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MORFOFISIOLOGIA DE GENÓTIPOS DE GERGELIM SUBMETIDOS A DIFERENTES ESTRATÉGIAS DE USO DE ÁGUA SALINA

ANDRÉ ALISSON RODRIGUES DA SILVA[1]; CASSIANO NOGUEIRA DE LACERDA[1]; GEOVANI SOARES DE LIMA[1]; LAURIANE ALMEIDA DOS ANJOS SOARES[1]; HANS RAJ GHEYI[1] E PEDRO DANTAS FERNANDES[1]

[1] Unidade Acadêmica de Engenharia Agrícola, Universidade Federal de Campina Grande, UFCG, Rua Aprígio Veloso, 882 - Universitário, Campina Grande, PB. E-mail: andrealisson_cgpb@hotmail.com; cassianonogueiraagro@gmail.com; geovani.soares@pq.cnpq.br; lauriane.soares@pq.cnpq.br; hgheyi@gmail.com; pedrodantasfernades@gmail.com.

1 RESUMO

Objetivou-se com este trabalho avaliar as trocas gasosas e o acúmulo de fitomassas de genótipos de gergelim sob estratégias de uso de águas salinas. A pesquisa foi conduzida em casa de vegetação, em delineamento de blocos casualizados em arranjo fatorial 6 x 2, sendo seis estratégias de uso de águas salinas aplicadas nas diferentes fases fenológicas das plantas (SE-irrigação com água de baixa salinidade durante todo ciclo de cultivo; VE - irrigação com água de alta salinidade na fase vegetativa; FL - na fase de floração; FR na fase de frutificação; VE/FL - nas fases vegetativa/floração; VE/FR - nas fases vegetativa/frutificação) e dois genótipos de gergelim (BRS Seda e BRS Anahí), com quatro repetições. Foram aplicadas água com alta salinidade (2,7 dS m^{-1}), em alternância com água com baixa concentração de sais (0,3 dS m^{-1}), em fases diferentes do ciclo. A irrigação com água de 2,7 dS m^{-1} durante a fase de floração, e nas fases vegetativa/floração, não comprometeu a condutância estomática, transpiração e taxa de assimilação de CO_2 dos genótipos de gergelim. A salinidade da água de 2,7 dS m^{-1} quando aplicada nas fases vegetativa/floração prejudicou o acúmulo de fitomassa pelas plantas de gergelim.

Palavras-chave: estresse salino, *Sesamum indicum* L., qualidade de água.

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MORPHOPHYSIOLOGY OF SESAME GENOTYPES SUBMITTED TO DIFFERENT STRATEGIES FOR THE USE OF SALINE WATER

2 ABSTRACT

The objective of this study was to evaluate gas exchange and phytomass accumulation of sesame genotypes under different strategies for the use of saline water. The research was conducted in a greenhouse, in a randomized block design in a 6 x 2 factorial arrangement, with six strategies for the use of saline water applied in the different phenological phases of the plants (SE - irrigation with low salinity water throughout the cultivation cycle; VE - irrigation with high salinity water in the vegetative phase; FL - in the flowering phase; FR - in

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the fruiting phase; VE/FL - in the vegetative/flowering phase; VE/FR - in the phases vegetative/fruiting) and two sesame genotypes (BRS Seda and BRS Anahí), with four replicates. Water with high salinity (2.7 dS m-1) was used, alternating with water with low salt concentration (0.3 dS m-1), at different stages of the crop cycle. Irrigation with water of 2.7 dS m-1 during the flowering phase, and in the vegetative/flowering phases, did not compromise the stomatal conductance, transpiration and CO2 assimilation rate of sesame genotypes. The water salinity of 2.7 dS m-1 applied in the vegetative/flowering phases impaired the accumulation of phytomass by sesame plants.

Keywords: saline stress, *Sesamum indicum* L., water quality.

3 INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the most important oilseeds in the world, mainly because of its high nutritional value (LIU et al., 2020). Owing to its high oil (44 to 58%), protein (18 to 25%) and carbohydrate (13%) contents, sesame has been widely used as a source of edible oil (TENYANG et al., 2017). Compared with vegetable oils, products derived from this oilseed have advantages for human health and nutrition, such as antihypertensive and antioxidant activity, prevention of arteriosclerosis and reduction in inflammation (SHAHIDI; LIYANA-PATHIRANA; WALL, 2006).

In Brazil, sesame production is concentrated primarily in the states of Mato Grosso, Mato Grosso do Sul, Pará, and Ceará, with Mato Grosso being the largest national producer (LACERDA et al., 2020). Compared with other oilseed crops, sesame is moderately sensitive to salt stress, with yield and quality severely limited by soil and/or water salinity, especially in semiarid regions (ZHANG et al., 2019).

Although the semiarid Northeast Region offers favorable soil and climate conditions for sesame cultivation, these conditions are insufficient to fully exploit the crop's potential due to limitations imposed by the region's rainfall patterns, making irrigation a good alternative for ensuring food production (LIMA et al., 2020). However, the water from the region's springs contains high salt concentrations, which can cause morphological, structural, and metabolic changes in plants (LIMA et al., 2016).

Often, in areas characterized by a scarcity of low-salinity water, the use of saline water for irrigation has the potential to partially meet plant water demands and maintain a certain level of crop productivity (ALHARBY; COLMER; BARRETT-LENNARD, 2018). However, continuous irrigation with saline water leads to an increase in the salt concentration in the root zone, affecting water and nutrient absorption and limiting crop growth and development (HUSSAIN et al., 2015).

