

## Postharvest and anthochron of gladiolus floral stems produced in greenhouse under different seasons and irrigation levels

### Pós-colheita e antocrono de hastes florais de gladiólo produzidas em casa de vegetação sob diferentes épocas e níveis de irrigação

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#### ABSTRACT

Cut flowers are delicate products whose quality and longevity depends on growing and postharvest conditions. The aim of the study was to evaluate the anthochron and the postharvest of gladiolus stems produced under different growing seasons and irrigation levels. The experiments were carried out in a greenhouse in the State of Rio de Janeiro (Brazil) during the winter/spring 2018 and autumn/winter 2019 periods. A randomized block design with 5 replications was used, considering irrigation levels of 45%, 60%, 80% and 100% of the crop water requirement. Irrigation management was performed by the automatic irrigation controller, installed in the 100% irrigation level treatment. As they reached the harvest point, considered to be “showing the color” of the three basal florets, the floral stems were harvested, always in the morning, and immediately taken to the laboratory for standardization of size (75 cm). During the storage period, the stems were kept at a temperature of 25 °C, with the base immersed in a container with 300 mL of water. Fresh mass, water absorption, anthochron and longevity evaluations were performed daily, in addition to a visual evaluation, performed using a proposed senescence scale. The occurrence of severe water deficit during cultivation interferes with the fresh mass of the stems in postharvest and increases the opening speed of the flowers. The floral stems’ longevity is reduced when gladiolus is produced under the 45% irrigation level. There are no significant differences in the longevity of flowers grown in the different seasons and the anthochron value is influenced by the water availability, being lower in the stems kept in field condition (0.70 to 0.80) in comparison to the postharvest condition (0.83 to 0.92).

**Index terms:** *Gladiolus x grandiflora* Hort.; automated irrigation system; vase life; water deficit.

#### RESUMO

As flores de corte são produtos delicados cuja qualidade e longevidade dependem das condições de cultivo e pós-colheita. O trabalho foi desenvolvido objetivando-se avaliar o antocrono e a pós-colheita de hastes de gladiólo produzidas sob diferentes épocas de cultivo e níveis de irrigação. Os experimentos foram conduzidos em casa de vegetação no Estado do Rio de Janeiro (Brasil), durante os períodos de inverno/primavera de 2018 e outono/inverno de 2019. O delineamento experimental foi em blocos casualizados, com quatro níveis de irrigação (45%, 60%, 80% e 100% da necessidade hídrica da cultura) e 5 repetições. O manejo da irrigação foi realizado pelo acionador automático para irrigação, instalado no tratamento 100%. A medida em que alcançavam o ponto de colheita, considerado como “mostrando a cor” dos três floretes basais, as hastes florais eram colhidas, sempre no período da manhã, e imediatamente levadas ao laboratório para padronização do tamanho (75 cm). Durante o armazenamento, as hastes foram mantidas à temperatura de 25 °C, com a base imersa em recipiente contendo 300 mL de água. As avaliações de massa fresca, absorção de água, antocrono e longevidade foram realizadas diariamente, além de uma avaliação visual, realizada por meio de uma escala de senescência proposta. A ocorrência de déficit hídrico acentuado durante o cultivo interfere na massa fresca das hastes em pós-colheita e aumenta a velocidade de abertura das flores. A longevidade das hastes florais é reduzida quando gladiólo é produzido com o nível de irrigação de 45%. Não há diferenças significativas na longevidade das flores cultivadas nas diferentes estações e o valor do antocrono é influenciado pela disponibilidade de água, sendo menor nas hastes mantidas em condição de campo (0,70 a 0,80) em comparação à condição pós-colheita (0,83 a 0,92).

**Termos para indexação:** *Gladiolus x grandiflora* Hort.; sistema de irrigação automatizado; vida de vaso; déficit hídrico.

## INTRODUCTION

Among the most appreciated cut flowers on the market, gladiolus, also known as Palma-de-Santa-Rita, stands out for its robustness, vivacity and magnificence (Tomiozzo et al., 2019). For the fact that it is an easy-to-manage culture that has a short cycle and low production cost (Barbosa, 2011), it has become an excellent alternative for increasing income and diversifying production in family farming (Uhlmann et al., 2019). Its cultivation is predominantly carried out under field conditions and plant development and flower quality are affected by environmental factors such as temperature and light (Uhlmann et al., 2017; Schwab et al., 2018). Nevertheless, the species develops properly in protected environments (Paiva et al., 1999), either to meet thermal requirements, minimizing the effect of low temperatures in cold regions (Bosco et al., 2020), or to carry out controlled studies, evaluating the development of the plant in response to water replacement and nitrogen fertilization levels (Porto et al., 2014).

