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WATER AVAILABILITY AND PRODUCTION OF POTTED ALSTROEMERIA IN GREENHOUSE

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Keywords:
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stem height
water deficit

ABSTRACT

The amount of available water in the substrate is one of the most important factors for the growth and development of potted ornamental species. The aim of the present study was to determine the water consumption of *Alstroemeria x hybrid* variety Firenze when submitted to different irrigation levels and to assess their effects on production factors. The experiment was carried out under controlled conditions of temperature at Colégio Politécnico of Universidade Federal de Santa Maria, in the state of Rio Grande do Sul, Brazil. Rhizomes of *Alstroemeria x hybrid* variety Firenze were transplanted into 20 liters rigid black plastic pots filled with substrate. Five treatments (90%, 75%, 60%, 45%, and 30% of container capacity) with 10 repetitions were arranged in a completely randomized design. The production components height and flowering stem diameter, number of flowers per stem, and stem fresh and dry matter content were evaluated over a year of production. Our results demonstrated an increase in water consumption as water availability increased, interfering with the production parameters, except for the number of flowers per stem and flower stems diameter.

Palavras-chave:
Alstroemeria x hybrida
comprimento de haste
déficit hídrico
flor de corte
irrigação

DISPONIBILIDADE HÍDRICA E PRODUÇÃO DA ALSTROEMERIA ENVASADA CULTIVADA EM AMBIENTE PROTEGIDO

RESUMO

A quantidade de água disponível no substrato é um dos fatores mais importantes no crescimento e desenvolvimento de espécies ornamentais em vasos. O objetivo deste trabalho foi determinar o consumo hídrico da *Alstroemeria x hybrida*, variedade Firenze, quando submetida a diferentes níveis de irrigação e avaliar seus efeitos sobre fatores de produção. O experimento foi conduzido em estufa climatizada do Colégio Politécnico da Universidade Federal de Santa Maria, RS, Brasil. Foram utilizados vasos com capacidade de 20 litros e uma muda por vaso. O delineamento experimental utilizado foi inteiramente casualizado, com cinco tratamentos, sendo 90%, 75%, 60%, 45% e 30% da capacidade de retenção de água no vaso e dez repetições. Foram avaliados durante um ano de produção os seguintes componentes de produção: altura e diâmetro da haste floral, número de flores por haste e massa verde e seca das hastes. Os resultados demonstraram que houve um incremento no consumo de água à medida que a disponibilidade hídrica aumentava, interferindo nos parâmetros de produção, exceto no número de flores e diâmetro das hastes florais.

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INTRODUCTION

The production of cut flowers is an important economic activity in some regions. For example in Brazil, the floriculture industry is one of the most dynamic and promising segments of agribusiness, presenting significant growth indicators in relation to the number of producers, as well as in acreage (JUNQUEIRA & PEETZ, 2014). Cut flowers and foliage industry rank in the second position in terms of magnitude, in a total of 34.33% of the gross value of production. The state of São Paulo is the main producer, consumer, and exporter of flowers and ornamental plants, being responsible for 74.5% of the Brazilian production (GOMES, 2013). The state of Rio Grande do Sul imports more than 87% of its flowers from São Paulo, which raises the final price (15% - 20%) mainly due to shipping costs. Thereby, local arrangements for production of cut flowers are important and they justify the adjustment of production's technologies to the environmental conditions of the region.

The species of the genus Alstroemeria are native from tropical or subtropical regions of South America (ALMEIDA, 2014). Currently, the hybrid species have developed a great buying demand due to their use as cut flowers. The hybridization results in plants with large flowers, a variety of colors, longer shelf life, and flower stems which can reach up to two meters high (TOMBOLATO, 2010). In addition, Alstroemeria has been used worldwide as a cut flower because of its excellent vase life and high commercial value (BAEZA et al., 2016).

The irrigation management stands out among the production techniques that need adaptation. In addition to the increase in productivity, proper irrigation management for each crop also promotes water, fertilizer, and electricity savings (DE SÁ, 2013).

