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Gas exchange and photosynthetic pigments of West Indian cherry under salinity stress and salicylic acid

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Abstract

West Indian cherry is a fruit species that stands out due to its socioeconomic importance, considering its use in the food and pharmaceutical industries. In this context, this study aimed to evaluate the gas exchange and photosynthetic pigments in the West Indian cherry cv. BRS 366 Jaburu as a function of irrigation with saline water and concentrations of salicylic acid. The study was conducted in a protected environment consisting of a greenhouse in Campina Grande, PB. The statistical design was in randomized blocks in a 5 x 4 factorial arrangement and treatments consisted of five levels of electrical conductivity of the irrigation water - ECw (0.8, 1.6, 2.4, 3.2, and 4.0 dS m^{-1}) and four concentrations of salicylic acid - SA (0, 1.0, 2.0, and 4.0 mM), with three replicates. Water salinity from 0.8 dS m^{-1} reduced transpiration, the CO_2 assimilation rate, and the instantaneous water-use efficiency of West Indian cherry plants. Salicylic acid did not mitigate the deleterious effects of salinity stress on the gas exchange and chlorophyll *a* of plants grown with water salinity levels higher than 0.8 dS m^{-1}. The salicylic acid concentration of 4.0 mM promoted an increase in the total chlorophyll content of West Indian cherry plants.

Keywords: *Malpighia emarginata* Sesse & Moc. ex DC., electrical conductivity, stress, mitigator

Introduction

Agriculture demands large water volumes, and the Brazilian Northeast region, due to high temperatures and evaporation rates and irregular rainfall, with average precipitations from 248 to 800 mm per year, turn irrigation into an essential practice to ensure crop production (Melo Filho et al., 2019). In this region, occurrence of water with high salt content is common. An alternative to supply the deficient water availability is the use of low-quality water, such as saline water originated from wells and weirs (Pinheiro et al., 2018).

Salt excess in the water stands out as one of the main abiotic stresses that limit agricultural production. However, plant tolerance to salinity stress varies across plant species and as a function of the exposure time, irrigation and fertilization management practices, in addition to edaphoclimatic conditions (Alvarenga et al., 2019).

Under stress conditions, plants produce organic compounds that regulate the physiological processes and provide tolerance. Therefore, in order to intensify crop production under irrigation with saline water, the exogenous application of salicylic acid stands out as an elicitor that mitigates the deleterious effects of salinity stress on the gas exchange, biosynthesis of photosynthetic pigments, and disease resistance (Trevisan et., 2017).

Salicylic acid acts in plants by signaling the genes of the defense system, activating proteins and enzymes that regulate the excess of reactive oxygen species (ROS). It controls osmotic and ionic homeostasis, improving water and nutrient absorption and the redistribution of Na^+ and Cl^- in the tissues, reflecting on the action of pigments and the photosynthetic efficiency (Nóbrega et al., 2018).

The induction imposed by salicylic acid on the tolerance to salinity stress depends on the plant species, the concentration of the acid, development phase of the

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crop, and the environmental conditions attributed to the plants, studies with sugarcane (Santos et al., 2019), rice (Jini & Joseph, 2017), basil (Silva et al., 2019a), and maize (Tahjib-Ul-Arif et al., 2018) have indicated that variation in the concentrations of salicylic acid promotes or inhibits plant growth due to these factors (Oraei et al., 2019).

According to Samadi et al. (2019), the foliar application of salicylic acid at the concentration of 100 µM was efficient in mitigating the salinity stress in strawberries, improving the action of the PSII, inducing compatible osmolytes and the phenol metabolism, and mitigating injuries to the membrane. For Araújo et al. (2018), salicylic acid mitigated the osmotic stress in the bean cultivar BRS Guariba during germination and early growth when the seeds were treated with the dose of 1.0 mM.

In view of this, the present study aimed to evaluate the gas exchange and photosynthetic pigments of the West Indian cherry cv. BRS 366 Jaburu irrigated with saline water and with the exogenous application of salicylic acid.

Material and Methods

The experiment was conducted in a protected environment consisting of a greenhouse, located at the Academic Unit of Agricultural Engineering (UAEA) of the Center of Technology and Natural Resources (CTRN) of the Federal University of Campina Grande (UFCG) in the municipality of Campina Grande, PB, 7°15'18'' S, 35°52'28'' W, with a mean elevation of 550 m.

