Universidade Federal Rural do Semi-Árido
Pró-Reitoria de Pesquisa e Pós-Graduação
https://periodicos.ufersa.edu.br/index.php/caatinga

ISSN 0100-316X (impresso)
ISSN 1983-2125 (online)
http://dx.doi.org/10.1590/1983-21252022v35n320rc

BIOMASS, GAS EXCHANGE AND PRODUCTION OF CHERRY TOMATO CULTIVATED UNDER SALINE WATER AND NITROGEN FERTILIZATION[1]

IARA ALMEIDA ROQUE[2]*, LAURIANE ALMEIDA DOS ANJOS SOARES[3], GEOVANI SOARES DE LIMA[2], IRACY AMÉLIA PEREIRA LOPES[3], LUDERLÂNDIO DE ANDRADE SILVA[2], PEDRO DANTAS FERNANDES[2]

ABSTRACT - Cherry tomato cultivation in the semi-arid region of northeastern Brazil is limited by water scarcity, so it is common to use water sources with high concentrations of salts in this region, which have a deleterious effect on plants, which can be alleviated through management strategies, and fertilization with nitrogen stands out. This study aimed to evaluate the growth, gas exchange and production of cherry tomato under irrigation with saline water and nitrogen fertilization. The experiment was carried out in a screened environment at the CCTA/UFCG in Pombal - PB from October 2020 to February 2021, using a randomized block design, in a 5 × 5 factorial scheme, with five levels of electrical conductivities of water - ECw (0.3; 1.3; 2.3; 3.3 and 4.3 dS m^{-1}) and five nitrogen doses - ND (50; 75; 100; 125 and 150% of the recommended dose for the crop), with three replicates. Irrigation water salinity from 0.3 dS m^{-1} reduced stomatal conductance, transpiration, CO_2 assimilation rate and production components of cherry tomato. Nitrogen fertilization from 50% of the recommendation reduced stomatal conductance, transpiration and CO_2 assimilation rate of cherry tomato. Irrigation with water of electrical conductivity from 0.3 dS m^{-1} associated with nitrogen dose of 150% of the recommendation intensified the effect of salt stress on dry biomass accumulation in cherry tomato.

Keywords: *Solanum lycopersicum* var. *cerasiforme.* Nitrogen. Salt stress.

FITOMASSAS, TROCAS GASOSAS E PRODUÇÃO DO TOMATE CEREJA CULTIVADO SOB ÁGUAS SALINAS E ADUBAÇÃO NITROGENADA

RESUMO - O cultivo de tomate cereja no semiárido do Nordeste brasileiro é limitado pela escassez hídrica, por isso é comum o uso de fontes de águas com elevadas concentrações de sais nessa região, que causam efeito deletério nas plantas, podendo ser amenizado por meio de estratégias de manejo, destacando-se a adubação com nitrogênio. Este trabalho teve como objetivo avaliar o acúmulo de fitomassas, as trocas gasosas e a produção do tomateiro cereja sob irrigação com águas salinas e adubação nitrogenada. O experimento foi conduzido em ambiente telado do CCTA/UFCG em Pombal – PB durante o período de outubro de 2020 a fevereiro de 2021, utilizando-se o delineamento de blocos ao acaso, em esquema fatorial 5 × 5, sendo cinco níveis de condutividades elétrica da água - CEa (0,3; 1,3; 2,3; 3,3 e 4,3 dS m^{-1}) e cinco doses de nitrogênio - DN (50; 75; 100; 125 e 150% da dose recomendada para a cultura), com três repetições. A salinidade da água de irrigação a partir de 0,3 dS m^{-1} reduziu a condutância estomática, a transpiração e a taxa de assimilação de CO_2 e os componentes de produção do tomate cereja. A adubação dose de nitrogênio a partir de 50% da recomendação diminuiu a condutância estomática, transpiração e a taxa de assimilação de CO_2 do tomate cereja. A irrigação com água de condutividade elétrica a partir de 0,3 dS m^{-1} associado a dose de nitrogênio de 150% da recomendação intensificou o efeito do estresse salino no acúmulo de fitomassas secas do tomate cereja.

Palavras-chave: *Solanum lycopersicum* var. *cerasiforme.* Nitrogênio. Estresse salino.

*Corresponding author
[1]Received for publication in 07/21/2021; accepted in 12/04/2022.
Paper extracted from the dissertation of the first author
[2]Academic Unit of Agricultural Engineering, Universidade Federal de Campina Grande, Campina Grande, PB, Brazil; yara.roque.sb@gmail.com – ORCID: 0000-0002-7807-3301, geovani.soares@pq.cnpq.br – ORCID: 0000-0001-9960-1858, luderlandioandrade@gmail.com- ORCID: 0000-0001-9496-5820, pedrodantasfernandes@gmail.com – ORCID: 0000-0001-5070-1030.
[3]Academic Unit of Agricultural Sciences, Center of Agrifood Science and Technology, Universidade Federal de Campina Grande, Pombal, PB, Brazil; lauriane.soares@pq.cnpq.br– ORCID: 0000-0002-7689-9628, iracyamelia.lopes@gmail.com– ORCID: 0000-0003-1641-6214.

INTRODUCTION

Tomato (*Solanum lycopersicum*) is a plant of Andean origin, belonging to the family Solanaceae, which also includes other known species such as potato, bell pepper and eggplant. It is one of the most important vegetables of economic importance and also one of the most widespread in the world, due to its great acceptability and consumption (QUINTANILHA; TAVARES; CORCIOLI, 2019). Among the tomato varieties, cherry tomato stands out for its use in the ornamentation of dishes and appetizers. In addition, this tomato group has shown great demand by consumers, reaching compensating prices in the market.

