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Gas exchange and growth of zucchini crop subjected to salt and water stress[1]

Trocas gasosas e crescimento da cultura da abobrinha submetida aos estresses salino e hídrico

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HIGHLIGHTS:

The combination of salt and water stresses increased the accumulation of CO_2 in the leaf mesophyll of zucchini cv. Caserta.
Photosynthesis and water use efficiency were affected by salinity, but to a lesser degree under 100% irrigation depth.
Irrigation with water of electrical conductivity above 1 dS m^{-1} negatively affected gas exchange and zucchini crop growth.

ABSTRACT: Semi-arid regions present the inherent problem of accumulation of salts in the soil due to the use of brackish water for irrigation, and water deficit compromises the growth and physiological indices of crops. This study evaluated the effect of salt and water stress on growth and gas exchange in the zucchini cv. Caserta crop. The study was conducted at the University of International Integration of Afro-Brazilian Lusophony, Redenção, Ceará State, Brazil. The experimental design was completely randomized, in a 5 × 2 factorial scheme with five levels of electrical conductivity of the irrigation water - ECw (0.5, 1.0, 1.5, 2.0, and 2.5 dS m^{-1}) and two water regimes (50 and 100% of the potential crop evapotranspiration - ETc), with five replicates. At 36 days after sowing, the following traits were evaluated: CO_2 assimilation rate, transpiration, stomatal conductance, internal carbon concentration, leaf temperature, relative chlorophyll index, and water use efficiency. At 45 days after sowing, the plant height, stem diameter, number of leaves, and leaf area were also evaluated. The use of brackish water (1 to 2.5 dS m^{-1}) reduced the growth parameters of zucchini cv. Caserta. The increase in ECw caused a decline in the physiological traits. Under 100% ETc, higher values of CO_2 assimilation rate, transpiration, and instantaneous water use efficiency were recorded, and there was 50% ETc for internal carbon concentration, even with the increase in ECw.

Key words: *Cucurbita pepo* L., water deficit, salinity, combined stress

RESUMO: A região semiárida apresenta o problema inerente de acúmulo de sais no solo devido ao uso de irrigação com água salobra, e o déficit hídrico que compromete o crescimento e os índices fisiológicos das culturas. Objetivou-se com este trabalho avaliar o efeito do estresse salino e hídrico no crescimento e nas trocas gasosas da cultura da abobrinha cv. Caserta. O trabalho foi realizado em área pertencente à Universidade da Integração Internacional da Lusofonia Afro-Brasileira, Redenção, Ceará, Brasil. O delineamento experimental utilizado foi inteiramente casualizado, em esquema fatorial 5 × 2 com cinco níveis de condutividade elétrica da água de irrigação - CEa (0,5, 1,0, 1,5, 2,0 e 2,5 dS m^{-1}), e dois regimes hídricos (50 e 100% da evapotranspiração potencial da cultura - ETc) com cinco repetições. Aos 36 dias após a semeadura foram avaliadas as variaveis:taxa de assimilação de CO_2, transpiração, condutância estomática, concentração interna de carbono, temperatura foliar, índice relativo de clorofila e a eficiência do uso da água. Aos 45 dias após a semeadura, foram avaliadas as seguintes variáveis: altura da planta, diâmetro do caule, número de folhas e área foliar. O uso de água salobra (1 a 2,5 dS m^{-1}) reduz os parâmetros de crescimento da abobrinha cv. Caserta. O aumento da CEa ocasionou redução nas variáveis fisiológicas. A lâmina de 100% proporcionou maiores valores para as variáveis taxa de assimilação de CO_2, transpiração, e eficiência instantânea no uso da água, e a lâmina de 50% para concentração interna de carbono, com o aumento da CEa.

Palavras-chave: *Cucurbita pepo* L., déficit hídrico, salinidade, estresse combinado

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Introduction

In the Northeast region of Brazil, as in other arid and semi-arid regions of the world, due to its peculiar edaphoclimatic conditions, presenting water deficit in most of the year, it is necessary to use brackish water, but the presence of excess salts in water and the soil, together with water deficit constitutes an obstacle for the agricultural production systems in this region (Ashraf et al., 2017; Costa et al., 2021; Goes et al., 2021).

Salt stress affects the physiological functions of plants, the outcome of a decrease in osmotic potential of the soil solution due to its effect on water retention, thus becoming less and less available for the plant (Sousa et al., 2019). This causes stomatal closure which helps in preventing excessive loss of water, also resulting in a limitation in the internal concentration of CO_2 and in the photosynthetic process (Sousa et al., 2021).

Associated with the problem of salts in the irrigation water, the semi-arid regions are also affected by the occurrence of long periods of drought (inducing water stress), and during the non-rainy period, the use of brackish water sources intensifies the decrease in morphophysiology and water availability for plants (Schmidt et al., 2017). Studies involving water and salinity stress already show satisfactory results. Pereira Filho et al. (2019) reported positive results in gas exchange and water use efficiency in fava bean.

