Revista Ciência Agronômica, v. 53, e20218070, 2022
Centro de Ciências Agrárias - Universidade Federal do Ceará, Fortaleza, CE
www.ccarevista.ufc.br

Scientific Article
ISSN 1806-6690

Quantitative and qualitative responses of *Euphorbia milii* and *Zamioculcas zamiifolia* exposed to different levels of salinity and luminosity[1]

Respostas quantitativas e qualitativas de *Euphorbia milii* e *Zamioculcas zamiifolia* expostas a diferentes níveis de salinidade e luminosidade

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ABSTRACT - The Brazilian Northeast region has favorable climatic conditions for the development of floriculture; however, water scarcity and salinization of part of its water sources act as an obstacle to this activity. In this context, the objective was to test the effects of increasing levels of salinity in irrigation water on the quantitative and qualitative responses of ornamental species *Euphorbia milii* and *Zamioculcas zamiifolia*, under different light conditions. The study was carried out using an experimental design in randomized blocks, in a split-split-plot scheme, with five replications. The plants were grown in 7 L pots, undergoing an initial period of acclimatization for 15 days with non-saline water so that their establishment would not be compromised; after this period, the plants were subjected to increasing levels of salinity in the irrigation water (0.5; 2.0; 3.5; and 5.0 dS m^{-1}) under four light intensities (full sun, 30%, 50% and 70% shading) for 60 days. The variables analyzed were plant height, stem diameter, belowground and shoot biomass, salinity tolerance and qualitative analysis. Shading had a greater impact on the qualitative variables of the plants than on the salinity tolerance based on quantitative variables. The environment with 30% shading is the most favorable for the cultivation of *E. milii* when using water with low to moderate salinity. Shading reduces direct radiation damage to *Z. zamiifolia* leaves and improves the visual quality of this species under high salinity.

Key words: Salt stress. Light intensity. Shading. Ornamental plants.

RESUMO - A região Nordeste brasileira apresenta condições climáticas favoráveis ao desenvolvimento da floricultura; contudo, a escassez hídrica e a salinização de parte de suas fontes hídricas atuam como entrave a essa atividade. Nesse contexto, objetivou-se testar os efeitos de níveis crescentes de salinidade da água de irrigação sobre as respostas quantitativas e qualitativas das espécies ornamentais *Euphorbia milii* e *Zamioculcas zamiifolia*, sob diferentes condições de luminosidade. A pesquisa foi realizada utilizando-se delineamento experimental em blocos casualizados, em esquema de parcelas subsubdivididas, com cinco repetições. As plantas foram cultivadas em vasos de 7 L, passando por um período inicial de aclimatação durante 15 dias com água não salina para que o seu estabelecimento não fosse comprometido; após esse período, as plantas foram submetidas a níveis crescentes de salinidade na água de irrigação (0,5; 2,0; 3,5; e 5,0 dS m^{-1}) sob quatro intensidades luminosas (pleno sol, 30%, 50% e 70% de sombreamento), durante 60 dias. As variáveis analisadas foram altura da planta, diâmetro do caule, biomassa da parte subterrânea e das partes aéreas, tolerância à salinidade e análise qualitativa. O sombreamento teve maior impacto nas variáveis qualitativas das plantas do que na tolerância à salinidade baseada em variáveis quantitativas. O ambiente com 30% de sombreamento é o mais propício para o cultivo da *E. milii* quando se utiliza água de baixa a moderada salinidade. O sombreamento reduz os danos diretos da radiação nas folhas de *Z. zamiifolia* e melhora a qualidade visual dessa espécie sob elevada salinidade.

Palavras-chave: Intensidade de luz. Estresse salino. Sombreamento. Plantas ornamentais.

DOI: 10.5935/1806-6690.20220033
Editor do artigo: Prof. Adriel Ferreira da Fonseca - adrielff@gmail.com
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Received for publication in 15/06/2021; approved in 03/03/2022
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INTRODUCTION

The floriculture and ornamental plants sector has expanded in recent decades in the northeastern region of Brazil (INSTITUTO BRASILEIRO DE FLORICULTURA, 2018), especially in areas of mountains and with milder climates. In this region, in 2018, there were about 1138 ornamental producers, with an average area of 1.8 ha (BRAINER, 2018). However, the Covid-19 Pandemic problem has strongly impacted the sector with losses throughout the production chain of R$ 800 million, estimated at R$ 150 million for producers, R$ 200 million for wholesalers and R$ 450 million for retailers (CONFEDERAÇÃO DA AGRICULTURA E PECUÁRIA DO BRASIL, 2021).

