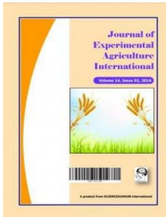

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Influence of Irrigation Depths in the Growth of Chrysanthemum Puritan Cultivar, Cultivated in Pots, under Open Field Conditions, in the Northwest Region of Espírito Santo

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Authors' contributions

This work was carried out in collaboration between all authors. Author RPP designed the study, conducted the experiment in the field with authors EJAB, GF, FV, FB and RMGM, managed the writing of the manuscript. Authors RPP and EJAB managed the analyses of study. Authors RPP and EJAB performed the statistical analysis. Authors GSC and RPP performed translation of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The present work aimed to evaluate the productive performance of chrysanthemum cultivated in an open field under different irrigation depths. The experiment was conducted in a completely randomized design, consisting of 6 treatments with 20 repetitions each. The treatments consisted of different levels of irrigation, with daily replacement of 50, 75, 100, 125, 150 and 175% of the crop evapotranspiration (ETc). The ETc was determined daily by drainage lysimeters installed at the base of six pots, used as reference (100% ETc). For the application of the treatments an auto compensating trickle irrigation system was used, with a dripper per pot flowing 1.3 liters per hour. The evaluations were made at 90 days after planting, when measurements of fresh mass of shoot

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system, dry mass of shoot system, fresh mass of the root system, dry mass of the root system, fresh mass of the flower, dry mass of the flower, plant height, stem diameter and flower diameter. The 175% ETc depth, which corresponded to an average daily depth of 10.69 mm, presented the best results for the analyzed characteristics, however, the plants did not present the quality standard necessary for commercialization due to the negative interference of the incident climatic conditions in open field plants.

Keywords: Open environment; Dendranthema grandiflora; evapotranspiration; irrigation management.

1. INTRODUCTION

In recent years, in Brazil, floriculture has shown relevant development, characterizing itself as a promising activity in agribusiness [1]. The floriculture involves the cultivation of flowers and ornamental plants with diversified purposes.

Floriculture is a significant element of the Brazilian economy, generating 215,818 direct jobs, 78,485 related to production, 8,410 related to distribution, 120,574 to retail and 8,349 to other functions. In 2014, the country presented about 14,992 hectares planted with flowers and ornamental plants, with 8,248 producers offering their dedication to the activity. Together, they grow more than 350 different species with three thousand varieties approximately [2].

The Chrysanthemum (*Dendranthema grandiflora*, Tzevelev) has an outstanding reputation and acceptance in the international market of ornamental plants. In the Brazilian scenario, São Paulo reached 70% of the national production in 2009, proving to be an important producer. Worldwide, the Netherlands stands out as the main exporter of the segment [3]. Its origin is subtropical and requires periods of short days before and during flowering, from 9 to 11 hours. It is a short-cycle plant that reveals a wide variety of colors and types of inflorescences [4].

Irrigation is a substantial practice for the cultivation of potted chrysanthemum. However, due management is disregarded by some producers, causing losses in plant growth and consequent reduction of productivity and plant quality [5].

Despite its relevance, technical-scientific knowledge about irrigation management for Chrysanthemum cultivation is still insufficient. According to Farias & Saad [5], water deficiency causes a reduction in productivity and excesses in irrigation affect the quality of flowers.

For these reasons, the objective of this study was to evaluate the influence of irrigation depth on the productive performance of chrysanthemum ‘Puritan’ cultivar cultivated in pots under open field conditions in the northwestern region of Espírito Santo, aiming to increase quality and potentiate flower production in region.

2. MATERIALS AND METHODS

The experiment was conducted in the experimental field of the Federal Institute of Espírito Santo - Campus Itapina, located in Colatina - ES, with geographic coordinates of 19°29' South latitude, 40°45' West longitude and 62 meters high. The climate of the region is Tropical Aw, according to the climatic classification of Köppen [6], characterized by the irregularity of rain and high temperatures.