Thus, the use of cultivation strategies that minimize the deleterious effects of excess salts on plants and soil can benefit agricultural production, especially in semiarid regions. According to Lacerda et al. (2009), the selection of tolerant species or genotypes, the use of water sources with high salt concentrations in the most tolerant stages of crops, the mixing of water of different qualities, and the cyclical use of water sources with different salt concentrations are strategies that can mitigate the effects of salt stress on plants and reduce changes in soil physicochemical properties.

Given the above, the objective of this work was to evaluate the gas exchange parameters and accumulation of phytomass in sesame genotypes according to strategies for using saltwater in protected environments.

4 MATERIALS AND METHODS

The experiment was conducted between November 2018 and January 2019 in a greenhouse belonging to the Center for Agro-Food Science and Technology - CCTA of the Federal University of Campina Grande - UFCG, Pombal, Paraíba, located at the geographic coordinates of 6°47'20” south latitude and 37°48'01” west longitude, at an altitude of 194 m.

The treatments consisted of six saline water use strategies (SWSs) applied at different stages of plant development: SE irrigation with low-salinity water throughout the crop cycle (control); VE irrigation with high-salinity water in the vegetative phase (15–31 DAS); FL irrigation with high-salinity water in the flowering phase (32–56 DAS); FR irrigation with high-salinity water in the fruiting phase (57–88 DAS); VE/FL irrigation with high-salinity water in the vegetative/flowering phase (15–56 DAS); VE/FR irrigation with high-salinity water in the vegetative/fruiting phase (15–31 DAS; 56–88 DAS); and two sesame genotypes (GENs) (BRS Seda and BRS Anahí), in a 6x2 factorial arrangement, distributed in a randomized block design, with four replications, totaling 48 experimental units.

The salinity levels of the waters, expressed in terms of the electrical conductivity of the irrigation water (ECa), were 0.3 and 2.7 dS m $^{-1}$ for water with low and high salt concentrations, respectively. Saline levels were defined on the basis of a study developed by Dias et al. (2019). With respect to the crop development phases, in the VE treatment, the application of water with high salinity began at the emergence of the first definitive leaf and ended at the opening of the first flower; in the FL treatment, irrigation with high CEa began at the opening of the first flower and continued until the formation of the fruits (capsule); in the FR treatment, the application of saltwater occurred from the emergence of the capsules until the end of the harvest.

Seeds of the BRS Seda and BRS Anahí genotypes were used. The BRS Seda sesame cultivar has white seeds, high commercial value, and is used in the food and confectionery industries. Under ideal soil, water, and plant management conditions, BRS Seda can reach a productivity of up to 2,500 kg ha $^{-1}$. The cultivar is tolerant to angular leaf spot, brown eye spot, and macrophominal wilt (EMBRAPA, 2007). BRS Anahí has a dark green stem, a medium height, a 90-day cycle, an unbranched growth habit, flowering at 39 days, and three fruits per leaf axil. The seeds are whitish in color, weigh an average of 4.22 mg, and have an oil content ranging from 50 to 52%. It is tolerant of macrophominal wilt, angular leaf spot, and brown eye spot (EMBRAPA, 2015).

Plastic pots with a capacity of 20 L were adapted as lysimeters for plant cultivation. Two holes were drilled at the base of the pots, into which transparent 4 mm-diameter drains were installed. The end of the drain inside the lysimeter was wrapped with a nonwoven geotextile blanket (Bidim OP 30) to prevent soil obstruction. Below each drain was a container to collect the drained water to estimate the plants' water consumption. The pots were filled with a Regolithic Neosol with a sandy-clay loam texture, which originated from the rural area of the municipality of São Domingos, Paraíba. The chemical and physical characteristics (Table 1) were obtained according to the methodology described by Teixeira et al. (2017).

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

Chemical characteristics							
pH (H_2O) (1:2.5)	P (mg kg $^{-1}$)	K^+	In the $^+$	Ca^{2+}	Mg^{2+}	Al^{3+}	$Al^{3+} + H^+$
		..............................cmol $_c$ kg $^{-1}$					
5.58	3.92	0.23	1.64	9.07	2.78	0.0	8.61
..........Chemical characteristics..........			.............Physical characteristics.................................				
CE $_{is}$ (dS m $^{-1}$)	RAS (mmol L $^{-1}$) $^{0.5}$	PST %	Granulometric fraction (g kg $^{-1}$) Sand	Silt	Clay	Humidity (dag kg $^{-1}$) 33.42 kPa [1]	1519.5 kPa [2]
2.15	0.67	7.34	572.7	100.7	326.6	25.91	12.96

pH – Potential of hydrogen, MO – Organic matter: Walkley-Black Wet Digestion; Ca^{2+} and Mg^{2+} extracted with 1 M KCl pH 7.0; Na^+ and K^+ extracted using 1 M NH_4OAc pH 7.0; Al^{3+} +H^+ extracted using 0.5 M CaOAc pH 7.0; CEes - Electrical conductivity of the saturation extract; CEC - Cation exchange capacity; RAS - Sodium adsorption ratio of the saturation extract; PST - Percentage of exchangeable sodium; [1,2] referring to field capacity and permanent wilting point

NPK fertilization was performed as recommended for pot trials (NOVAIS; NEVES; BARROS, 1991) and was applied via fertigation at ten-day intervals at 100, 150, and 300 mg kg $^{-1}$ soil N, K_2O, and P_2O_5, respectively. Urea and monoammonium phosphate were used as nitrogen sources. Monoammonium phosphate was used as the phosphorus source, and potassium chloride was used as the potassium source. Micronutrient fertilization was performed weekly via foliar application via solutions (1.0 g L $^{-1}$) of ubyfol [N (15%); P_2O_5 (15%); K_2O (15%); Ca (1%); Mg (1.4%); S (2.7%); Zn (0.5%); B (0.05%); Fe (0.5%); Mn (0.05%); Cu (0.5%); Mo (0.02%)].