Despite the importance of this vegetable for the Northeast region of Brazil, its production is limited by the scarcity of water with low salt concentrations, which occurs due to the climatic imbalance of this region, resulting from irregular rainfall, high evaporation rates, high temperatures and low relative humidity (LIMA et al., 2015; PINHEIRO et al., 2022). The use of waters with high concentrations of salts groundwater extracted through artesian wells is extremely important for the expansion of irrigated crops (SILVA; GUERRA; GOMES, 2019). However, excess salts in water can cause changes in plant physiology and growth, with negative effects on production (LACERDA et al., 2022).

Due to the osmotic effect, a gradient of concentration unfavorable to the absorption of water by plants arises, causing water stress. Under these conditions, plants close their stomata, due to the lack of turgor in guard cells, triggering reductions in transpiration, a process that limits the mass flow and raises leaf temperature, in addition to reductions in CO_2 uptake, thus compromising photosynthesis (LIMA et al., 2020a; SILVA et al., 2022). Another problem caused by salt stress is the ionic effect, due to the occurrence of competition of nutrients such as K^+ and Ca^+ with Na^+, causing a change in ionic homeostasis. The ionic effect is also characterized by toxicity by specific ions, mainly chlorine, sodium and boron (SOUSA et al., 2017).

An alternative that can minimize the effects of salt stress on cherry tomato is nitrogen fertilization (VIEIRA et al., 2016). Several studies have been conducted to assess the mitigating effect of nitrogen on plants subjected to salt stress (DIAS et al., 2020; PINHEIRO et al., 2020; SÁ et al., 2020; SILVA et al., 2020; SOARES et al., 2021). This fact is due to the role of nitrogen in plants, being part of several organic compounds, such as amino acids, proteins, chlorophyll, among others, which assist in osmotic adjustment and thus favor greater absorption of water and nutrients, and positively acting on ionic homeostasis (COSTA et al., 2020).

Nitrogen fertilization can mitigate the deleterious effects of salt stress, by favoring the increase of NO_3^- absorption to the detriment of Cl^-, reducing the Cl/N ratio in plants (BLANCO; FOLEGATTI; HENRIQUES NETO, 2008). Santos et al. (2016a) point out that there is evidence of competition in the absorption between nitrate and chloride, so that an increase in nitrate concentration in the root zone can inhibit a greater absorption of chloride by the plant.

Given the above, this study aimed to evaluate the growth, gas exchange and production of cherry tomato as a function of irrigation with saline water and nitrogen fertilization.

MATERIAL AND METHODS

The experiment was carried out from October 2020 to February 2021 in a screened environment at the Center for Science and Agri-Food Technology - CCTA of the Federal University of Campina Grande - UFCG, located in the municipality of Pombal, Paraíba, Brazil, located by the geographical coordinates: 6°46’13” South latitude and 37°48’6” West longitude, at an average altitude of 184 m. The municipality has an average annual rainfall of 700 mm, with semi-arid tropical climate (BSh), according to Köppen’s classification, adapted to Brazil (ALVARES et al., 2013). The data of maximum and minimum air temperature, rainfall and relative humidity collected during the experimental period are presented in Figure 1.

The experimental design used was randomized blocks, in a 5 × 5 factorial arrangement, referring to five levels of electrical conductivity of water - ECw (0.3; 1.3; 2.3; 3.3 and 4.3 dS m^{-1}) and five nitrogen doses - ND (50; 75; 100; 125 and 150% N), and the dose of 100% corresponded to 19.74 g of N per plant as recommended by Trani et al. (2015).

Sowing was carried out in a polyethylene tray with 162 cells with capacity of 50 ml, filled with substrate obtained from the mixture of sand, soil and manure in the proportion 1:1:2 (on volume basis), using 2 seeds per cell of the cultivar ‘Cereja Vermelho’, which has an indeterminate growth habit.

At 18 days after sowing, when the plants reached 10 cm in height and two pairs of true leaves, they were transplanted to pots adapted as drainage lysimeters, with 20 L capacity, which received a 3-cm-thick layer of crushed stone on a geotextile covering the base of the container. At the base of each container, a 15-mm-diameter hose was installed as a drain and connected to a plastic bottle (2 L) to collect the drained water. Then, the pots received 22 kg of a *Neossolo Flúvico* (Fluvent) of sandy loam texture, whose physical and chemical characteristics (Table 1) were determined according to Teixeira et al. (2017).

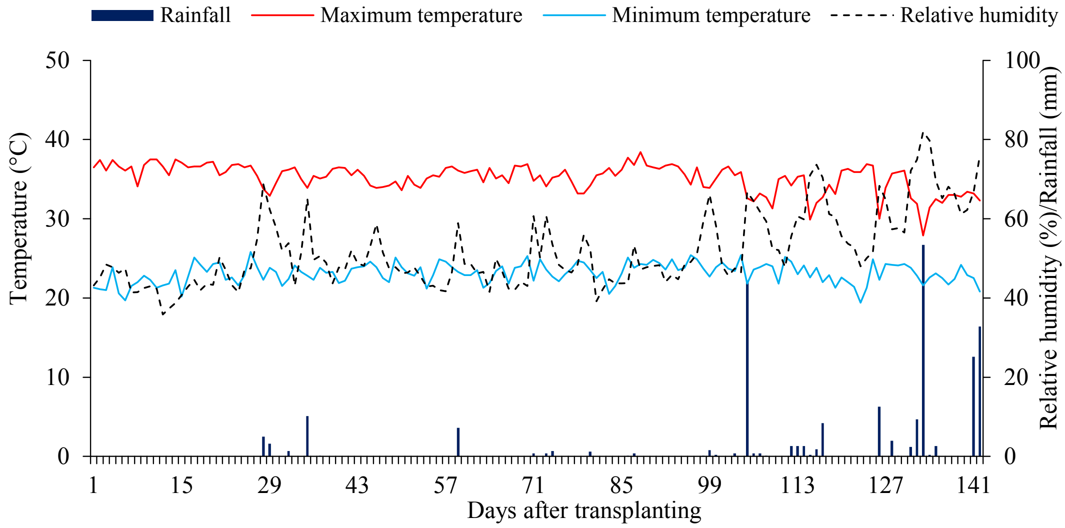

Figure 1. Data of maximum and minimum temperature, rainfall and relative humidity during the experimental period.