Five levels of electrical conductivity of the irrigation water - ECw (0.8, 1.6, 2.4, 3.2, and 4.0 dS m^{-1}) and four concentrations of salicylic acid - SA (0, 1.0, 2.0, and 4.0 mM) were tested, distributed in a randomized block design with a 5 x 4 factorial arrangement and three replicates. The concentrations of salicylic acid were based on the study of Trevisan et al. (2017) while the levels of ECw were in conformity with Dias et al. (2019).

The study used plants of the West Indian cherry cultivar BRS 366-Jaburu grafted onto the Crioulo rootstock originated from the Clonal Garden of EMBRAPA Agroindústria Tropical, in Pacajus – CE. The plants were grown in containers adapted as drainage lysimeters with a volume of 250 dm^3. Each lysimeter had two holes in the base in order to allow drainage and, below them, two drains connected the base to a plastic bottle (2 L volume) to monitor the drained volume and estimate the water consumption by the crop. To avoid clogging of the drains, a geotextile fabric was placed at the bottom of the lysimeters along with a 0.5 kg gravel layer.

The soil used in the study was classified according to Santos et al. (2013) as a Regolithic Neosol (Entisol) with a sandy-clay-loam texture (0-0.30 m depth), originated from the municipality of Esperança, PB. The soil was characterized analysing its physico-chemical attributes (Table 1) according to the methodology proposed by Teixeira et al. (2017).

Table 1. Physico-chemical attributes of the soil (0-0.30 m) used in the study (to fill the containers).

Chemical characteristics									
pH (H_2O) (1:2.5)	OM g kg^{-1}	P (mg kg^{-1})	K^+	Na^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H^+	EC_{se} (dS m^{-1})
			........................($cmol_c$ kg^{-1})........................						
5.63	18.30	18.20	0.21	0.17	3.49	2.99	0.00	5.81	0.61
Physical characteristics									
Size fraction (g kg^{-1})			Textural class	Water content (kPa)		AW	Total porosity	AD	PD
Sand	Silt	Clay		33.42[1]	1519.5[2]				
				....	dag kg^{-1}	....	m^3 m^{-3}	------(kg dm^{-3})----	
572.7	100.7	326.6	SCL	12.68	4.98	7.70	0.5735	1.13	2.65

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_4OAc at pH 7.0; Al^{3+}+H^+ extracted with 0.5 M CaOAc at pH 7.0; ECse - Electrical conductivity of the saturation extract; SCL - sandy-clay-loam;[1, 2] referring to the limits of field capacity and permanent wilting point, respectively; AW - Available water; AD - Apparent density; PD - Particle density.

Formative pruning were performed, in which the plants were grown on a single stem system, and the apical bud was pruned at 0.50 m height. Three of the lateral branches that emerged were kept, radially distributed in the last 0.20 m of the main stem. Any undesirable branching was eliminated as well as suckers and poorly located branches.

Fertilization with NPK was performed with monoammonium phosphate - MAP (11% N and 60% P_2O_5) as a phosphorus and nitrogen source, while urea (45% N) was used as a nitrogen source, taking into consideration the amount of N added through the MAP; finally, potassium chloride (60% K_2O) was used as a potassium source. The levels of 250, 120, and 240 g of N, P_2O_5, and K_2O, respectively, were applied per plant according to the recommendations of Cavalcanti (2008). Foliar fertilization with micronutrients was performed every fifteen days using a solution (1.0 g L^{-1}) of Dripsol® micro (1.1% magnesium, 0.85% boron, 0.5% copper (Cu-EDTA), 3.4% iron, and 0.05% molybdenum).

The saline water used for irrigation was obtained by adding the sodium chloride (NaCl), calcium chloride ($CaCl_2.2H_2O$), and magnesium chloride salts ($MgCl_2.6H_2O$) to public supply water of Campina Grande-PB in equivalent proportion of 7:2:1, respectively. This ratio represents the mean composition of the ion contents present in the different water sources used for irrigation in the semi-arid region of Northeastern Brazil (Medeiros, 1992).

The concentrations of salicylic acid were obtained by dissolving it in 30% ethyl alcohol (95.5%) in distilled water, for being a substance with low solubility in water at ambient temperature. The adjuvant Wil Fix® (0.5 mL L^{-1}) was added to reduce the superficial tension of the droplets on the leaf surface.

After pruning, the plants received, according to the treatment, the application of salicylic acid via spraying in the late afternoon, at a 20-day interval according to their respective treatments, totaling three applications.