Water consumption is a dramatic aspect in flower production (CASSANITI et al., 2013). The amount of water consumed by ornamental plants depends on the species, growing season, cropping system and plant growth stage. On average, 100 to 350 kilograms of water are necessary to produce one kilogram of dry matter (FORNES et al., 2007). Therefore, the limited supply of fresh water in many countries requires knowledge on the amount of water needed for every developmental stage of ornamental species. This is important in order to have an efficient irrigation management to avoid wastes and reduced costs.

The potted cultivation system with substrate limits the space available to the root system, which requires adequate control of water and nutrients (LUDWIG et al. 2013). This system is different from the conventional soil cropping system, wherein the volume explored by the roots is unlimited. The amount of available water in the substrate is one of the most important factors that affects growth and development of potted ornamental plants. Water deficit reflects in slow development and low crop yields (PARIZI et al., 2010). In contrast, water excess causes nutrient leaching from the substrate, which reduces root respiration rate, and also creates a propitious environment for the development of diseases.

According to Miralles-Crespo et al. (2010), several parameters are used as indicators to assess the water status in plants, such as water potential of leaves and stem, photosynthesis and leaf conductance. However, they are difficult to operate at field conditions. Then, the same authors state that studies have suggested that one of the sensitive indicators of water deficit in plants is growth, and more specifically, the diameter of the flowering stem.

The aim of this study was to determine the water consumption of *Alstroemeria x hybrid* subjected to different irrigation levels and to access their effects on production factors.

MATERIALS AND METHODS

The study was performed at the Sector of Floriculture (29º42'S 53º49'W; alt. 95 meters) at Colégio Politécnico of Universidade Federal de Santa Maria (UFSM), in the city of Santa Maria, located in the central region of the state of Rio Grande do Sul, in the South of Brazil. According to Köppen climate classification, the climate in Santa Maria is Cfa, humid subtropical climate, with warm summers and without defined dry season (HELDWEIN et al., 2009). Moreover, the daily temperature in the coldest month oscillates between -3°C and 18°C and the average annual temperature and relative humidity are 19.3°C and 78.4%, respectively. The experiment was carried out in a greenhouse under controlled conditions of temperature (ranging from 21°C to 29°C), from October of 2013 to December of 2014, completing a year of production. The greenhouse used has dimensions of 20 meters wide, 30 meters length and 3.5 meters high.

Rhizomes of *Alstroemeria x hybrid* variety Firenze were purchased from the Konst Alstroemeria Company, which imported the plants from the Asista Company, located in Holambra, southeastern of Brazil. After the 30 days of acclimatization, seedlings were transplanted into 20 liters (33 centimeters-diameter and 29 centimeters-height) rigid black plastic pots filled with substrate (mixture of soil, peat, and carbonized rice husk at a ratio of 3:1:1) and placed inside of a greenhouse upon wooden slatted. Fertigation management followed the recommendation of the Konst Alstroemeria Company (18N-6P-18K and electrical conductivity of 1.4 microsiemens per centimeter (µS/cm), performed every week simultaneously with the water repairing of the pots. The fertigation was the same for all treatments.

For the irrigation treatments, the maximum water holding capacity of the substrate was determined by placing the pots with the dried substrate in a recipient with water up to half its height for capillary saturation. Then, the pots were removed and left in the natural environment for draining. The pots were covered at the bottom with a plastic, and weighed after cessation of water flow, according to the adapted methodology by Kämpf et al. (2006). The capacity of the pot containers was calculated by the equation 1:

$$CC = M_2 - M_1 \tag{1}$$

where,

CC = container capacity of a 20 liters pot, dimensionless;

M_1 = mass of the pot with completely dry substrate (16.1 kilograms);

M_2 = mass of the pot in its maximum container capacity (21.400 kilograms), which was considered as CC of 100%. Subsequently, 30% (17.690 kilograms), 45% (18.485 kilograms), 60% (19.280 kilograms), 75% (20.075 kilograms), and 90% (20.870 kilograms) of container capacity were determined.

The water replenishment started after transplanting the seedlings. The humidity variation established in each treatment was obtained through the weighing of each pot on a weight scale every seven days, restoring manually the water until it reaches the predetermined value for each treatment. The water consumption of each treatment was quantified by the amount of water used in each replacement.