Cut flowers are considered delicate and perishable products, and their longevity depends on the conditions of cultivation, the appropriate moment of harvest and postharvest management (Dias-Tagliacozzo; Finger; Barbosa, 2005). Due to low heat loss inside greenhouses, the air temperature tends to be higher than in the outside (Bosco et al., 2020) causing the length of the development cycle to be shorter. Despite this, Islam and Haque (2011) observed better development and a greater number of florets per spike in gladiolus plants produced under a polyethylene tunnel when compared to open-air plants. As in the postharvest phase it is not possible to improve the quality of the product in relation to the moment of harvest, the management of the crop must be efficient, meeting the water, nutritional and edaphoclimatic needs, producing high quality flowers (Bastug et al., 2006).

When water deficit is applied throughout the growing cycle, some plants suffer a reduction in water potential causing stomatal closure, decreasing the rate of carbon dioxide assimilation and, consequently, photosynthesis (Taiz et al., 2017). The reduction in the photosynthetic rate limits the production of carbohydrates and inhibits the growth of the stem and the cellular expansion of many ornamental plants (Toscano; Ferrante; Romano, 2019). Gladiolus plants that grow under intense water deficits may have smaller floral stems and number of flowers produced (Demirel; Camoglu; Akcal, 2018), affecting the ornamental quality and the marketing of these flowers (Das et al., 2015).

Considering that the quality of the gladiolus floral stems is influenced by the adequate availability of water provided by irrigation, it can be inferred that the longevity of flowers can also be longer when compared to flowers produced under water deficit. The vase life of a cut gladiolus flower is short due to physiological and biochemical mechanisms that induce senescence (Hassan; Fetouh, 2019; Mohibe et al., 2020). However, no approach on the effects of water deficit on its longevity has been previously documented.

For gladiolus, the market demands the sale of stems with flowers still closed, when the first three floral buds show the corolla color, traditionally called by producers as the "button showing the color" (Barbosa, 2011; Schwab et al., 2015). This harvest point is recommended because the flowers are very fragile and can be easily damaged if handled or transported when they are opened (Barbosa, 2011).

Due to the short period of marketing of the gladiolus floral stems, the production planning becomes essential, as well as the harvesting and distribution logistics that depend on the flowers opening speed (Schwab et al., 2017). Anthochron is a term used to define the time interval between the opening of successive flowers in an inflorescence (Schwab et al., 2014) and it is an important characteristic to evaluate in species that have spike-type flowers. For some commercial cut flowers, more specifically for the gladiolus, whose harvest of the floral stems is done with the florets still closed, the definition of anthochron allows to understand the development of the plant during the reproductive phase and determine its postharvest life (Streck; Schwab, 2016). Its determination in water deficit conditions allows to broaden the understanding of how irrigation management can influence the gladiolus floral opening rate.

The gladiolus' demand follows the sales pattern of most flowers, and it is important that high-quality flowers are produced throughout the year (Paiva et al., 2020). It is especially important that the water volume is adjusted to the crop, producing high quality stems that can last longer, increasing marketing efficiency (Santos et al., 2020). Considering that the production of gladiolus flowers is influenced by the growing season (Schwab et al., 2014; Schwab et al., 2017) and that the longevity of flowers is reduced when the plants are grown under stress, we hypothesize that the gladiolus floral stems present lowest longevity when produced under deficit irrigation and that they are also affected by the conditions of the growing period. Therefore, the objective of this work was to evaluate the anthochron and the postharvest period of gladiolus stems produced

in greenhouse under different growing seasons and irrigation levels with automated management.

## MATERIAL AND METHODS

### Production of stems in greenhouse

Floral stems of gladiolus were produced in a greenhouse installed in Seropédica (Rio de Janeiro, Brazil) in two growing seasons. The winter/spring cultivation was carried out in the period from September 7<sup>th</sup> to November 27<sup>th</sup> of 2018 and the autumn/winter cultivation from April 12<sup>th</sup> to July 4<sup>th</sup> of 2019. During the winter/spring cycle, the reproductive phase of the stems occurred under higher average temperatures (20.5 to 41.5 °C) than those recorded for the autumn/winter cycle (18.3 to 40.7 °C), which explains the more significant accumulation of degree-days in the winter/spring cycle (Santos et al., 2020). The maximum and minimum values recorded for relative humidity (RH%) in the autumn/winter production were 89.8% and 21.2%, respectively, while in the winter/spring production, it was 88.8% and 18.7%, respectively. The monitoring of meteorological conditions inside the greenhouse was carried out via a weather station (WatchDog 2000 Series SPECTRUM, Technologies Inc.).