Zucchini, also known as Italian zucchini, is a plant of the Cucurbitaceae family that originated in Mexico. In Brazil, the Caserta cultivar of North American origin stands out, due to its high productivity, making it very important in the horticultural economy, coupled with its fast financial return (Castellanos-Morales et al., 2019; Souza et al., 2020). It is noteworthy that the crop has a water salinity threshold of 3.1 dS m^{-1} (Ayers & Westcot, 1999).

The aim of this study was to evaluate the effect of salt and water stress on gas exchange and growth in the zucchini cv. Caserta crop.

Material and Methods

This study was carried out between October and November 2019 at the Auroras Seedling Production Unit (UPMA), belonging to the University of International Integration of Afro-Brazilian Lusophony (UNILAB) in Redenção, in the state of Ceará, Brazil (latitude of 04º13'05"S, and longitude of 38º2'46"W, with an average altitude of 96 m). The climate of the region is of the BSh' type, as very hot temperature and rains prevail in the summer and autumn seasons (Alvares et al., 2013). Figure 1 presents the meteorological data obtained during the experiment.

The experimental design used was completely randomized, in a 5 × 2 factorial scheme with five levels of electrical conductivity of the irrigation water (ECw: 0.5, 1.0, 1.5, 2.0, and 2.5 dS m^{-1}) and two irrigation depths (50 and 100% of the crop evapotranspiration - ETc), with five replicates.

The seeds of zucchini (*Cucurbita pepo* L.) Caserta hybrid (Topseed Premium® - AGRISTAR, Santo Antônio de Posse, Brazil) used are characterized by having a determined growth in the form of a thicket. It has large yellow flowers, its fruits have a cylindrical shape, with a smooth, light green skin and dark green stripes. Fruit production is uniform and with an excellent standard of size and weight for the market. The sowing was performed in polyethylene trays (200 cells) containing the substrate stated in Table 1, with one seed in each cell.

At 10 days after sowing (DAS), the seedlings were transplanted into plastic pots with 25 L capacity, adapted as drainage lysimeter, filled with substrate consisting of sand, sandy soil, and bovine manure in the proportion of 5:4:1 (v/v), respectively whose chemical analysis was performed in a laboratory belonging to the Federal University of Ceará (UFC), shown in Table 1 according to the methodology of Teixeira et al. (2017).

The saline water solutions (ECw - 1.0, 1.5, 2.0, and 2.5 dS m^{-1}) were prepared by dissolving NaCl, $CaCl_2.2H_2O$, and $MgCl_2.6H_2O$, in the equivalent proportion of 7:2:1, respectively, simulating the average composition of irrigation water in northeast Brazil (Medeiros, 1992), using the supply water (ECw=0.5 dS m^{-1} – control) of the experimental area, following the relationship between ECw and its concentration - sum of cations ($mmol_c$ L^{-1} = EC × 10), according to Richards (1954).

The daily estimate of reference evapotranspiration (ETo) was calculated by the water balance, following the principle of the drainage lysimeter (Bernardo et al., 2019), according to Eq. 1.

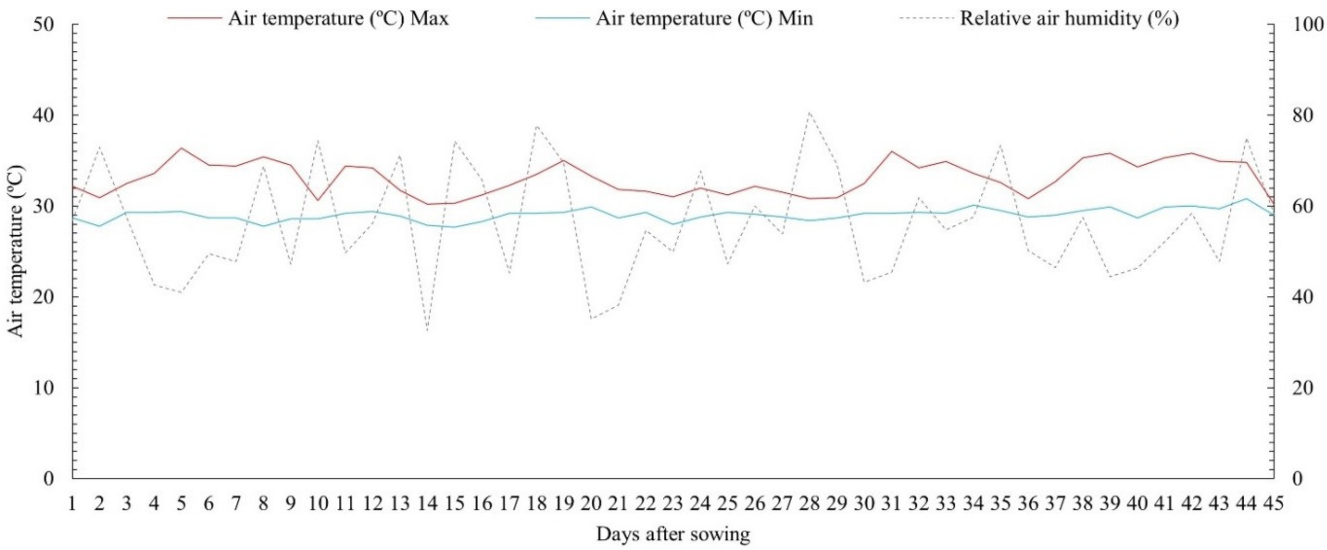


Figure 1. Mean values of temperature and relative air humidity during the experimental period