Once extra plants were growing in the pots, at each growth stage of each treatment, these plants were destroyed, so it was possible to ensure that the original plants were receiving suitable amount of water. Treatments (90%, 75%, 60%, 45%, and 30% of container capacity) were arranged in a completely randomized design with ten repetitions for each treatment.

The harvest of Alstroemeria initiated fifty days after the transplantation to the definitive pots and occurred continuously, so that at any time a new flowering stem was at the harvesting point. In addition to harvesting, height and diameter of the stems (centimeters), fresh and dry matter content of the flowering stems and the quantity of flowers in each stem were evaluated. The flowering stems were cut at substrate level, the stem length was measured with a graduated ruler and the stem diameter was measured at the midpoint of the stem with a Pocotest micrometer. The number of flowers per stem was obtained by counting. Immediately after harvested, fresh stems were weighed on a 2 kilograms precision scale and they were oven dried at 65°C until they reached a constant mass to measure dry weights.

Statistical analysis was performed by using analysis of variance (ANOVA) at 95% confidence interval to compare yield components between the treatments. Once the interaction was significant, data were analyzed by regression analysis.

RESULTS AND DISCUSSION

The results showed that water consumption is greater as the water availability increases (Figure 1). Greater variations in water consumption were observed due to the increase in air temperatures at 90 (Summer months) days after transplanting (DAT). A significant reduction in water consumption was observed during the subsequent months (210 to 270 DAT) because of lower temperatures and higher air humidity. This reduction corresponds to approximately 50% of the water consumed by all treatments during the Summer, except for the treatment with 90% of the container capacity, which maintained high water consumption. Despite the environmental conditions (temperature and relative humidity), there was not a great variation around 330 DAT (August and September) when compared to the previous months. In addition, it was observed an important increase in water consumption during August and September, which can be explained by the occurrence of the harvest peak.

The data analysis of the production parameters demonstrated a significant interaction between the CC, flowering stems' height, number of flowering stems, as well as fresh and dry matter content of stems. Our results demonstrated a crescent linear effect on the height of flowering stems (Figure 2), once stem height increased with increasing water availability. At lower CC (30%), the stems' height had an average of 62.2 centimeters when compared to the average of 77.6 centimeters of higher CC (90%), which corresponds to a length increase of 15.4 centimeters (28.8%). These results are similar to those ones found by Farias (2006) with chrysanthemum, Hernández (2011) with rose, and Girardi (2012) with gypsophila. Furthermore, our results demonstrate a close relation between the cell turgor and the performance of physiological functions, resulting in a greater growth and productivity of *Alstroemeria x hybrid* variety Firenze. Flowering stem height of cut flowers is an important quality factor that may determine its wider use. In addition, it allows periodic cuts at the base of the stem to control microbial obstruction of conducting sap vessels, extending the flowers' life.

The height (Figure 2) and number of flowering (Figure 3) stems' parameters had similar behavior. The average number of stems ranged from 19.7 to 40.8 at lower and higher container capacity, respectively. The increase in the number of stems (107%) was one of the most outstanding effects of the water availability. Similar results were achieved with other potted floral species regarding the number of stems and inflorescences as the water availability in the pot rose or increased (DE SÁ, 2013; PORTO et al., 2014). Besides water availability, soil temperature also affects Alstroemeria production. Ideal temperatures to stimulate the formation of flower buds in Alstroemeria are 10 to 17°C (BALL, 1998), below 20°C and about 14°C (TOMBOLATO, 2010). Our results suggest that greater water availability during the growth stages of *Alstroemeria x hybrid* variety Firenze aided to maintain a lower temperature in the substrate during the summer months, which stimulated regular growth and differentiation of a larger number of flowering stems. The increase in the number of flowering stems directly affects the profits due to an increase in quality and quantity of the final product.