The water used for irrigation in the lowest salinity treatment (0.3 dS m $^{-1}$) came from the public water supply system of Pombal - PB, while the ECw level of 2.7 dS m $^{-1}$ was prepared by dissolving NaCl (without iodine) in the water supply. In preparing the irrigation water for the highest salinity level, the relationship between ECw and salt concentration, taken from Richards (1954), was considered, according to Equation 1:

$$Q\ (\text{mmolc L}^{-1}) = 10 \times \text{CEa}\ (\text{dS}\ m^{-1}) \qquad (1)$$

where: Q = quantity of salts to be applied (mmol $_c$ L $^{-1}$); and CEa = electrical conductivity of water (dS m $^{-1}$).

Fifteen sesame seeds were sown per pot at a depth of 2 cm. After seedling emergence, thinning was performed in two stages: at 15 and 25 days after sowing (DAS), when the plants had two and three pairs of definitive leaves, respectively, leaving only one plant per pot. After sowing, irrigation was applied daily at 5:00 PM, and the volume corresponding to that obtained via the water balance was applied to each container. This volume of water to be applied to the plants was determined according to Equation 2:

$$VI = (Va - Vd)/(1-FL) \qquad (2)$$

where VI = volume of water to be used in the next irrigation event (mL); Va = volume applied in the previous irrigation event (mL); Vd = drained volume (mL); and FL = leaching fraction of 0.2.

Seventy days after sowing, gas exchange was evaluated by observing the following parameters: stomatal conductance (*gs*), transpiration (*E*), CO_2 assimilation rate (*A*), internal CO_2 concentration (*Ci*), instantaneous carboxylation efficiency (*EiCi*) and instantaneous water use efficiency (*EiUA*). At 88 days after sowing, the following parameters were determined: phytomass accumulation through dry phytomass of leaves (FSF), stems (FSC), roots (FSR), shoots (FSPA) and total (FST) phytomass, in addition to the root/shoot ratio (R/PA).

Gas exchange was assessed on the third fully expanded leaf, measured from the apex, via the portable gas exchange measuring device "LCPro+" from ADC BioScientific Ltda. To obtain dry matter, the stem of each plant was cut close to the ground, immediately separated into distinct parts (stem, leaf, and root), and then packaged in a paper bag. Each part was subsequently dried in a forced-air oven at 65°C until a constant weight was obtained. The material was then weighed, and the dry matter was obtained.

The data were subjected to a normality test of distribution (Shapiro–Wilk test) at the 0.05 probability level. Analysis of variance was subsequently performed via the F test. In cases of significance, the Scott–Knott clustering test of means ($p<0.05$) was used for the saline water use strategies, and the Tukey test ($p<0.05$) was used for the sesame genotypes via the SISVAR–ESAL statistical software version 5.6 (FERREIRA, 2019).

5 RESULTS AND DISCUSSION

Salinity water use strategies had a significant effect ($p<0.01$) on the stomatal conductance (*gs*), transpiration (*E) and* CO_2 assimilation rate (*A*) of sesame plants 70 days after sowing (Table 2). The genotypes, as well as the interaction between the factors (EUS × GEN), did not significantly affect any of the sesame variables analyzed.

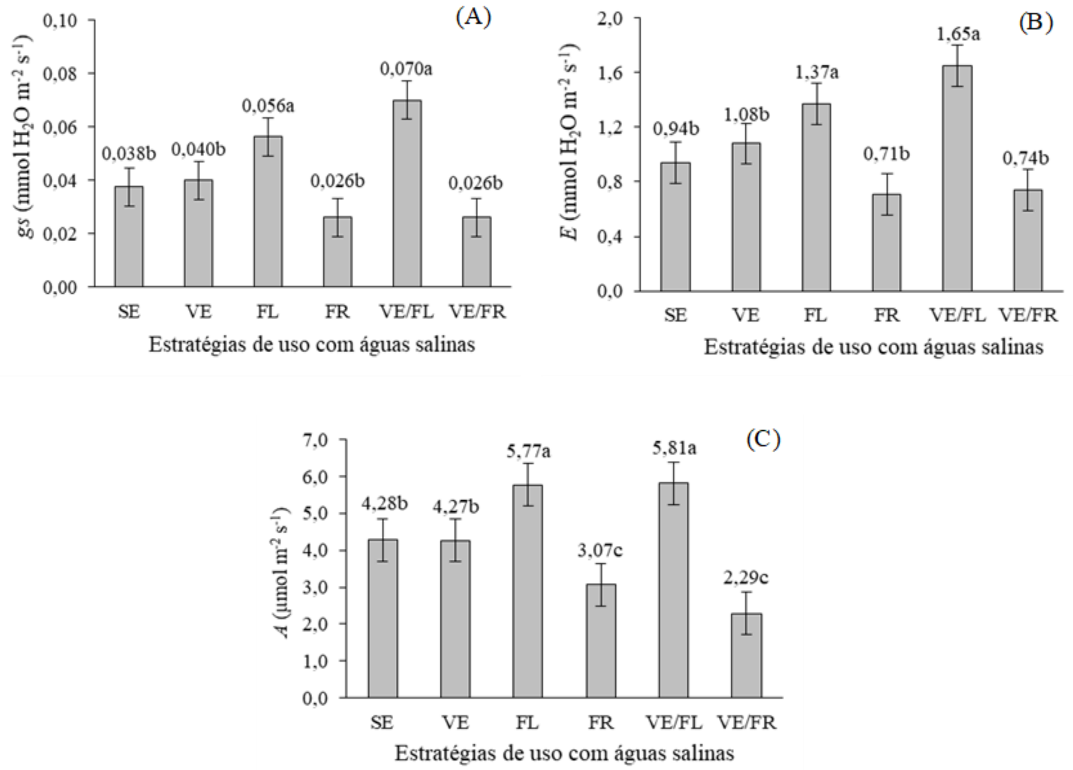
Table 2. Summary of the results of the analysis of variance of the internal $CO2_{concentration}$ (*Ci*), stomatal conductance (*gs*), transpiration (*E*), net assimilation rate (*A*), instantaneous water use efficiency (*EiUA*) and instantaneous carboxylation efficiency (*EiCi*) of sesame genotypes cultivated under saline water use strategies at 70 days after sowing.

