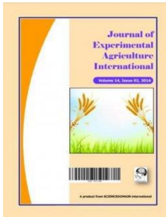

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Effects of Different Levels of Water Deficit on the Soil in Chrysanthemum Culture

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The cultivation of irrigated ornamental plants has been growing in Brazil and gaining prominence in Espírito Santo. In general, these species are sensitive to variations in water levels in the soil, being necessary to obtain information that makes it possible to maximize production through adequate irrigation management. On that note, the objective of this paper was to evaluate the growth, productivity and quality of chrysanthemum (Dendranthema grandiflorem cv. Faroe) with different levels of soil water deficit. The study was developed in a protected environment in the county of Venda Nova do Imigrante-ES. The experimental design was completely randomized, in the plot scheme subdivided in time with four replications, with five levels of soil water deficit (0%, 20%, 40%, 50% and 60%) and the subplot corresponded to six cuts along the phenological cycle of (30; 43; 57; 70; 83 and 95 days after transplanting). The height of the floral stem, the total dry mass, the floral button number and the quality components according to the Ibraflor were analyzed. There was an interaction between levels of soil water deficit (WD) and the days after transplanting (DAT), and the variables presented a significant response ($p < 0.05$). The lowest values of soil water deficit (0 and 20%) provided better development of chrysanthemum and plants with an A1 quality standard according to IBRAFLOR classification.

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Keywords: Dendranthema grandiflorem; irrigation; water availability.

1. INTRODUCTION

Floriculture has become an increasingly profitable activity within the Brazilian agribusiness, moving according to the Brazilian Institute of Floriculture [1], about R $ 7.2 billion in an area of 15 thousand hectares in the year of 2017. Besides being an activity in constant growth, it stands out as an alternative for generating both direct and indirect employment [2].

According to Farias [3], since the competition for this market is intense, the concern with improving the management for the flower production, such as irrigation, fertilization, types of cover, micrometeorological elements, harvesting and post-harvest are indispensable for obtaining satisfactory and quality production.

Among the aspects that potentiate the production, the correct management of irrigation becomes a fundamental practice for the cultivation of flowers mainly in the protected environment. The increase in the production, the quality and the value of the product to be commercialized, as well as to reduce the waste of large volumes of water, since Brazilian agribusiness consumes about 54% of the total volume captured, in which irrigation is the major responsibility for that demand [4,5].

There are several types of flowers cultivated and among them, the chrysanthemum for cutting has special prominence due its wide use by presenting a wide variety of shapes and colors, being one of the most popular flowers in the world and together with roses, carnations and gerberas, is part of the basic cast of all flower shops [6].

Among the researches on irrigation management in the chrysanthemum culture, we can mention Pereira et al. [7,8] Farias & Saad [9,3], Turan et al. [10] Lin et al. [11], Fernandes et al. [12], Jawaharlal [13] and Rêgo et al. [14], in which, independently of the evaluated characteristic, the treatments in which the crop did not suffer water deficit, presented the best results.

Due to the importance of the floriculture branch and the little information on irrigation management in the chrysanthemum culture to the local environmental conditions, this paper had as objective to study the influence that the water deficit in the soil exerts on the development and the production of the chrysanthemum culture (Dendranthema grandiflorem cv Faroe Islands).

2. MATERIALS AND METHODS

The experiment was conducted in 8 liters pots in a protected environment, from July to October 2015 in the town of São João de Viçosa, in the county of Venda Nova do Imigrante, State of Espírito Santo, latitude 20° 20'46.0"S and longitude 41° 11'33.6"W. The county has an altitude of 830 meters, the average annual temperature is around 18.5°C and air relative humidity of 85%.

The soil used to set up the experiment was taken from the natural profile of a Red Yellow Latosol, predominant in the region, collected at a depth of 0 to 0.30 m. After the collection, the soil was air dried, dewormed, passed in a sieve of up to 4 mm and homogenized. Samples were collected and sent to the laboratory for physical, chemical and water characterization (Table 1), as well as the soil water retention curve (Fig. 1), according to the EMBRAPA methodology [15].