Table 1. Chemical and physical characteristics of the substrate used in this study

Chemical attributes	Unit	Values
pH (H_2O)		6.6
OM[1]	g kg^{-1}	14.60
Ca	$cmol_c$ dm^{-3}	4.5
Mg	$cmol_c$ dm^{-3}	0.7
Na	$cmol_c$ dm^{-3}	0.67
Al	$cmol_c$ dm^{-3}	0.15
H + Al	$cmol_c$ dm^{-3}	1.49
K	$cmol_c$ dm^{-3}	0.78
ECse[2]	dS m^{-1}	0.09
ESP[3]	%	8
N	g kg^{-1}	0.93
C	g kg^{-1}	8.46
P	mg kg^{-1}	27
V[4]	%	82
C/N		9
Physical atributes		
Coarse sand	g kg^{-1}	665
Fine sand	g kg^{-1}	201
Silt	g kg^{-1}	92
Clay	g kg^{-1}	42
Soil density – Bulk	kg dm^{-3}	1.47
Soil density – Particle	kg dm^{-3}	2.76
Textural Classification		Loamy Sand

[1]OM - Organic matter; [2]ECse - Electrical conductivity of the soil saturation extract; [3]ESP - Percentage of exchangeable sodium; [4]V - Base saturation

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

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 0.15;

From ETo, the crop evapotranspiration (ETc) was estimated in relation to the crop coefficient (Kc) using Eq. 2. The crop coefficients used were 0.4 (11 - 21 DAS) and 0.65 (22 - 45 DAS) (Martim et al., 2018). The irrigation interval used was two days.

$$ETc = ETo \times Kc \quad (2)$$

where:

ETc - evapotranspiration of crop (mm);

ETo - reference evapotranspiration of water balance (mm); and,

Kc - Crop coefficients.

At 36 DAS the following physiological traits were evaluated: CO_2 assimilation rate (A, μmol CO_2 m^{-2} s^{-1}), stomatal conductance (gs, mol m^{-1} s^{-1}), transpiration (E, mmol m^{-2} s^{-1}), internal carbon concentration (Ci, μmol CO_2 mol^{-1}), instantaneous water use efficiency (WUEi - through the ratio between A/E, [μmol CO_2 m^{-2} s^{-1} (μmolm^{-2} s^{-1})$^{-1}$]), and leaf temperature (LT, °C) an artificial radiation source of 1,200 μmol m^{-2} s^{-1} was focused on fully expanded intermediate leaves of each plant through an IRGA - Infrared Gas Analyzer (LI 6400 XT from LICOR). The measurements were made in an open system with an airflow of 300 mL min^{-1} between 9:00 and 11:00 hours under natural conditions of air temperature and CO_2 concentration. Relative chlorophyll index (RCI, SPAD) measurements were performed on the same leaves with a portable meter (SPAD - 502 Plus, Minolta, Japan).

At 45 DAS, the following biometric variables were evaluated: plant height (PH, cm) measured from the base to the apex of the plant with a graduated ruler, stem diameter (SD, mm) was measured 2 cm above the substrate with a digital caliper, number of leaves (NL) by direct counting of fully expanded leaves and leaf area (LA, cm^2) using an area integrator (Area meter, LI-3100, Li-Cor, Inc. Lincoln, NE, USA).

In order to assess normality, data obtained were submitted to the Kolmogorov-Smirnov test ($p \leq 0.05$). After checking normality, data were subjected to analysis of variance using the F test. In cases of significance, for ECw or interaction, regression analysis was performed, while the water regime data were submitted to the Tukey test ($p \leq 0.05$), using the Assistat software 7.7 Beta (Silva & Azevedo, 2016).

Results and Discussion

According to Table 2, the variables stomatal conductance, relative chlorophyll index, and leaf temperature were influenced only by the ECw factor, while the irrigation depths factor did not significantly influence any variable. The interaction of factors was significant for the variables CO_2 assimilation rate, transpiration, internal carbon concentration, and water use efficiency.