FV	Mean squares					
	Ci	***gs***	***AND***	***THE***	***EiUA***	***EiCi***
EUS	1897.82 ^{ns}	2.4x10 $^{-3**}$	1,081 **	15.87 **	1.89 ^{ns}	5.3x10 $^{-4ns}$
GEN	0.19 ^{ns}	1.9x10 $^{-5ns}$	0.009 ^{ns}	0.17 ^{ns}	0.11 ^{ns}	2x10 $^{-6ns}$
(EUS x GEN)	979.69 ^{ns}	2.5x10 $^{-4ns}$	0.049 ^{ns}	2.70 ^{ns}	1.08 ^{ns}	2.4x10 $^{-4ns}$
Blocks	4942.58 ^{ns}	2.2x10 $^{-4ns}$	0.384 *	9.41 ^{ns}	0.89 ^{ns}	9.1x10 $^{-5ns}$
Residue	2693.13	3x10 $^{-4}$	0.098	2.60	1.76	2.6x10-4
CV (%)	13.52	18.02	14.31	18.44	16.54	34.63

EUS - Strategies for use with saline water; GEN - Genotype; FV - Source of variation; CV (%) - coefficient of variation; ** significant at 0.01 probability; * significant at 0.05 probability; ^{ns} not significant.

Compared with those of the SE, VE, FR, and VE/FR strategies, the stomatal conductance of the sesame plants differed significantly when saline stress was imposed during the flowering (FL) and vegetative/flowering (VE/FL) phases (Figure 1A). However, there was no significant difference when low-salinity water was used throughout the crop cycle, and high-salinity water (2.7 dS m $^{-1}$) was used during the vegetative, fruiting, and subsequent vegetative and fruiting phases. Thus, the deleterious effect of salinity stress is minimized when plants receive saltwater only during the flowering and vegetative/flowering phases. When plants are subjected to saline stress, the primary effect is the closure of stomata as a strategy to increase stomatal resistance to the flow of water vapor from the leaves to the external atmosphere to maintain the water potential in the leaves and avoid dehydration of guard cells, which can result in the restriction of the normal flow of CO2 to the carboxylation site (SILVA et al., 2018).

Figure 1. Stomatal conductance - *gs* (A), transpiration - *E (B) and net CO2* assimilation rate of sesame plants grown under different saline water use strategies (EUS) at 70 days after sowing (DAS).



Means followed by different letters are significantly different between treatments according to the Scott–Knott test ($p < 0.05$). The vertical bars represent the standard error of the mean ($n = 4$). SE = irrigation with low-salinity water throughout the crop cycle; VE = salt stress only in the vegetative phase (15–31 DAS); FL = salt stress in the flowering phase (32–56 DAS); FR = salt stress in the fruiting phase (57–88 DAS); VE/FL = salt stress in the vegetative and flowering phases (15–56 DAS); VE/FR = salt stress in the vegetative and fruiting phases (15–31 DAS; 56–88 DAS).

The transpiration of sesame plants is also influenced by saline water use strategies. According to the test of means (Figure 1B), plants grown under the FL and VE/FL strategies presented the highest *E values* (1.37 and 1.65 mmol H_2O m^{-2} s^{-1}, respectively), which differed significantly from those under the SE, VE, FR, and VE/FR strategies. However, when comparing plants grown under the SE, VE, FR, and VE/FR salinity-use strategies, there was no significant difference between these strategies.

The deleterious effects of salinity observed through the reduction of *E*, especially in the FR and VE/FR strategies, are the result of stomatal limitation due to the reduction in water absorption as a consequence of the reduction in soil water potential, which promotes a lower degree of stomatal opening, reducing the exit of water vapor and the entry of CO2 into the cell (LACERDA et al., 2020).

The reduction in stomatal conductance (Figure 1A) observed in sesame plants irrigated with high-salinity water during the fruiting and vegetative/fruiting stages may have negatively influenced the CO2 assimilation rate of sesame plants (Figure 1C), since these strategies (FR and VE/FR) presented the lowest A values (*3.07* and 2.29 µmol m $^{-}$

^{2} s $^{-1}$, respectively). However, the plants grown under the FL and VE/FL strategies presented the highest *A values* (5.77 and 5.81 µmol m $^{-2}$ s $^{-1}$, respectively), which differed significantly from those of the other strategies. Research by Dias et al. (2018) evaluated the gas exchange and photochemical efficiency of sesame (S *Sesamum indicum* L.) under irrigation with water of different salinities (0.6 to 3.0 dS m $^{-1}$) throughout the cultivation cycle and reported a reduction in the CO2 $_{\text{assimilation rate}}$ with increasing water salinity.