Irrigation with the different levels of water electrical conductivity was performed by adopting a 3-day irrigation interval and applying in each lysimeter, an adequate water volume suficient to maintain soil moisture close to field capacity. The volume applied was determined according to the water requirement of the plants based on the water balance in the root zone, obtained by the difference between the water volume applied minus the volume drained in the last irrigation. In order to avoid salt accumulation in the root zone, a 0.10 leaching fraction was applied (Ayers & Westcot, 1999) at 30 days intervals.

The effects of the treatments on the West Indian cherry plants were evaluated at 40 days after pruning through the gas exchange variables: stomatal conductance - *gs* (mol H_2O m^{-2} s^{-1}), CO_2 assimilation rate - *A* (μmol m-^{2} s^{-1}), transpiration - *E* (mmol H_2O m^{-2} s^{-1}), and internal CO_2 concentration – *Ci* (μmol mol^{-1}), with the aid of a portable infrared gas analyzer (IRGA), model LCPro + Portable Photosynthesis System®. After data collection, the instantaneous water-use efficiency - WUE - *A*/*E* [(μmol m^{-2} s^{-1}) (mmol H_2O m^{-2} s^{-1})$^{-1}$], WUEi – the intrinsic water-use efficiency *A*/*gs* [(μmol m^{-2} s^{-1}) (μmol mol^{-1})$^{-1}$], and the instantaneous carboxylation efficiency - CEi - *A*/*Ci* [(μmol m^{-2} s^{-1}) (μmol mol^{-1})$^{-1}$] were evaluated.

The photosynthetic pigments of chlorophyll *a*, chlorophyll *b*, chlorophyll *total*, and carotenoids (Arnon, 1949) were also evaluated at the same time using three plant tissue disks collected from the third leaf of a branch located in the intermediate region of the canopy. The material was immersed in 80% acetone and stored in the dark for 48 hours. The extracts obtained were read in a spectrophotometer at the absorption wavelengths of 470, 646, and 663 nm. The values observed in the readings were subjected to the following equations: chlorophyll *a* (Chl *a*) = 12.21 ABS663 – 2.81 ABS646; chlorophyll *b* (Chl *b*) = 20.13 A646 – 5.03 ABS663; carotenoids (Car) = (1000 ABS470 – 1.82 Chl *a* – 85.02 Chl *b*)/198, and total chlorophyll (Chl *total*) = 17.3 A646 + 7.18 A663. The data of the contents of chlorophyll *a*, *b*, *total*, and carotenoids were expressed as mg g^{-1} of fresh matter (FM).

The collected data were subjected to analysis of variance by the F-test at the 0.05 level of probability and, when significant, polynomial (linear or quadratic) regression analysis was performed using the statistical software SISVAR/ESAL (Ferreira, 2014). In case of significance of the interaction between factors, response surfaces plots were prepared using the software TableCurve 3D.

Results and Discussion

There was a significant interaction between salinity and salicylic acid concentration on stomatal conductance, instantaneous carboxylation efficiency, and intrinsic water-use efficiency, and an isolated effect of both factors on transpiration (Table 2). The water salinity levels significantly influenced the CO_2 assimilation rate and the water-use efficiency. The studied factors had no effect on the internal CO_2 concentration (*Ci*).

The increase in the electrical conductivity of the irrigation water promoted a marked reduction in plant transpiration in the West Indian cherry cultivar BRS 366 Jaburu, obtaining the maximum estimated value of 1.49 mol H_2O m^{-2} s^{-1} and the minimum of 0.96 mol H_2O m^{-2} s^{-1} in plants cultivated under the water salinity levels of 0.8 and 4.0 dS m^{-1}, respectively (Figure 1A). When comparing the West Indian cherry plants irrigated with the ECw of 4.0 dS m^{-1} with the ones that received the lowest water salinity level (0.8 dS m^{-1}), a reduction of 0.53 mol H_2O m^{-2} s^{-1} is verified. According to Lima et al. (2017), the reduction in transpiration occurs due to the partial closure of the stomata. This mechanism reduces plant dehydration and causes an imbalance in the water content of the leaf epidermis, restricting water loss from the leaves to the atmosphere, consequently influencing the decrease in the CO_2 assimilation rate due to the stomatal behavior. These results are similar to those found by Lima et al. (2019), who verified the highest transpiration rate for the West Indian cherry cv. BRS 366 Jaburu (1.34 mol H_2O m^{-2} s^{-1}) at 130 days after transplanting in plants grown with the water of electrical conductivity of 0.8 dS m^{-1}.

