Salt stress and exogenous application of hydrogen peroxide on photosynthetic parameters of soursop

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ABSTRACT: This study aimed to evaluate the gas exchanges and photosynthetic pigments of soursop seedlings cv. ‘Morada Nova’ irrigated with saline waters and subjected to exogenous application of hydrogen peroxide by seed soaking and foliar spraying. The study was carried out using plastic bags under greenhouse conditions at the Center of Technology and Natural Resources of the Federal University of Campina Grande, PB, Brazil, using a eutrophic Regolithic Neosol of sandy loam texture. Treatments were arranged in a randomized block design, in a 5 x 5 factorial scheme, which consisted of five levels of electrical conductivity – ECw (0.7; 1.4; 2.1; 2.8 and 3.5 dS m⁻¹) of irrigation water and five concentrations of hydrogen peroxide - H₂O₂ (0, 25, 50, 75 and 100 µM), with four replicates and three plants per plot. As the salt stress increased, there were reductions in internal CO₂ concentration, instantaneous carboxylation efficiency and water use efficiency, and instantaneous carboxylation efficiency was the most sensitive variable. Hydrogen peroxide at concentrations of 25 and 50 µM attenuated the deleterious effects of water salinity on stomatal conductance, CO₂ assimilation rate and chlorophyll a content, and the concentration of 25 µM was the most efficient. The content of chlorophyll b and carotenoids of soursop cv. ‘Morada Nova’ had the deleterious effects caused by the salinity of irrigation water mitigated by the exogenous application of hydrogen peroxide in the concentration of 25 μM.

Key words: Annona muricata L., saline waters, physiology

Estresse salino e aplicação exógena de peróxido de hidrogênio nos parâmetros fotosintéticos da graviroleira

RESUMO: Objetivou-se com este trabalho avaliar as trocas gasosas e os pigmentos fotosintéticos de mudas de graviroleira cv. Morada Nova irrigadas com águas salinas e submetidas à aplicação exógena de peróxido de hidrogênio via embebição das sementes e pulverizações foliares. O estudo foi conduzido em sacolas plásticas sob condições de casa de vegetação pertencente ao Centro de Tecnologia e Recursos Naturais da Universidade Federal de Campina Grande, PB, utilizando-se um Neossolo Regolítico Eutrófico de textura franco-arenosa. Os tratamentos foram distribuídos no delineamento de blocos casualizados, em arranjo fatorial 5 x 5, sendo cinco níveis de condutividade elétrica da água de irrigação – CEa (0.7; 1.4; 2.1; 2.8 e 3.5 dS m⁻¹) e cinco concentrações de peróxido de hidrogênio – H₂O₂ (0, 25, 50, 75 e 100 µM), com quatro repetições e três plantas por parcela. Com o aumento do estresse salino, ocorreu diminuição na concentração interna de CO₂, na eficiência instantânea da carboxilação e na eficiência no uso da água, sendo a eficiência instantânea da carboxilação a variável mais sensível. O peróxido de hidrogênio nas concentrações de 25 e 50 µM atenuou os efeitos deletérios da salinidade da água sobre a condutância estomática, taxa de assimilação de CO₂ e no teor de clorofila a, sendo a concentração de 25 µM a mais eficiente. O teor de clorofila b e carotenóides da graviroleira cv. Morada Nova teve os efeitos deletérios causados pela salinidade da água de irrigação mitigados pela aplicação exógena de peróxido de hidrogênio na concentração de 25 µM.

Palavras-chave: Annona muricata L., águas salinas, fisiologia
**Introduction**

Soursop is a fruit crop that has stood out for having potential of commercialization in the domestic market, with relevant economic importance and prospects for export, and the northeast region of Brazil is the largest producer (Braga Sobrinho, 2010; Cavalcante et al., 2017). Soursop consumption, either fresh or processed, has increased due to its nutritional importance and forms of use in human diet, besides the medicinal properties of its leaves, fruits, seeds and roots (Freitas et al., 2013).