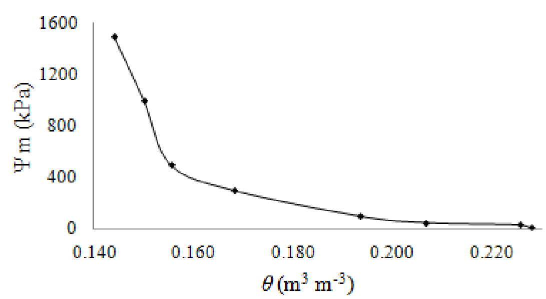

Fig. 1. Water retention curve in soil used for irrigation management

The liming and fertilization were performed according to the results obtained in the soil fertility analysis and the nutritional requirement of the crop as established in the manual of Recommendation of Liming and Fertilization for the State of Espírito Santo, 5th approximation [16].

The experimental design was completely randomized, in the split plot subdivided in time of 5x6, being the water deficit in the soil in five levels (0%, 20%, 40%, 50% and 60%) and in the subplot the days after the transplanting at six levels (30,43,57,70,83,95).

Table 1. Physical-chemical and water characteristics of the soil used in the experiment

Characteristics	Value
pH in water	5.58
Organic matter (g kg^{-1})	40.02
Phosphorus (mg dm^{-3})	50.71
Potassium (mg dm^{-3})	223.00
Sodium (mg dm^{-3})	13.00
Base Saturation (%)	38.72
Calcium (cmolc dm^{-3})	4.18
Magnesium (cmolc dm^{-3})	0.77
Aluminum (cmolc dm^{-3})	0.00
Sum of Bases (cmolc dm^{-3})	5.58
Effective CTC (cmolc dm^{-3})	5.58
Total CTC (cmolc dm^{-3})	14.40
Sand (%)	61.00
Silt (%)	11.00
Clay (%)	28.00
Soil Density (kg dm^{-3})	1.04
Field Capacity (m^{-3} / m^{-3})	0.23
Wilting Point (m^{-3} / m^{-3})	0.14

The protected environment where the experiment was conducted was covered with arched polyethylene film with 60% sombrite sides. The external dimensions were 6.0 m x 4.0 m totaling an area of 24 m^2 and a height of 2.5 m, and 3.0 m in the central span.

The chrysanthemum variety used in the experiment was the Faroe, the inflorescence is the Pom-Pom kind, of medium size with white color, coming from certified producers of the region and transplanted on July 03, placing one per pot. Up to 30 days after planting, all pots were irrigated to ensure the establishment of the crop. After this period, the treatments were started. The cultural dealings, when necessary, were carried out manually. The withdrawal of the central bud for induction of lateral budding was done at 60 DAT, and the phytosanitary control was performed weekly using the products recommended for cultivation, thus avoiding the spread of insects and diseases.

In order to determine the water deficit values, five soil moisture intervals were chosen to perform the irrigation management, with the initial value being close to the moisture of the field capacity (0%), and after this value was decreasing the levels of water available for plant, that is, 20%, 40%, 50% and 60% of water deficit in the soil. Thus, when the mass of the pots reached the desired moisture value, the water slides were restored until reaching the reference mass of the field capacity.

To determine the initial mass of the pots, ten pots were irrigated until saturated and submitted to free drainage, with the surface covered with a plastic to avoid evaporation, during 24 hours and later they were weighed.

For the growth analyses, the height of the floral stems and total dry mass (TDM) were analyzed. The height of the stems was measured by means of a graduated scale, from the lap to the apex, to determine the total dry mass, the plants were cut and oven dried at 65ºC with forced air circulation until reaching constant weight, both in function days after transplanting.

For the analysis of production, the floral button number and the IBRAFLOR classification were used. The number of flower buds (NFB) was obtained by direct counting throughout the phenological cycle of the crop and the classification was according to the quality standard demanded by the market, respecting tolerance limits for minor defects (A1) and severe (A2), in which the plants must be: free from pests and diseases; firm stems, with good support and do not present lateral "thieves branches"; uniform flowering; all with the same state of maturation and with firm staining.

Data were submitted to analysis of variance and when the effect was significant, the regression analyses were performed. The models were chosen based on the significance of 5% of the regression coefficients, using the test "t" and the coefficient of determination R^2.

3. RESULTS AND DISCUSSION

The treatments with higher water deficit (50% and 60%) resulted in the lower volumes of water applied (Table 2). However, only in the treatments with 0 and 20% of the water deficit in which the frequency of irrigation was enough to keep the crop well supplied with water, no there being deficit that could hinder the development. These values differ from the work done by Farias et al. [9] evaluating the development of the chrysanthemum culture in different soil water stresses, in which the treatments submitted to the lower tensions, resulted in the smaller water slides applied could hinder its development.