Part of the Northeast region of Brazil has abiotic limitations for the production of flowers and ornamental plants, especially salinity. The largest groundwater reserves in this region are brackish (total dissolved solids above 500 mg L^{-1}), notably in the crystalline basement, which corresponds to 75% of the area of the Ceará State (AGÊNCIA DE DESENVOLVIMENTO DO ESTADO DO CEARÁ, 2017). In groundwater with salinity above 1000 mg L^{-1}, sodic chlorinated and mixed chlorinated waters predominate (NEVES *et al*., 2017; SILVA JÚNIOR; GHEYI; MEDEIROS, 1999). The salinity of these water sources impacts the physiological responses, growth and visual quality of plants, due to osmotic and ionic effects (CASSANITI *et al*., 2013; LACERDA *et al*., 2020, 2021; NIU; RODRIGUEZ; MCKENNEY, 2012; OLIVEIRA *et al*., 2018). However, adopting appropriate management practices is an alternative for the use of brackish water in irrigated agricultural production (LACERDA *et al*., 2021; NOBRE *et al*., 2013), including for the exploitation of ornamental plants (GARCÍA-CAPARRÓS; LAO, 2018).

Luminosity is another important factor in plant growth as it boosts the photosynthetic process, regulating plant morphology, physiology and phytochemical content (SPALHOLZ; PERKIN-VEAZIE; HERNÁNDEZ, 2020). The species *Euphorbia milii* requires direct sunlight of at least 4 hours per day, a condition that favors the flowering of plants throughout the year. The species *Zamioculcas zamiifolia*, in turn, does not require much luminosity and can have good adaptation in internal environments of low natural light or in external environments without direct incidence of the sun. They are tropical and subtropical plants and both *E. milii* and *Z. zamiifolia* do not require frequent irrigations and can be grown in soils of medium fertility and well drained. The choice of these species is justified by the important economic expansion and the scarce knowledge about the tolerance of these plants to salt stress, when they are grown in full sun or under shading conditions.

In general, the use of shading is a necessary condition for the production of ornamentals under tropical climate conditions, contributing to alleviating the impacts of other biotic and abiotic stress factors. This study is based on the hypothesis that shading reduces the effects of salinity on plants, but this response also depends on the light requirement of each species. In this context, this study aimed to evaluate the salinity tolerance of *E. milii* and *Z. zamiifolia* and to define adequate shading levels for the use of brackish water in the cultivation of these ornamentals.

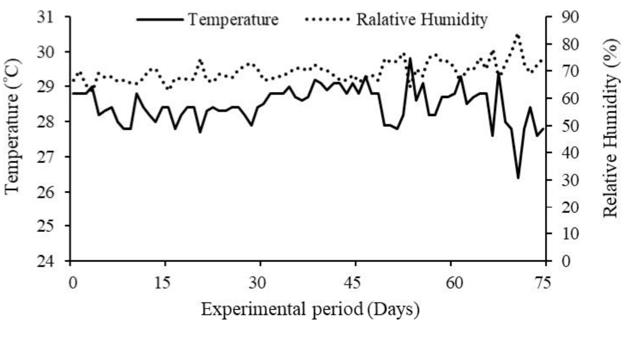
MATERIAL AND METHODS

The experiment was carried out from October 2017 to January 2018, in the area of the Center for Teaching and Research in Urban Agriculture - NEPAU of the Federal University of Ceará - UFC, Pici Campus, in Fortaleza, Ceará, Brazil, located at the geographic coordinates 03° 44’ South latitude and 38° 33’ West longitude, at an average altitude of 20 meters.

During the experimental period, the total rainfall was recorded at the experiment site. Air temperature, relative humidity and global solar radiation were collected from the climatological station of the National Institute of Meteorology, about 9.0 km away from the experimental area. Daily data of average temperature and relative humidity are shown in Figure 1. During the experiment, global solar radiation in the city of Fortaleza reached an average of 17.9 ± 3.1 MJ m^{-2} day^{-1}, which is the reference value for the environment in full sun. For the other environments, the estimated average values were 12.53, 8.95 and 5.37 MJ m^{-2} day^{-1}, respectively for 30, 50 and 70% shading.

The experimental design was randomized blocks in a split-split-plot scheme, with five replications, the plots referring to the environment factor (full sun, 30%, 50% and 70% shading), the subplots to salinity levels in irrigation water - ECw (0.5; 2.0; 3.5; and 5.0 dS m^{-1}), and sub-subplots to the species *Euphorbia milii* and *Zamioculcas zamiifolia*. A total of 160 experimental units were used, with two 7 L pots each (one plant per pot), totaling 320 plants.