The greenhouse was 35.0 m long and 8.0 m wide, it had 2.5 m of central height and it was covered with 100-micron thick transparent plastic, without any cooling or artificial temperature control system. The plants were grown in 11.0 L pots containing substrate composed of a mixture of bovine manure and sandy and clayey soil materials, in the proportion of 1:2:2 (by volume). The analysis of the substrate used presented the following chemical characteristics: pH 6.2; 0.13 cmolc dm<sup>-3</sup> Na<sup>2+</sup>; 4.5 cmolc dm<sup>-3</sup> Ca<sup>2+</sup>; 1.9 cmolc dm<sup>-3</sup> Mg<sup>2+</sup>; 122 mg dm<sup>-3</sup> P; 83 mg dm<sup>-3</sup> K<sup>+</sup>; V value = 80% for the first crop; and pH 5.8; 0.1 cmolc dm<sup>-3</sup> Na<sup>2+</sup>; 3.8 cmolc dm<sup>-3</sup> Ca<sup>2+</sup>; 1.6 cmolc dm<sup>-3</sup> Mg<sup>2+</sup>; 134 mg dm<sup>-3</sup> P; 84 mg dm<sup>-3</sup> K<sup>+</sup>; V value = 76% for the second crop.

The gladiolus cv. Amsterdam was used, which has white flowers and, approximately, 75 days of cycle. Vernalized medium-sized bulbs (circumference from 12 to 14 cm) were purchased from Terra Viva and planted in a triangular arrangement, with a spacing of 10 cm between bulbs and 10 cm deep (Ahmad et al., 2013, Santos et al., 2020).

The pots were drip irrigated using spaghetti microtubes (PDAEXT001000354/PLASNOVA) with an average diameter of 0.8 mm and lengths of 80, 60, 35 and 20 cm, corresponding to discharges of 2.6; 3.4; 4.5 and 5.7 L h<sup>-1</sup>, respectively, at a pressure of 20 kPa. The uniformity tests

indicated a uniformity coefficient above 95%. Thereafter, irrigation levels (IL) were defined and corresponded to 45% (L1), 60% (L2), 80% (L3) and 100% (L4) of the crop water requirement. Irrigation management was carried out using two automatic controllers for irrigation (Medici et al., 2010), whose sensors were installed in the center of two pots at 10 cm depth in the control treatment (L4). Thus, when the system was activated, all pots were irrigated simultaneously, with volumes of water corresponding to the respective flow rates of the emitters (treatments). In total, 5.24, 6.68, 8.65 and 10.81 L (winter/spring cycle) and 4.91, 6.58, 8.25 and 10.25 L of water per plant (autumn/winter cycle) were applied for the 45% (L1), 60% (L2), 80% (L3) and 100% (L4) treatments, respectively (Santos et al., 2020).

### Postharvest evaluation

The floral stems were harvested, always in the morning, as they reached the harvest point, with the 3 basal florets starting to open, a characteristic established by the R2 stage of the phenological scale of gladiolus (Schwab et al., 2015). After harvesting, the stems were immediately placed in a container with water to prevent dehydration during transport and transferred to the laboratory. At the harvest time, no stems smaller than 75 cm were observed in the different cultivation cycles. The harvested stems were classified and 81.7% and 92.5% of high-quality stems (class 90 or 110) were obtained in the winter/spring and autumn/winter cultivations, respectively. In the laboratory, the stems went through a standardization to ensure uniform size (75 cm) and adequacy to the quality criteria for marketing (Veiling Holambra, 2019). It was used to homogenize the lengths for postharvest analysis, regardless of the quality class obtained at the time of harvest.

During the postharvest analysis period in a laboratory, the environment temperature was maintained at, approximately, 25 °C. The plants were kept on wooden supports, in which each stem was allocated in a 10 x 10 cm mesh. Visual and analytical assessments on the selected stems were performed daily.

### Longevity

The stems were kept in containers with university campus supply water and their longevity was evaluated and expressed in days of vase life, from the harvest day until the moment of complete senescence of 50% of the flowers in the stalk, or until the occurrence of a break in the floral stem due to loss of turgor. Thus, to evaluate the quality of the inflorescences during vase life, a senescence scale was proposed.