The increase in the ECw decreased the CO_2 assimilation rate (A) independent of the applied irrigation depth. Based on the regression equation, for a unit ECw increase, there was

Table 2. Summary of analysis of variance for CO_2 assimilation rate (A), transpiration (E), stomatal conductance (gs), relative chlorophyll index (RCI), internal carbon concentration (Ci), instantaneous water use efficiency (WUEi), and leaf temperature (LT) in zucchini plants under different electrical conductivity of water (ECw) and irrigation depths (ID)

Source of variation	DF	Mean square						
		A	E	gs	RCI	Ci	WUEi	LT
ECw	4	14.85**	2.72*	0.009*	22.57*	177.66*	0.05*	1.87**
Linear regression	1	35.20**	8.10**	0.014*	80.38*	33.75*	0.35**	6.69*
Quadratic regression	1	22.19^{ns}	2.52*	0.013*	0.12^{ns}	264.29^{ns}	0.29*	0.03^{ns}
ID	1	0.33^{ns}	0.02^{ns}	0.001^{ns}	13.50^{ns}	218.70^{ns}	0.05^{ns}	0.0009^{ns}
ECw × ID	4	22.45**	2.95*	0.004^{ns}	9.85^{ns}	749.53*	0.35**	0.14^{ns}
Residue	50	3.15	0.36	0.002	12.98	188.10	0.05	0.24
CV (%)		18.04	13.08	27.21	11.79	5.07	10.75	1.35

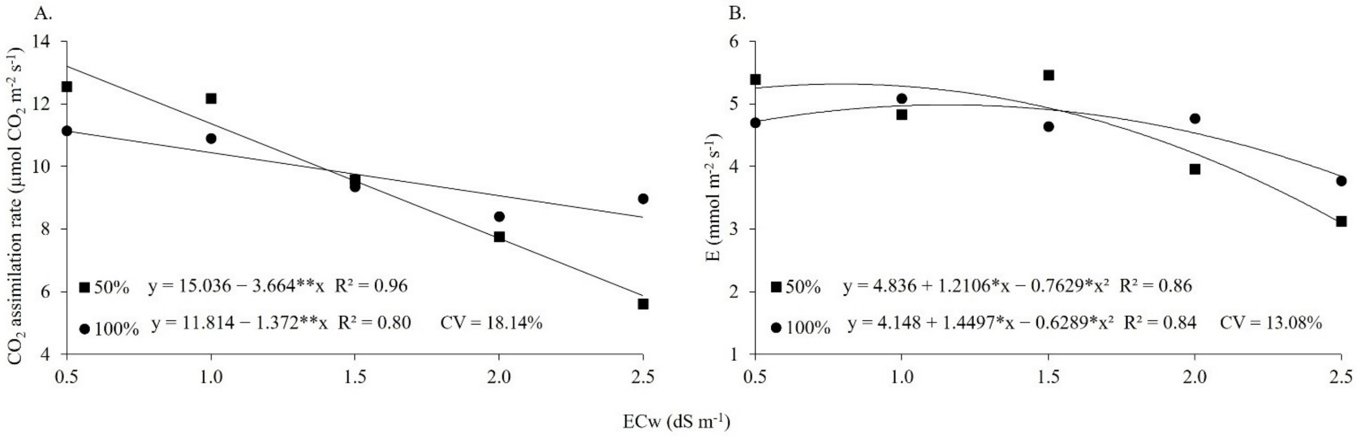
DF - Degrees of freedom; CV - Coefficient of variation; *; **, ns - Significant at $p \leq 0.05$ and $p \leq 0.01$, and not significant, respectively, by F test a reduction of 24.36 and 11.61% in the treatments at 50 and 100% ETc, respectively (Figure 2A). The deposition of salts reduced the photosynthetic rate due to osmotic effects, toxicity in the metabolism caused by ions, and partial closure of the stomata (Prazeres et al., 2015), but the 100% irrigation depth from the saline level of 1,5 dS m^{-1}, possibly provided a greater displacement of salts from the soil surface, causing greater leaching in the root zone (Ferreira et al., 2006). Consequently, a higher CO_2 assimilation rate was observed, compared to the 50% irrigation depth.

Studies corroborating this result were described by Costa et al. (2019) when a 42.5% reduction in photosynthetic rate in the zucchini crop was observed (ECw of 2.6 dS m^{-1}) compared to the control treatment (ECw of 0.8 dS m^{-1}), and Pereira Filho et al. (2019) who found that saline stress associated with 50% ETc reduced the photosynthetic rate of bean crop by 44.25% in relation to 100% ETc.

The increase in irrigation water salinity also negatively affected the transpiration of zucchini plants, but with lesser intensity at the 100% ETc depth. Data obtained were best adjusted to the quadratic model. According to the equations, the highest rates revealed were 5.31 and 4.98 mmol m^{-2} s^{-1} in plants irrigated with ECw 0.79 and 1.15 dS m^{-1} under 50 and 100% ETc, respectively (Figure 2B).

