Revista Brasileira de Agricultura Irrigada
Brazilian Journal of Irrigated Agriculture
ISSN: 1982-7679 (on-line)
v.16, p. 81-89, 2022
Fortaleza, CE - www.inovagri.org.br

DOI: 10.7127/rbai.v1601292

EFFECT OF SALINITY AND DIFFERENT LIGHT ON BIOMASS SHARING OF THE ORNAMENTAL SPECIES Euphorbia milii AND Zamioculcas Zamiifolia

EFEITO DA SALINIDADE E DIFERENTES LUMINOSIDADES SOBRE A PARTIÇÃO DE BIOMASSA DAS ESPÉCIES ORNAMENTAIS Euphorbia milii E Zamioculcas Zamiifolia

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ABSTRACT: Part of the Northeast region of Brazil presents abiotic limitations for the production of flowers and ornamental plants, especially salinity and excessive solar radiation. This research aimed to test the effects of increasing salinity levels and different light conditions on the biomass partitioning of the ornamental species Euphorbia milii and Zamioculcas zamiifolia. The experimental design was in randomized blocks in subdivided plots, with five repetitions, with the plots referring to the environmental factor (full sun, 30, 50 and 70% shade), the subplots to the salinity levels in the irrigation water - ECw (0.5; 2.0; 3.5; and 5.0 dS m-1), and the subplots to the ornamental species Euphorbia milii and Zamioculcas zamiifolia, with two plants per repetition, totaling 320 experimental units. Shading at 30% stimulated greater biomass partitioning to flowers, however, at higher shading levels a reduction in the proportion of flowers and an increase in biomass in leaves was observed in the Euphorbia milii species. Zamioculcas zamiifolia allocated the highest biomass fraction (about 65% of photoassimilates) to the roots and rhizomes at all salinity levels, but shading had little influence on photoassimilate partitioning in this species.

Keywords: light intensity, salt stress, ornamental plants.

RESUMO: Parte da região Nordeste do Brasil apresenta limitações abióticas para a produção de flores e de plantas ornamentais, especialmente a salinidade e o excesso de radiação solar. Essa pesquisa objetivou testar os efeitos de níveis crescentes de salinidade e diferentes condições de luminosidade sobre a partição de biomassa das espécies ornamentais Euphorbia milii e Zamioculcas zamiifolia. O delineamento experimental foi em blocos casualizados em esquema de parcelas subsubdivididas, com cinco repetições, sendo as parcelas referentes ao fator ambiente (pleno sol, 30%, 50% e 70% de sombreamento), as subparcelas aos níveis de salinidade na água de irrigação - CEa (0,5; 2,0; 3,5; e 5,0 dS m-1), e as subsubparcelas às espécies ornamentais Euphorbia milii e Zamioculcas zamiifolia, com duas plantas por repetição, totalizando 320 unidades experimentais. O sombreamento de 30% estimulou maior partição de biomassa para as flores, entretanto, em maiores níveis de sombreamento observou-se redução na proporção de flores e aumento de biomassa nas folhas da espécie Euphorbia milii. A espécie Zamioculcas zamiifolia alocou maior fração de biomassa (cerca de 65% de fotoassimilados), para o conjunto raízes + rizomas em todos os níveis de salinidade, porém, o sombreamento teve pouca influência na partição de fotoassimilados nesta espécie.

Palavras-chave: intensidade de luz, estresse salino, plantas ornamentais.

Protocolo 1292.22 – 20-01-2022 - Aprovado em 05-05-2022
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Editor de área: Geocleber Sousa

INTRODUCTION

Previously restricted to the Southeast region, the expansion of the floriculture area in the country - currently 15 thousand hectares - was only possible thanks to the Brazilian climatic diversity that came to favor the cultivation of temperate and tropical flowers. This expansion reached the Brazilian Northeast, which even with important abiotic limitations especially water deficit, excess solar radiation and salinity of its water sources, maintains its production base settled in 1,138 producers, with an average area of 1.8 ha; the cultivated area is around 2,000 hectares (BRAINER, 2018).

The state of Ceará was the one that stood out in northeastern floriculture, benefited by the high luminosity and some areas with mild climate, exploring both tropical and temperate cut flowers, in open cultivation and greenhouse areas. The state stood out as the fourth national exporter contributing 8.9% of the 2017 values, exporting to the main international Ceará flower markets (North American, followed by the Netherlands and Canada) bulbs, tubers, rhizomes, foliage, leaves and branches of dried plants, for bouquets and seedlings of other ornamental plants (BRAINER, 2018). Currently ranked sixth in exports (IBRAFLOR, 2018), the state is trying to regain its hegemony after having gone through a severe water crisis in 2018.

