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EVAPOTRANSPIRAÇÃO E COEFICIENTE DE CULTIVO (Kc) PARA A CULTURA DA BOCA-DE-LEÃO EM AMBIENTE PROTEGIDO

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RESUMO: Este esse trabalho teve por objetivo estimar a evapotranspiração e os coeficientes de cultivo pelo método da lisimetria de drenagem para o cultivo da boca-de-leão (*Antirrhinum majus* L.) em ambiente protegido. O experimento foi conduzido na região da serra da Ibiapaba. Os vasos foram preenchidos com o solo da estufa de condução, e saturados por ascensão capilar. A observação da evapotranspiração da cultura (ETc) foi realizada através do método da microlisimetria de drenagem, com aplicação inicialmente de volume conhecido (0,5 L), seguido de aumento gradual (0,25 L) conforme a necessidade, garantindo a ocorrência do volume drenado. A condução seguiu até o momento em que as inflorescências apresentavam no mínimo 10 flores totalmente abertas (63 DAT). A boca-de-leão apresentou uma ETc acumulada de 121,8 mm, com máxima de 4,6 mm, já próximo à colheita. Os coeficientes de cultivo obtidos foram 0,42; 0,78; 1,1 e 1,3, correspondendo respectivamente às fases Inicial, vegetativa I, vegetativa 2 e floração.

Palavras-chaves: *Antirrhinum majus* L., microlisimetria de drenagem, flor de corte

EVAPOTRANSPIRATION AND CROP COEFFICIENT (Kc) FOR SNAPDRAGON CULTIVATION IN A PROTECTED ENVIRONMENT

ABSTRACT: This study aimed to estimate evapotranspiration and crop coefficients using the drainage lysimetry method for growing snapdragons (Antirrhinum majus L.) in a protected environment. The experiment was conducted in the Ibiapaba mountain range. Pots were filled with soil from the greenhouse and saturated by capillary rise. Crop evapotranspiration (ETc) was observed using the drainage microlysimetry method; a known volume (500 ml) was initially applied, followed by a gradual increase (250 ml) as needed to ensure the drainage volume. The training continued until the inflorescences had at least 10 fully open flowers (63 DAT). The snapdragons presented an accumulated ETc of 121.8 mm, with a maximum of 4.6 mm, close to that of the harvest. The obtained crop coefficients were 0.42, 0.78, 1.1 and 1.3, corresponding to the Initial, Vegetative I, Vegetative 2 and Flowering phases, respectively.

Keywords: *Antirrhinum majus* L., Drainage microlysimetry, cut flower.

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1 INTRODUCTION

Widespread across various parts of the world, the use of protected environments has established itself as a technique that enables the production of various crops (Ghani). *et al.*, 2019), among which is the cultivation of cut flowers, such as Snapdragon (*Antirrhinum) Majorus* L.), which, although considered perennial, is usually cultivated annually and presents an inflorescence with flowers that resemble a feline snout; hence, its name is characteristic (Silva *et al.*, 2014).

According to The Observatory According to the Organization of Economic Complexity (OECD), in 2022, the largest exporter of cut flowers was the Netherlands, with US$10.6 billion in exports. In that same year, Brazil's contribution to exports was US$35.2 thousand, which is equivalent to 0.23% (OEC, 2025). Although these Brazilian exports have lost momentum, the sector has been favored by the domestic market, with a per capita growth of 8% in 2017, with Ceará standing out, occupying the 4th position, presenting excellent edaphoclimatic conditions compared to those of other Brazilian states or countries in the floriculture sector, such as the high number of hours of sunshine per year and the absence of frost and hail (Instituto Agropolos, 2019).

As with large-scale conventional crops, irrigation management in cut flower cultivation is key for optimizing the resources used, since in this sector, consumption is “by sight,” highlighting the intrinsic importance of observing the plant’s water status through crop evapotranspiration (ETc) and the crop coefficient (Kc), which are crucial indicators for proper irrigation management, especially in protected environments such as greenhouses, which represent 53% of the total area cultivated with flowers in the Ibiapaba region, Ceará, Brazil, according to a survey conducted by Barreto *et al.* (2022).