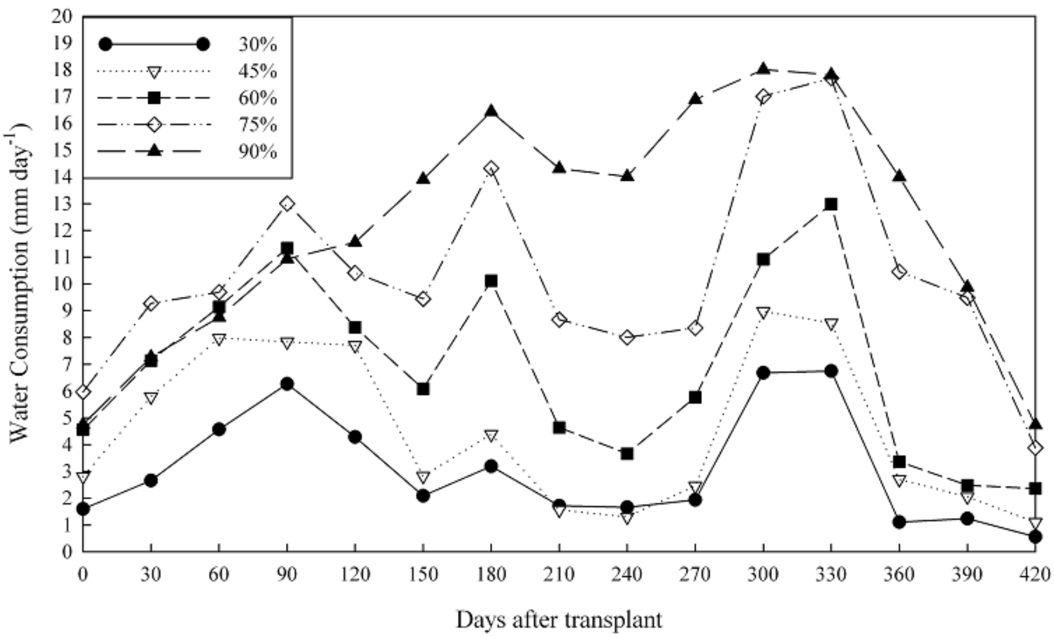


Figure 1. Water consumption (mm day^{-1}) of potted *Alstroemeria x hybrid* variety Firenze subjected to 30%, 45%, 60%, 75% and 90% of the container capacity.

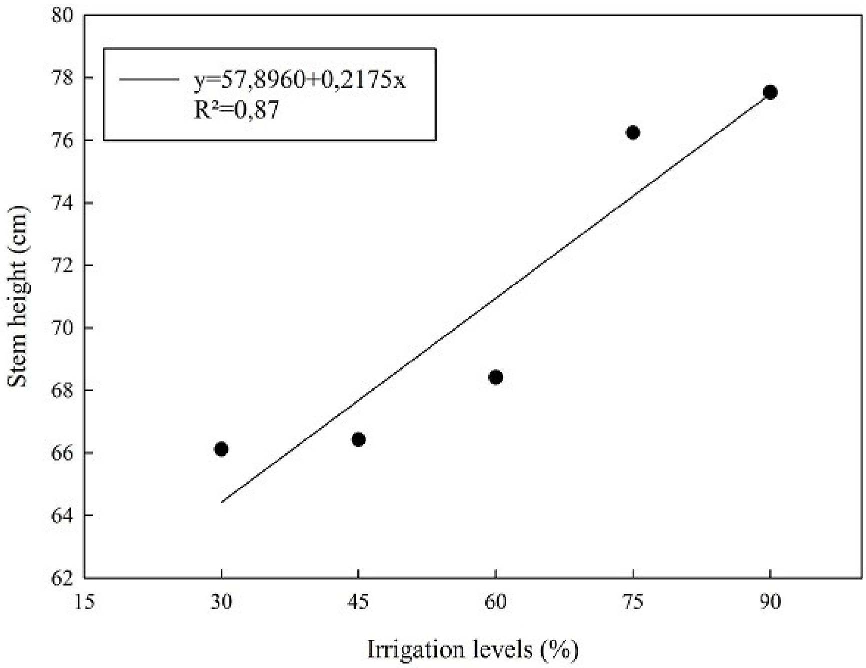


Figure 2. Relation between water availability and stem height of *Alstroemeria x hybrid* variety Firenze.