Table 1. Chemical and physical characteristics of the soil used in the experiment.

Chemical characteristics								
pH H_2O)	OM	P	K^+	Na^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+
(1:2.5)	g kg^{-1}	(mg kg^{-1})	……………cmol$_c$ kg^{-1}……………					
5.58	2.93	39.2	0.23	1.64	9.07	2.78	0.0	8.61
……Chemical characteristics………				……Physical characteristics……				
ECse	CEC	SAR	ESP	Particle-size fraction (g kg^{-1})			Moisture (dag kg^{-1})	
(dS m^{-1})	cmol$_c$ kg^{-1}	(mmol L^{-1})$^{0.5}$	%	Sand	Silt	Clay	33.42 kPa[1]	1519.5 kPa[2]
2.15	22.33	0.67	7.34	572.7	100.7	326.6	25.91	12.96

pH - Hydrogen potential, OM – Organic matter: Walkley-Black Wet Digestion; Ca^{2+} and Mg^{2+} extracted with 1 M KCl at pH 7.0; Na^+ and K^+ extracted with 1 M NH_4OA_c at pH 7.0; Al^{3+}+H^+ extracted with 0.5 M CaOAc at pH 7.0; ECse - Electrical conductivity of saturation extract; CEC - Cation exchange capacity; SAR - Sodium adsorption ratio of saturation extract; ESP - Exchangeable sodium percentage; [1, 2] referring to the limits of field capacity and permanent wilting point.

Fertilization with NPK was performed according to the recommendation of Trani et al. (2015), started 10 days after transplanting (DAT). Monoammonium phosphate (50% P_2O_5) was applied, 20.35 g per pot, to meet the phosphorus requirement. Since monoammonium phosphate has 12% N, it was necessary to complement it with urea (45% N) to meet the N requirement, according to established doses, applying 19.25, 28.88, 38.9, 48.1 and 57.57 g per plant for the doses of 50, 75, 100, 125 and 150%, respectively. To meet the potassium recommendation, 65.94 g of potassium chloride (60% K_2O) were supplied as top-dressing in weekly applications, via irrigation water. The nutritional requirement of micronutrients was met through complementation with foliar fertilization, and the applications were carried out every two weeks, with the commercial product Dripsol Micro Rexene®, which contains: Mg - 1.2%; B - 0.85%; Zn - 4.2%; Fe - 3.4%; Mn - 3.2%; Cu - 0.5% and Mo - 0.06%.

The levels of electrical conductivity of the waters were established based on studies conducted by Vieira et al. (2016). The water used in the irrigation of the treatment of lower salinity (0.3 dS m^{-1}) was obtained from the public supply system of Pombal-PB, and the other ECw levels were prepared from the dissolution of sodium chloride (NaCl) considering the relationship between ECw and the concentration salts (RICHARDS, 1954), according to Equation 1:

$$Q\ (\text{mmol}_c\ L^{-1}) = 10 \times ECw \qquad (1)$$

Where:
Q = Quantity of salts to be applied (mmol$_c$ L^{-1});
ECw = Electrical conductivity of water (dS m^{-1}).

Before transplanting, the soil moisture content was increased to the level corresponding to the maximum water retention capacity. Subsequently, the irrigations were carried out daily with water of low electrical conductivity (0.3 dS m^{-1}) until 17 DAT. After this period, irrigation with the different salinity levels began, and the volume of water applied was determined according to the water need of the plants, obtained using Equation 2:

$$VC = \frac{VA - VD}{1 - LF} \quad (2)$$

Where:
VC - volume consumed (L);
VA - volume of water applied to plants on the previous day;
VD - volume drained, quantified in the morning of the next day; and
LF - leaching fraction estimated at 15%, applied every 15 days to minimize the accumulation of salts in the root zone.

Cultural practices consisted of pruning of shoots in the axils of the leaves until 45 DAT and pruning of the apical bud at 67 DAT (TAKAHASHI, 2014), and the control of pests and diseases was performed by chemical intervention, with insecticides and fungicides recommended for the crop.

Gas exchange was measured at 110 days after transplantation (DAT) based on stomatal conductance - *gs* (mol m^{-2} s^{-1}), internal CO_2 concentration - *Ci* (mmol CO_2 mol^{-1}), transpiration - *E* (mmol H_2O m^{-2} s^{-1}) and CO_2 assimilation rate - *A* (μmol CO_2 m^{-2} s^{-1}). These data were then used to estimate the instantaneous water use efficiency - *WUEi* (*A/E*) [(μmol m^{-2} s^{-1}) (mmol H_2O m^{-2} $s^{-1})^{-1}$] and the instantaneous carboxylation efficiency - *CEi* [(μmol m^{-2} s^{-1}) (μmol mol^{-1})].

Gas exchange determinations were carried out with an infrared gas analyzer - IRGA (Infrared Gas Analyser, LCpro - SD model, from ADC BioScientific, UK) between 7:00 and 10:00 a.m., in fully expanded leaf, under natural conditions of air temperature, CO_2 concentration and using an artificial radiation source of 1200 μmol m^{-2} s^{-1}, established through the curve of photosynthetic response to light.

Harvest began at 59 DAT and lasted until 141 DAT, when the fruits reached the R4 maturity stage, i.e., ripe red (MONTEIRO et al., 2018), and then the fruits were taken to the Hydraulics and Irrigation Laboratory - CCTA - UFCG, to determine the number of fruits per plant (NF) by simple counting, fresh fruit weight - FFW (g per plant) and average fruit weight - AFW (g per fruit), on a scale with 0.01 g precision.