Therefore, this study aimed to estimate evapotranspiration and crop coefficients using the drainage lysimetry method for snapdragon cultivation in the Ibiapaba mountain range region of Ceará.

2 MATERIALS AND METHODS

The study was conducted in a protected greenhouse environment located in the municipality of São Benedito in the microregion of the Ibiapaba plateau, Northwest Region of the state of Ceará, Brazil. According to Lopes, Sarmento and Oliveira (2016), the maximum and minimum temperatures are 30 °C and 15 °C, respectively, and the average annual insolation is 2,800 h, indicating a local climate classified as hot tropical (mild semiarid, subhumid and humid), with an annual rainfall of 1306.2 mm, concentrated from January to May (IPECE, 2017).

The experiment was conducted in a half-open space (24.0 m × 6.0 m) of a greenhouse belonging to the Ceará School of Floriculture (Tec Flores), administered by the Agropolos Institute of Ceará (IACe), at the geographic coordinates 04° 03' 34" S and 40° 53' 39" W, at an altitude of 867 m. The soil in the area is classified as Neossol. Quartzarenic Orthic The soil type was classified as latosolic according to the Brazilian Soil Classification System (see Santos *et al.* (2025)). The greenhouse was characterized by a 3.2 m high arched structure, with anti-aphid netting on the outer sides, covered with 200 µm transparent polyethylene, approximately 3 years old, and with visual evidence of dust accumulation. No anti-aphid netting was observed in the skylight.

This experiment was conducted from February to April, which coincides with the region’s rainy season. Snapdragon seedlings were provided by Ball® Horticultural do Brasil, 35 days after sowing (DAS), and transplanted at 40 DAS (ensuring acclimatization to the growing location). Fertilization was carried out according to Al-Mana. *et al.* (2021), resulting in the supply of 3.2 g plant $^{-1}$ of N (3.56 g of urea), P (5.3 g of monoammonium phosphate - MAP) and K (5.3 g of potassium chloride – KCl).

The pots used for this experiment were 28 cm in diameter (0.062 $m^{-2)}$ and 26 cm high, with a volumetric capacity of approximately 15 $dm^{-3.}$ The pots were filled with soil from the area under the greenhouse.

Prior to transplanting, to achieve field capacity, the pots were subjected to capillary rise saturation using a 300 L water tank, with water added until it reached a height of 10 cm from the rim of the pots. The entire process lasted 24 hours.

After saturation, in the late afternoon, the pots were removed and placed on spaced bricks to allow gravity to drain the excess water, remaining there until the following morning, when a known volume of water (0.5 L) was added, and after drainage, the seedlings were transplanted, with 3 placed in each pot, arranged in a triangular shape, and spaced 15 cm apart.

ETc) began and was performed using the drainage microlysimetry method, with an initial supply of a known volume (0.5 L), which was maintained until the need to increase the applied volume was observed; this process continued until the end of the experiment. A gradual increase of 0.25 L was established, which was increased as needed, thus ensuring the occurrence of a drained volume.

Reference evapotranspiration (ETo) was estimated using the class A pan method, as proposed by Allen *et al. (1998). Since this is a protected greenhouse environment, where the effect of wind on evaporation in the Class A pan can be considered negligible, a pan coefficient (*Kt) of 1.0 was chosen, as highlighted by Lopes Filho (2002), when dealing with conditions similar to those observed in this research. Therefore, the crop coefficient (kc) values for the snapdragons were obtained by the relationship between the crop evapotranspiration and reference evapotranspiration (ETo) according to the sequence of equations presented below:

$$ETo = EV \times Kt \quad (1)$$

$$ETc = \frac{(VF - VD)}{Av} \quad (2)$$

$$Kc = \frac{ETc}{ETo} \quad (3)$$

where EV is the evaporation of class "A" pan (mm); Kt is the pan coefficient (dimensionless); ETo is the reference evapotranspiration (mm); ETc is the crop evapotranspiration (mm); VF is the supplied volume (L); VD is the drained volume (L); Av is the area of the vessel (m^{-2}); and Kc is the crop coefficient (dimensionless).