In the northeastern semi-arid region according to an estimate by Embrapa (2017) there are at least 200,000 wells, with 6,492 of them drilled in the state of Ceará in the last 4 years, prioritizing important urban centers and the rural zone. However, most of this water has not been used due to the high concentrations of soluble salts, where salt accumulation has become an aggravating factor in irrigated areas, compromising up to 30% of the public irrigation projects in Northeast Brazil (CODESVASF, 2017) and constituting a major problem for agriculture. The increase in the saline concentration of the waters raises the sodium chloride content, making the waters more and more sodium and less calcium, to the detriment of the calcium and magnesium bicarbonate content, which tends to precipitate due to low solubility (SILVA JÚNIOR et al., 1999).

An important source of water for irrigation is groundwater, whose use is widespread worldwide, mainly for urban water supply and irrigation. In a large part of the semi-arid region of the Brazilian Northeast the largest groundwater reserves are saline, due to the predominance of crystalline rocks in its subsoil, which imposes brackish and saline characteristics on these waters. In Ceará, groundwater inserted in area of crystalline embasement, occurs in 75% of the state (ADECE, 2017).

Some studies have demonstrated the effect of salt on ornamental plants. Maciel et al. (2012) found that with increasing water salinity, ornamental sunflower plants grown in hydroponics showed a linear reduction in the mass of dry matter of the aerial parte.

Don et al. (2010) in a study on the tolerance of gerbera (Gerbera jamesonii L.) to salt stress at levels of 0, 10, 20, 30 and 40 mM for ten weeks, found that increasing salinity caused a significant decrease in stem biomass. However, this type of water can be an important option when adopting proper management practices (NOBRE et al., 2013; GARCÍA-CAPARRÓS & LAO, 2018; LACERDA et al., 2021).

The management adopted may influence the partitioning of photoassimilates in plants subjected to salt and light stress. Melo & Alvarenga (2009) in studies with plants of Catharanthus roseus (L.) G. Don ‘Pacifica White’ found that shading significantly alters dry matter distribution. The lower conversion efficiency of radiation into biomass is due to a reduction in photosynthetic rates. Certain plants only achieve high photosynthetic rates at high light intensity; others, however, even living in the shade, achieve maximum photosynthesis rates at low light intensity (TAIZ et al., 2017).

In this context, this research aimed to test the effects of increasing salinity levels and different light conditions on the biomass partitioning of the ornamental species Euphorbia milii and Zamioculcas zamiifolia.

MATERIAL AND METHODS

The research was conducted in the experimental area of the Núcleo de Pesquisa em Agricultura Urbana (NEPAU) of the Universidade Federal do Ceará, Fortaleza, Ceará, Brazil, in the period from October 2017 to January 2018. The average temperature during the experimental period was 27.8°C and the average relative humidity 66.5%.

The experimental design was in randomized blocks in subdivided plots, with five repetitions, with the plots referring to the environment factor (full sun and black mesh screens with 4.0 m wide by 6.0 m long and transparency to solar radiation of 30, 50 and 70%), the subplots to the salinity levels in irrigation water - ECw (0.5, 2.0, 3.5, and 5.0 dS m-1), and the subplots to the species E. milii and Z. zamiifolia with two plants per replication, totaling 320 experimental units.

The seedlings of the species E. milii (transplanted with 4 to 6 definitive leaves) and Z. zamiifolia (transplanted with an age of 6 to 8 months) were purchased standardized as to size, stem diameter, number of stems, and phytosanitary condition. At 15 days after transplanting, irrigation was started with saline solutions of 0.5, 2.0, 3.5, and 5.0 dS m-1, obtained by dissolving the salts of NaCl, $CaCl_2.2H_2O$, and $MgSO_4.7H_2O$, in order to obtain an equivalent proportion between Na:Ca:Mg of 7:2:1, this proportion being a representative approximation of most water sources available for irrigation in Northeastern Brazil (MEDEIROS, 1992).

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 0.15 in order to provide free drainage of water through the holes at the end. bottom of the vessels, preventing excessive accumulation of salts in the root zone. For each treatment a pot was used as a drainage lysimeter, in order to obtain the water volumes for each irrigation event. For the foundation fertilization, 1 gram per pot of the 10-10-10 formula (N-P-K) was used, and for the top dressing, 1 gram per pot of the same formula was used 5 days after transplanting. As a source of micronutrients, the organo-mineral Torped was applied via foliar application at 15 days after transplanting.