Salinity stress reduces the entry of CO2 $_{\text{into}}$ cells as a result of a lower degree of stomatal opening, thus contributing to a reduction in the rate of CO2 assimilation (SILVA et al., 2018). Furthermore, low rates of CO2 assimilation $_{\text{result}}$ in excess light energy in photosystem II, causing disturbances in photochemical reactions and decreases in photosynthetic rates, negatively affecting plant growth and development (FREIRE et al., 2014).

Salinity water use strategies had a significant effect on all the analyzed sesame variables, except for R/PA (Table 3). The genotype factor had a significant effect ($p<0.01$) on the FSC, FSR, FSPA and FST. The interaction between the factors (EUS × GEN) significantly influenced ($p<0.05$) the dry matter of the stems and roots of the sesame plants at 88 days after sowing (DAS).

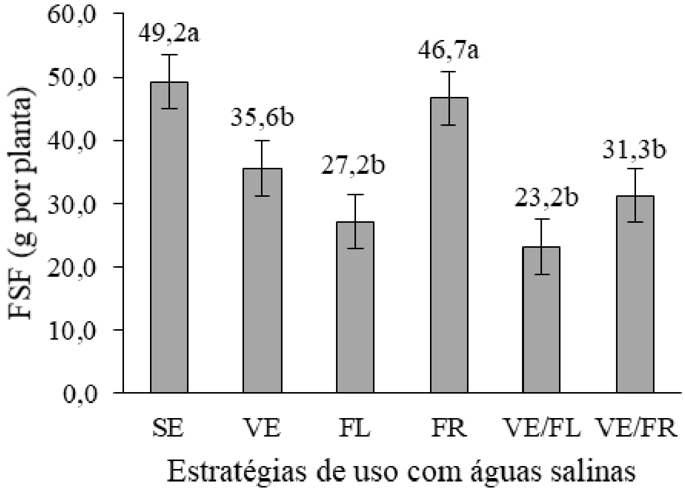
Table 3. Summary of the analysis of variance results for the dry matter contents of the leaves (FSF), stems (FSC), roots (FSR), aerial parts (FSPA), and total parts (FST) and the dry matter ratios of the roots and aerial parts (R/PA) of the sesame genotypes cultivated under saline water use strategies at 70 days after sowing.

FV	Mean Squares					
	FSF	**FSC**	**FSR**	**FSPA**	**FST**	**R/PA**
EUS	883.4 **	2040.5 **	511.8 *	4163.4 **	6003.0 **	0.05 ^{ns}
GEN	578.7 ^{ns}	36653.4 **	5715.0 **	46444.1 **	84473.4 **	0.03 ^{ns}
EUS x GEN	52.0 ^{ns}	658.2 *	456.2 *	651.2 ^{ns}	530.0 ^{ns}	0.04 ^{ns}
Blocks	222.0 ^{ns}	198.8 ^{ns}	311.2 ^{ns}	791.6 ^{ns}	338.2 ^{ns}	0.06 ^{ns}
Residue	159.5	268.6	182.7	591.7	1080.2	0.028
CV (%)	17.13	13.95	21.68	13.32	13.32	20.92

EUS - Strategies for use with saline water; GEN - Genotype; FV - Source of variation; CV (%) - coefficient of variation; ** significant at 0.01 probability; * significant at 0.05 probability; ^{ns} not significant.

The dry matter of the leaves of sesame plants grown with low ECw water (0.3 dS m $^{-1}$) throughout the cycle and high salinity (2.7 dS m $^{-1}$) in the fruiting stage (FR) was significantly greater than that of those subjected to high salinity water in the vegetative (VE), flowering (FL), continuous application in the vegetative and flowering (VE/FL) and vegetative and fruiting (VE/FR) stages (Figure 2). Notably, irrigation with saline water (ECw = 2.7 dS m $^{-1}$) in the VE, FL, VE/FL and VE/FR strategies (Figure 2) did not significantly differ from each other. The reduction in the accumulation of dry matter in the leaves may have occurred because of the application of water with high saline concentrations in the initial stages of the crop (VE/FL), a period in which most cultivated species are sensitive to salt stress. Salinity stress causes interruptions in physiological processes in plant cells, inhibiting plant growth and causing severe damage to the photosynthetic apparatus (SAMADDAR et al., 2019).