In the semi-arid region of Northeast Brazil, where the low rainfall levels unevenly distributed along the year are limiting factors for agricultural production, the practice of irrigation is the only way to guarantee a cultivation with water security (Lacerda et al., 2016). However, waters from the sources of this region are mostly saline, which may cause morphological, structural and metabolic modifications in plants (Lima et al., 2016). In addition, the effect of water salinity on crops is variable among species (Brito et al., 2014).

As a result, studies have been conducted using saline waters for cultivation in the Northeast region, for instance of sugar apple (Sá et al., 2015), citrus (Barbosa et al., 2017) and guava (Bezerra et al., 2018). Hence, it is extremely important to conduct research aiming to assess other fruit crops such as soursop, because studies involving the use of saline water in its cultivation are scarce.

In this context, alternatives have been sought to attenuate the effects caused by salt stress on crops, among which the exogenous application of hydrogen peroxide (H$_2$O$_2$), in the form of spray and/or in the pre-treatment of seeds at low concentrations, has proved to be promising in the acclimation of crops to salt stress (Gondim et al., 2011). In addition, H$_2$O$_2$ works as a signaling molecule in plants under biotic and abiotic stresses, being involved in several processes such as root gravitropism, tolerance to oxygen deficiency, strengthening of cell wall, senescence, photosynthesis, stomatal closure and in the control of cell cycle (Gechev et al., 2006; Petrov & Breusegem, 2012).

This study aimed to evaluate the gas exchanges and photosynthetic pigments of soursop seedlings cv. Morada Nova' irrigated with saline waters and subjected to exogenous application of hydrogen peroxide.

**Material and Methods**

The study was conducted in the period from May to October 2017, using 2 dm$^3$ plastic bags, under greenhouse conditions at the Center of Technology and Natural Resources of the Federal University of Campina Grande (CTRN/UFCG), located in the municipality of Campina Grande, PB, Brazil, situated by the geographic coordinates 7º 15’ 18’’ S and 35º 52’ 28’’ W, at mean altitude of 550 m.

The treatments resulted from the combination of five levels of irrigation water electrical conductivity – ECw (0.7; 1.4; 2.1; 2.8 and 3.5 dS m$^{-1}$) and five concentrations of hydrogen peroxide - H$_2$O$_2$ (0, 25, 50, 75 and 100 μM), arranged in randomized blocks, in 5 x 5 factorial scheme, with four replicates and three plants per plot, totaling 300 plants.

The levels of irrigation water electrical conductivity (1.4; 2.1; 2.8 and 3.5 dS m$^{-1}$) were prepared by dissolving the salts NaCl, CaCl$_2$, H$_2$O and MgCl$_2$, H$_2$O, in equivalent proportion of 7:2:1, respectively, in water from the local supply system (ECw = 1.10 dS m$^{-1}$). This proportion is commonly found in sources of water used for irrigation in small properties of the Northeast region (Medeiros et al., 2003), based on the relationship between ECw and the concentration of salts recommended by Richards (1954). The level of 0.7 dS m$^{-1}$ was obtained by diluting water from the local supply system in rainwater (ECw = 0.02 dS m$^{-1}$).

The plastic bags were filled with 2.6 kg of dry substrate composed of soil (84%), sand (15%) and humus (1%). The soil used in the experiment was a eutrophic Regolithic Neosol of sandy loam texture, collected in the 0-20 cm layer, from the rural area of the municipality of Lagoa Seca, PB, properly pounded to break up clods and sieved. Its physical and chemical characteristics were determined according to methodology proposed by Donagema et al. (2011): Exchangeable Ca$^{2+}$, Mg$^{2+}$, Na$^+$, K$^+$, Al$^{3+}$+H$^+$ = 2.60; 3.66; 0.16; 0.22 and 1.93 cmol kg$^{-1}$, respectively; pH (water 1:2.5) = 5.9; ECse = 1.0 dS m$^{-1}$; organic matter = 1.36%; sand, silt and clay = 732.9, 142.1, and 125.0 g kg$^{-1}$, respectively; bulk density = 1.39 kg dm$^{-3}$; moisture content at 33.42 and 1519.5 kPa = 11.98 and 4.32 dag kg$^{-1}$, respectively.