The salt treatments were completed at 60 days, where the plants were collected from the two pots in each experimental plot to obtain the biomass of the different plant parts. The samples of these organs were weighed and placed in paper bags and taken to an oven at 65 ºC, where they remained until they reached a constant weight. With the biomass data of the different plant parts, the mass ratios (biomass partition) of roots or roots + rhizomes, leaves, stem + branches, and flowers were estimated, taking the total dry biomass of the plant as a reference.

RESULTS AND DISCUSSION

The biomass partitioning of the researched ornamental plants was influenced by the different salinity and shading levels (Tables 1 and 2). In the Euphorbia milii species, plants kept under 30% shade showed the highest percentage value of flower dry mass (FLDM) representing 26.81% of total plant biomass; with increasing shading levels, biomass allocation to flowers decreased, while leaf biomass increased (Table 1).

Even though Euphorbia milii is a characteristic plant of light-intensive environments, this species did not perform completely satisfactorily in producing flowers in full sun; such a result may be associated with light stress, occurring an imbalance between light uptake by the pigments and consequently affecting the photosynthetic activity of the plants (WILLADINO & CAMARA, 2010).

Zhao et al. (2012) in a study on the herbaceous peony flower (Paeonia lactiflora Pall), found that shading promoted a reduction in photosynthetic capacity, decreased soluble sugars and soluble protein contents, causing as a consequence a delay in the initial flowering date, prolonged flowering time, and reduced flower fresh weight. Plants subjected to salt stress can also alter the normal process of flowering, either by delaying or anticipating it; excessive concentration of ions in the soil averages that flowering is impaired by toxicity. Silva et al. (2017) evaluating the rosette crop, found that different levels of soil salinity directly affected flower buds.

Table 1. Percentage (%) of participation in the total dry mass of the variables dry matter of leaves (DML), stem + branches (MSC), roots (RDM) and flowers (FLDM) in plants of the species *Euphorbia milii* cultivated in full sun and shaded roofs with 30, 50 and 70% shade and submitted to increasing levels of salinity in the irrigation water - ECw.

% share in total dry matter					
Environment	EC levels	DML	MSC	RDM	FLDM
Full sun	0.5	29.20 ±2.10b	43.65 ±4.55a	7.53 ±1.16b	19.62 ± 3.17b
	2.0	33.04 ±2.07b	34.07 ±4.87b	8.22 ±0.61b	24.67 ±2.99a
	3.5	37.79 ±1.91a	22.77 ±3.13c	9.83 ±0.74a	29.62 ±2.13a
	5.0	38.22 ±1.95a	31.88 ±3.38b	9.49 ±0.52a	20.41 ±3.32b
Average		34.56 ±2.00	33.09 ±3.98	8.76 ±0.75	23.98 ±2.90
30%	0.5	38.05 ±2.04a	25.95 ±2.91b	8.22 ±0.40b	27.78 ±1.91b
	2.0	34.53 ±4.50a	33.41 ±4.14a	8.90 ±1.12b	23.17 ±2.71b
	3.5	36.25 ±2.06a	21.22 ±1.34b	10.52 ±0.60a	32.01 ±2.34a
	5.0	33.69 ±3.97a	33.23 ±4.04a	8.77 ±0.72b	24.31 ±2.19b
Average		35.63 ±3.14	28.45 ±3.10	9.10 ±0.71	26.81 ±2.28
50%	0.5	40.27 ±2.55a	27.49 ±1.75a	7.85 ±0.97a	24.39 ±1.90a
	2.0	48.03 ±2.53a	26.32 ±2.41a	7.98 ±0.64a	17.67 ±1.77b
	3.5	45.59 ±2.76a	21.44 ±1.74b	7.84 ±1.02a	25.12 ±3.16a
	5.0	35.79 ±2.25b	27.10 ±4.57a	7.92 ±0.60a	29.19 ±3.03a
Average		42.42 ±2.52	25.58 ±2.61	7.89 ±0.80	24.09 ±2.46
70%	0.5	42.32 ±1.78a	38.30 ±1.87a	7.82 ±0.62b	11.56 ±1.22b
	2.0	45.23 ±2.54a	31.37 ±2.73b	8.70 ±0.69b	14.70 ±1.82a
	3.5	44.14 ±2.26a	31.21 ±2.74b	11.29 ±0.66a	13.35 ±1.97a
	5.0	44.23 ±2.04a	31.43 ±1.43b	9.47 ±0.54b	14.87 ±2.49a
Average		43.98 ±2.15	33.07 ±2.19	9.32 ±0.62	13.62 ±1.87

Values are average ± standard error of the average (n = 5); averages followed by the same letters do not differ by Tukey test ($P < 0.05$).