At 141 DAT, the plants were collected and separated into leaves, stem and roots, being subjected to drying in a forced circulation oven at a temperature of 65 °C. After drying, the samples were weighed to determine leaf dry biomass (LDB), stem dry biomass (SDB) and root dry biomass (RDB).

The data were analyzed for normality and homoscedasticity (Shapiro-Wilk Test) and then subjected to analysis of variance by the F test ($p \leq 0.05$). When significant, linear and quadratic polynomial regression analysis was performed for water salinity levels and nitrogen doses using SISVAR statistical software (FERREIRA, 2019). When there was significance of the interaction between factors, TableCurve 3D software was used to create the response surfaces.

RESULTS AND DISCUSSION

There were significant effects of water salinity levels (SL) and nitrogen doses (ND) on stomatal conductance (*gs*), transpiration (*E*) and CO_2 assimilation rate of cherry tomato plants (Table 2). Nitrogen doses significantly affected *gs*, *E* and *A* of cherry tomato. The interaction between the factors (SL × ND) did not significantly influence any of the variables analyzed.

Table 2. Summary of the analysis of variance for stomatal conductance - *gs* (mol m^{-2} s^{-1}), transpiration - *E* (H_2O mmol m^{-2} s^{-1}), internal CO_2 concentration - *Ci* (mmol CO_2 mol^{-1}), CO_2 assimilation rate - *A* (μmol CO_2 m^{-2} s^{-1}), instantaneous water use efficiency - *WUEi* [(μmol m^{-2} s^{-1}) (mmol H_2O m^{-2} $s^{-1})^{-1}$] and instantaneous carboxylation efficiency - *CEi* [(μmol m^{-2} s^{-1}) (μ mol^{-1})] of cherry tomato grown with saline water and nitrogen fertilization, at 110 days after transplanting.

Sources of variation	DF	Mean squares					
		gs^1	*E*	*Ci*	A^1	*WUEi*	CEi^1
Salinity Levels (SL)	4	0.025^{**}	5.868**	269.100ns	161.296**	1.285ns	0.005ns
Linear Regression	1	0.090^{**}	20.805**	136.326ns	591.033**	3.905*	0.018*
Quadratic Regression	1	0.002^{ns}	2.379ns	593.376ns	38.425ns	0.911ns	0.000*
Nitrogen Doses (ND)	4	0.020^{*}	4.300**	411.433ns	110.181*	1.023ns	0.005ns
Linear Regression	1	0.063^{**}	9.332**	1109.760ns	339.091**	2.963*	0.016ns
Quadratic Regression	1	0.000^{ns}	3.195ns	493.733ns	35.153ns	0.290ns	0.001ns
Interaction (SL × ND)	16	0.006^{ns}	1.394ns	200.241ns	40.843ns	0.304ns	0.001ns
Blocks	2	0.033^{*}	4.937*	2990.880ns	222.735**	12.106**	0.015*
Residual	48	0.00197	0.9758	960.649	14.4509	0.6633	0.00101
CV (%)		17.60	19.53	16.79	17.17	18.94	25.19
Mean		0.252	5.058	184.60	22.14	4.30	0.1261

ns, *, ** respectively not significant and significant at $p \leq 0.05$ and ≤ 0.01; CV= coefficient of variation; [1]data transformed to $\sqrt{x}$.

The stomatal conductance of cherry tomato decreased linearly with increasing salinity of irrigation water, by 8.15% per unit increase in ECw (Figure 2A). Plants irrigated with ECw of 4.3 dS m^{-1} had a decrease in *gs* of 32.56% compared to those that were subjected to the lowest salinity level (0.3 dS m^{-1}). Stomatal closure in plants under salt stress occurred possibly because *gs* is dependent on stomatal cells that receive water and become turgid, which leads to the opening of the ostiole, and such mechanism is affected when the plant cannot absorb water from the soil, due to the osmotic effect caused by salt stress. Thus, stomatal closure prevents the loss of water to the atmosphere and can ensure the survival of the plant under salinity conditions (DIAS et al., 2018; DIAS et al., 2019).

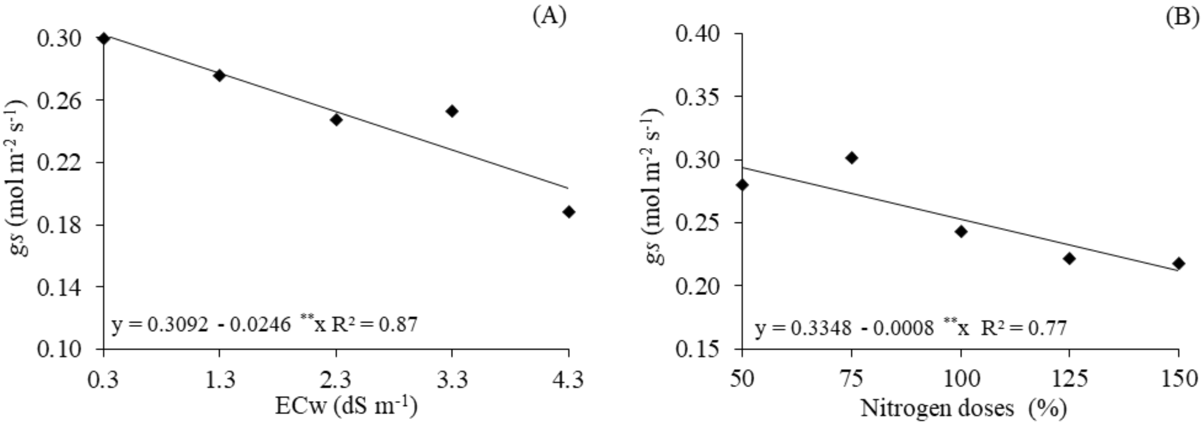

Figure 2. Stomatal conductance – *gs* of cherry tomato plants, as a function of the levels of electrical conductivity of water – ECw (A) and nitrogen doses - ND (B), at 110 days after transplanting.