It was observed that the height of the floral stem was negatively affected by the water deficit in the soil, resulting in a decrease in the values throughout the crop cycle (Fig. 2, Table 3). In the case of a medium-cycle cultivar in which flowering occurs from 10 to 12 weeks, the height of the floral stem considered ideal by the consumer market was found at 70 and 83 DAT at 0%, 20% and 40% of the water deficit and at 95 DAT values of 0% and 20% of the water deficit. In the other periods and treatments, the height found was less than 80 cm.

Collaborating with the results found Pereira et al. [7], when studying water replenishment levels in the pot chrysanthemum culture, observed that the largest flower stems were found in the treatments in which the crop did not suffer water deficit.

The height of the floral stem is of great importance for the crops, because it is a measure highly related to the production of the phytomass and foliar area [17]. According to Taiz and Zeiger [18], water stress causes the roots to produce abscisic acid, the hormone responsible, among other responses, for decreased growth and leaf production.

All treatments showed a decrease in dry mass values as a function of the increase in water deficit (Fig. 3, Table 4). This decrease was on the order of 58%, 43%, 55%, 54.5% and 51% at 43,57,70,83 and 95 DAT, respectively, when comparing the value of 0% and 60% of the water deficit in the soil. Similar results were observed by Farias et al. [19], when studying the growth of chrysanthemum in pots under different soil water stresses, observed a decrease of the dry mass when the tensions were higher.

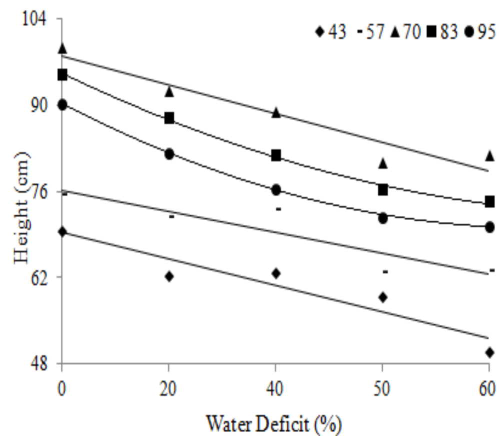

Fig. 2. Chrysanthemum floral stem height as a function of soil water deficit for the days after transplanting, Venda Nova do Imigrante - ES, BRAZIL, 2015

Table 2. Total water volume applied as a function of soil water deficit during the experiment, Venda Nova do Imigrante - ES, BRAZIL, 2015

DW (%)	Total sheet of applied water (L)				
	43 (DAT)	57 (DAT)	70 (DAT)	83 (DAT)	95 (DAT)
0	1.6	3.19	5.32	6.55	8.97
20	1.59	3.24	5.84	8.25	10.82
40	1.59	3.63	5.11	8.08	9.01
50	1.45	2.53	3.65	6.77	7.22
60	1.06	2.31	3.56	5.06	6.47

Table 3. Adjusted equations and coefficient of determination (R) for the height of the floral chrysanthemum stem as a function of soil water deficit for the days after transplanting

DAT	Equations	R
43	$\hat{y} = 68.2339 - 0.0372 . WD^{*} - 0.00372^{*} . WD^{2}$	0.8532
57	$\hat{y} = 76.6274 - 0.2110^{*} . WD$	0.7974
70	$\hat{y} = 99.0474 - 0.3069^{*}. WD$	0.9272
83	$\hat{y} = 94.9718 - 0.3512^{*}. WD$	0.9911
95	$\hat{y} = 89.6672 - 0.3359^{*}. WD$	0.9902

** Significant at 5% probability*

Table 4. Adjusted equations and coefficient of determination (R) for total dry mass of chrysanthemum as a function of soil water deficit for the days after transplanting

DAT	Equations	R
43	$\hat{y} = 15.6363 - 0.1906^{*} . WD - 0.0015^{*} . WD^{2}$	0.9900
57	$\hat{y} = 33.9089 - 0.2438^{*}. WD$	0.8898
70	$\hat{y} = 50.1859 - 0.4619^{*} . WD$	0.8986
83	$\hat{y} = 51.0708 - 0.4654^{*}. WD$	0.9786
95	$\hat{y} = 57.3577 - 0.7743^{*} . WD - 0.0047^{*} . WD^{2}$	0.9611