The conduction of the experiment was carried out during the period from 04/08/2018 to 07/06/2018. During this period, the climatic conditions were monitored by means of an ONSET® weather station, installed near the experiment site. The collected data were used to characterize the local climate and later, related to the productive performance of the chrysanthemum.

The maximum, average and minimum temperature recorded during the conduction period of the experiment was 34.2°C; 24.08°C and 13.11°C, respectively. The accumulated rainfall volume was 181.2 mm, with the highest volume observed at 33 days after planting (DAP) of 36.4 mm (Fig. 1). The reference evapotranspiration (ETo), estimated by the Penman-Monteith method FAO-56 standard [7], had the minimum and maximum value of 1.08 mm d^{-1} and 4.33 d^{-1}, respectively, with the average of the period of 2.68 mm d^{-1} (Fig. 2).

The stakes of chrysanthemums ‘Puritan’ were obtained from a supplier company of seedlings that performed the hormonal treatment with indolebutyric acid (IBA) to favor its rooting.

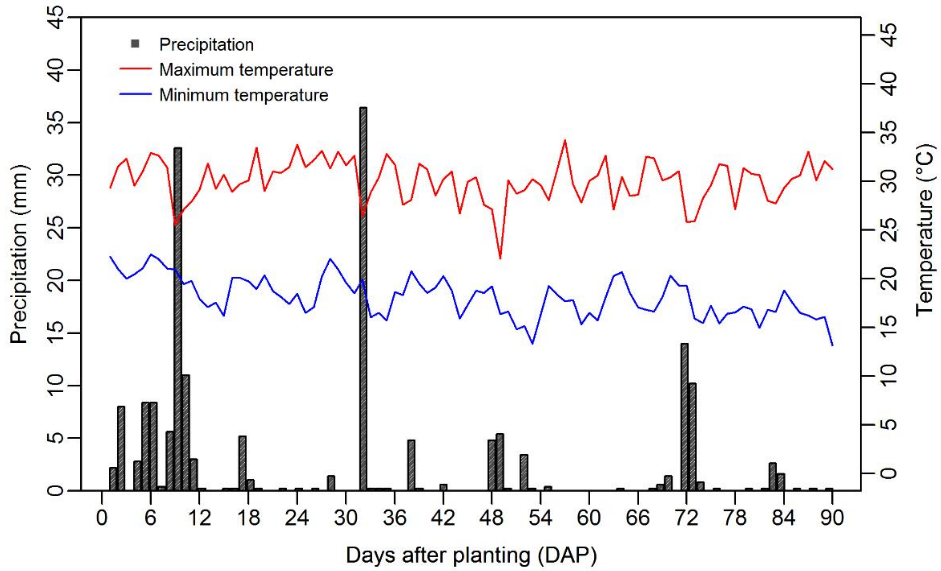

Fig. 1. Variation of maximum and minimum temperature and rain precipitation during the conduction period of the experiment