Since this is a cut flower, the criterion used for harvesting the plants and completing this research was the opening of flower buds, considering between 8 and 10 fully opened flowers for cutting the plants.

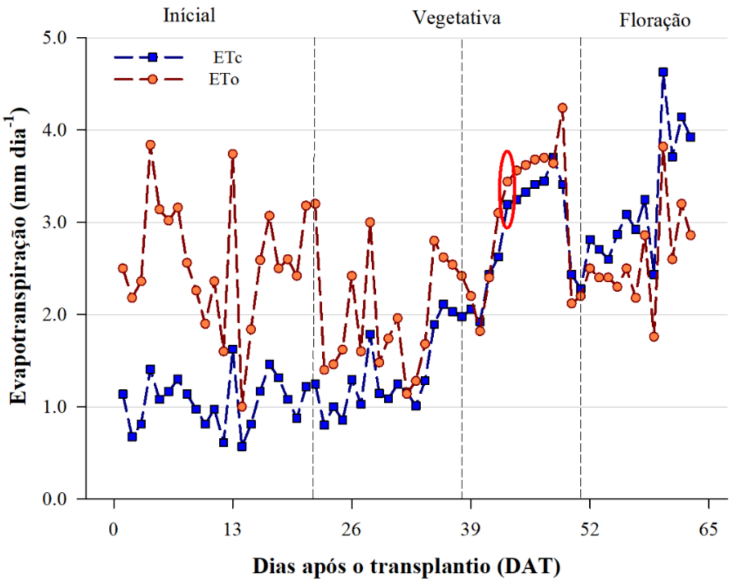
For the purpose of estimating crop coefficients according to the specificities of each physiological stage of development, this experiment considered observations made with plants in the field and the responses of water demand observed according to the collected data.

3 RESULTS AND DISCUSSION

The total crop cycle was 103 days, with only 63 days corresponding to the crop in the field after transplanting. The crop water demand (ETc) during the growing cycle was 121.8 mm, with a maximum daily demand of 4.6 mm, which was observed on a day close to harvest.

The evolution of crop evapotranspiration (ETc) and reference evapotranspiration (ETo) observed throughout the snapdragon cycle are shown in Figure 1. Notably, after 40 DAT (days after transplanting), the water demand increased, with consumption equal to or even exceeding the ETo. The highlighted points correspond to 43 DAT, when the beginning of inflorescence emergence occurred at the plant apex. During the subsequent 12 days, inflorescence development occurred, characterized by growth due to the emission of flower buds. After this period, the maturity of the buds resulted in the opening of the flower, with the first buds located at the base of the inflorescence, leading to the flowering phase, where the formation and opening of flower buds occurred simultaneously, resulting in an average water demand up to 30% higher than ETo.

Figure 1. Reference evapotranspiration (ETo) by the Class A pan method and crop evapotranspiration (ETc) by the drainage lysimetry method for snapdragon cultivation in a protected environment.



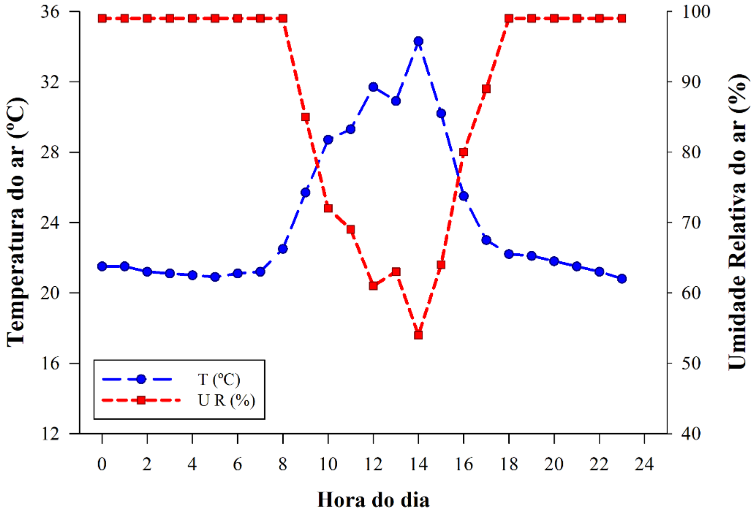
Source: authors

The increased water demand of the crop near or during flowering is corroborated by several other studies, where the flowering and fruiting phase is considered the phase with the greatest consumption (see Allen *et al.* (1998)); this is due to the plant's strategy of prolonging the species, with the formation of reproductive structures, which in snapdragons corresponds to the elongation of the inflorescence, emission and opening of flower buds, and after pollination, the formation of capsules with seeds and seed maturation.

