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Morphological Behavior of Green Onion (*Allium fistulosum* L.) Irrigated with Saline Water in a Protected Environment

Comportamento Morfológico da Cebolinha Verde (*Allium fistulosum* L.) Irrigada com Água Salina em Ambiente Protegido

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ABSTRACT - To elucidate the tolerance of green onion to high salinity, this study aimed to evaluate the effect of the application of saline water on the irrigation of green onion grown in a protected environment in the Agreste de Alagoas region. The experiment was developed in a protected environment at the Federal University of Alagoas - Arapiraca Campus. The experimental design was entirely randomized, and the treatments were composed of five irrigation blades: one level of salinity and four repetitions. Irrigation occurred daily via drainage lysimeters. Two cultivation cycles of 30 days each were carried out. At the end of each cycle, the following parameters were analyzed: plant height (PH), number of tillers (NT), root length (RT), fresh mass of the aerial part (FMAP), dry mass of the aerial part (DMAP), fresh mass of the root (FMR) and dry mass of the root (DMR). The data were subjected to analysis of variance (ANOVA) via SISVAR 5.6. A statistically significant difference was found, and the Tukey test was applied ($p < 0.05$). In the first cycle, the variables PH, FMAP and DMR had significant effects on the number of irrigation slides. In the second cycle, only the PH was significant, highlighting the influence of saline irrigation on the increase in this variable. Thus, in both cycles, the PH was the only variable with a significant effect on the number of saline irrigation blades. FMAP and DMR were influenced by the saline water used. Saline irrigation is an alternative for the management of green onion in a protected environment under the conditions of Agreste in the state of Alagoas.

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Keywords: Saline irrigation. Water quality. Salinity stress. Water management.

RESUMO - Visando preencher lacunas no entendimento sobre a tolerância da cebolinha verde à salinidade elevada, o presente estudo objetivou avaliar o efeito da aplicação de água salina na irrigação da cebolinha verde cultivada em ambiente protegido na região Agreste de Alagoas. O experimento foi desenvolvido em ambiente protegido na Universidade Federal de Alagoas – Campus Arapiraca. O delineamento experimental foi inteiramente casualizado e os tratamentos foram compostos por cinco lâminas de irrigação; um nível de salinidade e quatro repetições. A irrigação ocorreu diariamente com base nos lisímetros de drenagem. Realizaram-se dois ciclos de cultivo, de 30 dias cada. Ao final dos ciclos, foram analisadas: Altura de planta (AP); Número de perfilhos (NP); Comprimento da raiz (CR); Massa fresca da parte aérea (MFPA); Massa seca da parte aérea (MSPA); Massa fresca da raiz (MFR) e Massa seca da raiz (MSR). Os dados foram submetidos à análise de variância ANOVA, utilizando o SISVAR 5.6, constatada diferença estatística significativa, aplicou-se o teste de Tukey ($p < 0,05$). No primeiro ciclo, as variáveis AP, MFPA e MSR apresentaram efeito significativo às lâminas de irrigação. No segundo ciclo, apenas an AP foi significativa, destacando an influência da irrigação salina no incremento desta variável. Assim, nos dois ciclos a AP foi a única variável com efeito significativo às lâminas de irrigação salina. A MFPA e a MSR tiveram influência da água salina utilizada. A irrigação salina é uma alternativa para o manejo da cebolinha verde em ambiente protegido, nas condições de Agreste do estado de Alagoas.

Palavras-chave: Irrigação salina, Qualidade da água, Estresse salino, Manejo da água.

INTRODUCTION

Green onion (*Allium fistulosum* L.) is an important member of the Amaryllidaceae family (KIM et al., 2023) and is a perennial species originating from East Asia (WANG et al., 2023). This crop has antioxidant and antibacterial properties (WANG et al., 2020) and is highly productive in the state of Alagoas (SILVA et al., 2014); however, the cultivation of this vegetable in the region is limited by the poor quality of irrigation water (SILVA et al., 2017a).

In the production process of this vegetable, constant irrigation is needed, and it is necessary to consider the quality of the water applied (SILVA et al., 2020a), as well as the cultivation environment. In this context, irrigation has emerged as a tool that enables an increase in productivity, especially in regions with water scarcity (SILVA et al., 2021), whereas protected cultivation stands out as a technique that allows the creation of microclimates prone to the establishment and development of crops, causing less interference from external factors in these production systems (SILVA et al., 2022).