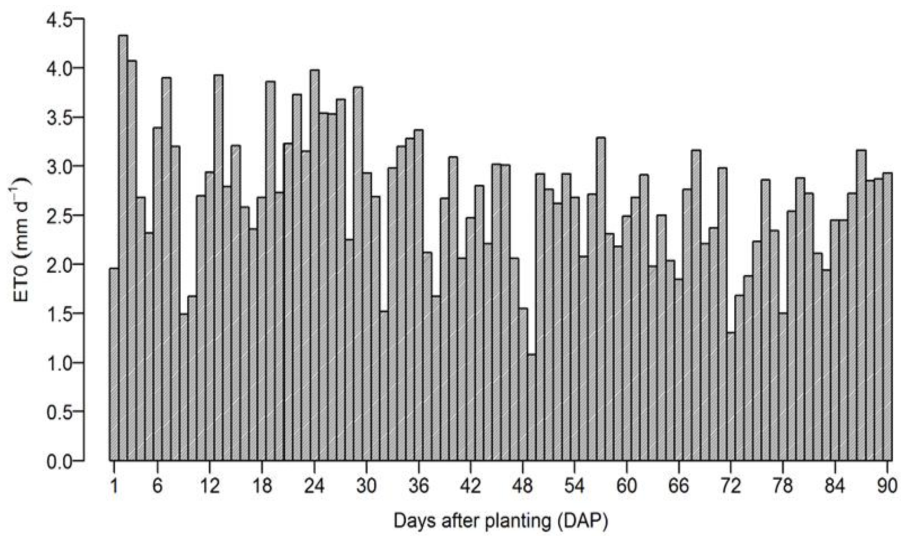

Fig. 2. Variation of reference evapotranspiration (ETo) during the period of conduction of the experiment

For the planting, black plastic pots number 13, with a volume of approximately 0.8 dm³, previously filled with 70% of the substrate Plantimax® and 30% of sifted underground soil, arranged side by side inside a greenhouse with dimensions of 25 x 5 meters.

The planting was done in the previously irrigated pots, in a total of four stakes per pot, distributed equally spaced around it. After the planting, the pots were again irrigated and covered with transparent polyethylene plastic and this cover was removed after 7 days.

On the 14th day after the planting of the cuttings, the pinch of the plants (aerial part removal), leaving about 5 to 6 lateral buds per plant for sprouting.

The pots remained 21 days in a greenhouse, from the planting of the cuttings in the pots. During this period, the daily supply of 4 hours of artificial lighting controlled by timers was performed in the interval from 8:00 pm to 0:00 am, using fluorescent lamps of 25 W, located at 2 m high and spaced between each other at 1.5 x 1.5 m.

On the 22nd day after planting, the pots were taken to the open field and placed on ceramic bricks to avoid direct contact between the roots and soil. The bricks used had dimensions of 19 x 19 x 9 cm, were previously leveled and spaced 30 x 30 cm in the treatments (Fig. 3).

The experiment was set up in a completely randomized design with 6 treatments and 20 repetitions. The treatments consisted of different levels of irrigation, daily replacement of 50, 75, 100, 125, 150 and 175% of the crop evapotranspiration (ETc). For application of the water depths, the auto compensating trickle irrigation system was used, a dripper per pot flowing 1.3 liters per hour, with service pressure of 2 kgf cm^{-2}.

To determine the water depth to be restored in each treatment, six pots were used as reference (100% ETc), where a volume of 200 ml of water per pot was added daily in the morning. The drained volume was collected by plastic containers installed at the base of the pots and then quantified and used for the determination of the evapotranspiration of the previous day's plants (Eq.1), being used to define the treatments of the day of measurement. After the treatments were defined, the irrigation system was scheduled to irrigate at 10 am.

$$ETc = \frac{\bar{X}a - \bar{X}d}{A} \qquad (Eq. 1)$$

$ETc = Crop\ evapotranspiration\ (mm\ d^{-1});$
$\bar{X}a = Applied\ volume\ average\ (L);$
$\bar{X}d = Drained\ volume\ average\ (L);$
$A = Container\ area\ (m^2).$

On the 52nd day after planting, the flower buds were thinned, leaving only the main bud of each stem. The plants were conducted without the application of growth regulators, while fertilization and phytosanitary control were performed according to the recommendations for the crop [4].

The evaluations were made at 90 days after planting, when the plants had all the inflorescences open. Fresh mass of the shoot system (FMSS), dry mass of the shoot system (DMSS), root fresh mass (RFM), root dry mass (RDM), flower fresh mass (FFM), flower dry mass (FDM), plant height (PH), stem diameter (SD) and flower diameter (FD) were measured.