### Water absorption

The stems were placed in containers with 300 mL of water, which was weighed, discarded and replaced daily. Water absorption was calculated according to the methodology described by Van Doorn, Abadie and Belde (2002) and Vieira et al. (2012), using Equation 1:

$$V = \frac{(W_{Mi} - W_{Mf})}{FMS_i} \quad (1)$$

in which: V – water absorption ( $\text{mg} \cdot \text{g}^{-1}$  FM); FM – fresh mass of stem (g);  $W_{Mi}$  – initial water mass (g);  $W_{Mf}$  – final water mass (g); and  $FMS_i$  - final fresh mass of stem in each day (g).

### Fresh mass variation

The stems were weighed daily, and the fresh mass variation was determined according to Van Doorn, Abadie and Belde (2002), using Equation 2:

$$FMV = \frac{(M_f \times 100)}{M_i} \quad (2)$$

In which: FMV – fresh mass variation (%);  $M_f$  – final mass of stem (g);  $M_i$  – initial mass of stem (g).

### Scale of senescence scores of floral stems of gladiolus

The scale of senescence scores was proposed relating the flower opening dynamics during the longevity period (Figure 1).

Score 4	Score 3	Score 2	Score 1	Score 0
				
Stems without visible damage	Stems showing visible damage (E.g.: darkening of the sepals, sunburn)	Stems with at least 2 basal florets showing wilting and the beginning of darkening	Stems showing complete wilting in at least 3 basal florets and darkening of the edge of the flowers	Stems with 50% of the flowers showing complete wilting and darkening, or stem breakage due to loss of turgor

**Figure 1:** Senescence scale for assessing the longevity of gladiolus cv. Amsterdam inflorescences.

## Anthochron

For the anthochron analysis, evaluations were carried out in two different conditions: in a greenhouse and in laboratory, during the postharvest longevity assessment. However, in the greenhouse, it was evaluated only in the winter/spring cultivation. The anthochron of the floral stems in the greenhouse was determined by the daily count of the florets which were opening since the moment the plants reached the point of harvest, while in the postharvest condition, the daily count of the flowers that were opening was performed since the harvest was carried out until the moment the stems reached the score 0 of the proposed scale. The anthochron evaluation was performed on 5 stems per plot, totalizing 25 stems per treatment. The evaluation was carried out by observing the floral opening, considering as an open flower the moment in which the anthers were visible to the evaluator. It was estimated according to the methodology proposed by Schwab et al. (2014), as the inverse of the angular coefficient of the linear regression between the number of opened florets and the opening time of florets, as long as the coefficient of determination is greater than 0.90.

## Experimental design and statistical analysis

The experimental design during the production of the stems was randomized blocks with 5 blocks composed of 4 plots, one from each treatment (IL). Each experimental unit (plot) was composed of 4 pots with 3 plants, totalizing 12 plants per plot. For the postharvest evaluation, 6 stems were harvested per plot in the winter/spring cultivation and 4 stems in the autumn/winter cultivation, totalizing 30 and 20 stems per treatment, respectively. The reduction in the number of stems in the autumn/winter cycle of 2019 was due to the incidence of fusariosis in 8.8% of the total plants in the experiment, which ended up in some plants that did not produce the floral stem and others that were not evaluated. In addition, in the autumn/winter cultivation, 5 stems per plot were left in the pots to evaluate the anthochron.

Data were subjected to the homoscedasticity test and, after being checked for normality, to analysis of variance at 5% probability level ( $p \leq 0.05$ ) by F test. For water absorption, fresh weight variation and the scale scores, the average values observed in the replications were calculated. Longevity data were subjected to the analysis of variance by the F test ( $p \leq 0.05$ ) and the means were compared by the Tukey's test ( $p \leq 0.05$ ). Linear regression analysis was also performed for the anthochron variable, according to Schwab et al. (2014), and the Student's t test ( $p \leq 0.05$ ) was used to assess the quality of the fit.