In the species E. milii much of the photoassimilates were allocated to the leaves as opposed to root investment, in all environments studied regardless of the different salinity levels (Table 1). Shading caused an increase in the proportion of leaves and a reduction in the proportion of flowers, with biomass partitioning to flowers being drastically reduced at the highest level of shading. In the full sun treatment, the leaf biomass accounted for 34.56% of the total biomass, while the stem biomass was 33.09% and the root biomass 8.76%; under the highest shade level (70%), leaf biomass accounted for 43.98% of the total biomass (with an increase of 27.2% in relation to plants in full sun), root biomass 9.32%, and stem biomass 33.07%. Melo & Alvarenga (2009) in a study with the ornamental species Catharanthus roseus also found lower values of leaf dry matter in the full sun treatment.

Zamioculcas zamiifolia allocated the highest biomass fraction to the roots and rhizomes in all environments and at all salinity levels (Table 2), with values of 65.0, 64.1, 66.1 and 63.3% of the total plant biomass, respectively in full sun and shade at 30, 50 and 70%; the photoassimilated biomass was preferentially allocated to the vigorous root system of this species consisting of thick roots forming potato-like underground rhizomes; this improvement in water and nutrient uptake provides this species with a greater capacity to survive in heavily shaded places where other plants would be unlikely to survive. Vidal et al. (2016) in studies with sunflower cultivar Charrua, also found higher values for root biomass. Leaf dry mass accounted for 8.54, 9.38, 6.47 and 6.93% and stem dry mass 26.44, 26.5, 27.42 and 29.72% of the total dry mass under 0, 30, 50 and 70% shade respectively. Shadier environments (50 and 70%) promoted greater stem dry mass accumulation

Table 2. Percentage (%) of participation in the total dry mass of the variables dry matter of leaves (DML), stem + branches (MSC) and roots + rhizomes (MSRR) in plants of the species *Zamioculcas zamiifolia* cultivated in full sun and shaded with 30, 50 and 70% shade and submitted to increasing levels of salinity in the irrigation water - ECw.

		% share in total dry matter		
Environment	EC levels	DML	MSC	MSRR
Full sun	0.5	6.23 ±0.77b	26.62 ±2.68a	67.15 ±3.00a
	2.0	9.07 ±1.08a	24.72 ±1.56b	66.21 ±2.45a
	3.5	8.88 ±0.42a	26.76 ±0.97a	64.36 ±1.01a
	5.0	10.01 ±2.09a	27.69 ±1.08a	62.30 ±2.74b
Average		8.54 ±1.09	26.44 ±1.57	65.00 ±2.30
30%	0.5	7.61 ±1.34b	28.35 ±3.10a	64.04 ±3.04a
	2.0	8.48 ±0.88b	30.01 ±2.45a	61.50 ±2.92b
	3.5	12.52 ±1.69a	22.99 ±1.67b	64.49 ±2.74a
	5.0	8.92 ±0.98b	24.68 ±3.39b	66.40 ±3.29a
Average		9.38 ±1.22	26.50 ±2.66	64.10 ±2.99
50%	0.5	3.88 ±0.21b	30.14 ±3.06a	65.99 ±3.21a
	2.0	6.44 ±1.05a	28.90 ±1.70a	64.66 ±2.08a
	3.5	7.07 ±1.59a	26.66 ±2.14b	66.27 ±1.77a
	5.0	8.50 ±1.07a	24.00 ±1.70b	67.50 ±2.15a

Average		6.47 ±0.98	27.42 ±2.15	66.10 ±2.31
	0.5	4.89 ±0.97b	31.44 ±3.54a	63.68 ±3.95a
70%	2.0	8.76 ±1.38a	33.64 ±1.59a	57.60 ±2.49b
	3.5	8.05 ±1.08a	28.85 ±2.84a	63.09 ±3.32a
	5.0	6.04 ±0.65b	24.96 ±1.59b	69.01 ±1.78c
Average		6.93 ±1.02	29.72 ±2.39	63.34 ±2.88

Values are average ± standard error of the average (n = 5); averages followed by the same letters do not differ by Tukey test ($P < 0.05$).