In irrigation, water salinity is one of the main environmental stresses that impacts plant metabolism (GOES et al., 2021). In Northeast China, the increase in demand for irrigation has led to the use of most water sources; thus, producers use water with different salinity levels at some stage

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of the crop production process (SOUSA et al., 2021), highlighting the need for studies that evaluate the impacts of saline irrigation on plant development.

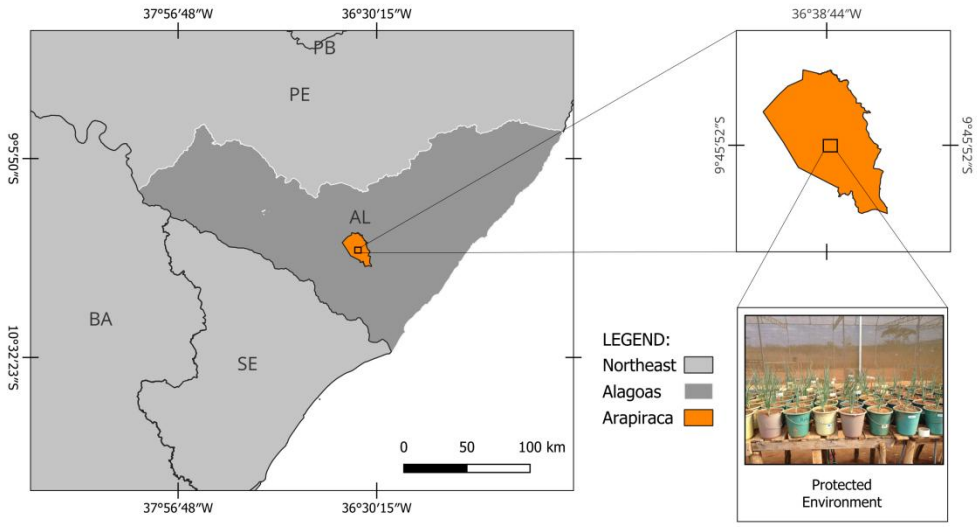
Taking into account the quality of the water used in the production process, this study seeks to fill gaps in the understanding of the tolerance of green onion to high levels of salinity. Thus, with the importance of culture, especially for the state of Alagoas, the results will have direct implications for agricultural production, aiming to increase productively under adverse conditions.

Therefore, the present study aimed to evaluate the effect of the application of saltwater on the irrigation of green onion (*Allium fistulosum* L.) grown in a protected environment in the Agreste region of Alagoas.

MATERIAL AND METHODS

The experiment was developed in a protected environment at the Federal University of Alagoas - Arapiraca Campus, located in the municipality of Arapiraca - Alagoas (Figure 1), with the following coordinates: 9° 41’ 56” south latitude and 36° 41’ 08” west longitude, with an altitude of 246 m.

Figure 1. Location of the experiment in a protected environment.



Source: Authors, 2024.

Twenty-five (25) plastic containers with a capacity of 3 liters were used for the experiment and were arranged on a wooden structure. Five of these 25 containers were used to make the lysimeters — an instrument used in the measurement of reference evapotranspiration (RET) and crop (CET).

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The soil used in the experiment was classified as Red Argissol (SANTOS et al., 2018) and presented the following chemical characteristics (Table 1). NPK fertilization was carried out on the basis of the recommendation for culture before the vegetables were transplanted into each container.

Table 1. Chemical characterization of the soil used in the experiment.

pH	O.M	P	K	Ca	Mg	Al	H+Al	V
(H_2O)	(%)	(mg dm^{-3})			(cmol dm^{-3})			(%)
5.6	1.07	11	109	1.4	0.8	0.09	1.2	67.8

V - saturation by bases.

Source: Alves et al. (2023).

The experimental design used was entirely randomized (DIC), and the treatments were composed of five irrigation blades: L1, 50%; L2, 75%; L3, 100%; L4, 125%; and L5, 150%; and a level of salinity (100% well water + salt addition = 4.10 dS m-1) and four repetitions, totaling 20 plots.

Green onion seedlings from producers in the region were used and transplanted into moist soil. Irrigation occurred daily on the basis of existing drainage lysymeters in the protected environment via the SLIMCAP application (SANTOS, 2018). The plants were subsequently evaluated and harvested 30 days after the treatments were applied. Two cultivation cycles were carried out, each lasting 30 days.

At the end of each cycle, the following quantitative variables were analyzed: plant height (PH), number of tillers (NT), root length (RL), fresh mass of the aerial part (FMAP), dry mass of the aerial part (DMAP), fresh mass of the root (FMR) and dry mass of the root (DMR).