The increase in nitrogen doses caused a linear reduction in the stomatal conductance of cherry tomato plants (Figure 2B), equal to 6.78% for each 25% increase in N dose. When comparing the gs of plants grown under 150% of the N recommendation to that of plants that received the lowest dose (50%), there was a decrease of 27.13%. Decrease in *gs* due to the increase in nitrogen availability can occur due to several factors, such as the reduction in leaf concentration of potassium (an important element for the normal functioning of stomata), as a result of the competition of K^+ cations and Na^+ present in the soil (BRITTO; KRONZUCKER, 2002).

Due to the partial closure of the stomata, leaf transpiration (*E*) was reduced with the increase in salinity levels (ECw) by 6.42% per unit increment in ECw. Plants subjected to irrigation with ECw of 4.3 dS m^{-1} reduced their *E* by 25.68% compared to those that received the lowest salinity level (Figure 3A). Due to the stomatal closure, there was lower transpiration of the plants, which may have resulted in lower absorption of water and nutrients, because transpiration generates a negative water pressure in the aerial part that can only be balanced through greater water absorption by the roots (FERNANDES et al., 2021; DIAS et al., 2022). Tatagiba et al. (2014), evaluating the effect of different salt concentrations in the nutrient solution on tomato cultivation, also correlated the decrease in *E* of plants under the effect of higher salinity (150 mmol L^{-1} of NaCl) to stomatal closure.

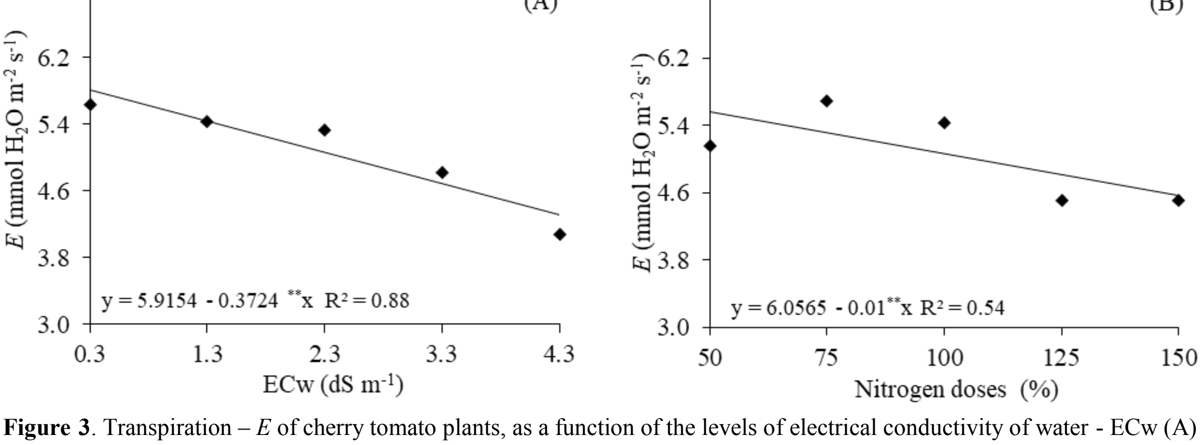

Figure 3. Transpiration – *E* of cherry tomato plants, as a function of the levels of electrical conductivity of water - ECw (A) and nitrogen doses - ND (B), at 110 days after transplanting.

As observed for stomatal conductance (Figure 2B), nitrogen doses caused a reduction in the transpiration of cherry tomato plants, equal to 4.5% for each 25% increase in ND (Figure 3B). This decrease in *E* is probably related to stomatal closure (Figure 2B), as a strategy to maintain high cell water potential and reduce the absorption of toxic ions, especially Na^+ and Cl^-. The results obtained in this study differ from those reported by Dias et al. (2019), who evaluated gas exchange and production of West Indian cherry irrigated with saline waters (0.8 and 4.5 dS m^{-1}) and fertilization with nitrogen doses (70; 85; 100; and 115% N) and found that transpiration was not influenced by nitrogen.

Due to the reductions observed in stomatal conductance and transpiration, the CO_2 assimilation rate was compromised when plants were irrigated with high-salinity water (4.3 dS m^{-1}), with a reduction of 7.94 μmol m^{-2} s^{-1} when compared to plants cultivated with low-salinity water (0.3 dS m^{-1}). Stomatal closure, induced by salinity, may have caused an imbalance in the photosynthesis process, because tomato is a plant with photosynthetic metabolism C3, which needs to keep the stomata open longer for CO_2 to be fixed by the RuBisCO enzyme in the Calvin cycle (GUIMARÃES et al., 2019). Pereira et al. (2020) evaluated the tomato 'Santa Clara' and found a decrease in the CO_2 assimilation rate with the increase of NaCl concentration in the irrigation water, with reductions of 11.8, 24.1 and 49.4% when plants were subjected to 50, 100 and 150 mM of NaCl, respectively.

The increase in nitrogen doses also had a decreasing linear effect on the CO_2 assimilation rate (*A*), with a reduction of 5.33% for each 25% increase in ND in cherry tomato plants at 110 DAT (Figure 4B). Excess nitrogen may have caused nutritional imbalance and thus led to an antagonistic effect by NH_4^+ and NO_3^-, impairing the absorption of other essential nutrients such as Mg^{2+}, which is important in photosynthesis, participating in the formation of ATP in chloroplasts and SO_4^{2-} present in coenzymes that participate in the photosynthesis process such as ferredoxin (RAMOS, 2020).