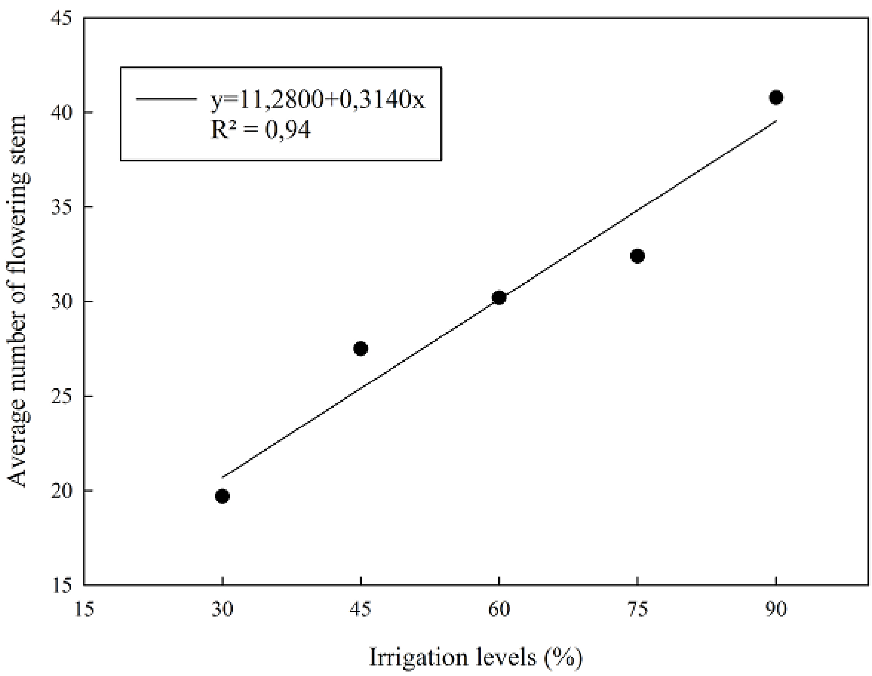
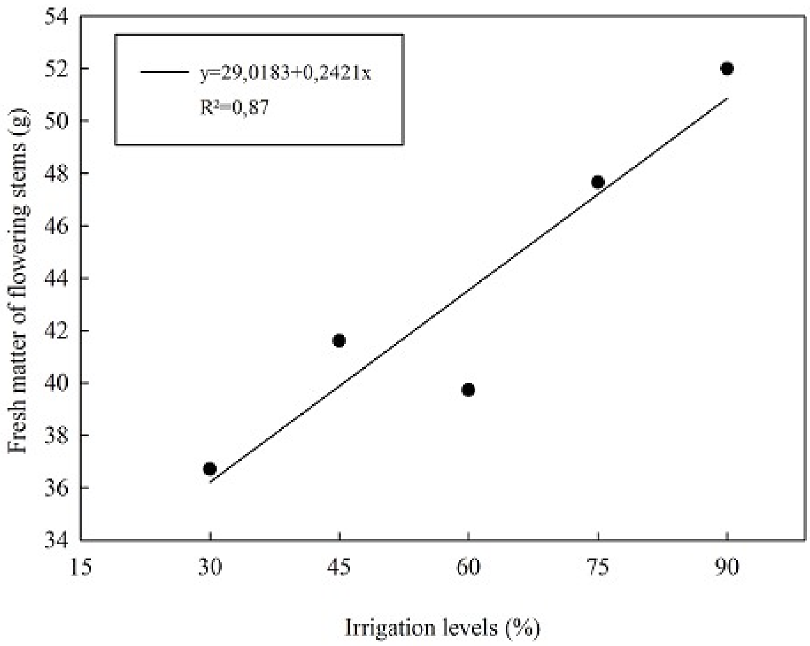
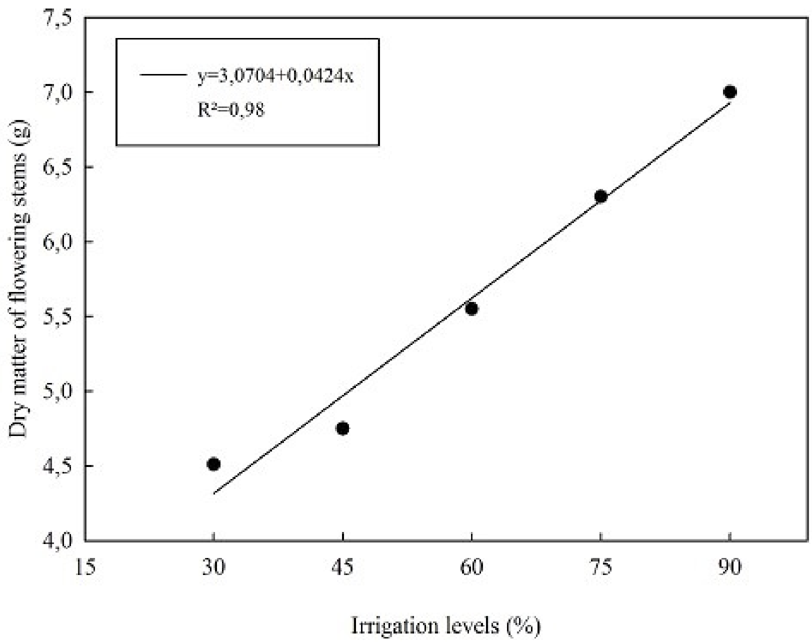