The data were subjected to ANOVA at the 5% probability level via the statistical software SISVAR 5.6 (FERREIRA, 2011). If a statistically significant difference was found between treatments, the Tukey test ($p < 0.05$) was applied.

RESULTS AND DISCUSSION

Table 2 displays the values of the average squares for the first cycle of the crop. For this cycle, the variables PH, FAMP and DRM were significant at the 5% probability level ($p < 0.05$). That is, the salinity of the water had a positive effect on these variables but did not influence the other variables (Table 3). This contributes to the use of the saline water resources available in the region, which constitute a management alternative for the culture studied.

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Table 2. Average square values for the variables in the first cycle of the culture.

	Average Square Values							
	DF	PH	NT	RL	FMAP	DMAP	FMR	DMR
Blades	4	23.50*	21.93^{NS}	95.38^{NS}	61.83*	11.25^{NS}	12.20^{NS}	0.55*
Residue	15	7.27	12.08	34.03	21.55	4.53	7.72	0.18
Total	19							

DF - Degree of freedom * significant at 5% probability and ^{NS} - not significant

Source: Authors, 2024.

Table 3. Average of the variables in the first cycle of the culture.

Variables				
Blades	NT	RL	FMR	DMAP
(%)	(unit)	(cm)	(g)	
50	11.50 a	20.75 a	1.75 a	7.25 a
75	15.25 a	32.00 a	4.75 a	9.25 a
100	16.25 a	33.00 a	5.25 a	6.25 a
125	12.75 a	28.75 a	4.50 a	4.75 a
150	17.00 a	30.50 a	6.25 a	8.25 a

Averages followed by the same letter do not differ from each other at the 5% probability level. Source: Authors, 2024.

Figure 2 shows the increase in the PH and FAMP of the plants subjected to saline irrigation. The slopes of 75--150% of the samples were statistically similar in terms of these two variables. However, the largest blade is recommended because it maximizes the height of the plant and the amount of fresh mass in the aerial part of the green onion.

This highlights that the use of water with high salt contents in a protected environment can be an alternative for the development of specific variables of green onion culture. The equation that was best adjusted was the polynomial, with R^2 values ranging from 0.64--0.76.

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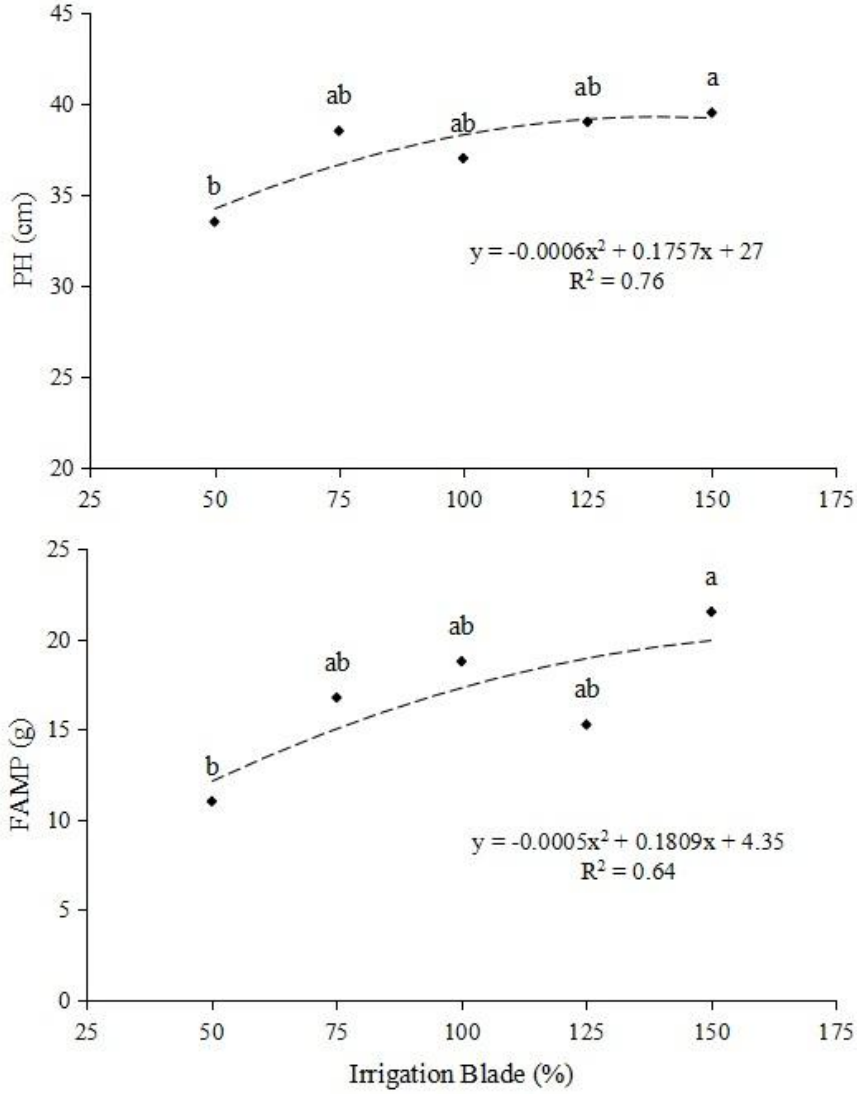
Figure 2. Increase in the PH and FAMP of plants subjected to saline irrigation.