The seeds used in the experiment were obtained from fruits harvested in a commercial orchard located in the municipality of Macaparana, PE. Seeds were extracted manually, air dried, and their dormancy was broken by means of a distal cut to the embryo, according to methodology proposed by Mendonça et al. (2007).

Prior to sowing, the seeds were subjected to a pre-treatment with hydrogen peroxide, in which they were soaked at the concentrations of the respective treatments for a period of 24 h, whereas seeds of the control treatment (0 μM) were soaked in distilled water for the same period of time. Then, sowing was carried out by planting three seeds of sour sop cv. Morada Nova’ at 3 cm depth, equidistantly distributed. At 20 days after germination, thinning was performed leaving only one plant per bag with highest vigor.

Prior to sowing, the moisture content in the soil was increased to the maximum retention capacity using the water according to each treatment. After sowing, irrigation was performed daily, applying in each plastic bag a water volume sufficient to maintain the soil close to field capacity. The applied volume was determined according to plant water needs, estimated by water balance by subtracting the volume drained from the volume applied in the previous irrigation, plus a leaching fraction of 0.10, applied every 20 days, in order to control the excessive accumulation of salts in the root zone.

Fertilization with nitrogen, potassium and phosphorus was applied as topdressing, based on the methodology described by Novaes et al. (1991). The quantities of 0.58 g of urea, 0.65 g of potassium chloride and 1.56 g of monoammonium phosphate, equivalent to 100, 150 and 300 mg kg$^{-1}$ of the substrate of N, K$_2$O and P$_2$O$_5$, respectively, were applied as topdressing in four equal portions through fertigation, at 15 day intervals, with the first application at 15 days after sowing (DAS). In order to meet deficiencies of micronutrients, the leaves were sprayed...
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Foliar application of H₂O₂ was carried out manually using a sprayer at 17 h, with solution corresponding to each treatment, at 90, 105 and 120 DAS, spraying the abaxial and adaxial sides of the leaves in order to ensure complete wetting. Control treatment plants were not treated with spraying.

At 120 DAS, gas exchanges were measured based on stomatal conductance (mol H₂O m⁻² s⁻¹), transpiration (mmol H₂O m⁻² s⁻¹), CO₂ assimilation rate (µmol m⁻² s⁻¹) and internal CO₂ concentration (µmol m⁻² s⁻¹) (CI) in the third leaf, counted from the apex, with irradiation of 1200 µmol photons m⁻² s⁻¹ and air flow rate of 200 mL min⁻¹, using the portable photosynthesis meter "LCPro+" of ADC BioScientific Ltda. These data were used to quantify the instantaneous water use efficiency (WUEI) (A/E) [(µmol m⁻² s⁻¹) (mol H₂O m⁻² s⁻¹)] (Jaimez et al., 2005).

Photosynthetic pigments (chlorophylls a and b and carotenoids) were quantified by following the laboratory methods developed by Arnon (1949), in which plant extracts are obtained from samples of discs of the third mature leaf from the apex. These extracts were used to determine the concentrations of chlorophylls a and b and carotenoids in the solutions using a spectrophotometer at the absorbance (ABS) wavelengths (470, 646, and 663 nm), using the following equations: Chlorophyll a (Chla) = (12.21 x ABS663) – (2.81 x ABS646); Chlorophyll b (Chlb) = (20.13 x ABS646) – (5.03 x ABS663) and Carotenoids (Car) = [(1000 x ABS470) – (1.82 x Chla) – (85.02 x Chlb)]/198. The obtained values for the contents of chlorophylls a and b and carotenoids in the leaves were expressed in mg g⁻¹ FM (fresh matter).

The collected data were subjected to analysis of variance by F test at 0.05 and 0.01 probability levels and, when significant, were expressed in mg g⁻¹ FM. The increase of stomatal conductance in soursop plants cv. 'Morada Nova' indicates a recovery in the stomatal movement, possibly signaled by the exogenous application of H₂O₂.