An analysis of the variation in air temperature and relative humidity shown in Figure 2 reveals that snapdragons are very demanding in terms of water, especially when they begin to produce inflorescences, since the temperature variation during the day remained below 30 °C for most of the evaluated times, regardless of the possibility of high values under the environmental conditions of this study (protected greenhouse environment). It is possible that the greenhouse effect inside the environment was mitigated by the characteristics of the growing environment, which did not have material close to the zenithal opening; therefore, the hot air that should have accumulated was easily evacuated to the atmosphere.

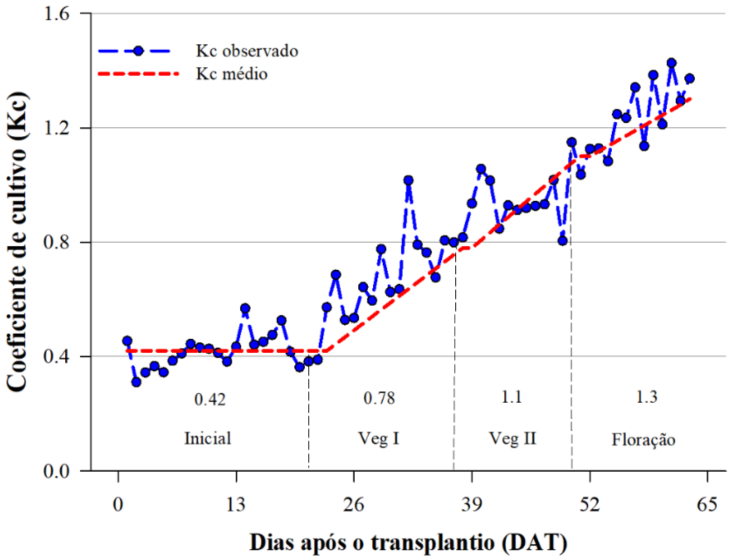
Temperatures above 30 °C were recorded only between 12:00 and 16:00, with a maximum of 34.3 °C observed at 14:00.

Figure 2. Daily variation in air temperature (°C) and relative air humidity (%) at 59 DAT during snapdragon cultivation, corresponding to the flower bud opening phase of the crop.



Source: authors

Figure 3. Daily variation in air temperature (°C) and relative air humidity (%) at 59 DAT during snapdragon cultivation, corresponding to the flower bud opening phase of the crop.



Source: authors

During the experiment, the plants exhibited accelerated vegetative growth (Figure 3); thus, 2 phases of vegetative development were defined: Veg I and Veg II. In terms of irrigation management, this division will optimize the supply of water to the plants, increasing the efficiency of water use and reducing the surplus in the VEG I phase, adequately supplying the plant's demand in the preflowering phase (VEG II) and ensuring that the most important characteristics for commercialization develop adequately in this phase, namely, the stem diameter and the inflorescence, which are considered crucial in the cultivation of snapdragons in the region where this work was conducted.

Piroli *et al.* (2022), working with lisianthus, also reported kc values. for two phases of vegetative development. With respect to chrysanthemum, Pereira *et al.* (2021) reported a kc of 1.29 for the reproductive phase up to the time of cutting. Oliveira *et al.* (2014) reported that scientific studies on crop coefficients for ornamental plants are scarce and that the available values are quite discrepant, which makes it difficult to compare crop coefficients.

4 CONCLUSIONS

Snapdragon (*Antirrhinum) (Majus* L.) showed accelerated vegetative growth, with a total evapotranspiration of 121.8 mm. The obtained crop coefficients were 0.42 (initial), 0.78 (veg I), 1.1 (veg II), and 1.3 (flowering).

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