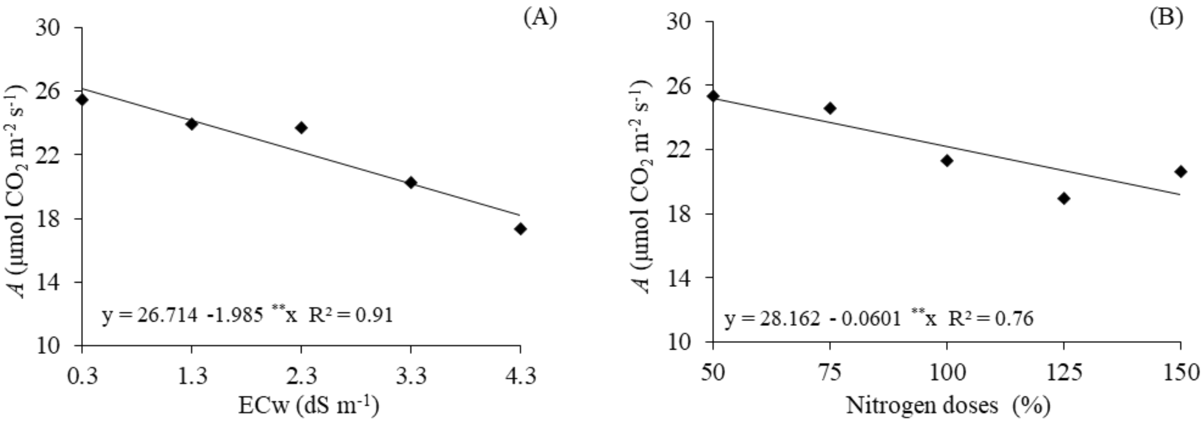

Figure 4. CO_2 assimilation rate - *A* of cherry tomato plants, as a function of the levels of electrical conductivity of water - ECw (A) and nitrogen doses - ND (B), at 110 days after transplanting.

There was a significant effect of the interaction between salinity levels (SL) and nitrogen doses (ND) for leaf dry biomass (LDB), stem dry biomass (SDB), root dry biomass (RDB), fresh fruit weight (FFW) and average fruit weight (AFW). The single factor ND influenced the number of fruits (NF) of cherry tomato, at 141 DAT (Table 3).

For leaf dry biomass (Figure 5A), it was verified that plants subjected to ECw of 0.3 dS m^{-1} and fertilized with an estimated N dose of 122% obtained the maximum value of 97.83 g per plant. However, fertilization with 150% of the recommendation led to minimum value (22.60 g per plant) in plants grown under ECw of 4.3 dS m^{-1}. Thus, it can be inferred that the increase in nitrogen dose intensified the deleterious effects of salt stress on leaf dry biomass accumulation in cherry tomato plants. The decrease in leaf biomass accumulation may be related to the changes observed in gas exchange, especially by the closure of stomata, as observed in stomatal conductance (Figure 2B) and, consequently, the reduction in leaf transpiration (Figure 3B) and CO_2 assimilation rate (Figure 4B).

According to Kluge, Tezotto-Uliana and Silva (2015), what determines the total amount of fixed carbon available for the leaf is the photosynthetic rate, which is influenced by the opening and closing of stomata, transpiration and CO_2 assimilation, among other factors. Vieira et al. (2016), when evaluating the effects of electrical conductivity of water (ECw ranging from 0.3 to 4.5 dS m^{-1}) and four N doses (60, 100, 140 and 180 mg kg^{-1} of soil) in cherry tomato, found that plants subjected to N doses of 60, 100, 140 and 180 mg kg^{-1} of soil showed reductions of 12.28, 12.96, 14.80 and 13.90% in leaf dry biomass per unit increase in ECw, at 125 days after transplanting.

Table 3. Summary of the analysis of variance for leaf dry biomass (LDB, g per plant), stem dry biomass (SDB, g per plant), root dry biomass (RDB, g per plant), fresh fruit weight (FFW, g per plant) and number of fruits (NF, g per fruit) of cherry tomato grown with saline waters and nitrogen doses, at 141 days after transplanting (DAT).

Sources of variation	DF	Mean Square					
		LDB	SDB	RDB	NF	FFW	AFW
Salinity levels (SL)	4	11570.65**	25106.13**	244.13**	10818.2**	342321.6**	7.736**
Linear Regression	1	46014.53**	96653.13**	955.33**	32761.3**	1157281.4**	27.389**
Quadratic Regression	1	12.10^{ns}	3677.06**	14.17*	10195.0**	209160.7**	2.81**
Nitrogen Doses (ND)	4	891.41**	388.05*	325.41**	1839.9ns	15012.6ns	0.496ns
Linear Regression	1	1216.89**	594.09*	600.43**	223.5ns	6360.9ns	0.945*
Quadratic Regression	1	1380.14**	22.86ns	513.31**	1253.6ns	17.1ns	0.196ns
Interaction (SL × ND)	16	280.35**	905.41**	125.35**	1259.4ns	23522.4*	0.837**
Blocks	2	177.37^{ns}	96.60ns	6.61ns	3455.3ns	23308.0ns	0.020ns
Residual	48	99.32	123.99	2.45	1142.60	11178.92	0.21198
CV (%)		14.72	13.52	10.47	24.78	28.26	17.44
Mean		56.24	82.36	14.95	136.41	373.21	2.64

$^{ns, *, **}$, respectively not significant and significant at $p \leq 0.05$ and $p \leq 0.01$; CV= coefficient of variation.