Based on F test (Table 1), irrigation water salinity significantly affected stomatal conductance (gs), transpiration (E), CO₂ assimilation rate (A), internal CO₂ concentration (CI), instantaneous carboxylation efficiency (EICI) and instantaneous water use efficiency (WUEI). The concentrations of hydrogen peroxide and the interaction between factors (Salinity levels – SL x Hydrogen Peroxide - H₂O₂) had significant effect on gs, E and A.

The increase in irrigation water electrical conductivity negatively affected the stomatal conductance of soursop plants cv. 'Morada Nova' in the control treatment, i.e., those which did not receive exogenous application of H₂O₂. According to the regression equation (Figure 1A), there was a linear effect, with reduction of 13.64% per unit increase in ECw. In relative terms, stomatal conductance decreased by 42.23% between plants subjected to the highest level of salinity (3.5 dS m⁻¹) and plants at the lowest level (0.7 dS m⁻¹). However, H₂O₂ concentrations of 25 and 50 µM led to higher transpiration when compared to the plants subjected to the highest level of salinity (3.5 dS m⁻¹) with value of gs is higher than the control, up to 2.6 dS m⁻¹ and the concentration of 75 µM from 2.3 dS m⁻¹, with value of gs is higher than the control.

The increase of stomatal conductance in soursop plants cv. 'Morada Nova' indicates a recovery in the stomatal movement, possibly signaled by the exogenous application of H₂O₂. Pre-exposure of plants to moderate stresses or to signaling metabolites such as H₂O₂ may result in a metabolic signaling in the cell (increase of metabolites and/or antioxidant enzymes) and, therefore, lead to better physiologic performance when the plant is exposed to more severe conditions of stress (Forman et al., 2010).

By analyzing the interaction between irrigation water salinity and H₂O₂ concentrations on the transpiration of soursop plants cv. 'Morada Nova', according to the regression equation (Figure 1B), it is possible to note that the H₂O₂ concentration of 25 µM led to higher transpiration when compared to the values of plants in the control treatment (0 µM) for all studied levels of salinity. The other H₂O₂ concentrations intensified the deleterious effects of water salinity. The reductions per unit increase in ECw were, respectively, 12.57, 9.23, 15.41, 17.33 and 18.58% for the concentrations of 0, 25, 50, 75 and 100 µM.

CO₂ assimilation rate decreased linearly with increasing electrical conductivity of irrigation water. According to the regression equation (Figure 2A), in plants of the control treatment (0 µM), there was a linear reduction of 21.79% per unit increase in ECw, i.e., reduction of 72.01% in the CO₂ assimilation rate of plants irrigated with water of highest ECw.

**Results and Discussion**

| Source of variation | F Test | Gs | E | A | CI | EICI | WUEI |
|---------------------|--------|----|----|---|----|------|------|
| Salinity levels (SL) |        | ** | ** | ** | ** | **   | **   |
| Linear regression   |        | ** | ** | ** | ** | **   | **   |
| Quadratic regression| ns     | ns | ns | ns | ns | ns   | ns   |
| Hydrogen Peroxide (H₂O₂) | ** | ** | ** | ns | ns | ns   | ns   |
| Linear regression   |        | ** | ** | ** | ** | ns   | ns   |
| Quadratic regression| ns     | ns | ns | ns | ns | ns   | ns   |
| Interaction (SL x H₂O₂) | ** | ** | ** | ns | ns | ns   | ns   |
| Blocks              |        | ns | ns | ns | ns | ns   | ns   |
| CV (%)              |        | 19.99 | 14.66 | 17.88 | 18.94 | 25.30 | 23.45 |

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Table 1. Summary of F test for stomatal conductance (gs), transpiration (E), CO₂ assimilation rate (A), internal CO₂ concentration (CI), instantaneous carboxylation efficiency (EICI) and instantaneous water use efficiency (WUEI) of soursop plants cv. 'Morada Nova' irrigated with saline waters and subjected to exogenous application of hydrogen peroxide, at 120 days after sowing.
salinity level (3.5 dS m⁻¹), compared to the lowest level (0.7 dS m⁻¹). However, there was an increase of 2.17 µmol m⁻² s⁻¹ in the CO₂ assimilation rate of soursop plants cv. ‘Morada Nova’ subjected to the H₂O₂ concentration of 25 µM and irrigated with 3.5 dS m⁻¹ water, compared to the control treatment (0 µM) in respective treatment.