Figure 1 - Average daily values of temperature and relative humidity during the experimental period



The substrate for filling the pots was composed of the mixture of *arisco* (light-textured sandy material normally used in constructions in Northeast Brazil) and humus in the proportion of 3:1, whose physical and chemical characteristics are presented in Table 1. Each pot received a 2 to 3-cm-thick layer of crushed stone to facilitate drainage, and the volume was completed with the growing substrate.

The seedlings of species *E. milli* (transplanted with 4 to 6 true leaves) and *Z. zamiifolia* (transplanted with age of 6 to 8 months) were acquired with the highest possible uniformity regarding size, stem diameter, number of stems and phytosanitary status. At 15 days after transplanting, irrigations were initiated with saline solutions of 0.5, 2.0, 3.5, and 5.0 dS m^{-1}, prepared from NaCl, $CaCl_2.2H_2O$ and $MgSO_4.7H_2O$ salts, in order to obtain an equivalent ratio between Na:Ca:Mg of 7:2:1, and this proportion is a representative approximation of most sources of water available for irrigation in northeastern Brazil. The irrigations were carried out in order to maintain soil moisture at field capacity, and the pots were irrigated every 2 days, applying a leaching fraction of 15% in each irrigation event, so that the water could permeate through the holes of the lower extremity carrying the salts and avoiding their excessive accumulation in the root zone. For each treatment, one pot was used as a drainage lysimeter, in order to obtain the water volumes for each irrigation event.

Basal fertilization consisted of 1 gram per pot of the 10-10-10 (N-P-K) formulation and top-dressing fertilization consisted of 1 g per pot of the same formulation at 5 days after transplanting. In addition to nitrogen, this formulation meets the plant's needs for potassium (whose level is low in the substrate) and also provides P supplementation to stimulate flowering; these nutrients are responsible for vital functions and yield levels. Complementing these fertilizations, foliar application of the organomineral fertilizer Torped was performed once to supply the micronutrients and ensure satisfactory levels of the essential elements. Pest control was limited to manual collection of some caterpillars, which occurred only in the environment in full sun. With regard to invasive plants, the elimination was also performed manually.

At 50 days after the beginning of saline treatments, the photosynthesis rate (*A*) was measured in mature leaves of the middle third of the plants. These measurements were performed between 8:00 and 10:30 h using an infrared gases analyzer (model Li - 6400XT, LICOR, USA), under ambient conditions of temperature and relative humidity, with constant CO_2 concentration (400 ppm). The light intensity used simulated the conditions of each environment, with values of 1350, 945, 677 and 405 μmol m^{-2} s^{-1}, respectively for the environments in full sun, 30% 50% and 70% shading.

At 60 days after the saline solution began to be applied, plant height and stem diameter were measured using a tape measure graduated in centimeters (it can reach only up to 5 tenths of error) and a digital caliper with resolution of 0.1 mm, respectively. Then, the plants were harvested and separated into roots, stems and leaves. For the species *E. milii*, the flowers were also collected. For the species *Z. zamiifolia*, the belowground part was the sum of roots and rhizomes. The samples were weighed, placed in paper bags and taken to the oven at 65 ºC, to obtain the dry biomass.

The reductions in the production of shoot dry biomass, root dry biomass, total biomass and photosynthesis rate (obtained with simulated light of each environment) (Table 4) were estimated in relation to the lowest salinity level (percentage reduction), which were used as indices to compare the tolerance of the two species studied in the different environments. For production reductions up to 20%, 40%, 60% and > 60%, plants were classified as tolerant (T), moderately tolerant (MT), moderately sensitive (MS) and sensitive (S), respectively (SOARES FILHO *et al*., 2016).

Table 1 - Chemical and physical characteristics of the substrate used in the cultivation of ornamental species *Euphorbia milii* and *Zamioculcas zamiifolia*

OC	pH (H_2O)	ECse	Ca^{2+}	Mg^{+2}	K^+	Na^+	Al^{3+}	(H + Al)	S	T
g kg^{-1}	(1:2.5)	dS m^{-1}	----------	----------	----------	$cmol_c$ dm^{-3}	----------	----------	----------	----------
8.58	5.8	0.26	3.60	3.40	1.12	1.53	0.25	2.15	9.7	11.8
P	N	V	C/N	m	ESP			Sand	Silt	Clay
$mgdm^3$	g kg^{-1}	%	-	%	%			----------	g kg^{-1}	----------
32.0	0.91	82	9	3	13			800	123	77

OC - organic carbon (Walkley-Black method); ECse - electrical conductivity of saturation extract; Ca^{2+}, Mg^{2+}, Al^{3+} (extraction in 1 mol L^{-1} KCl); H+Al [extraction in 1 mol L^{-1} Ca $(C_2H_2O_2)_2$, pH 7,0]; Na^+, K^+, P (extraction by Mehlich-1); S - sum of bases; T - cation exchange capacity [S+(H+Al)]; V - base saturation

The data were subjected to analysis of variance to evaluate the effects of single factors and of the interaction between factors. The effects of water salinity levels and shading on quantitative responses were tested in regression analysis, and the model was chosen based on adjusted R^2 and the significance of the coefficients of the equation. The statistical analyses were performed using SigmaPlot 11 Software.