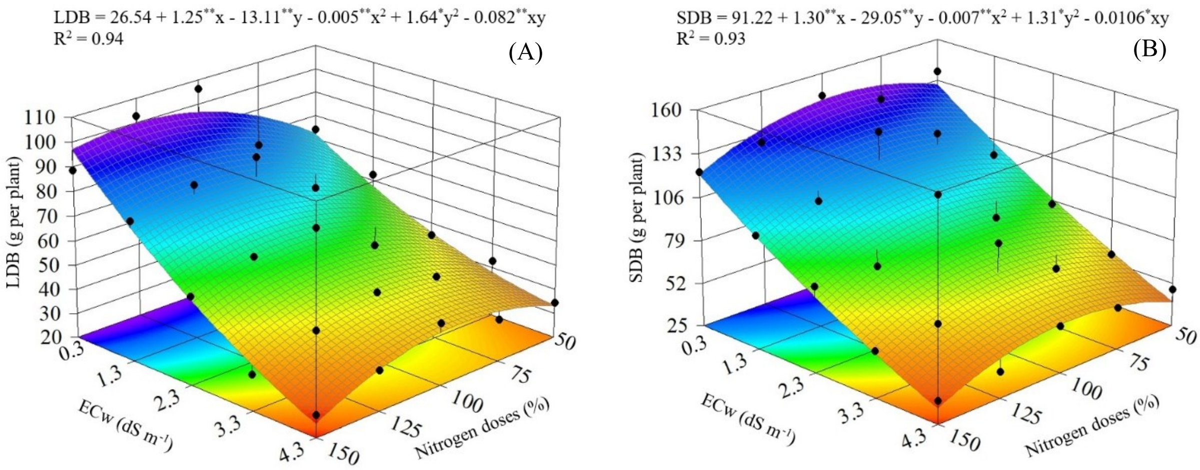

Figure 5. Leaf dry biomass - LDB (A) and stem dry biomass - SDB (B) of cherry tomato as a function of the interaction between the levels of electrical conductivity of irrigation water – ECw and the doses of nitrogen fertilization - ND, at 141 days after transplanting (DAT). X and Y correspond to ECw and nitrogen doses. * and ** represent significance at 0.05 and 0.01 probability levels, respectively.

As observed for LDB (Figure 5A), the stem dry biomass of tomato plants was also significantly influenced by the interaction between the factors (Figure 5B). It was verified that plants subjected to fertilization with N dose of 92% reached the maximum value for SDB (142.68 g per plant) under irrigation with the lowest ECw level (0.3 dS m^{-1}). On the other hand, fertilization with 150% N caused a decrease in SDB in plants subjected to ECw of 4.3 dS m^{-1}, leading to a minimum value of 21.19 g per plant. Salt stress caused by the high concentration of salts in irrigation waters was intensified with the increase in nitrogen doses. According to Duarte, Dias and Teles Filho (2007), high levels of fertilizers in the soil combined with the lack of rainfall necessary to leach the excess salts and the continuous evaporation of soil water can increase the salt content in the soil solution and thus compromise crop yield. Lima et al. (2016), when evaluating biomass accumulation in bell pepper plants under irrigation with saline water (ECw of 0.6 and 3.0 dS m^{-1}), also found a reduction in stem dry biomass accumulation of 2.94 g in plants irrigated with water of 3.0 dS m^{-1} compared to those under the lowest level of water salinity (0.6 dS m^{-1}).

Regarding root dry biomass (Figure 6A), plants fertilized with 100% N and subjected to irrigation with water of 2.3 dS m^{-1} obtained the highest RDB accumulation, 16.35 g per plant. On the other hand, plants irrigated with water of 0.3 dS m^{-1} and fertilized with 50% of N recommendation had the lowest RDB (10.42 g per plant). The ionic effect caused by the excess Na^+ supplied by high-salinity water probably inhibited the absorption of phosphorus by plants, because this nutrient in tomato crop accelerates the formation of roots (BECKER et al., 2016). Barros, Freire and Silva (2018), when evaluating the effects of water salinity (0.5; 2.0; 3.5; 5.0; 6.5 and 8.0 dS m^{-1}) on the vegetative behavior of cherry tomato, found that the increase in salt content in irrigation water caused a linear reduction in root dry biomass.

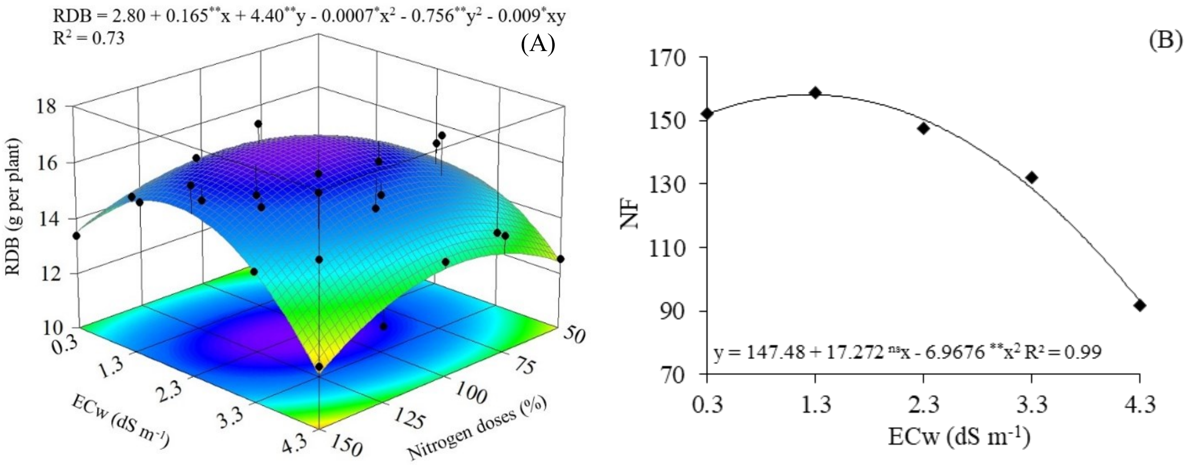

Figure 6. Root dry biomass (RDB) of cherry tomato as a function of the interaction between the levels of electrical conductivity of irrigation water - ECw and doses of nitrogen fertilization - ND, at 141 days after transplanting (DAT) and Number of fruits per plant - NF, under electrical conductivity of irrigation water - ECw. X and Y correspond to ECw and nitrogen doses. * and ** represent significance at 0.05 and 0.01 probability levels, respectively.