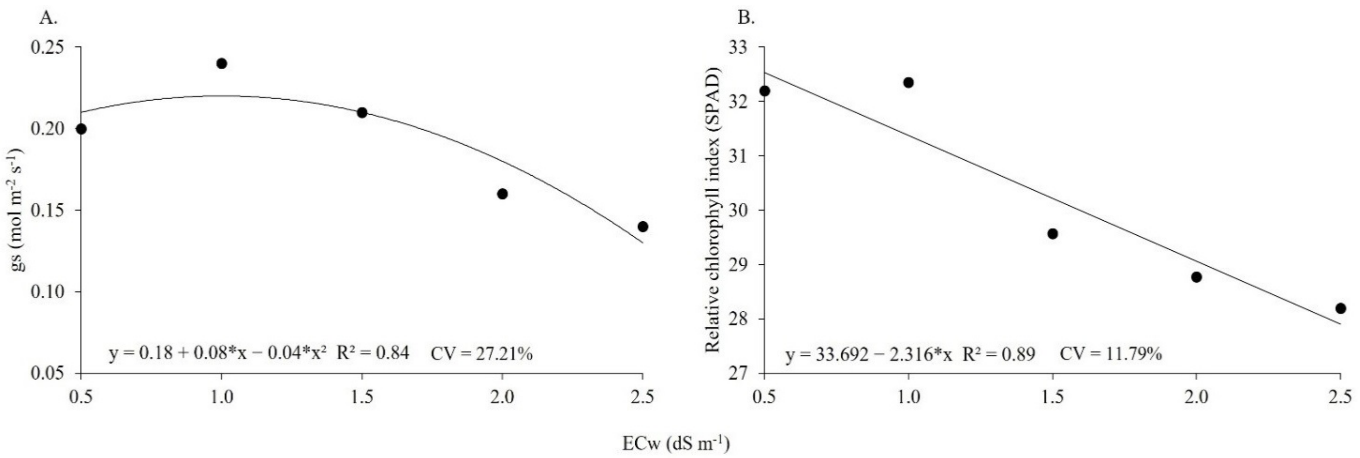
Application of the 100% water depth provided a greater ability for plants to regulate transpiration thereby contributing to a decline in the ions absorbed by zucchini plants (Pereira Filho et al. 2019). Nevertheless, the increase in the electrical conductivity of irrigation water caused a decrease in transpiration, justified by the effect of the ions present in irrigation water (Na^+ and Cl^-) that caused a decline in stomatal opening thereby provoking a decrease in transpiration (Prazeres et al., 2015). Similar behavior, indicating stomatal closure inhibiting transpiration, has also been reported by Bosco et al. (2009) in eggplant crops as a result of an increase in ECw.

The effect of salt stress on the variable stomatal conductance (gs) can be seen in Figure 3A, it has been verified that the quadratic polynomial model revealed a maximum value of 0.22 mol m^{-1} s^{-1} and a minimum of 0.13 mol m^{-1} s^{-1} for ECw of 1.0 and 2.5 dS m^{-1}, respectively. It has been reported that the accumulation of salts in the substrate through irrigation water reduces water availability as a consequence of a decrease in leaf water potential leading to loss of turgor and reduction in stomatal conductance (Melo et al., 2017). Dantas et al. (2021) evaluated the physiological behavior of the zucchini crop grown in a nutrient solution of increasing salinity (2.1, 3.1, 4.1, and 5.1 dS m^{-1}), and obtained reductions in stomatal conductance.



*, ** - Significant at $p \leq 0.05$ and $p \leq 0.01$ by F test, respectively; CV - Coefficient of variation

Figure 2. CO_2 assimilation rate - A (A) and transpiration - E (B) in zucchini plants irrigated with water of different electrical conductivity (ECw) and two irrigation depths (▪ 50 and ● 100% of ETc), 36 days after sowing



*, ** - Significant at $p \leq 0.05$ and $p \leq 0.01$ by F test, respectively; CV - Coefficient of variation

Figure 3. Stomatal conductance - gs (A) and relative chlorophyll index (B) of zucchini plants as a function of electrical conductivity of water (ECw), 36 days after sowing

The results obtained regarding relative chlorophyll index (Figure 3B) showed linear reductions with the increase in irrigation water salinity (6.87% per unit increase), thus, according to the equation, it presents 32.53 in the lowest conductivity (0.5 dS m^{-1}) and 27.90 in the highest conductivity (2.5 dS m^{-1}), corresponding to a difference of 14.23%.

The linear decrease in chlorophyll content revealed that plants exposed to salinity in irrigation water, tend to have reduced chlorophyll levels due to the increase in chlorophyllase enzyme, which degrades molecules of this pigment (Rouphael et al., 2017), besides causing a decrease in chlorophyll biosynthesis and tissue differentiation in chloroplasts (Sousa et al., 2021). In line with this study, Costa et al. (2019) when irrigating the zucchini crop with brackish water (ECw = 2.6 dS m^{-1}) at 100% ETc, obtained an average reduction of 20% in chlorophyll content.