Source: Authors, 2024.

Studies in a protected environment using saline irrigation blades in a green onion culture point to the results verified in the present study, such as those of Silva et al. (2020b), who reported an increase in plant height and fresh mass of the aerial part at the highest levels of water in the soil. França et al. (2020), studying the response of vegetables in a protected environment with saline water management, reported similar behavior, where the greatest development in terms of plant height was associated with the tallest blade (150%).

The results obtained in this study highlight the influence of saline water management on the development of crops with regional appeal, showing how the proper use of water with

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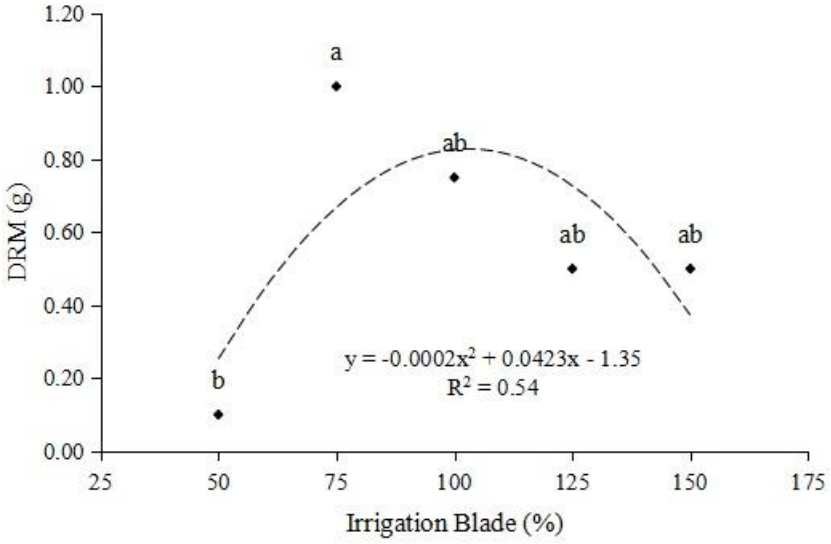
high levels of salt can be an alternative for the expansion of these crops. Notably, the height of the plant together with the fresh mass of the aerial part are the marketable parts of the green onion; thus, the use of elevated salt irrigation blades in a protected environment enhances the increase in these variables, reflecting the contribution to marketing.

Figure 3 shows the increment of the DRM variable subjected to saline irrigation. Notably, statistically, the 75--150% of the slides were similar. However, unlike the previous variables, the 75% blade had the best behavior. That is, the application of an intermediate salt level was sufficient to obtain a greater dry mass of the root. The slides above this level presented a decrease in this variable. This behavior is possibly explained by the greater concentration of salts in the higher blades, which results in greater absorption by the culture. This absorption can inhibit root growth, reflecting a decrease in DRM, as shown in Table 3, where the highest number of slides (125 and 150%) inhibited this variable.

Figure 3. Increase in DMR subjected to saline irrigation blades.



Source: Authors, 2024.

Moreira Neto et al. (2021), studying saline irrigation in vegetables, reported that high concentrations of salts in water contribute to a reduction in the dry mass of the root. Similarly, Silva et al. (2017b) reported that saline stress caused a reduction in this variable in basic culture. These results corroborate those obtained in the present study.