Fig. 3. Chrysanthemums ‘Puritan’ cultivated in pots, under open field conditions, placed on ceramic bricks

The obtained data were submitted to analysis of variance at 5% probability in software R [8]. Subsequently, when a significant effect of irrigation levels was found by the F test, regression models were adjusted to demonstrate their stimulation in the development of chrysanthemum.

3. RESULTS AND DISCUSSION

The analysis of variance showed a significant effect of the application of different irrigation depths in all the evaluated characteristics ($P < 0.05$). It was observed through the regression analysis that the variables fresh mass of the shoot system (FMSS), dry mass of the shoot system (DMSS), root fresh mass (RFM), root dry mass (RDM), fresh flower mass (FFM), flower dry mass (FDM), plant height (PH), stem diameter (SD) and flower diameter (FD) presented a linear effect (Table 1) and positive according to the depths tested.

The average crop evapotranspiration during the period of conduction of the experiment was 6.11 mm d^{-1}, representing an average applied volume of 81.04 ml and 141.81 ml per pot, for treatments with integral replacement (100% ETc) and 175% of the evapotranspirated volume, respectively (Table 2). Similar results were obtained by Farias & Saad [9] when analyzing the growth of the chrysanthemum 'Puritan', submitted it to different water stresses, observed that the best commercial quality was obtained with the voltages -2, -6 and -10 KPa, representing an average application of 11.22, 18.36 and 19.38 mm d^{-1}. These results evidenced the great water requirement presented by the Puritan cultivar, requiring a daily water replacement that is superior to the volume lost by the evapotranspiration process so that it can develop satisfactorily.

Though the adjusted linear regression model ($\hat{y} = 0.3463 + 0.0896x$, $R^2 = 0.95$) was estimated to be the highest weight found for the root fresh mass was 16.02 grams, representing an increase of 232,36% and 72.25% in relation to the treatments of 50% and 100% (control) of ETc, respectively (Fig. 4A). These results demonstrate that the chrysanthemums suffered water stress in the smallest applied depths, even when the entire volume of water lost by the crop evapotranspiration was restored. These results are not interesting, since plants with an underdeveloped root system have less substrate exploration capacity and less water and nutrient absorption, resulting in a lower response to fertilization and consequently lower plant development.

About the fresh mass of the shoot system, it was observed through the linear regression model ($\hat{y} = 1.0214 + 0.1869x$, $R^2 = 0.9$) that it had a minimum weight of 10.36g and a maximum weight of 33,72g, in the treatments of 50% and 175% of ETc, respectively (Fig. 4B), representing a growth around 225% in relation to the smallest applied depth. These results differ from those obtained by Rêgo et al. [10] that found a quadratic effect for the different levels of irrigation on the chrysanthemum crop.

The chrysanthemums also showed a better growth with the increase of the applied irrigation depths, reaching a maximum estimated height of 16.00 cm with the treatment of 175% of ETc (Fig. 4C). Although the plants responded positively with the increase of the applied depths, the results were not satisfactory, since the quality standard establishes a minimum height of 18 cm for chrysanthemums grown in pots number 13 [11], that is, none of the applied treatments provided a satisfactory response within the standards required for commercialization.

Table 1. Result of regression analysis and coefficient of variation (CV) for the variables analyzed

	FMSS	DMSS	RFM	RDM	FFM	FDM	PH	SD	FD
Linear effect	0*	0*	0*	0*	0*	0*	0*	0*	0.009*
Quadratic effect	0.426^{NS}	0.574^{NS}	0.489^{NS}	0.377^{NS}	0.298^{NS}	0.867^{NS}	1^{NS}	0.243^{NS}	0.590^{NS}
Cubic effect	0.840^{NS}	0.977^{NS}	0.140^{NS}	0.584^{NS}	0.876^{NS}	0.856^{NS}	0.512^{NS}	0.005*	0.083^{NS}
Regression deviations	0.403^{NS}	0.176^{NS}	0.867^{NS}	0.727^{NS}	0.239^{NS}	0.006*	0.251^{NS}	0.061^{NS}	0.142^{NS}
CV (%)	22.77	30.5	25.02	33.93	24.55	26.3	13.91	21.72	16.04