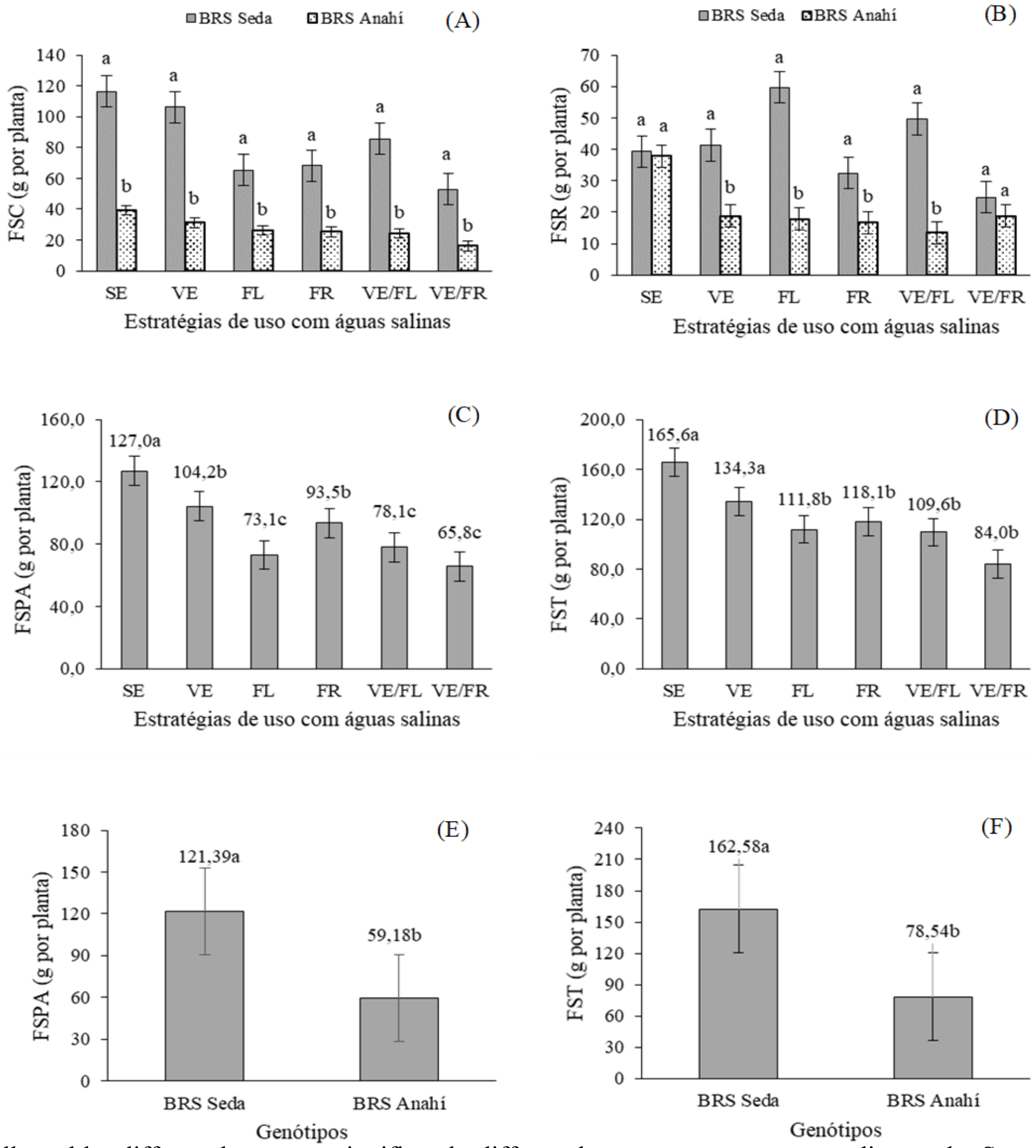
Figure 2. Leaf dry matter (LSF) of sesame plants grown under different saline water use (SWS) strategies at 88 days after sowing (DAS).



Means followed by different letters are significantly different between treatments according to the Scott–Knott test ($p < 0.05$). The vertical bars represent the standard error of the mean ($n = 4$). SE = irrigation with low-salinity water throughout the crop cycle; VE = salt stress only in the vegetative phase (15–31 DAS); FL = salt stress in the flowering phase (32–56 DAS); FR = salt stress in the fruiting phase (57–88 DAS); VE/FL = salt stress in the vegetative and flowering phases (15–56 DAS); VE/FR = salt stress in the vegetative and fruiting phases (15–31 DAS; 56–88 DAS).

The interaction effect between the saline water use strategy and genotype significantly influenced the accumulation of stem dry matter in sesame plants (Figure 3A). The mean comparison test revealed that, for all the saline water use strategies, the BRS Seda genotype achieved the highest dry matter accumulation, differing statistically from BRS Anahí, indicating the superiority of BRS Seda in terms of FSC accumulation. Root dry matter (Figure 3B) was influenced by the interaction (EUA × GEN) only when the plants were subjected to the VE, FL, FR, and VE/FL strategies, with effects similar to those of FSC (Figure 3A). The BRS Seda genotype presented the highest FSR accumulation, which differed statistically from that of BRS Anahí. However, the comparison of the genotypes cultivated under the SE and VE/FR salinity use strategies revealed no significant differences.

Figure 3. Stem dry matter – FSC (A) and root dry matter – FSR (B) as a function of the interaction between the different saline water use strategies and sesame genotypes; shoot dry matter – FSPA (C) and total dry matter – FST (D) as a function of the different saline water use strategies; shoot dry matter – FSPA (E) and total dry matter – FST (F) as a function of the sesame genotype at 88 days after sowing (DAS).



Means followed by different letters are significantly different between treatments according to the Scott–Knott test ($p < 0.05$). The vertical bars represent the standard error of the mean ($n = 4$). SE - irrigation with low-salinity water throughout the crop cycle; VE - salt stress only in the vegetative phase (15–31 DAS); FL - salt stress in the flowering phase (32–56 DAS); FR - salt stress in the fruiting phase (57–88 DAS); VE/FL - salt stress in the vegetative and flowering phases (15–56 DAS); VE/FR - salt stress in the vegetative and fruiting phases (15–31 DAS; 56–88 DAS).

The lower accumulation of stem and root dry matter (Figures 3A and 3B) observed in the sesame genotype BRS Anahí in relation to BRS Seda may be related to the variability of the genetic materials, since the BRS Anahí genotype stands out for its medium size and unbranched growth habit (EMBRAPA, 2015). On the other hand, BRS Seda has a branched growth habit and is medium in size (EMBRAPA, 2007).