** Significant at 5% probability*

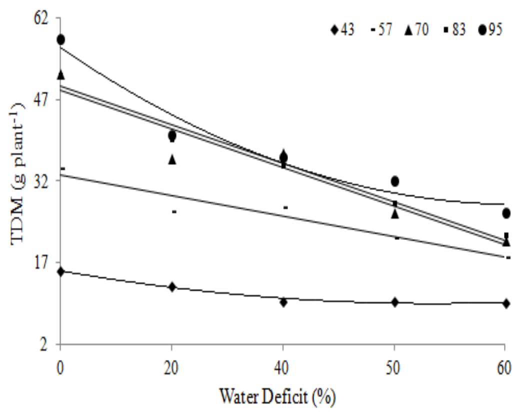

Fig. 3. Total dry mass of chrysanthemum as a function of soil water deficit for the days after transplanting, Venda Nova do Imigrante - ES, BRAZIL, 2015

It is known that the lowest rates of accumulation of dry mass occur where there is water deficit in the soil [20]. Since the dry matter production is the result of the photosynthetic activity of the leaves and consequently, the efficiency with which the photoassimilates are converted [21], under water stress, the plants use the mechanism of closure of the stomata to avoid the loss of water, also reducing the photosynthetic rate and the accumulation of photoassimilates [18], thus compromising the development of the plant.

In relation to the floral bud number, it was observed that it was also affected by soil water deficit (Fig. 4, Table 5), occurring to decrease in the periods analyzed as a function of the increase in soil water deficit of up to 59% when compared to the water deficit from 0% to 60%. Collaborating with the results, Pereira et al. [7] looking for the correct management of irrigation in the culture of the potted chrysanthemum, found the largest and best inflorescences when the water replenishment was of integral form.

The decrease in the floral bud production when submitted to water stresses may be related to the decrease in the amount of leaves produced by the crop caused by the smaller height of the floral stem, because the leaves accumulate nutrients and organic compounds that will be translocated to the reproductive organs during the crop cycle, exerting negative influence on crop yield [22]. Knowing the nutritional conditions of the crop is an important factor to understand its development [23] and significantly assists studies like this.

According to the quality classification required by the market, the best quality standard (A1) was obtained in the water deficit of 0,20 and 40%, demonstrating a strong correlation between the quality of the plants and the water deficit. Farias et al. [19], when studying the growth and quality of chrysanthemum in different soil water stresses, observed that the best quality standard (A1) occurred only in plants that did not have water stress.

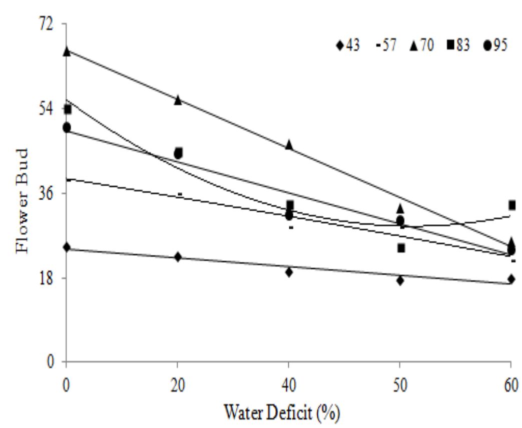

Fig. 4. Chrysanthemum floral bud as a function of soil water deficit for the days after transplanting, Venda Nova do Imigrante - ES, BRAZIL, 2015

Table 5. Adjusted equations and coefficient of determination (R) for the floral bud of chrysanthemum as a function of soil water deficit for the days after transplanting

DAT	Equations	R
43	$\hat{y} = 24.6940 - 0.1262^{*}.WD$	0.9530
57	$\hat{y} = 38.9736 - 0.1017^{*}. WD - 0.0028^{*}. WD^2$	0.9546
70	$\hat{y} = 68.3707 - 0.6741^{*}. WD$	0.9633
83	$\hat{y} = 55.3867 - 0.8360^{*}. WD + 0.0067^{*}. WD^2$	0.8766
95	$\hat{y} = 50.9569 - 0.4413^{*}. WD$	0.9747

** Significant at 5% probability*

4. CONCLUSIONS

Soil water deficit values influenced stem height, total dry mass, floral bud number and the quality classification required by the Faroe cultivar market in a protected environment. For all variables studied, soil water deficit levels that provided better responses were between 0 and 20% WD. Due to the best results, mainly the variables of interest in the consumer market, it is recommended to the producer the irrigation management in which the plants do not suffer water stress (0 and 20% WD).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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