Table 2. Summary of the F-test for the internal CO_2 concentration (*Ci*), transpiration (*E*), stomatal conductance (*gs*), CO_2 assimilation rate (*A*), water-use efficiency (WUE), instantaneous carboxylation efficiency (*CEi*), and intrinsic water-use efficiency (WUEi) of plants of the West Indian cherry cv. BRS 366 Jaburu irrigated with saline water and with the exogenous application of salicylic acid.

Source of variation	F-test						
	Ci	*E*	*gs*	*A*	WUE	*CEi*	WUEi
Water salinity levels (SL)	ns	**	**	**	**	*	**
Linear regression	ns	**	**	**	**	*	*
Quadratic regression	ns	*	*	*	**	ns	ns
Salicylic acid (SA)	ns	*	*	ns	ns	**	ns
Linear regression	ns	ns	*	ns	ns	ns	ns
Quadratic regression	ns	*	ns	ns	*	ns	ns
Interaction (SL x SA)	ns	ns	**	ns	ns	*	**
Blocks	ns	ns	ns	ns	ns	**	ns
CV (%)	20.26	23.55	23.01	23.69	22.35	18.25	15.35

ns, *, **, respectively non-significant and significant at $p < 0.05$ and $p < 0.01$; CV = coefficient of variation.

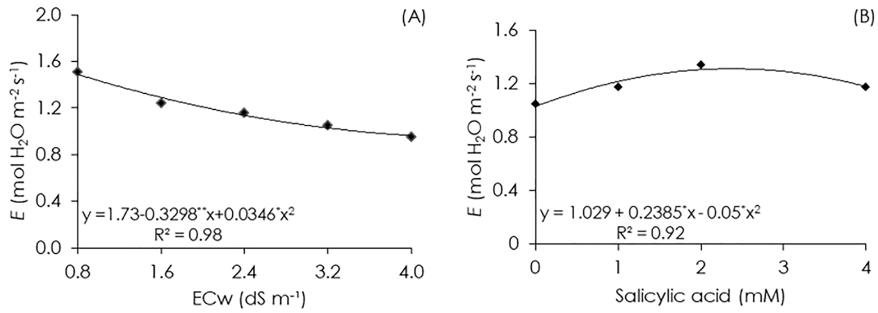

Figure 1. Transpiration - *E* of plants of the West Indian cherry cv. BRS 366 Jaburu as a function of water salinity – ECw (A) and the exogenous application of salicylic acid (B).

For the concentrations of salicylic acid (AS), a quadratic effect is noted on the transpiration *(E)* of West Indian cherry plants (Figure 1B), with the maximum estimated value of 1.31 mol H_2O m^{-2} s^{-1} obtained when the plants received the concentration of 2.4 mM, while the lowest value of 1.03 mol H_2O m^{-2} s^{-1} was observed in the plants that did not receive the exogenous application of salicylic acid. Possibly, the highest transpiration rate observed when the salicylic acid was applied exogenously relates to the higher stomatal opening since it promotes water and CO_2 entry into the cells, resulting in increased transpiration.

The CO_2 assimilation rate of the West Indian cherry plants (Figure 2A) also decreased as a function of the increased salinity levels of the irrigation water, whose maximum estimated value of 7.99 mol H_2O m^{-2} s^{-1} was observed in the plants irrigated with the ECw of 0.8 dS m^{-1}, reducing from this level. It is noted that the plants irrigated with the ECw of 4.0 dS m^{-1} showed a reduction of 3.43 mol H_2O m^{-2} s^{-1} (43.05%) in relation to the plants under the lowest salinity level (0.8 dS m^{-1}), obtaining a minimum value of 4.55 mol H_2O m^{-2} s^{-1} at the estimated ECw of 3.7 dS m^{-1}. For Braz et al. (2019), the increase in the salt concentration in the soil reduces the osmotic potential of the soil solution, which by causing the closure of the stomata limits the CO_2 assimilation rate due to the decrease in stomatal conductance and restricts CO_2 entry into the leaves by reducing the pressure of CO_2 in the intracellular space.