## RESULTS AND DISCUSSION

### Anthochron of floral stems in the greenhouse

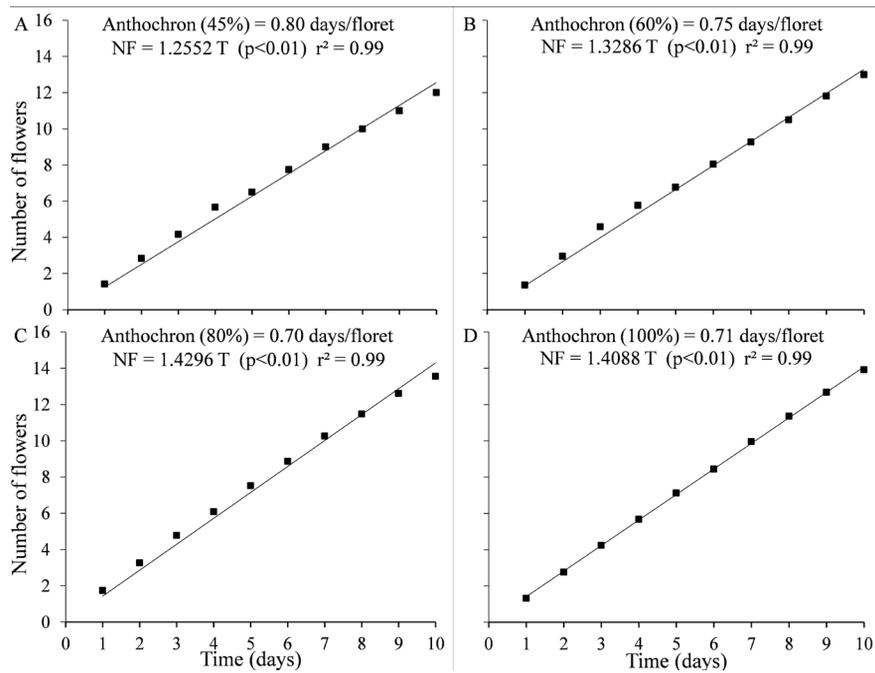
There was a reduction in the floral opening rate of gladiolus plants, cv. Amsterdam, submitted to water deficit in the greenhouse. The opening rate followed a linear trend and the anthochron was 0.80; 0.75; 0.70 and 0.71 days/floret, respectively, for the treatments with 45, 60, 80 and 100% of the applied volume of water (Figure 2).

In cut gladiolus, the anthochron depends on the cultivar and on the period of cultivation; floral stems of cv. Amsterdam grown throughout the year can present significant difference between the maximum and minimum anthochron value (floret per day) of 1.39 and 0.65, respectively; this is equivalent to a 0.74 floret variation per day (Schwab et al., 2014). The floral opening rate is an important characteristic to be evaluated in gladiolus because the cut flower stems are commercialized when they are still closed, and they complete their opening during the postharvest life (Barbosa, 2011). Therefore, it is essential to understand how the crop management can affect the stems' physiology in the production phase and in postharvest.

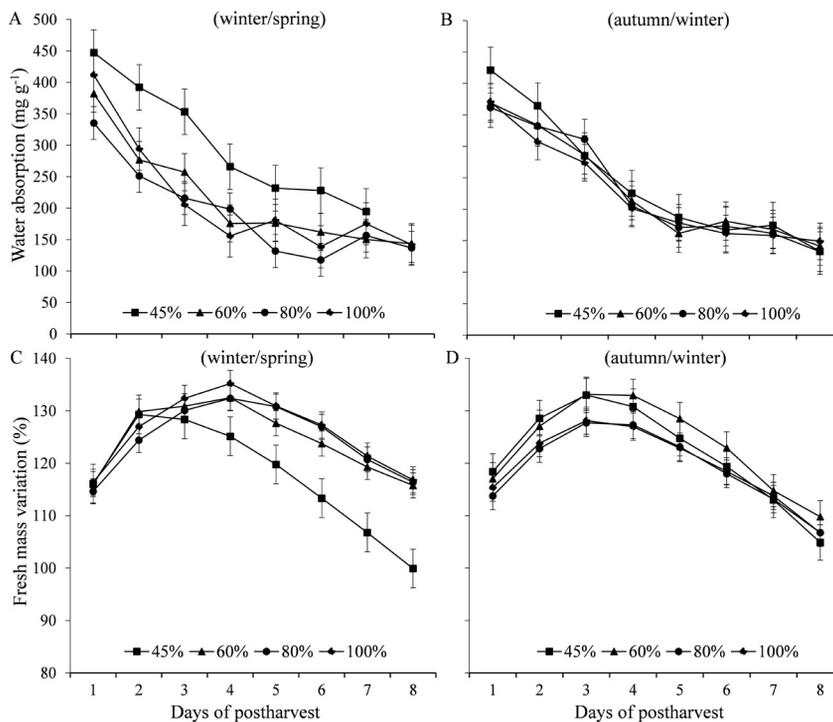
Some studies report that the gladiolus anthochron of the cvs. 'Amsterdam', 'Peter Pears', 'Rose Friendship', and 'Jester' is influenced by environmental characteristics such as temperature and radiation during flowering; to these gladiolus cultivars, the base temperature for opening the florets is 6 °C and the optimum and maximum temperatures are 22.5 °C and 35 °C, respectively (Schwab et al., 2014; Muttoni, et al., 2017; Schwab et al., 2017). The results presented in this study demonstrate that the lower water availability during the cultivation also negatively affects the anthochron. Considering that the longevity of flowers depends on the quality of the floral stems at the time of harvest, water deficit conditions during the production of the stems can affect their longevity.