** Significant at 5% probability by F test; NS not significant.*

Table 2. Treatments and average water depths applied to the chrysanthemum 'Puritan'

Treatments (% ETc)	Average water depth applied (mm d^{-1})	Average water depth applied (ml d^{-1})
50	3.06	40.52
75	4.58	60.78
100	6.11	81.04
125	7.64	101.3
150	9.17	121.55
175	10.69	141.81

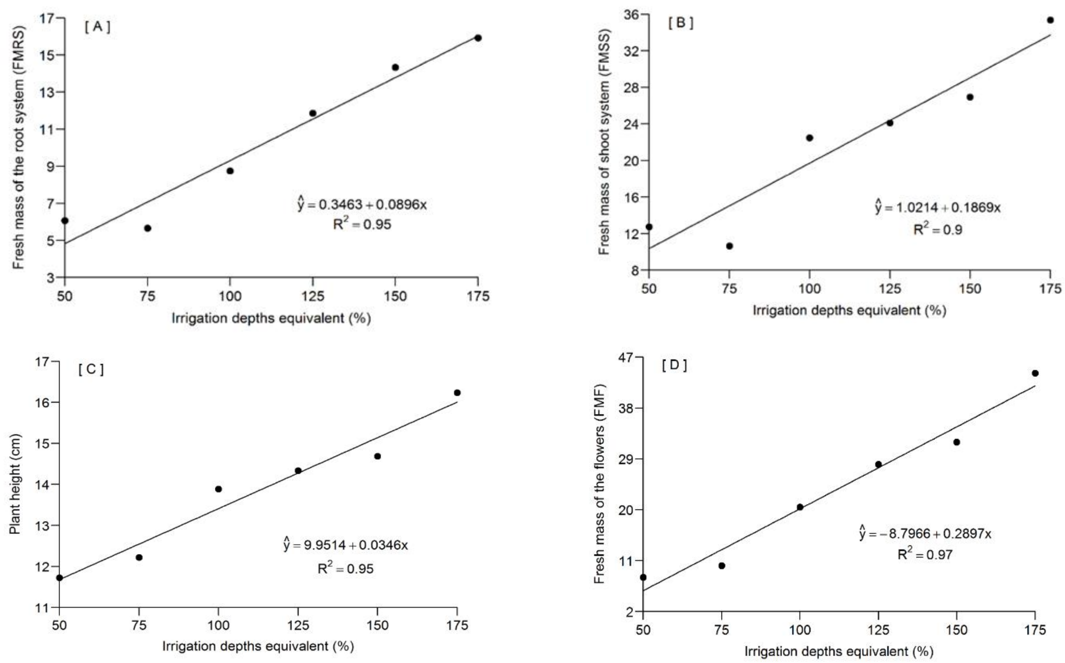

Fig. 4. Effect of the application of different irrigation depths on the fresh mass of the root system (A), fresh mass of the shoot system (B), plant height (C) and fresh mass of chrysanthemum flowers (D)

The low plant growth, even in the larger applied depths, can be explained by the effect of water stress, caused by excessive evaporative demand and limited water supply in the smallest treatments, provoking stomata closure as an attempt to maintain water content favorable in the plant tissues for a longer time. This reduction of the stomatal opening restricts the exchange of gases between the interior of the leaf and the atmosphere causing a decrease in the assimilation of CO_2 that is used in the photosynthetic process [12,13]. According to Taiz et al. [14], when plants are submitted to water deficit, cell dehydration occurs and that adversely affects several basic physiological processes, inducing reduction of cell and leaf expansion, photosynthetic inhibition, abscission and leaf death. These factors are undesirable in the commercial production of flowers, as they directly affect chrysanthemum plants, reducing the quality demanded by the market.