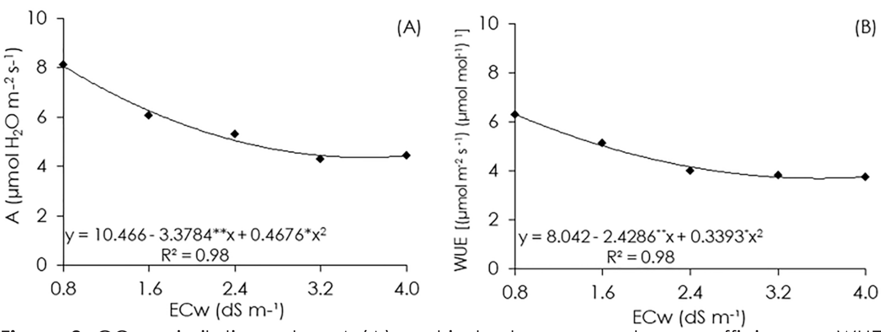

Figure 2. CO_2 assimilation rate – *A* (A) and instantaneous water-use efficiency – WUE (B) of plants of the West Indian Cherry cv. BRS 366 Jaburu as a function of water salinity – ECw.

The instantaneous water-use efficiency decreased quadratically as the water salinity levels were increased. In Figure 2B, it is verified that the maximum estimated value of the WUE of 6.3 [(μmol m^{-2} s^{-1}) (mmol H_2O m^{-2} s^{-1}) $^{-1}$] was obtained when the plants were irrigated with the lowest ECw level (0.8 dS m^{-1}), markedly decreasing until 4.0 dS m^{-1}. The increase in the soil salt content due to the irrigation water throughout the crop cycle reduces the soil osmotic potential. Plants decrease the stomatal opening under stress conditions, influencing the water uptake efficiency (Nobre et al., 2014). In a study with passion fruit under irrigation with saline water (ECw varying from 0.7 to 2.8 dS m^{-1}), Silva et al. (2019b) verified that salinity levels negatively affected gas exchange in plants. Furthermore, the increase in the soil salinity levels leads to stomatal closure, reduces Na^+ and Cl^- absorption, and decreases water loss, CO_2 assimilation, and the water-use efficiency necessary to the photosynthetic process (Silva et al., 2015).

Regarding stomatal conductance in West Indian cherry plants (Figure 3A), it is observed that, regardless of the application of salicylic acid (SA), the increase in the electrical conductivity of the irrigation water promoted reductions in the *gs*. The highest *gs* value (0.104 mmol H_2O m^{-2} s^{-1}) was recorded with the management of 0.8 dS m^{-1} without exogenous SA. In turn, the lowest value (0.037 mmol H_2O m^{-2} s^{-1}) was verified in the plants subjected to the AS concentration of 4 mM. Comparing this value to the highest *gs* value, a 64.32% reduction is verified (0.067 mmol H_2O m^{-2} s^{-1}).