### Postharvest of cut flower stems

The absorption of water by the stems decreased as a function of the days after harvest, with different variation among treatments. There was greater water absorption on the first day, with a reduction on the subsequent days. This trend occurred in all treatments, but there was a higher initial absorption in the treatment of 45%, in both cycles (Figure 3A, B). With a greater water deficit, the floral stems become more dehydrated, and after hydration during postharvest, they absorb more water to promote the opening of the flowers and keep their fresh mass.



**Figure 2:** Flower opening rate (anthochron) of gladiolus cv. Amsterdam, evaluated in plants grown in the greenhouse under the irrigation levels of 45% (A), 60% (B), 80% (C) and 100% (D), in the autumn/winter cultivation.



**Figure 3:** Water absorption ( $\text{mg g}^{-1}$  fresh mass of stem) and fresh mass variation (%) of gladiolus stems, cv. Amsterdam, grown under different irrigation levels in the winter/spring cycle of 2018 (a and c) and in the autumn/winter cycle of 2019 (b and d), respectively. Bars represent standard error.

Floral stems grown under lower irrigation levels (45% and 60%) showed, in the first postharvest days, a greater increase of fresh mass when compared to those that was grown in the highest irrigation levels (80% and 100%), in both cycles. Throughout the storage period, the fresh mass decreased in all treatments, but earlier in the floral stems grown with a lower level of irrigation (L1) and in the winter/spring cycle when in comparison to the other treatments and cycle. In this case, the reduction in fresh weight occurred since the third day of storage, while for the other treatments this reduction was observed since the fifth day. In the autumn/winter cultivation, the fresh mass began to decrease for all treatments since the fourth day, as occurred for the treatments of higher water deficits (45% and 60%) in the previous cultivation.

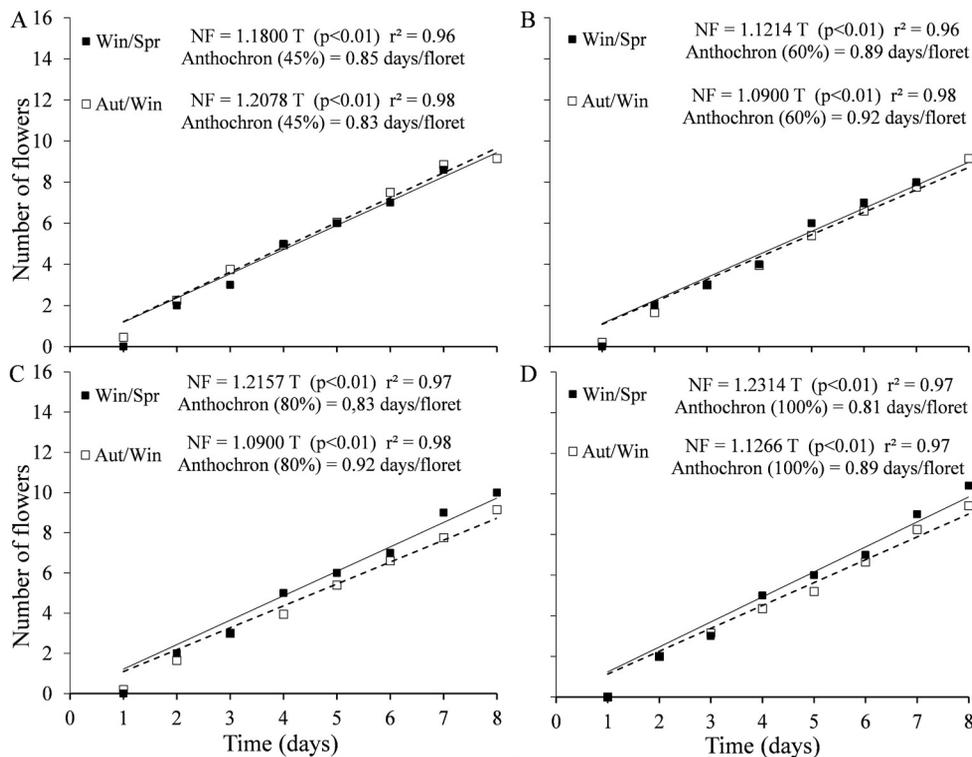
The fresh mass of the gladiolus floral stems increases on the first days due to the absorption of water to promote initial rehydration. However, studies indicate that after the first days of postharvest there is a loss of mass of the floral stems, mainly due to natural transpiration and low hydraulic conductance in the xylem, considered as the main causes of loss of turgor that contributes to the

deterioration of the product, causing visual changes (Silva et al., 2019; In et al., 2017).