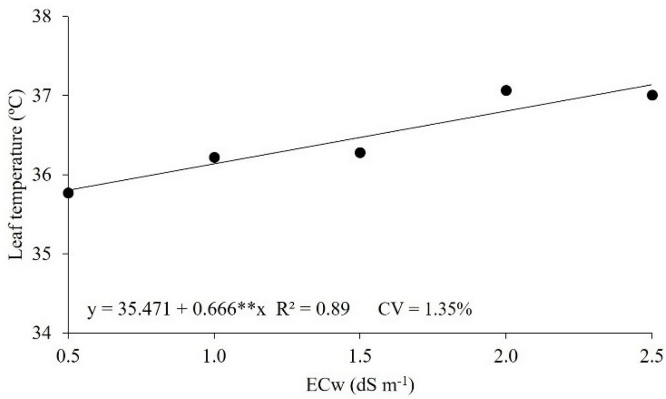
The instantaneous water use efficiency (WUEi) had a different response as regards irrigation depths with the increase in electrical conductivity of the water, where the 50% depth adjusted to the polynomial model obtaining 2.29 [μmol CO_2 m^{-2} s^{-1} (μmol m^{-2} s^{-1})$^{-1}$] at electrical conductivity of 1.11 dS m^{-1}, while the 100% depth responded in a linear decreasing manner (Figure 4A).

The decline in WUEi with the increasing electrical conductivity of water is justified, due to the effect of salts in inhibiting the effective conversion of water consumed in phytomass due to changes in the soil osmotic and water potentials (Lima et al., 2018). The maximum point obtained at 50% depth demonstrates the ability of the zucchini crop to adapt to the saline environment and maintain a rate of photosynthesis, even under conditions that limit water absorption. Dantas et al. (2021) also obtained reductions of WUEi in zucchini crops with increasing salinity levels of the nutrient solution (2.1 to 5.1 dS m^{-1}) in a hydroponic system.

According to Figure 4B, for both irrigation depths, a linear response was recorded for the internal carbon concentration (Ci), where unfolding of the equations indicated an increase of 7.01% in the case of 50% ETc and a reduction of 3.97% for 100% ETc, per unit increase in ECw. The difference in Ci between the lowest and highest water depths under maximum water salinity level (2.5 dS m^{-1}) was 34.07 μmol CO_2 mol^{-1}.

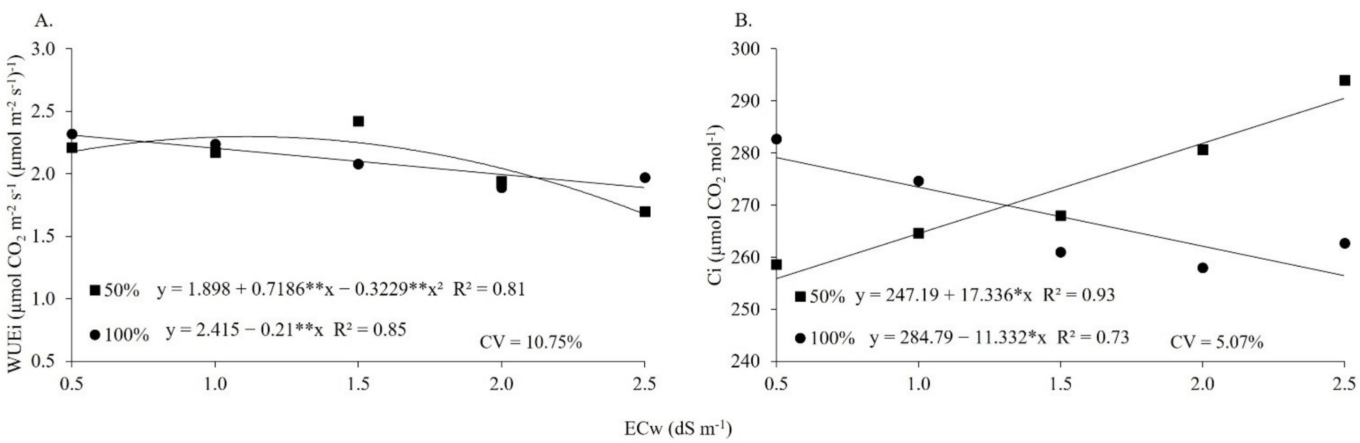
The response of plants subjected to the 50% irrigation depth with increasing ECw may be related to greater stomatal control during the stress period, thereby increasing the accumulation of CO_2 in the leaf mesophyll, and reducing the use of this gas for the synthesis of sugars (Taiz et al., 2017). As regards the 100% water regime, there was a reduction in the internal concentration of CO_2 with the increase in salts concentration. This result may be associated with the greater amount of water applied in this treatment, consequently resulting in lower concentration of salts and greater transpiration and stomatal opening. Silva et al. (2018), when evaluating the effect of increasing the salinity of irrigation water (0.5, 1.5, 2.5, and 3.5 dS m^{-1}) on soursop cultivated in potted conditions, found an opposite trend to this study. These authors observed a linear increase of 12.49% in internal CO_2 concentration per unit increase in ECw.