As observed in the variables gs and E (Figures 1A and B), the H₂O₂ concentration of 100 µM did not attenuate the deleterious effect of salinity on the CO₂ assimilation rate of soursop plants cv. ‘Morada Nova’; the opposite occurred. Thus, it can be inferred that the excess of reactive oxygen species had a toxic effect, mainly caused by the oxidative stress.

The salt stress reduced stomatal conductance, transpiration and CO₂ assimilation rate in soursop plants cv. ‘Morada Nova’, comparing to control treatment (0.7 dS m⁻¹). Closure of stomata in plants results in a restriction to CO₂ entry in leaf mesophyll cells, which may increase the susceptibility to photochemical damage because the reduction in CO₂ assimilation rate causes excessive light energy in the photosystem II (Silva et al., 2010).

The beneficial effect of hydrogen peroxide at low concentrations may be associated with its role as a signaling molecule, regulating several pathways, including responses to saline stress (Baxter et al., 2014). Therefore, H₂O₂ is related to the regulation of several mechanisms under conditions of abiotic and biotic stresses (Malolepsza & Rózalska, 2005).

The internal CO₂ concentration (CI) of soursop plants cv. ‘Morada Nova’ decreased linearly in response to the increasing levels of ECw and, according to the regression equation (Figure 2B), it can be noted that at ECw of 1.4 dS m⁻¹ there was a reduction of 3.62% compared to the control treatment (0.7 dS m⁻¹); for ECw levels of 2.1, 2.8 and 3.5 dS m⁻¹, the reductions were respectively equal to 7.25, 10.87 and 14.5%. These reductions of internal CO₂ concentration with increase in salinity levels observed in soursop cv. ‘Morada Nova’ are...
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For the instantaneous carboxylation efficiency (EICI), irrigation water salinity had a negative effect and, according to the regression equation (Figure 3A), there was a reduction in EICI of 18.49% per unit increase in electrical conductivity of water, i.e., reductions of 59.47% in the EICI of plants irrigated with water of highest salinity (3.5 dS m\(^{-1}\)) compared to the lowest level (0.7 dS m\(^{-1}\)). According to Taiz & Zeiger (2017), as the stress becomes more severe, the dehydration of mesophyll cells inhibits photosynthesis, thus damaging the metabolism and consequently hampering carboxylation efficiency.

Instantaneous water use efficiency (WUEI) was also negatively affected by irrigation water salinity (Figure 3B). The linear model fitted indicates that irrigation using water with EC\(_w\) of 0.7 dS m\(^{-1}\) (control treatment) led to the highest WUEI [4.48 µmol m\(^{-2}\) s\(^{-1}\) (mol H\(_2\)O m\(^{-2}\) s\(^{-1}\))] whereas the highest level of salinity (3.5 dS m\(^{-1}\)) caused the lowest value [3.37 µmol m\(^{-2}\) s\(^{-1}\) (mol H\(_2\)O m\(^{-2}\) s\(^{-1}\))], i.e., a reduction of 24.74% [1.11 µmol m\(^{-2}\) s\(^{-1}\) (mol H\(_2\)O m\(^{-2}\) s\(^{-1}\))] between the highest (3.5 dS m\(^{-1}\)) and lowest (0.7 dS m\(^{-1}\)) levels of irrigation water salinity. It can be inferred the irrigation water salinity directly affects WUEI in soursop plants cv. ’Morada Nova’. Thus, the reduction of WUEI observed in the present study may be related to the accumulation of salts in the soil along the crop cycle, a situation that contributes to the reduction of the osmotic potential of the soil and, consequently caused greater difficulty for water absorption by plants (Nobre et al., 2014).