The turgor of cut flowers depends on the balance between the use of water and its supply; and some physiological processes of absorption, transport, loss of water and the ability of tissues to retain it are also involved in their water balance (Dias-Tagliacozzo; Finger; Barbosa, 2005). Loss of mass can be caused by transpiration, by the decrease in water absorption that can occur due to the obstruction of the xylem by microorganisms or by genetically determined factors (Pietro et al., 2012).

In the postharvest evaluation (Figure 4), the anthochron was 0.85, 0.89, 0.83, and 0.91 in the winter/spring cycle and 0.83, 0.92, 0.92, and 0.89 in the autumn/winter cycle.

The anthochron of cut flowers during postharvest in laboratory was higher than in the greenhouse (Figure 2), with the florets opening since the first day, that is, the day after the harvest (time zero). This result suggests that the opening of the florets in the greenhouse occurs more quickly, probably due to the maintenance of the supply of nutrients and carbohydrates to the stems, as they are still linked to the plant, unlike the stems in postharvest that received only water supply.



**Figure 4:** Flower opening rate (anthochron) of gladiolus, cv. Amsterdam, evaluated in postharvest plants of the treatments of 45% (a), 60% (b), 80% (c) and 100% (d) irrigation levels, in the winter/spring and autumn/winter cultivations.

The floral opening is related to cell expansion and requires water and energy absorption (Mattos et al., 2018). Therefore, the greater water supply to the stems during cultivation promotes a faster floral opening compared to the plants grown under water deficit. The sucrose levels of the floral stems kept in the greenhouse may have contributed to the osmotic potential and maintenance of plant turgor, in addition to being a substrate for maintaining respiration, which contributes to the higher rate of floral opening (Hussen; Yassin, 2013).

Stems cultivated with a lower irrigation level opened the flowers more slowly in the greenhouse when compared to those that received a greater amount of water (Figure 2). However, in the postharvest evaluation, the result was reversed, and the opening of the florets happened faster in the stems that received less water and slower in those that received more volume of water. These results indicate that the opening of floral stems in the postharvest of gladiolus is associated with water availability during cultivation, and it is strongly influenced by the mechanical action of hydration at the beginning of the postharvest phase, especially of flowers grown under water deficit.

For the stems of the treatment of 45% of the applied volume of water, lower values of anthochron during postharvest imply a shorter marketing period for the producer. When the flowers open more quickly and the distribution site is far from the production site, the stems can arrive with more advanced maturation than expected commercially, besides the possibility of greater risk of mechanical damage to the flowers during transport, when their marketing is done at local fairs.

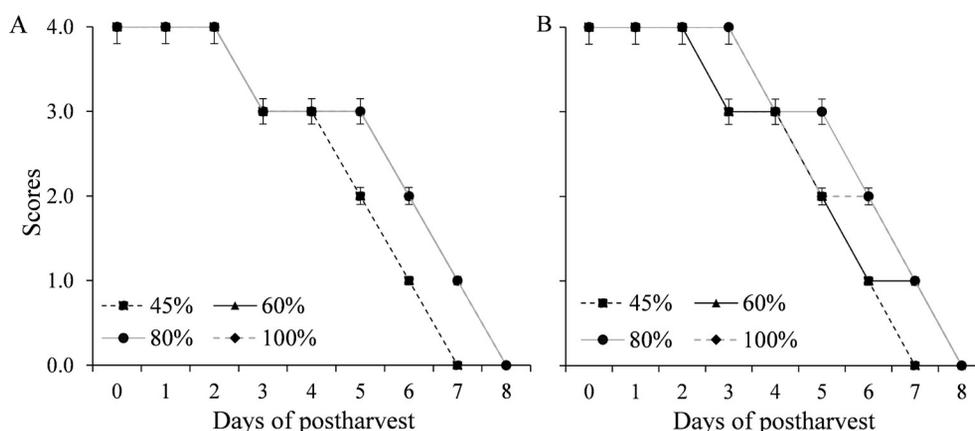
The water supply is one of the factors that affect the anthochron due to the interference in the production and the

translocation of carbohydrates in the plant during flowering (Streck; Schwab, 2016). Schwab et al. (2014) were the first to use the term “anthochron” for gladiolus and found values of 0.99 and 1.27 days per floret, for the cv. Amsterdam grown in Rio Grande do Sul, respectively, in spring and late summer. The values found in the present study are lower even for the stems that received 100% of the crop’s water requirement, indicating that in tropical conditions, such as in Seropédica (Rio de Janeiro), the opening of the stem’s flowers happens faster than in subtropical regions.

