). The same happened for the Si dose, where the dose influenced the average weight, increasing the value at a dose of 1.5 g L^{-1}. For the average values of shell thickness, there was an interaction between tension and Si dose. The availability of water provided a higher value of shell thickness at a tension of -65 kPa with Si application, but the deficit treatment was equivalent to the treatment control.

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The deficit reduced the accumulation of this element in the aerial part of the plants, but treatments containing Si were shown to attenuate the effects of water deficit. Si influenced PMF and EC, these factors were probably affected by the addition of phytoliths, as was the case with the increase in stem diameter.

CONCLUSIONS

The water tension in the soil affects plant development and the quality of watermelon *cv. Sugar Baby* (*Citrullus lanatus*) fruits.

The application of silicon promotes beneficial effects due to lack of water during cultivation.

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