According to Figure 5, the leaf temperature responded linearly and positively with increasing ECw, so according to the equation at the lowest conductivity (0.5 dS m^{-1}) the temperature was 35.80 °C and at the highest (2.5 dS m^{-1}) 37.14 °C, corresponding to 1.88% per unit increase. This trend in leaf temperature increase may be a direct result of the decrease in transpiration, providing stomatal closure, and decreasing photosynthetic rates (Sousa et al., 2021). Sales et al. (2021) evaluating the effect of saline stress (5 dS m^{-1}) in



** - Significant at $p \leq 0.01$ by F test, respectively; CV - Coefficient of variation

Figure 5. Leaf temperature of zucchini plants under different electrical conductivities of water (ECw), 36 days after sowing



** - Significant at $p \leq 0.01$ by F test, respectively; CV - Coefficient of variation

Figure 4. Instantaneous water use efficiency - WUEi (A) and internal carbon concentration - Ci (B) in zucchini plants irrigated under different electrical conductivity of water (ECw) and two irrigation depths (▪ 50 and ● 100% of ETc), 36 days after sowing

okra crop irrigated with 100% ETc, obtained results similar to the data presented in this study, that is, a 3.5% increase in leaf temperature.

According to Table 3, all the biometric variables of the zucchini crop (plant height, leaf area, number of leaves, and stem diameter) were influenced only by the electrical conductivity of the water (ECw) factor.

Quadratic behavior was observed for the height of zucchini plants under different ECw (Figure 6A), verifying a maximum value of 11.02 cm in the plants that received irrigation of 1.03 dS m^{-1}. The height of plants subjected to saline irrigation water was directly affected because high concentrations of salts decrease the turgid potential of cells, thus affecting their development (Lima et al., 2018). Results similar to this study were reported by Sousa et al. (2019) in the melon crop, the authors observed a 27% decrease in height when the irrigation water salinity increased from 0.3 to 3.5 dS m^{-1}.

Table 3. Summary of the analysis of variance for plant height (PH), leaf area (LA), number of leaves (LN), and stem diameter (SD) of zucchini plants under different electrical conductivities of water (ECw) and irrigation depths (ID)

SV	DF	Mean Square			
		PH	LA	NL	SD
ECw	4	5.97*	6762.78**	2.21*	4.06**
Linear regression	1	1.14^{ns}	17931.48**	4,80*	10.62**
Quadratic regression	1	3.51*	2483.99^{ns}	4.03*	1.02^{ns}
ID	1	1.53^{ns}	3570.83^{ns}	0.07^{ns}	4.76^{ns}
ECw×ID	4	7.11^{ns}	1384.48^{ns}	0.19^{ns}	1.66^{ns}
Residue	50	6.11	1549.27	0.67	1.46
CV (%)		20.34	25.57	12.31	21.86