Notably, the deleterious effect of irrigation water salinity on RSF is minimized when plants receive saltwater only during the flowering and vegetative/flowering phases. According to Minhas et al. (2020), the cyclical use of saline water, in addition to improving crop performance, presents operational advantages over water mixing, as it does not require the creation of infrastructure to mix the water in the desired proportions.

The dry matter of the aerial part of sesame plants grown with low ECw water (0.3 dS m $^{-1}$) throughout the cycle was greater than that of those subjected to high-salinity water in the vegetative (VE), flowering (FL), fruiting (FR) phases and continuous application in the vegetative and flowering (VE/FL) and vegetative and fruiting (VE/FR) phases (Figure 3C). Notably, irrigation with saline water (ECw = 2.7 dS m $^{-1}$) in the FL, VE/FL and VE/FR strategies (Figure 3C) did not significantly differ from each other. However, when comparing the FSPA of the plants grown under the VE and FR treatments, superiority was observed in relation to those subjected to irrigation with water, with an ECw of 2.7 dS m $^{-1}$ in the FL, VE/FL and VE/FR treatments. Thus, the deleterious effect of salinity stress is clearly minimized when plants receive saltwater only during one phenological phase, with the exception of the flowering phase. In general, the reduction in phytomass accumulation in plants under saline stress reflects the energy expenditure for maintaining metabolic activities and, therefore, inhibits plant growth (KUMAR et al., 2017). In a study developed by Suassuna (2013) evaluating the emergence and initial growth of six sesame (*Sesamum indicum* L.) genotypes under irrigation with saline water (0.6 to 4.6 dS m $^{-1}$), a reduction in FSPA was observed with increasing irrigation water salinity.

The total dry matter of sesame plants grown with low-salinity water (CEa = 0.3 dS m $^{-1}$) throughout the cycle (SE) and high-salinity water (2.7 dS m $^{-1}$) in the vegetative phase differed significantly from that of those subjected to high-salinity water in the flowering (FL), fruiting (FR) and continuous application in the vegetative and flowering (VE/FL) and vegetative and fruiting (VE/FR) phases (Figure 3D). Notably, irrigation with 2.7 dS m $^{-1}$ $^{\text{water}}$ during the FL, FR, VE/FL and VE/FR phases (Figure 3D) did not significantly differ from each other.

The total dry matter mass represents the potential for dry matter accumulation, and the higher its value is, the greater the plant's efficiency in transforming light energy into photoassimilates (FERNANDES et al., 2011). Thus, the results observed in this study show that the use of water with an ECw of 2.7 dS m $^{-1}$ in the vegetative phase does not compromise the TSF of sesame plants. On the other hand, the TSF was negatively affected when continuously irrigated with high-salinity water (2.7 dS m $^{-1}$) during the vegetative and fruiting phases (Figure 3D).

A comparison of the means for shoot dry matter (Figure 3E) and total dry matter (Figure 3F) revealed that the BRS Seda genotype had the greatest accumulation of matter in relation to BRS Anahí. When the FSPA and FST of the BRS Seda genotype were compared with those of BRS Anahí, a superiority of 62.21 g plant $^{-1}$ for FSPA and 84.04 g per plant for FST was noted. The greater accumulation of dry matter observed in the BRS Seda genotype than in the BRS Anahí genotype is in agreement with the morphological characteristics described by the Brazilian Agricultural Research Corporation - Embrapa (2007, 2015).

6 CONCLUSIONS

Irrigation with high-salinity water during the flowering and vegetative/flowering phases does not compromise the stomatal conductance, transpiration, or CO_2 assimilation rate of sesame genotypes. A water salinity of 2.7 dS m $^{-1}$ applied continuously during the vegetative and flowering phases impaired the accumulation of phytomass in sesame plants.

7 REFERENCES

ALHARBY, H.F.; COLMER, T.D.; BARRETT-LENNARD, EG Salinization of the soil solution decreases the further accumulation of salt in the root zone of the halophyte *Atriplex nummularia* Lindl. growing above shallow saline groundwater. **Plant, Cell & Environment** , Glasgow, vol. 41, no. 1, p. 99-110, 2018.

DIAS, AS; LIMA, GS; GHEYI, HR; NOBRE, RG; FERNANDES, PD; SILVA, FA Gas exchange and photochemical efficiency of sesame under saline stress and ammonium nitrate fertilization. **Irriga** , Botucatu, v. 23 , n. 2, p. 220-234, 2018.

DAYS, AS; LIMA, GS; PINHEIRO, FWA; GHEYI, HR; SOARES, LA A .; NOBRE, RG; OLIVEIRA, SG Gas exchanges and growth of sesame (*'Sesamum indicum* ', L.) cultivated under saline waters and nitrogen-potassium fertilizers. **Australian Journal of Crop Science** , Lismore, vol. 13, no. 9, p. 1526-1532, 2019.

EMBRAPA. **Sesame, BRS Silk** . Campina Grande: Embrapa CNPA, 2007. 2 p.

EMBRAPA. **Sesame, BRS Anahí** . Campina Grande: Embrapa CNPA, 2015. 2 p.

FERNANDES, PD; BRITO, MEB; GHEYI, HR; SOARES FILHO, WS; MELO, AS; CARNEIRO, PT Growth of citrus hybrids and rootstock varieties under salinity. **Acta Scientiarum Agronomy** , Maringá, v. 33, n. 2, p. 259-267, 2011.