The visual (sensory) quality analysis of the plants was performed according to Ureña, D'árrigo and Girón (1999) and Neves *et al*. (2018). Forty-five people participated in the study, 63% male and 37% female, aged 18 to 35 years (80%), 36 to 55 years (11%) and 56 to 70 years (9%). The judges participated in the sensory analysis, attributing scores according to criteria of the hedonic scale for overall appearance, with nine numerical points: disliked extremely (1); disliked very much (2); disliked moderately (3); disliked slightly (4); indifferent (5); liked slightly (6); liked moderately (7), liked very much (8) and liked extremely (9). The affective method (preference test) was also applied, asking the following question to the evaluators: "In your opinion as a consumer which of the plants would you buy"?.

RESULTS AND DISCUSSION

According to Table 2, all variables were significantly influenced by the single effects of the environment and/or salinity of irrigation water. Responses to the effects of the double interactions environment x species (A x C) on plant height and salinity x species (B x C) on stem diameter, as well as of both on photosynthesis, were observed.

Plant height was influenced by the interaction between environment and species ($p < 0.05$), while stem diameter was influenced by the interaction between salinity and species ($p < 0.05$). According to Figure 2A, the quadratic model was the one that best fitted to demonstrate the effect of shading on the height of *E. milii* plants in the various environments evaluated. According to the mathematical model, the maximum height was estimated at the shading level equivalent to 46.1%, with a trend of reduction at higher shading levels, which can be justified by the fact that *E. milii* is a full sun plant characteristic of environments with high light intensity. Fava *et al*. (2015), in a study with the ornamental species *Strelitzia reginae*, found an increase in stem height up to 30% shading; like *E. milii*, this species is also grown in full sun and blooms all year round in hot climate.

Differently, the height of *Z. zamiifolia* increased linearly with shading, but the difference between full sun and 70% shading was only 10% (Figure 2A). This result is close to that obtained by Jeong *et al*. (2009), who evaluated growth and quality for *Begonia* species under shading between 62% and 76%. Growth in height in shaded environments is considered a typical morphogenic response, with greater biomass partition to the shoots of plants (FALSTER; DUURSMA; FITZJOHN, 2018). According to Dousseau *et al*. (2007), the growth efficiency under different radiation conditions is related to the plant's ability to adjust biomass allocation and physiological behavior.

E. milii and *Z. zamiifolia* plants showed a linear reduction in stem diameter with the increase in the electrical conductivity of the irrigation water (Figure 2B), with reductions on the order of 19.8% and 22.3%, respectively, when comparing plants irrigated with 5.0 dS m^{-1} to those of the control treatment. Reduction in diameter caused by salinity has been reported even in ornamental plants (BEZERRA *et al*., 2020; LI *et al*., 2015; SANTOS JÚNIOR *et al*., 2016), resulting from the osmotic and ionic effects that impact the processes of cell division and expansion (MUNNS; TESTER, 2008).

Table 2 - Summary of the analysis of variance (F values) for plant height (PH), stem diameter (SD) and photosynthesis (A) of ornamental plants grown in full sun and under 30%, 50% and 70% shading and subjected to increasing salinity levels

	F values		
	PH	SD	A
Environment (E)	10.923*	1.416^{ns}	6.524*
Salinity (B)	0.265^{ns}	22.639**	82.235**
A x B	0.845^{ns}	2.433^{ns}	1.584^{ns}
Species (C)	1226.123**	1767.378**	394.206**
A x C	3.807*	0.127^{ns}	27.767**
B x C	0.687^{ns}	16.511**	12.231**
A x B x C	0.530^{ns}	1.845^{ns}	3.200**

ns = non-significant effect; Significance level: $^{*}P \leq 0.05$; $^{**}P \leq 0.01$

The variables shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM) and flower dry matter (FLDM) (only for *E. milii*) were significantly influenced by the single factors salinity and/or species. The double interaction salinity x species (B x C) had a significant effect on the variables analyzed and the interaction between species (A x C) influenced only shoot dry matter (Table 3).