Another factor that probably influenced the obtained results was the air temperature. An average temperature of 24.08°C was observed during the period of conduction of the experiment, and it is considered ideal for chrysanthemum cultivation, since the plants presented a better productive performance in the range between 18 and 25°C, having tolerated limits from 3 to 30°C [15]. However, in the same period, it was observed temperatures above the tolerated limit, reaching a maximum value of 34.2°C. According to Whealy et al. [16], high temperatures may influence the growth of some Chrysanthemum cultivars, which may lead to delayed induction, floral anomalies and unequal flowering.

Table 3. Linear regression models adjusted for root dry mass, dry mass of the shoot system, stem diameter, flower diameter and flower dry mass of the chrysanthemum Puritan cultivar

Characteristic evaluated	Adjusted regression model
Dry mass of the root system (g)	$\hat{y} = 0.7528 + 0.0084x$ ($R^2 = 0.86$)
Dry mass of the shoot system (g)	$\hat{y} = 1.4579 + 0.0291x$ ($R^2 = 0.84$)
Stem diameter (cm)	$\hat{y} = 3.1225 + 0.0108x$ ($R^2 = 0.63$)
Flower diameter (cm)	$\hat{y} = 4.264 + 0.0106x$ ($R^2 = 0.50$)
Dry mass of the flower (g)	$\hat{y} = -0.4655 + 0.0359x$ ($R^2 = 0.86$)

In relation to the flower fresh mass, the adjusted linear model ($\hat{y} = - 8.7966 + 0.2889x$, $R^2 = 0.97$) estimated a weight of 41.90 grams in the highest treatment performed, representing an increase of 107.73% in relation to the control (Fig. 4D). Pereira et al. [17], also observed a linear behavior for the effect of water replacement levels on chrysanthemum inflorescences. However, these authors verified the presence of larger and better flowers with the complete replacement of the volume of water consumed by the pot.

Due to the number of flowers per pot remained practically constant in relation to the adopted conduction system, the results showed that the increase of the irrigation depths favored the production of larger flowers and it provided the increase of the obtained weights.

Although the increasing application of irrigation depths favored the production of larger Chrysanthemum flowers, they presented low visual quality due to the conditions found in the field. In this way, the quality of the flowers was affected, mainly by the climatic conditions, as wind and rain cause the tipping of the pots and consequently they cause lesions in the flowers, leaves and stem. The rain can also cause the branch to break due to the accumulation of water in the flowers, overloading the stems that cannot resist weight and they break easily.

Without loss of generalities and for reasons already presented, the other characteristics evaluated showed the same behavior according to the application of different irrigation depths tested. According to the adjusted linear regression models presented in Table 3, it can be observed that the 175% ETc depth provided a greater response to root dry mass, dry mass of the shoot system, stem diameter, flower diameter and flower dry mass, where values of 2.22 g, 6.55 g, 5.01 cm, 6.11 cm and 5.81 g, respectively, were found.

Open-air cultivation provides lower implantation costs compared to the protected-environment cultivation system. However, this system does not provide control of rainfall, frost, winds, and other natural events, and should be used only for more rustic species with the capacity to withstand these climatic adversities without loss of quality [18]. Another advantage of Chrysanthemum cultivation in a protected environment is the optimization of photoperiod control for floral induction when it is desired to produce flowers in long days [19].

Considering the results obtained, being the city of Colatina-ES a region that presents high temperatures, it is suggested that new studies be done in different climatic conditions and with daily water supplies in a parceled way.