The F test (Table 2) shows significant effect (p < 0.01) of irrigation water salinity levels on chlorophyll a (Chla) and chlorophyll b (Chlb). The hydrogen peroxide concentrations and the interaction between factors (SL x H\(_2\)O\(_2\)) significantly influenced (p < 0.01) all variables analyzed.

The regression equation (Figure 4A) indicates that, in plants of the control treatment (0 µM), there was a reduction in Chla content of 15.2% per unit increase in irrigation water electrical conductivity. On the other hand, in soursop plants cv. ’Morada Nova’ subjected to treatments with hydrogen peroxide concentrations of 25 and 50 µM, the deleterious effects of salinity on Chla content were attenuated. Plants under the highest level of salinity (3.5 dS m\(^{-1}\)) subjected to 50 µM of H\(_2\)O\(_2\) obtained the highest means of Chla (4.92 mg g\(^{-1}\) FM), which represented an increase of 2.32 mg g\(^{-1}\) compared to the control treatment (0 µM) at the same salinity level. However, the concentrations of 75 and 100 µM did not attenuate the negative effects of irrigation water salinity on the Chla contents of soursop plants cv. ’Morada Nova’.

For chlorophyll b (Chlb) (Figure 4B), the H\(_2\)O\(_2\) concentration of 50 µM led to the highest means, which corresponded to 1.59, 1.78 and 1.66 mg g\(^{-1}\) FM, when plants were irrigated with the respective EC\(_w\) levels of 2.1, 2.8 and 3.5 dS m\(^{-1}\). In addition, plants in the control treatment (0 µM) (Figure 4B) had reduction of 13.87% in chlorophyll b content per unit increase in EC\(_w\). However, plants subjected to concentration of 50 µM and exposed to salt stress at the highest EC\(_w\) level (3.5 dS m\(^{-1}\)) showed increase of 0.875 mg g\(^{-1}\) FM in the chlorophyll b content, compared to those subjected to the control treatment. The reduction in chlorophyll b content observed in plants of the control treatment (0 µM) may be attributed to the increase in the activity of the chlorophyllase enzyme, which degrades molecules of this photosynthesizing pigment (Freire et al., 2013). Gondim (2012), evaluating foliar pre-treatment with H\(_2\)O\(_2\) as a strategy to minimize the deleterious effects of salinity on corn plants, observed that the highest contents of chlorophyll were obtained in plants pre-

**Table 2. Summary of F test for chlorophyll a (Chla), chlorophyll b (Chlb) and carotenoids (Car) of soursop plants cv. ’Morada Nova’ irrigated with saline waters and subjected to exogenous application of hydrogen peroxide, at 140 days after sowing**

| Source of variation | Chla | Chlb | Car |
|---------------------|------|------|-----|
| Salinity levels (SL) | **  | **  | ns  |
| Linear regression    | **  | **  | ns  |
| Quadratic regression | ns  | ns  | ns  |
| Hydrogen Peroxide (H\(_2\)O\(_2\)) | **  | **  | **  |
| Linear regression    | ns  | ns  | *   |
| Quadratic regression | **  | **  | ns  |
| Interaction (SL x H\(_2\)O\(_2\)) | **  | **  | **  |
| Blocks               | ns  | ns  | ns  |
| CV (%)              | 8.11| 15.69| 14.87|

ns, **: Respectively, not significant, significant at p < 0.01 and p < 0.05

**Figure 3.** Instantaneous carboxylation efficiency - EICI (A) and instantaneous water use efficiency - WUEI (B) of soursop plants as a function of irrigation water salinity

| Equation referring to the Figure 3A |
|-------------------------------------|
| y = 0.0365 - 0.0049\(^\text{x}\) x\(^2\) |
| R\(^2\) = 0.94 |

| Equation referring to the Figure 3B |
|-------------------------------------|
| y = 4.755 - 0.395\(^\text{x}\) x\(^2\) |
| R\(^2\) = 0.73 |
treated with H$_2$O$_2$ at concentration of 10 mM, despite being subjected to salt stress (80 mM of NaCl).