Table 4 shows the percentages of reduction in quantitative variables and the classification of salinity tolerance for the two species under different cultivation environments. Both species were tolerant to salinity up to 2.0 dS m^{-1}, regardless of the cultivation environment, considering the data of shoot, belowground and total biomass production, with greater impacts on shoot growth than on roots. For salinity levels of 3.5 and 5.0 dS m^{-1}, moderately tolerant and moderately sensitive classifications predominate, respectively. Considering the data of belowground dry matter, the species *Z. zamiifolia* showed classification of moderately sensitive for full sun and moderately tolerant for the environment with 70% shading. This result may be an indication of unsatisfactory performance of the control plants of this species under full sun conditions, since it prefers more shaded environments. On the other hand, the species *E. milii* shows better performance under intermediate levels of shading (30 and 50%), considering the shoot dry matter data. Shading allows the modulation of a microclimate at the crop level, leading to lower water demand by the plant with the reduction of evapotranspiration, which results in lower salt stress, thus supporting the hypothesis raised in the present study by the results obtained. Shading also promotes control of ionic homeostasis and hormonal balance of the plant to cope with salt stress (GÁLVEZ *et al*., 2020).

Figure 2 - (A) Plant height of ornamental species *E. milii* and Z. *zamiifolia* cultivated in full sun and under 30%, 50% and 70% shading. (B) Stem diameter (SD) of ornamental species *E. milii* and *Z. zamiifolia* subjected to increasing levels of electrical conductivity in irrigation water - ECw. Significance level: $^{*}P \leq 0.05$; $^{**}P \leq 0.01$

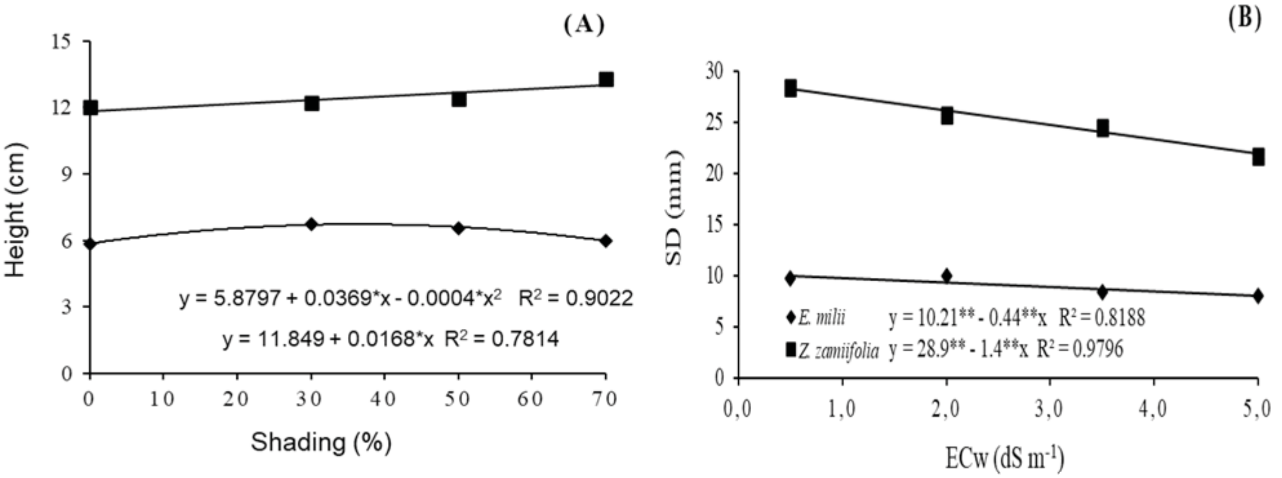


Table 3 - Summary of the analysis of variance (F values) for shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM) and flower dry matter (FLDM) of ornamental plants grown in full sun and under 30%, 50% and 70% shading and subjected to increasing levels of salinity in irrigation water

	F values			
	SDM	RDM	TDM	FLDM
Environment (A)	3.353*	0.965ns	1.694ns	26.209**
Salinity (B)	3.940*	12.760**	21.352**	6.526**
A x B	1.217ns	1.030ns	1.144ns	3.66ns
Species (C)	289.771**	1276.996**	1833.388**	-
A x C	2.894*	0.974ns	1.696ns	-
B x C	2.935*	12.621**	19.004**	-
A x B x C	1.150ns	1.022ns	1.066ns	-

ns = non-significant effect; Significance level: $^{*}P \leq 0.05$; $^{**}P \leq 0.01$

Table 4 - Relative reductions in shoot dry matter, belowground dry matter, total dry matter and photosynthesis rate of the species *E. milii* and *Z. zamiifolia* grown in full sun and under 30%, 50% and 70% shading, and the respective classifications of salinity tolerance