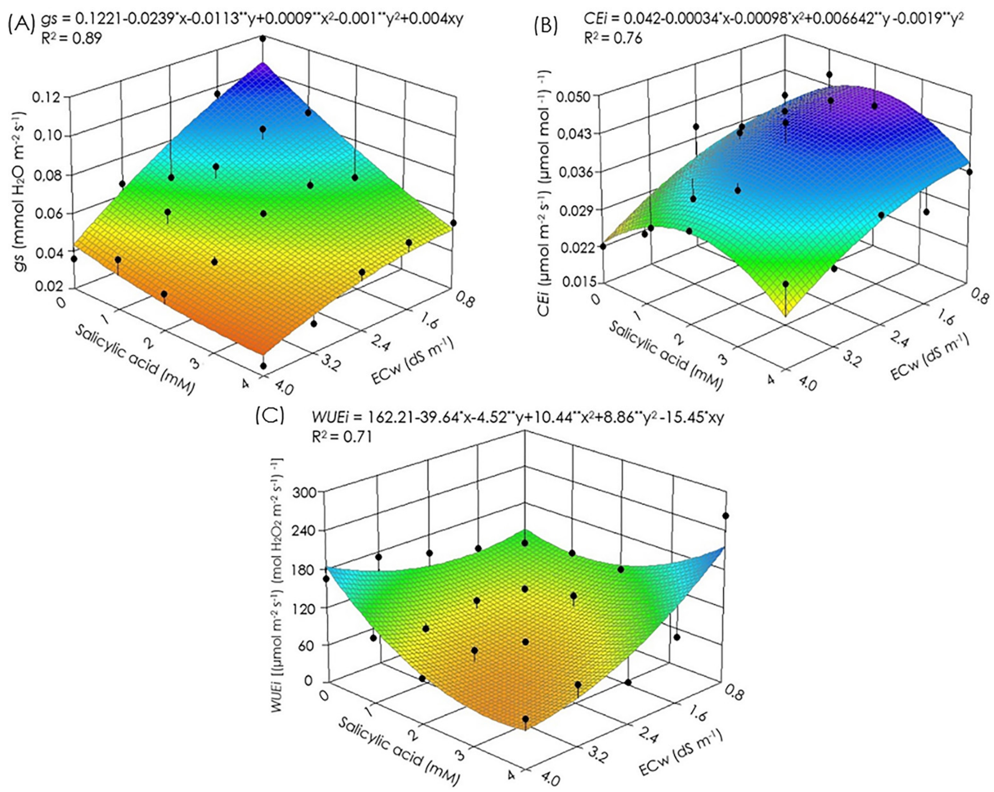

Figure 3. Stomatal conductance – *gs* (A), instantaneous carboxylation efficiency –*CEi* (B), and intrinsic water-use efficiency– WUEi (C) of plants of the West Indian cherry cv. BRS 366 Jaburu as a function of the interaction between water salinity - ECw and concentrations of salicylic acid. X and Y correspond to the ECw and the concentrations of salicylic acid, respectively.

The reduction in the stomatal conductance of plants grown under salinity stress is a strategy to maintain water homeostasis and reduce the absorption of toxic ions (mainly Na^+ and Cl^-) (Taiz et al., 2017). Thus, the *gs* reduction is the first defense mechanism activated by plants under stress conditions, avoiding water loss to the atmosphere when the absorption is hindered by the roots within a saline medium since the osmotic closure mechanism reduces the photosynthetic rate, implying a lower accumulation of photoassimilates used in the metabolism (Sousa & Sousa, 2017). The instantaneous carboxylation efficiency (*CEi*) was affected by the SL x SA interaction (Figure 3B). The plants subjected to the concentration of 1.6 mM and irrigated with 0.8 dS m^{-1} reached the highest value of 0.047 (μmol m^{-2} s^{-1}) (μmol mol $^{-1}$) $^{-1}$) de *Ci*. On the other hand, the lowest *CEi* of 0.021 (μmol m^{-2} s^{-1}) (μmol mol $^{-1}$) $^{-1}$) was recorded in plants subjected to the concentration of 4 mM and irrigated with 4.0 dS m^{-1}, corresponding to a 48.8% reduction compared to the highest *CEi*.

According to Lee et al. (2014), salicylic acid can increase the activity of the ribulose-1.5-bisphosphate carboxylase-oxygenase enzyme (Rubisco), contribute to potassium absorption, increase the ATP content and, with that, maintain the optimal K^+/Na^+ ratio in the plants. It should be highlighted that, in the present study, the beneficial effect of salicylic acid (estimated value of 1.6 mM) could be recorded in the improvement of the *CEi*. In studies using 1.0 and 2.0 mM of SA in the Jalapeño pepper crop (*Capsicum annuum* L. cv. Chichimeca), Sánchez-Chávez et al. (2011) verified maximum increments in the photosynthetic activity of 59 and 54 %, respectively, in relation to the minimum value found at the concentration of 0.8 mM.

Regarding the intrinsic water-use efficiency (Figure 3C), the plants subjected to the salicylic acid concentration of 4.0 mM and irrigated with 0.8 dS m^{-1} reached the highest *WUEi* of 211.4 [(μmol m^{-2} s^{-1}) (mol H_2O_2 m^{-2} s^{-1}) $^{-1}$]. While, the plants sprayed with a concentration of 4 mM and irrigated with water of 4.0 dS m^{-1} expressed the lowest *WUEi* of 47.17 [(μmol m^{-2} s^{-1}) (mol H_2O_2 m^{-2} s^{-1}) $^{-1}$], corresponding to a 77.69% [164.64 (μmol m^{-2} s^{-1}) (mol H_2O_2 m^{-2} s^{-1}) $^{-1}$] reduction in the intrinsic water-use efficiency compared to the plants that achieved the highest *WUEi*. When cultivating *Erythrina velutina* (Willd), Figueiredo et al. (2019) verified the negative influence of SA at the concentration of 2.0 mM on the *WUEi*, with a 38.7 % reduction compared to the absolute control (without SA).