Salinity influenced the partitioning of photoassimilates between the aerial part and the root. For the species Euphorbia milii, the DMAP/RDM ratio fitted a quadratic model (Figure 1A) with an increase from the ECw = 3.0 dS m-1, observing a decrease in dry matter partition to the roots and an increase in the proportion of aerial parts. The reduction of osmotic potential in the root environment, caused by increased salinity, results in water deficit (ACOSTA-MOTOS et al., 2017) and limits in the ability of roots to extract and transport water to the aerial part impairing plant growth (SANCHEZ-BLANCO et al., 2014). Suassuna et al. (2014) also observed a reduction in root biomass of 23% in sesame grown under salt stress.

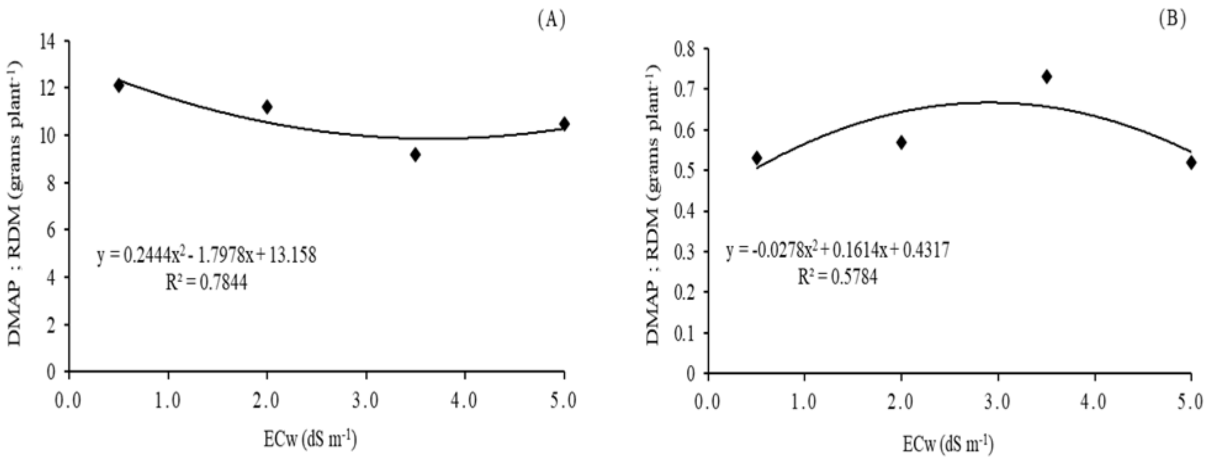

Figure 1. DMAP/RDM ratio of the ornamental species *E. milii* (A) and *Z. zamiifolia* (B) submitted to increasing levels of electrical conductivity in the irrigation water - ECw.

In Zamioculcas zamiifolia the DMAP/RDM ratio also fitted a quadratic model (Figure 1B), with increasing levels up to a certain level (3.0 dS m-1) and then decreasing in response to increasing salinity, with greater partitioning of photo-assimilates to the roots and reduced dry matter partitioning to the aerial parts. Including controlled ion homeostasis, plants contemplate adaptive mechanisms to cope with salt stress such as increased root to aerial part ratio and reduced water potentials and stomatal conductance (ACOSTA-MOTOS et al., 2015). Freitas et al. (2012) in a study on medicinal plants found that greater dry matter allocation to the roots of P. grandis plants of the genus Plectranthus, provided increased tolerance up to 1.6 dS m-1, when grown in a greenhouse.

Oliveira et al. (2015) researching the cabbage crop found that the highest root-tohead ratio (0.31) was achieved at salinity of 1.3 dS m-1.

CONCLUSION

Shading at 30% stimulated greater biomass partitioning to flowers in plants of the species Euphorbia milii, but at higher levels of shading, greater biomass partitioning to leaves and a reduction in the proportion of flowers were observed.

Zamioculcas zamiifolia allocated the largest fraction of biomass to the root + rhizome assembly (about 65% of photoassimilates) at all salinity levels, but shading had little influence on photoassimilate partitioning in this species.

ACKNOWLEDGMENTS

To the Instituto Nacional de Ciência e Tecnologia em Salinidade (INCTSal), Agência de Desenvolvimento do Estado do Ceará (ADECE) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the financial support for this research. To the Universidade Federal do Ceará for the space granted.

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