Environments	Electrical conductivity (dS m^{-1})					
	2.0	3.5	5.0	2.0	3.5	5.0
	E. milii			*Z. zamiifolia*		
	Shoot dry matter (relative reduction, %)					
Full sun	17.7 T	35.4 MT	53.1 MS	9.2 T	23.5 MT	27.5 MT
30% shading	11.6 T	23.1 MT	34.7 MT	14.6 T	29.3 T	43.9 MS
50% shading	0.0 T	13.2 T	43.2 MS	10.1 T	20.1 MT	30.0 MT
70% shading	15.5 T	31.0 MT	46.6 MS	16.4 T	32.7 MT	49.1 MS
	Belowground dry matter (relative reduction, %)					
Full sun	0.0 T	0.0 T	38.4 MT	13.3 T	26.8 MT	40.2 MS
30% shading	8.7 T	17.4 T	26.1 MT	11.9 T	24.1 MT	36.1 MT
50% shading	0.0 T	8.2 T	39.6 MT	8.5 T	17.0 T	25.4 MT
70% shading	9.2 T	18.4 T	27.6 MT	12.4 T	25.3 MT	38.1 MT
	Total dry matter (relative reduction, %)					
Full sun	17.2 T	34.4 MT	51.6 MS	12.0 T	24.0 T	36.0 MT
30% shading	9.2 T	18.3 T	27.5 MT	13.2 T	26.4 MT	40.1 MS
50% shading	0.0 T	9.7 T	41.4 MS	9.3 T	18.6 T	27.9 MT
70% shading	15.0 T	30.0 MT	45.0 MS	14.2 T	28.3 MT	42.5 MS
	Photosynthesis rate (relative reduction, %)					
Full sun	24.6 MT	49.2 MS	73.9 S	36.0 MT	72.2 S	100.0 S
30% shading	16.7 T	33.4 MT	50.2 MS	33.7 MT	67.4 S	100.0 S
50% shading	0.0 T	0.0 T	46.8 MS	27.8 MT	55.6 MS	83.5 S
70% shading	21.6 MT	43.2 MS	64.8 S	26.3 MT	52.6 MS	78.9 S

T - Tolerant; MT - Moderately Tolerant; MS - Moderately Sensitive; S – Sensitive

On the other hand, the photosynthesis rate proved to be a quantitative indicator much more sensitive than biomass production, being a variable that can anticipate a possible intensification of stress due to excess radiation and/or salinity. For *E. milii*, the environments with 30 and 50% shading promoted the best results, and the species was classified as tolerant or moderately tolerant up to 3.5 dS m^{-1}, under these two conditions of luminosity (Table 4). The species *Z. zamiifolia* showed greater sensitivity to salts, especially in full sun and 30% shading environments, in which it was classified as sensitive from salinity of 3.5 dS m^{-1}, with reductions greater than 60% in the photosynthesis rate.

The effects of salinity on shoot dry matter and leaf physiological responses can be justified by water imbalance at the soil-plant interface and also by toxicity, associated with the accumulation of ions in leaf tissues (MUNNS; TESTER, 2008); in the full sun environment part of the older leaves of *Z. zamiifolia* showed burns on the edges, resulting in visual damage, as also observed in other species (CAI *et al*., 2014; CASSANITI *et al*., 2013; CASSANITI; LEONARDI; FLOWERS, 2009). The significant reductions in photosynthesis rate caused by salinity in the environments with higher luminosity (Table 4) are in accordance with the visual observations of leaf damage.

Harmful effects caused by salts result in changes in the biochemical and physiological mechanisms of the plants, triggering different responses in the species such as reductions in biomass and nutrient absorption (GARCÍA-CAPARRÓS *et al*., 2016). Hancioglu *et al*. (2019), when studying the effects of irrigation water salinity on the yield and quality parameters of oregano (*Origanum onites* L.), concluded that in comparison with the control, there were reductions of 27, 38, 49 and 77% in the yield of dried leaves for treatments with 1.8, 2.5, 3.5 and 5.0 dS m^{-1}, respectively. Cavalcante *et al*. (2010), studying chrysanthemum cultivation in pot, found that shoot dry matter production was reduced by approximately 36% from the EC of 2.1 dS m^{-1} to 4.9 dS m^{-1}. Maciel *et al*. (2012), in a study with ornamental sunflower using brackish water in hydroponic system, also found reduction in SDM at the salinity level of 6.0 dS m^{-1}.

The biomass of flowers of the species *E. milii* was influenced by the single effects of the environment and salinity of irrigation water ($p < 0.05$), with no interaction between the factors ($p > 0.05$). The maximum flower production was estimated at the shading level equivalent to 25% (Figure 3A) and at the electrical conductivity of 2.0 dS m^{-1} (Figure 3B), with pronounced reductions in response to the decrease in luminosity and the increase in salinity from these points, respectively.