The number of fruits per plant (NF) of cherry tomato under the effect of the levels of electrical conductivity of irrigation water (ECW) was described by the quadratic model (Figure 6B), whose maximum estimated value was obtained in plants subjected to irrigation with ECw of 1.3 dS m^{-1} (158.15 fruits per plant). From this ECw level, there was a reduction, and the lowest NF was obtained in plants grown under ECw of 4.3 dS m^{-1}. The reduction in the number of fruits may be associated with the effects of salinity on flower abortion, which was intensified due to high temperatures, low relative humidity (Figure 1), and evapotranspiration conditions; with stomatal closure, the plant reduces the absorption of water and nutrients, resulting in alteration in ionic homeostasis (SANTOS et al., 2016b).

The fresh fruit weight (FFW) of cherry tomato plants fertilized with 100% N reached the maximum value (558.94 g per plant) under irrigation with ECw of 0.3 dS m^{-1} (Figure 7A). When using the dose of 150% N, there was a decrease in FFW, with the minimum value (268.59 g plant) obtained in plants subjected to the highest level of water salinity (4.3 dS m^{-1}). The decline in FFW is also related to the effects of salinity, due to changes in the osmotic potential of the soil solution, which caused a reduction in the consumption of water and nutrients by plants. This situation possibly caused changes in the ionic homeostasis of plants, which probably favored the translocation of part of the photoassimilates produced by the photosynthetic process for acclimatization of plants cultivated under stress (LIMA et al., 2019). Results similar to those obtained in the present study were found by Batista et al. (2021), who studied cherry tomato in hydroponic system using brackish water in the nutrient solution (EC_{NS} = 2.5; 4.0; 5.5; 7.0 and 8.5 dS m^{-1}) and found that the fruit yield of the cultivar red cherry tomato decreased with the increase in the electrical conductivity of the nutrient solution.

For the average weight of tomato fruits (Figure 7B), it was observed that plants fertilized with an estimated dose of 93% of the N recommendation reached the maximum value (3.32 g per fruit) under irrigation with ECw of 0.3 dS m^{-1}. The minimum value of 1.99 g per fruit was obtained in plants subjected to fertilization with 50% N and irrigation with ECw of 4.3 dS m^{-1}. The reduction in fruit weight of plants under salt stress conditions occurs due to the restriction in the absorption of nutrients caused by osmotic and ionic stress, resulting from the high concentration of salts in the soil solution, especially Na^+ and Cl^- ions (LIMA et al., 2019). Lima et al. (2020b), in an experiment conducted to evaluate the gas exchange, growth and production of mini watermelon irrigated with waters of different salinities (ranging from 0.3 to 4.3 dS m^{-1}), found that fruit diameter and fresh fruit weight were reduced sharply with increasing water salinity.

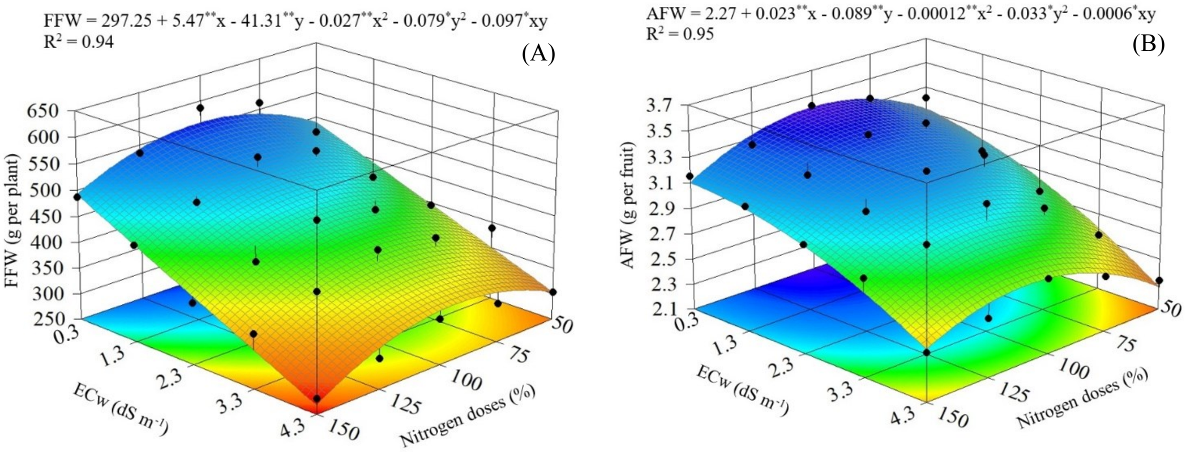

Figure 7. Fresh fruit weight - FFW (A) and average fruit weight - AFW (B) of cherry tomato as a function of the interaction between the electrical conductivity of irrigation water - ECw and nitrogen doses - ND. X and Y correspond to ECw and nitrogen doses. * and ** represent significance at 0.05 and 0.01 probability levels, respectively.

CONCLUSIONS

Irrigation water salinity from 0.3 dS m^{-1} reduces stomatal conductance, transpiration and CO_2 assimilation rate and the production components of cherry tomato. Fertilization with nitrogen dose from 50% of the recommendation reduces stomatal conductance, transpiration and CO_2 assimilation rate of cherry tomato. Irrigation with water of electrical conductivity from 0.3 dS m^{-1} associated with nitrogen dose of 150% of the recommendation intensifies the effect of salt stress on the dry biomass accumulation of cherry tomato.

ACKNOWLEDGEMENTS

To the Coordination for the Improvement of Higher Education Personnel (CAPES) for granting the master’s scholarship to the first author.

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