The floral opening in the postharvest period is an important factor from a commercial point of view, because the higher the opening speed, the faster this stem needs to get to the place of sale to avoid loss of quality.

The first signs of senescence on the stems were the darkening of the sepals, according to the scale of scores, which started to appear since the second day of evaluation on all treatments in the winter/spring cycle (Figure 5A). Since this day, the score dropped from 4 to 3 and the stems received the same scores, except for the treatment of 45% of the applied volume, in which the visual quality decreased more quickly, reaching the minimum score on the seventh day.

The stems grown with 80 and 100% of the water volume applied in the autumn/winter cycle (Figure 5B) remained with a maximum score until the third day of evaluation, decreasing from this point and reaching a minimum score on the eighth day, when the stems already had at least 50% of the flowers completely wilted. The stems grown in autumn/winter remained with maximum quality for a longer time than the ones obtained from winter/spring, with the exception of the treatments of 45 and 60% of the applied volume, which in the autumn/winter cultivation started to drop in quality on the second day (Figure 5B).



**Figure 5:** Scores received by gladiolus floral stems, cv. Amsterdam, during postharvest evaluation in the winter/spring (a) and autumn/winter (b) cultivations. Bars represent standard error.

The longevity of the floral stems was significantly influenced by the different irrigation levels, but there was no influence of the growing season (Table 1). The stems' vase life reached 8 days in both cycles. In the winter/spring cultivation, the longest vase life was obtained in the stems produced with 100% of the applied volume (8 days), not differing statistically from the treatments with 60 and 80% of the water volume.

**Table 1:** Longevity (days) of gladiolus cv. Amsterdam floral stems grown under different irrigation levels.

Irrigation level (%)	Longevity (days)	
	Winter/spring	Autumn/winter
45	7.0 Ab	7.6 Aa
60	7.4 Aab	7.8 Aa
80	7.8 Aa	8.2 Aa
100	8.0 Aa	8.2 Aa
CV (%)	4.63	

\*Means followed by the same capital letter in the lines and lowercase letter in the columns do not differ statistically from each other by the Tukey's test, at 5% probability level.

Stems produced with 45% of irrigation level had a reduction in vase life of 1 day when compared to the ones produced under higher irrigation levels in the winter/spring period. This result suggests that when gladiolus plants are grown with a water deficit of 55% (promoted by the 45% irrigation level), not only the quantitative parameters are negatively affected but also the postharvest longevity of the floral stems. However, the irrigation levels did not affect the floral stem's longevity when the cultivation was done during the autumn/winter period.

The cut flowers cultivation under water deficit causes a reduction in the photosynthetic rate, and it results in less storage of carbohydrates in the plant. The content of carbohydrates stored in the cut flower during cultivation is important to maintain physiological processes such as floral opening and plant respiration in the postharvest phase, assisting to maintain longevity (Reid; Jiang, 2012; Van der Meulen-Muisers et al., 2001). Therefore, its depletion can accelerate the process of plant deterioration (Sonego; Brackmann, 1995). When the plant has a low carbohydrate reserve, this depletion in the postharvest period occurs faster and can influence the plant's vase life.

In the autumn/winter period, longevity did not differ from the winter/spring cultivation, suggesting that the growing season does not influence the stem's

postharvest, which varies from 7 to 8 days. The same result was found by Hassan and Fetouh (2019), who studied the longevity of gladiolus stems treated with moringa extract and observed that the vase life of the stems reached 8 days in the untreated plants. A shorter postharvest longevity implies lower quality of the product and a smaller marketing window for the producer.

## CONCLUSIONS

The flower stems' longevity is reduced when gladiolus is irrigated with 45% of the crop water requirement. There are no significant differences in the longevity of flowers grown in the different seasons (winter/spring and autumn/winter cycle) in the environmental conditions presented in this work. The anthochron values are lower in stems kept in field condition (0.70 to 0.80) than those observed in postharvest condition (0.83 to 0.92), being influenced by water availability.

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