As regards to the carotenoid content, the regression equation (Figure 4C) shows a linear decreasing effect in the control treatment plants (0 μM), with a decrease in carotenoid content of 14.55% per unit increment of ECw, resulting in a reduction of 0.844 mg g$^{-1}$ FM in plants irrigated with water of 3.5 dS m$^{-1}$ relative to the lowest level (0.7 dS m$^{-1}$). However, it was verified that the plants submitted to hydrogen peroxide had an increase in the carotenoid content with the imposition of salt stress, especially in the concentrations of 25 and 100 μM, whose increases were, respectively, 0.848 and 0.708 mg g$^{-1}$ FM, at 3.5 dS m$^{-1}$, in relation to the control treatment (0.7 dS m$^{-1}$), indicating that the hydrogen peroxide was effective in the acclimation of soursop plants cv. Morada Nova to saline stress. Carotenoids are pigments that may exert a photoprotective action of the photochemical apparatus, being the increase of carotenoids possibly a defense mechanism, predicting photooxidative damage to chlorophyll molecules (Raven et al., 2007).

The reduction in the content of carotenoids in the control treatment occurred possibly because of the degradation or inhibition in the synthesis of carotenoids, mainly due to photooxidation, leading to damage to photosynthetic membranes, besides affecting other cell processes such as division and expansion (Silva et al., 2014).

**Figure 4.** Chlorophyll a (A), chlorophyll b (B) and carotenoids (C) of soursop plants cv. ‘Morada Nova’ as a function of the interaction between irrigation water electrical conductivity - ECw and hydrogen peroxide concentrations

| Equations referring to the Figure 4A | Equations referring to the Figure 4B | Equations referring to the Figure 4C |
|--------------------------------------|--------------------------------------|--------------------------------------|
| $y_0$=5.364-0.8457$x$ R² = 0.88     | $y_0$=1.523-0.2114$x$ R² = 0.90     | $y_0$=2.071-0.3014$x$ R² = 0.97     |
| $y_{25}$=2.335-0.6514$x$ R² = 0.98  | $y_{25}$=0.423+0.2186$x$ R² = 0.95  | $y_{25}$=1.209+0.1871$x$ R² = 0.87  |
| $y_{50}$=2.362+0.0741$x$ R² = 0.97  | $y_{50}$=-0.061+1.7919$x$ R² = 0.92 | $y_{50}$=-0.385+1.6317$x$ R² = 0.72 |
| $y_{75}$=1.336+2.2319$x$ R² = 0.982 | $y_{75}$=-0.236+1.2225$x$ R² = 0.83 | $y_{75}$=-0.833+2.3667$x$ R² = 0.592 |
| $y_{100}$=-0.602+4.1169$x$ R² = 0.94| $y_{100}$=-0.222+3.3504$x$ R² = 0.88 | $y_{100}$=-0.644+3.9586$x$ R² = 0.89 |

**Conclusions**

1. As the salt stress increases, there is a reduction in the photosynthetic parameters of soursop plants cv. ‘Morada Nova’.

2. Exogenous application of hydrogen peroxide at concentrations of 25 and 50 μM attenuated the deleterious effects of salt stress on stomatal conductance, CO$_2$ assimilation rate and chlorophyll a content.

3. Hydrogen peroxide concentrations of 75 and 100 μM in interaction with irrigation water salinity cause reductions in transpiration, CO$_2$ assimilation rate and chlorophyll a content of soursop plants cv. ‘Morada Nova’.

4. The content of chlorophyll b and carotenoids of soursop cv. ‘Morada Nova’ had the deleterious effects caused by the salinity of irrigation water mitigated by the exogenous application of hydrogen peroxide in the concentration of 25 μM.

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