FERREIRA, DF SISVAR: A computer analysis system to fixed effects split plot type designs. **Brazilian Journal of Biometry** , Lavras, v. 37, n. 4, p. 529-535, 2019.

FREIRE, JLO; DIAS, TJ; CAVALCANTE, LF; FERNANDES, P. D; LIMA NETO, AJ Quantum yield and gas exchange in yellow passion fruit under water salinity, biofertilization and mulching. **Agronomic Science Journal** , Fortaleza, v. 45, n. 1, p. 82-91, 2014.

HUSSAIN, RA; AHMAD, R.; WARAICH, EA; NAWAZ, F. Nutrient uptake, water relations, and yield performance of different wheat cultivars (*Triticum aestivum* L.) under salinity stress. **Journal of Plant Nutrition** , New York, vol. 38, no. 1-3, p. 2139-2149, 2015.

KUMAR, D.; AL HASSAN, M.; NARANJO, MA; AGRAWAL, V.; BOSCAIU, M.; VICENTE, O. Effects of salinity and drought on growth, ionic relations, compatible solutes and activation of antioxidant systems in oleander (*Nerium oleander* L.). **PloS one** , San Francisco, v. 12, no. 9, p. e0185017, 2017.

LACERDA, CF; OLIVEIRA, EV; NEVES, AL; GHEYI, HR; BEZERRA, MA; COSTA, CA Morphophysiological responses and mechanisms of salt tolerance in four ornamental perennial species under tropical climate. **Brazilian Journal of Agricultural and Environmental Engineering** , Campina Grande, v. 24 , n. 10, p. 656-663, 2020.

LACERDA, CF; NEVES, ALR; GUIMARÃES, FVA; SILVA, FLB; PRISCO, JT; GHEYI, HR Water and nutrient use efficiency in cowpea plants irrigated with saline water at different development stages. **Agricultural Engineering** , Jaboticabal, v. 29, n. 2, p. 221-230, 2009.

LIMA, GS; LACERDA, CN; SOARES, LAA; GHEYI, HR; ARAÚJO, RHCR Production characteristics of sesame genotypes under different strategies of saline water application. **Revista Caatinga** , Mossoró, v. 33, n. 2, p. 490-499, 2020.

LIMA, GS; SANTOS, JB; SOARES, LAA; GHEYI, HR; NOBRE, RG; PEREIRA, RF Saline water irrigation and foliar proline application in 'All Big' bell pepper cultivation. **Comunicata Scientiae** , Bom Jesus, v. 7, n. 4, p. 513-522, 2016.

LIU, HM; YAO, YG; YAN, YY; WANG, XD Elucidation of the structural changes of sesame hull hemicelluloses during roasting. **International Journal of Biological Macromolecules** , Guildford, vol. 161, no. 1, p. 1535-1544, 2020.

MY, PS; RAMOS, TB; BEN-GAL, A.; PEREIRA, LS Coping with salinity in irrigated agriculture: Crop evapotranspiration and water management issues. **Agricultural Water Management** , Amsterdam, v. 227, no. 1 , p. e105832, 2020.

NOVAIS, RF; NEVES, JCL; BARROS, NF Controlled environment test. *In* : OLIVEIRA, AJ (ed.). **Soil fertility research methods** . Brasília, DF: Embrapa-SEA, 1991. chap. 12, p. 189-253.

RICHARDS, LA **Diagnosis and improvement of saline and alkali soils** . Washington, DC: Department of Agriculture, 1954. 160 p.

SAMADDAR, S.; CHATTERJEE, P.; CHOUDHURY, AR; AHMED, S.; SA, T. Interactions between *Pseudomonas* spp. and their role in improving the red pepper plant growth under salinity stress. **Microbiological research** , Geisenheim, v. 219, no. 1, p. 66-73, 2019.

SHAHIDI, F.; LIYANA-PATHIRANA, CM; WALL, DS Antioxidant activity of white and black sesame seeds and their hull fractions. **Food Chemistry** , London, vol. 99, no. 3, p. 478-483, 2006.

SILVA, EM; LIMA, GS; GHEYI, HR; NOBRE, RG; SÁ, FVS; SOUZA, L.P. Growth and gas exchanges in soursop under irrigation with saline water and nitrogen sources. **Brazilian Journal of Agricultural and Environmental Engineering** , Campina Grande, v. 22, n. 11, p. 776-781, 2018.

SUASSUNA, JF **Tolerance of sesame genotypes to saline stress** . 2013. Thesis (Doctorate in Agricultural Engineering) – Federal University of Campina Grande, Campina Grande, 2013.

TEIXEIRA, PC; DONAGEMMA, GK; FONTANA, A.; TEIXEIRA, W, G. **Manual of soil analysis methods** . 3rd ed. Brasília, DF: Embrapa, 2017. 573 p.

TENYANG, N.; PONKA, R.; TIENCHEU, B.; DJIKENG, FT; AZMEERA, T.; KARUNA, MS; WOMENI, HM Effects of boiling and roasting on proximal composition, lipid oxidation, fatty acid profile and mineral content of two sesame varieties commercialized and consumed in Far-North Region of Cameroon. **Food Chemistry** , London, vol. 221, no. 1, p. 1308-1316, 2017.

ZHANG, Y.; WEI, M.; LIU, A.; ZHOU, R.; LI, D.; DOSSA, K.; YOU, J. Comparative proteomic analysis of two sesame genotypes with contrasting salinity tolerance in response to salt stress. **Journal of Proteomics** , Valencia, v. 201, no. 1, p. 73-83, 2019.