There was a significant effect of the interaction between factors (SL x SA) on the chlorophyll *a* content of the West Indian cherry plants (Table 3). In isolation, the salinity levels significantly influenced the contents of Chl *a*, Chl *b*, and Car. In turn, the concentrations of salicylic acid promoted a significant difference in the Chl *a* and Chl *T* contents of the West Indian cherry plants.

Table 3. Summary of the F-test for the contents of chlorophyll *a (Chl a)*, chlorophyll *b (Chl b)*, total chlorophyll (Chl *T*), and carotenoids (Car) of plants of the West Indian cherry cv. BRS 366 Jaburu cultivated with saline water and with the exogenous application of salicylic acid.

Source of variation	F-test			
	Chl *a*	Chl *b*	Chl T	Car
Water salinity levels (SL)	*	*	ns	**
Linear regression	*	**	ns	*
Quadratic regression	ns	ns	ns	*
Salicylic acid (SA)	*	ns	*	ns
Linear regression	*	ns	**	ns
Quadratic regression	ns	ns	*	ns
Interaction (SL x SA)	**	ns	ns	ns
Blocks	ns	ns	ns	ns
CV (%)	18.25	17.44	15.34	17.58

ns, *, **, respectively non-significant and significant at $p < 0.05$ and $p < 0.01$; CV= coefficient of variation.

Figure 4 shows that the plants cultivated with water of 1,5 dS m^{-1} and subjected to the SA concentration of 4 mM expressed the highest content of Chl *a* (12.25 mg g^{-1}). On the other hand, the lowest content of Chl *a* (6.57 mg g^{-1} FM) was obtained in the West Indian cherry plants irrigated with 4.0 dS m^{-1} and in the absence of SA, corresponding to a 43.56% reduction compared to those with the highest value of Chl *a*. Salicylic acid reacts as an antioxidant substance under abiotic stress conditions, removing the excess of reactive oxygen and improving the photosynthetic synthesis by increasing the chlorophyll pigments when stimulating the activity of the rubisco enzyme during plant metabolism (Safeer et al., 2019).

The contents of chlorophyll *b* and carotenoids increased quadratically in response to the salinity levels of the irrigation water. Through the regression equations

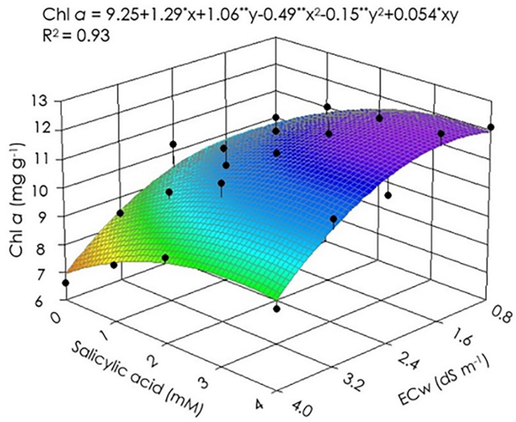

Figure 4. Contents of chlorophyll *a* in plants of the West Indian cherry cv. BRS 366 Jaburu as a function of the interaction between water salinity - ECw and concentrations of salicylic acid. X and Y correspond to the ECw and the concentrations of salicylic acid, respectively.

(Figure 5A and 5B), it is verified that the maximum values estimated for Chl *b* and Car (3.64 and 3.25 mg g^{-1} FM) were reached when the plants were irrigated with the ECw of 3.6 and 4.0 dS m^{-1}, respectively. When comparing the contents of chlorophyll *b* and carotenoids of the West Indian cherry plants grown under the ECw of 4.0 dS m^{-1} to the ones subjected to the lowest salinity level (0.8 dS m^{-1}), it is possible to observe an increase of 0,74 and 0,80 mg g^{-1} FM, respectively. The increase in the content of carotenoids under saline conditions is a plant strategy to dissipate energy via the xanthophylls, avoiding photoinhibition and photooxidation injuries in the plant tissues (Oliveira et al., 2018). In turn, the increase in chlorophyll *b* relates to photosynthesis, being able to improve the photosynthetic rate (Dias et al., 2019).