Neves *et al*. (2018), when studying the ornamental species *Catharanthus roseus*, also verified a quadratic effect on the flower biomass production, with maximum flower production at salinity levels around 2.5 dS m^{-1}.

Hormones involved in flowering such as abscisic and jasmonic acids may undergo changes caused by the deleterious effect of salts (ROGERS, 2013). Aydinsakir, Tepe and Buyuktas (2010), when studying the effects of saline irrigation water levels on flowering and flower quality of *Oberon*, *Athena* and *Cordula* freesia hybrids, verified that the irrigation water level reduced the number and dry matter of flowers. However, the results obtained in the present study (Figure 3) and with other ornamental species (NEVES *et al*., 2018; OLIVEIRA *et al*., 2018) demonstrate that this harmful effect of salinity on flowering depends on the level of stress applied and also on the plant species under study.

Sensory analysis makes it possible to determine differences in the responses of ornamental plants (OLIVEIRA *et al*., 2018), which are often not evidenced by analyses of purely quantitative variables (NIU; RODRIGUEZ; MCKENNEY, 2012; OLIVEIRA *et al*., 2018; ROSSINI; ANZANELLOB**;** FOGLIATTOC, 2012). The qualitative analysis, considering the overall appearance, clearly demonstrated that the species *E. milii* has better results with 30% shading, maintaining good performance up to the salinity of 3.5 dS m^{-1} under this luminosity condition (Table 5). This can be explained, in part, by the maintenance and even increase in flower production at moderate levels of shading (Figure 3A) and salinity (Figure 3B). This result of the overall appearance coincides with the preference test data, as a greater number of judges chose plants of this species from the environment with 30% shading, for the salinity levels of 0.5, 2.0 and 3.5 dS m^{-1} (Figure 4A). Similar results have been obtained with other species (NEVES *et al*., 2018; OLIVEIRA *et al*., 2018).

On the other hand, the species *Z. zamiifolia* has low levels of overall evaluation in the full sun treatment, regardless of the level of salinity (Table 5), a result widely confirmed by the preference test (Figure 4B). This species shows good qualitative evaluation for the salinity level of 2.0 dS m^{-1}, considering the shading levels of 30, 50 and 70%. For this last level of shading, this species has very good evaluations, better than those of the control treatment, even at the highest level of salinity. The preference test data also demonstrate that the full sun environment is unfeasible for the cultivation of *Z. zamiifolia*, regardless of salinity level (Figure 4B), and shading of 30 to 50% can be recommended for its cultivation under conditions of low salinity.

Our results demonstrate the positive effect of shading on the cultivation of *Z. zamiifolia* when using high-salinity water, evidenced in part by the photosynthetic response (Table 4) and by the visual evaluation of potential buyers (Table 5; Figure 4B). The choice of the consumer public considered the absence of visual damage to the leaves caused by the increase in Na^+ and Cl^- toxicity, which was verified only in plants of this species cultivated in full sun, with negative consequences on the decorative value.

Figure 3 - Flower dry matter (FLDM) of ornamental species *E. milii* cultivated in full sun and under 30%, 50% and 70% shading (A) and subjected to increasing levels of electrical conductivity in irrigation water - ECw (B). Significance level: $^{**}P \leq 0.01$