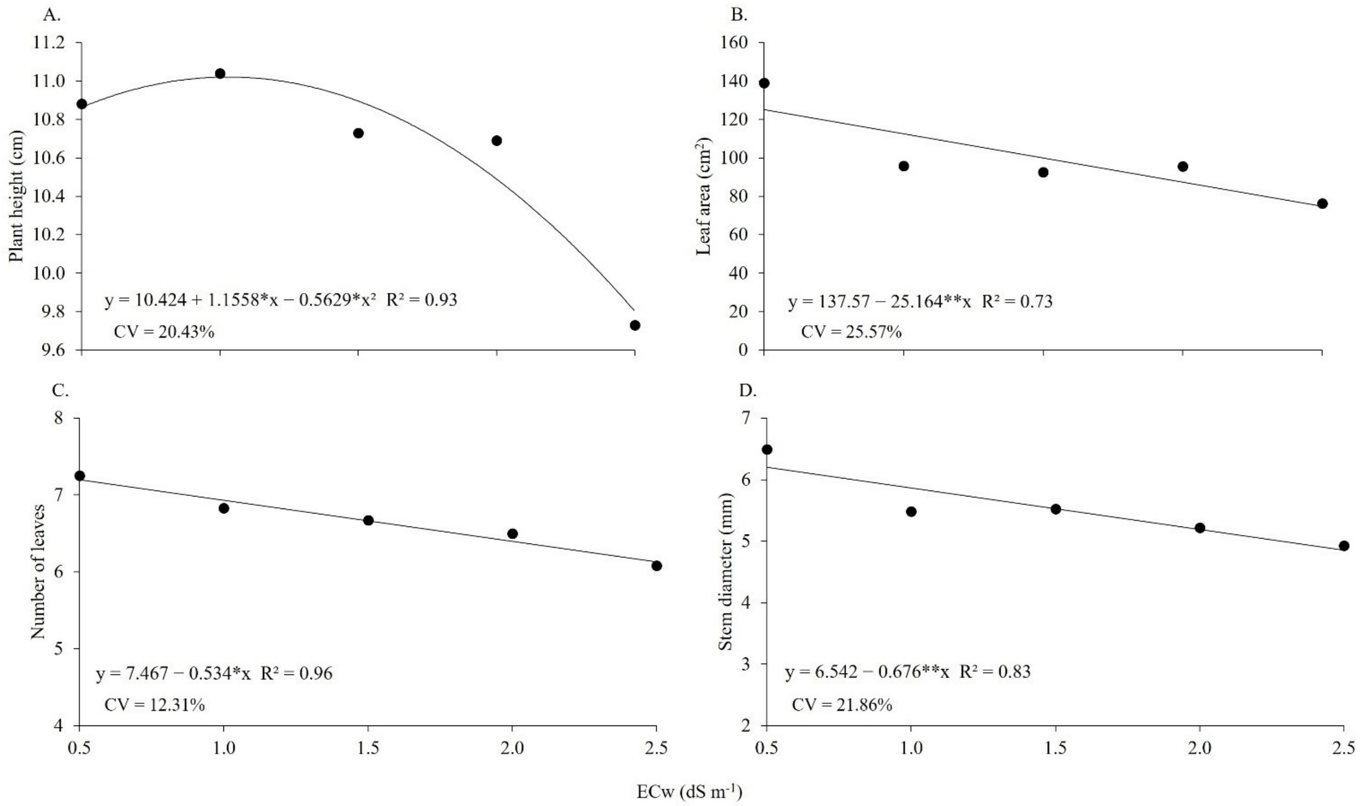
SV - Source of variation; DF - Degrees of freedom; CV - Coefficient of variation; *; **, ns - Significant at $p \leq 0.05$ and $p \leq 0.01$, and not significant, respectively, by F test

It can be seen in Figure 6B that saline stress affected the leaf area of zucchini plants, and the decreasing linear model was the one that best-fitted the data, with an 18.29% decrease per unit increase in the ECw. Based on the regression equation, a reduction of 40.26% occurred between the lowest and highest salinity.

This result showed that a reduction in leaf area is one of the first responses of glycophytic plants subjected to salinity, given the acclimatization that these plants undergo to survive the osmotic effect and toxicity of salts (Acosta-Motos et al., 2017). Rouphael et al. (2017) working with zucchini crop, irrigated with non-saline and saline water, detected the same trend, and observed a 46.72% reduction in leaf area in comparison between the extremes.

The number of leaves also decreased linearly with saline stress at 45 DAS (Figure 6C), according to the equation the decrease corresponded to 7.15% per unit increase in the ECw, noting a reduction of 14.83% between the lowest and highest salinity. This reduction is related to the decreased water uptake by the plant in response to the osmotic effect of the salinity of the irrigation water, which interfered with the metabolic and hormonal processes of zucchini plants (Lima et al., 2018). This restriction can also be attributed to the sensitivity to Na^+ and Cl^- ions that cause toxicity and physiological disturbances to plants (Sousa et al., 2019). It is noteworthy that this effect was observed in the present experiment.

Likewise, Oliveira et al. (2014) when evaluating saline stress in pumpkin crop, also found a reduction (32%) in the number of leaves at the highest saline level (3.5 dS m^{-1}). Increased water conductivity reduced stem diameter in zucchini cv.



** - Significant at $p \leq 0.05$ and $p \leq 0.01$ by F test, respectively; CV - Coefficient of variation

Figure 6. Plant height (A), leaf area (B), number of leaves (C), and stem diameter (D) of zucchini plants as a function of electrical conductivity of water (ECw), at 45 days after sowing

Caserta (Figure 6D), showing a decline of 21.79% (1.35 mm) between the extreme levels (0.5 and 2.5 dS m^{-1}), according to the regression equation presented. The deleterious effects of salinity on water and nutrient uptake in plants caused a decrease in stem diameter. Oliveira et al. (2014) when analyzing the initial development of pumpkins subjected to salt stress, found a reduction in stem diameter when the plants were irrigated with water of 3.5 dS m^{-1}.

Conclusions

1. The use of brackish water (1 to 2.5 dS m^{-1}) reduced the growth in height, leaf area, number of leaves, stem diameter, stomatal conductance, chlorophyll, and increased the leaf temperature of zucchini cv. Caserta.

2. The interaction of electrical conductivity of irrigation water and irrigation depths influenced the values of CO_2 assimilation rate, transpiration, instantaneous water use efficiency, and internal carbon concentration.

3. Under 100% ETc, higher values of CO_2 assimilation rate, transpiration, and instantaneous water use efficiency were recorded, while 50% ETc increased the internal carbon concentration, even with the increase in ECw.

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