The results for chlorophyll *b* in the West Indian cherry plants diverge from those reported by Pinheiro et al. (2019) when evidencing that the increase in salinity corresponding to 3.8 dS m^{-1} decreases the content of chlorophyll *b* compared to the water salinity of 0.8 dS m^{-1}, which resulted in the maximum value (0.84 mg g^{-1} FM), for this crop. This divergence is the result of the increase in the activity of the chlorophyllase enzyme due to salt stress, responsible for the degradation of photosynthetic pigments (Silva et al., 2019c). While, the increase in the content of carotenoids as a function of salinity is a plant strategy to minimize damage to the photosynthetic apparatus since carotenoids transfer the absorbed light to the chlorophyll, acting in the photosynthetic processes (Taiz et al., 2017). Studying the West Indian cherry crop under salt stress (0.8 and 3.8 dS m^{-1}), Lima et al. (2018) observed an increase of 2.7 mg g^{-1} FM in the carotenoid content when the plants were irrigated with water with the electrical conductivity of 3.8 dS m^{-1}.

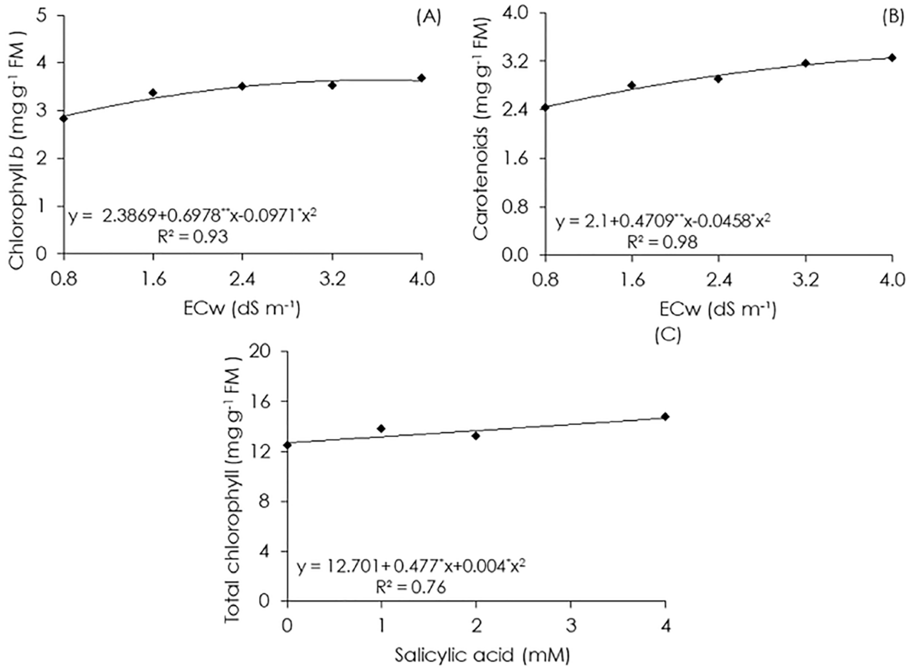

Figure 5. Contents of chlorophyll *b* (A) and carotenoids (B) in plants of the West Indian cherry cv. BRS 366 Jaburu as a function of water salinity – CEa, and contents of total chlorophyll – Chl *T* (C) as a function of the exogenous application of salicylic acid - SA.

The concentrations of salicylic acid promoted a quadratic increase in the total chlorophyll content of the West Indian cherry plants. Comparing the contents of total chlorophyll of the plants cultivated under 4.0 mM of salicylic acid in relation to the control treatment (0 mM), an increment of 1.97 mg g^{-1} FM is verified. Trevisan et al. (2017) also reported an increase in the total chlorophyll content with the increase in the concentration of salicylic acid (4.0 mM) during the crop development of strawberry. These results highlight that salicylic acid positively influences the synthesis of chlorophyll and, consequently, the photosynthetic processes of plants of the West Indian cherry cv. BRS Jaburu.

Conclusions

Irrigation water salinity from 0.8 dS m^{-1} decreases transpiration, the CO_2 assimilation rate, and the water-use efficiency as well as induces an increase in the synthesis of chlorophyll *b and* carotenoids.

Salicylic acid at the concentrations of 1.6, 4,0, and 4.0 mM promoted the maximum values for the instantaneous carboxylation efficiency, intrinsic water-use efficiency, and chlorophyll *a* in West Indian cherry plants irrigated with the water salinity of 0.8 dS m^{-1}.

The exogenous application of salicylic acid until the concentration of 4.0 mM stimulates total chlorophyll biosynthesis in plants of the West Indian cherry cv. BRS 366 Jaburu.

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