Figure 3. Relation between water availability and flowering stems quantity of *Alstroemeria x hybrid* variety Firenze.

The fresh and dry matter content of flowering stems (Figure 4) also had a significant crescent linear response, in which the mass of flowering stems increased following water availability. According to Shao et al. (2008), water stress is characterized by the reduction of the water content, turgor, total water potential, wilting, stomatal closure, and decreased cell growth. Thus, a plant suffering by water stress tends to show a decrease in its fresh matter and consequently in its dry matter content. In this study, both the fresh and dry matter content reflected the behavior of the flowering stems height; longer stems had greater fresh and dry matter content. Plants with low percentage of dry matter tend to have fragile parts or structures due to reduced lignin and cellulose content. In the present study, the dry matter content of flowering stems reduced 75.04% between the higher (90%) and the lower CC (30%) treatments. Likewise, Callistemon plants subjected to water stress produced the smallest plants, and total dry matter reduced 47% when compared to the control treatment (ÁLVAREZ et al., 2011).



(a)



(b)

Figure 4. Relation between water availability and fresh (a) and dry (b) matter of flowering stems of *Alstroemeria x hybrid* variety Firenze.

Although the number of flowers per stem and flowering stems height were lower in the treatment with lower water availability, no significant differences for these parameters were observed. The average number of flowers per stem in the treatments of 30% and 45% of CC were 7.04 and 6.85 flowers, respectively. The great number of flowers per stem was observed in the treatments with 90% and 75% of CC (9.05 and 8.48 flowers, respectively). The number of flowers per stem found in this study is within the variability (3.2 to 10 flowers) when compared to published data (OLDONI, 2012). Moreover, when compared to the Brazilian standard of the Veiling Cooperative of Holambra (10 flowers per stem), only the treatment with the highest CC (90%) will attend this standard.

This affirmation about the number of flowers agrees with the results found in this study, in which treatments with greater CC had thicker stems and consequently greater number of flowers per stem. The stem thickness and the number of flowers per stem are factors dependent on the solar radiation and photoperiod, therefore, as long as the period of light increases, more flowers and thicker stem diameter are expected (VAN LABEKE & DAMBRE, 1993). Besides, our results demonstrate that water availability also contributes to the increase in stem thickness and number of flowers per stem. Therefore, it is essential to know the actual water requirements of the crop during the growing season.

CONCLUSIONS

According to the methodology we used and due to the conditions in which the study was carried out, we concluded that:

- The water consumption by *Alstroemeria x hybrid* variety Firenze is higher in treatments with greater limits of water availability (90% and 75% CC).
- The water availability of 90% is required to produce long flower stems, which reflects directly in the quality of the final product.
- The number of flowers per stem and the stem diameter parameters did not exhibit interference on water availability.

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