Table 4 displays the values of the average squares for the second cycle of the crop. In this cycle, only the PH variable was significant at the 5% probability level ($p < 0.05$). This highlights the influence of saline irrigation on the increase in the variables mentioned above. This result contributes to the development of management focused on the use of water with high salt contents, which is an alternative for regions with a lack of adequate water resources

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for the cultivation of green onion. Similar results were reported by Silva et al. (2020b), who verified the significance of plant height in plants irrigated with saltwater during two cultivation cycles. The other variables analyzed were not significant (Table 5); that is, saline irrigation in this cycle did not influence these variables.

Table 4. Average square values for the variables in the second cycle of the culture.

	Average Square Values							
	DF	PH	NT	RL	FMAP	DMAP	FMR	DMR
Blades	4	42.83*	10.08^{NS}	1.88^{NS}	26.45^{NS}	5.20^{NS}	0.20^{NS}	0.33^{NS}
Residue	15	10.7	22.1	5.37	25.6	3.18	0.52	0.23
Total	19							

DF - Degree of freedom * significant at 5% probability and ^{NS} - not significant

Source: Authors, 2024.

Table 5. Average of the variables in the second cycle of the culture.

		Variables				
Blades	NT	RL	FMAP	DMAP	FMR	DMR
(%)	(unit)	(cm)		(g)		
50	14 a	24 a	13.25 a	3.50 a	1.50 a	0.50 a
75	13 a	24.50 a	13.25 a	3.00 a	1.50 a	0.10 a
100	15 a	23.75 a	14.75 a	4.00 a	1.50 a	0.50 a
125	12.25 a	24.75 a	14.75 a	4.25 a	1.75 a	0.25 a
150	16.25 a	23.00 a	19.50 a	6.00 a	2.00 a	0.75 a

Source: Authors, 2024.

Figure 4 shows the increment of the PH variable in the second cultivation cycle subjected to saline irrigation blades. This variable showed behavior similar to that observed in the first cycle, with the slides of 75--150% showing similarity, statistically, the latter being the one that had the best performance.

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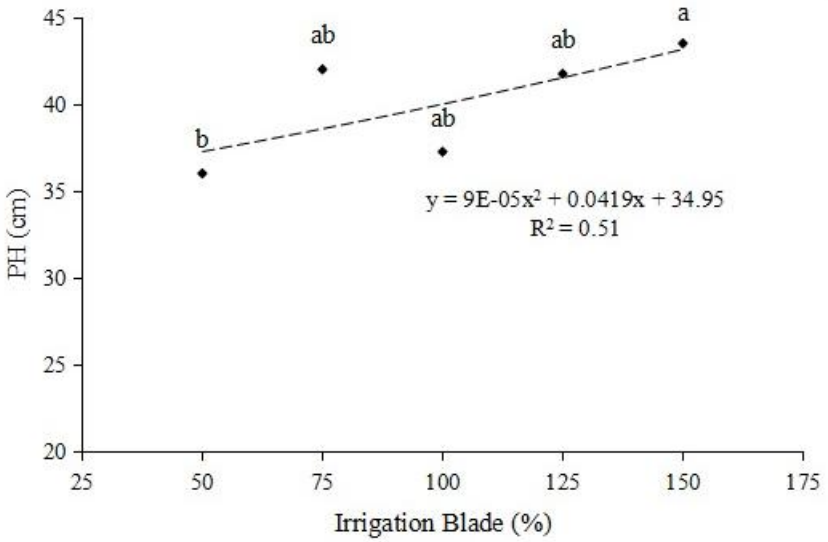
Figure 4. The PH increased during the second cycle when the plants were subjected to saline irrigation.



Source: Authors, 2024.

The equation that had the best fit was the polynomial, with $R^2 = 0.51$. Similar results were reported by Santos et al. (2020) in studies with green onion irrigated with saline water, where the plant height variable was significant for the irrigation blade. The results obtained in this study allow us to identify greater salt irrigation blades for green onion growing in a protected environment, which is a management technique that allows an increase in important variables in this crop, from a commercial point of view.

CONCLUSIONS

For the two cultivation cycles, plant height (PH) was the only variable with a significant effect on the number of saline irrigation blades.

The FAMP and DRM variables were influenced by the saline water used.

Saline irrigation is an alternative for the management of green chives in a protected environment under the conditions of Agreste in Alagoas.

The authors suggest conducting new studies to verify the ideal irrigation blade between the intervals of 75 and 150% of the CET to determine if there is a point of maximum development of green onion in a protected environment.

CONFLICT OF INTEREST

The authors declare that the work has no conflict of interest.

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