4. CONCLUSION

According to the results obtained in the present study, it can be concluded that the irrigation management with the of 175% depth of the crop evapotranspiration, which corresponded to an average daily depth of 10.69 mm, showed better results in all evaluated parameters, however, due to negative interference of climatic conditions, the plants did not present the quality standard necessary for commercialization. Therefore, potted chrysanthemum cultivation should preferably be carried out in a protected environment.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Junqueira AH, Peetz MS. Inner market for the products of the Brazilian floriculture: Characteristics, trends and recent socialeconomic importance. Revista Brasileira de Horticultura Ornamental. 2008;14(1):37-52.
2. IBRAFLOR - Instituto Brasileiro de Floricultura. Mercado interno. Holambra: Ibraflor; 2015. Available:http://www.ibraflor.com/ns_mer_interno.php (Accessed 10 Dez. 2018)
3. Rego JL, Viana TVA, Azevedo BM, Araújo WF, Furlan RA, Bastos FGC. *Chrysanthemum* yield as affected by various irrigation depths. Horticultura Brasileira. 2009;27(1):45-48. Available: http://dx.doi.org/10.1590/S0102-05362009000100009
4. Gruszynski C. Commercial production of *Chrysanthemum* vase cut and garden. Agropecuária, Guaíba. 2001;166.
5. Farias MF, Saad JCC. Growth and quality of *Chrysanthemum* produced in Greenhouse. Horticultura Brasileira, Brasilia. 2005;23(3):740-742. Available: http://dx.doi.org/10.1590/s0102-05362005000300010
6. Köppen W. Das geographische system der klimate. In: Köppen GW, Geiger MR. (eds.) Handbuch der Klimatologie, Berlin. 1936;44. Available:http://koeppen-geiger.vu-wien.ac.at/pdf/Koppen_1936.pdf
7. Allen RG, Pereira LS, Raes D, Smith M. Crop evapotranspiration: Guidelines for computing crop water requirements. (Irrigation and Drainage Paper, 56) Rome: FAO. 1998;1-300.
8. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria; 2018. Available:https://www.R-project.org/
9. Farias MF, Saad JCC. Analysis of the growth of pot *Chrysanthemum*, Puritan cultivar, irrigated under different water tensions in greenhouse. Acta Scientiarum. Agronomy. 2011;33(1):75-79. Available:http://dx.doi.org/10.4025/actasciagron.v33i1.1763
10. Rego JL, Viana TVA, Azevedo BM, Bastos FGC, Gondim RS. Effects of irrigation levels on the *Chrysanthemum*. Revista Ciência Agronômica. 2004;35(2):302-308.
11. Holambra V. Vase *Chrysanthemum*. 2017;6. Available:http://veiling.com.br/uploads/padrao/crisantemo-pt-06-09-11-e-13.pdf (Accessed 20 Jun. 2017)
12. Krieg DR. Stress tolerance mechanisms in above ground organs. In: Proceedings of the workshop on adaptation of plants to soil stress. INTSORMIL, Nebraska. 1993;94(2):65-79.
13. Larcher W. Plant ecophysiology. São Carlos: Rima; 2000.
14. Taiz L, Zeiguer E, Moller IM, Murphy A. Physiology and plant development. 6. ed. Porto Alegre: Artmed. 2017;858.
15. Petry C. Ornamental plants: Aspects for production. Editora da Universidade de Passo Fundo: Passo Fundo. 2ed; 2008.
16. Whealy CA, Nell TA, Barret JE, Larson RA. High temperature effects on growth and floral development of *Chrysanthemum*. Journal American Society Horticultural Science. 1987;112: 464-468.
17. Pereira JRD, Carvalho JA, Paiva PDO, Silva EL, Faquin V. Fertigation interruption time and water replacement levels effects over the culture of *Chrysanthemum* (*Dendranthema grandiflora*). Ciência Agrotécnica. 2003;27(3):658-664. Available:http://dx.doi.org/10.1590/S1413-70542003000300022
18. Barbosa JG, Grossi JAS, Finger FL, Santos JM. Commercial production of roses. Aprenda Fácil Editora, Viçosa. 2015;225.
19. L'Abbate RC. Production of cut flowers in protected cultivation. Master Dissetation. Viçosa: Universidade Federal de Viçosa. 2017;18.

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