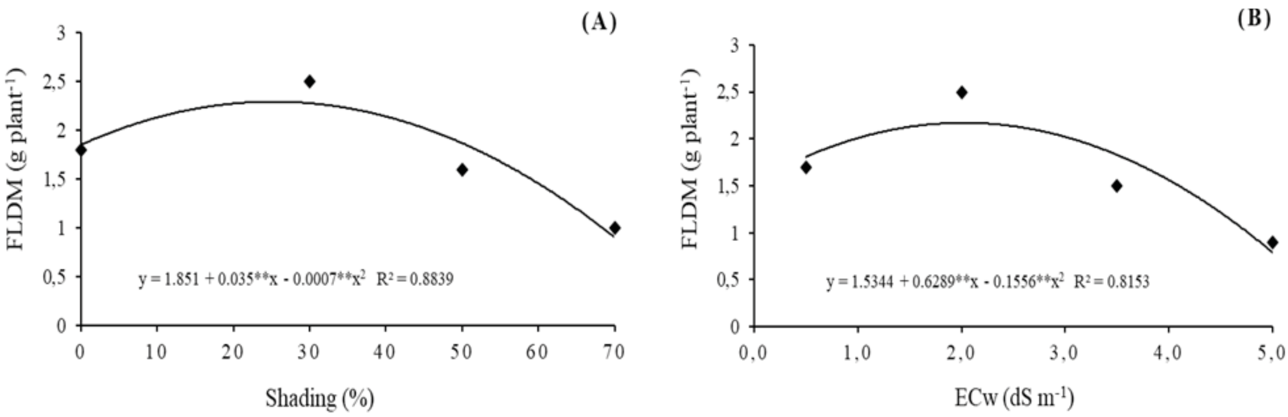
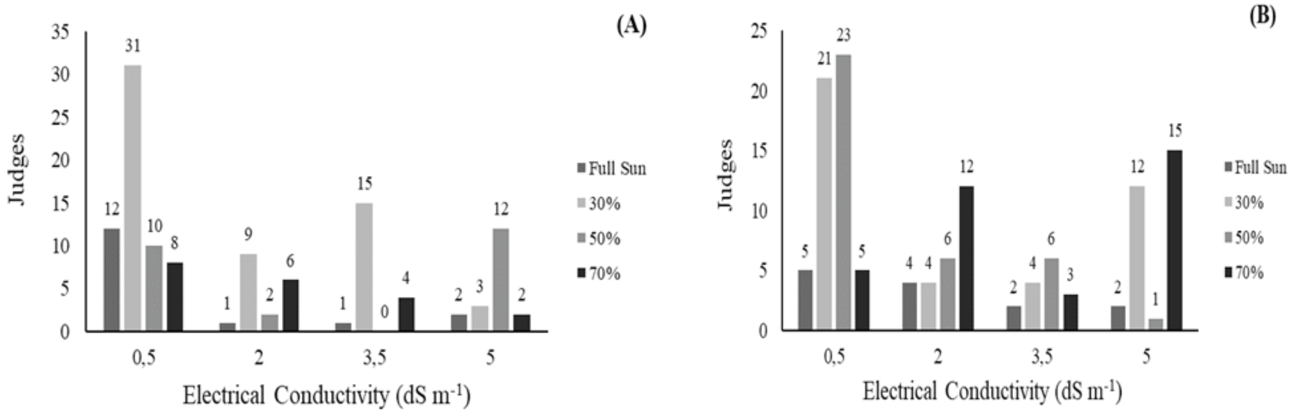


Table 5 - Means of the scores attributed to the visual quality (overall appearance) of *E. milii* and *Z. zamiifolia* plants, according to the criteria of hedonic scale for overall appearance

ECw (dS m^{-1})	Shading Levels (%)			
	0	30	50	70
	------------------- *Euphorbia milii* -------------------			
0.5	7.11 ± 0.23	8.04 ± 0.18	7.15 ± 0.19	6.73 ± 0.25
2.0	6.11 ± 0.32	7.00 ± 0.22	5.31 ± 0.36	6.02 ± 0.27
3.5	5.57 ± 0.33	6.91 ± 0.28	4.77 ± 0.33	6.51 ± 0.24
5.0	5.20 ± 0.34	6.64 ± 0.25	6.97 ± 0.27	6.40 ± 0.25
Mean	6.00 ± 0.30	7.15 ± 0.24	6.05 ± 0.28	6.41 ± 0.25
	------------------- *Zamioculcas zamiifolia* -------------------			
0.5	5.73 ± 0.34	7.91 ± 0.14	7.75 ± 0.13	6.73 ± 0.23
2.0	5.71 ± 0.31	6.97 ± 0.20	7.08 ± 0.13	7.22 ± 0.26
3.5	6.31 ± 0.27	6.55 ± 0.26	5.64 ± 0.34	6.68 ± 0.23
5.0	5.31 ± 0.33	6.40 ± 0.24	5.93 ± 0.30	7.42 ± 0.20
Mean	5.77 ± 0.31	6.96 ± 0.21	6.60 ± 0.22	7.01 ± 0.30

Values are means ± standard error of the mean (n = 45)

Figure 4 - Number of judges that declared intention to purchase ornamental species *E. milii* (A) and *Z. zamiifolia* (B) cultivated in full sun and under 30%, 50% and 70% shading and subjected to increasing levels of electrical conductivity



CONCLUSIONS

1) Shading had a greater impact on the qualitative variables of the two species than on salinity tolerance based on quantitative variables;

2) The environment with 30% shading is the most suitable to the cultivation of *E. milii* when low- to moderate-salinity water is used. In this environment, there was higher accumulation of flower biomass and plants had greater commercial acceptance;

3) Shading reduces direct damage of radiation in *Z. zamiifolia* and favors its visual quality under high salinity.

ACKNOWLEDGMENTS

To INCTSal, ADECE and CNPq for the financial assistance to conduct the study. I thank UFC for the space granted and for providing the opportunity to complete the doctoral thesis, from which this present article was extracted.

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