AGRONOMY (AGRONOMIA)

Revista Brasileira de Ciências Agrárias
ISSN (on line) 1981-0997
v.17, n.2, e1708, 2022
Recife, PE, UFRPE. www.agraria.pro.br
DOI: 10.5039/agraria.v17i2a1708 - Protocol 1708
Subm. 31/12/2021 • App. 02/06/2022 • Pub. 29/06/2022

Longevity and post-harvest quality of cut ornamental sunflower floral

Shayne Rodrigues de Moura[1*], Cândida Maria Anjos da Silva[1], Jarina Coelho Cotting[1], Mayara Suzanne de Melo Barbosa[1], Rafaela Ribeiro de Souza[1], Márkilla Zunete Beckmann-Cavalcante[1]

[1] Universidade Federal do Vale do São Francisco, Petrolina, PE, Brasil. E-mail: shaynermoura@gmail.com; candidama@outlook.com; jarina_cotting@hotmail.com; mayaa_melloo@hotmail.com; rfag.fisio@gmail.com; markilla.beckmann@univasf.edu.br

ABSTRACT: The postharvest quality and longevity of cut flowers is influenced by several factors, with the development stage being one of the determining aspects. The determination of the harvest point is variable and must be carried out depending on the physiology of flower development and the proximity of the consumer market. In this sense, the objective was to determine the harvesting point and the ideal stem length for harvesting 'Sol Vermelho' ornamental sunflower. The experimental design adopted was completely randomized, arranged in a 2 × 4 factorial scheme (harvest point × stem length), where stems harvested at stages R4 and R5.5 and in four lengths of 50, 60, 70, and 80 cm were used. The results demonstrate that the early harvest (R4 stage) of the ornamental sunflower flower 'Sol Vermelho' stems is a viable alternative that allows greater post-harvest durability and, consequently, the commercialization of the stems for a longer period of time. In addition, stems harvested at stage R5.5 (open flowers) with lengths of 50 and 60 cm can be recommended for sale in regions close to the production sites.

Key words: cut flower; durability; harvest point; *Helianthus annus*; semiarid

Longevidade e qualidade pós-colheita de girassol ornamental de corte

RESUMO: A qualidade pós-colheita e longevidade de flores de corte é influenciada por diversos fatores, sendo o estágio de desenvolvimento um dos aspectos determinantes. A determinação do ponto de colheita é variável e deve ser realizada em função da fisiologia de desenvolvimento das flores e das proximidades do mercado consumidor. Neste sentido, objetivou-se a determinação do ponto de colheita e o comprimento de haste ideal para a colheita de girassol ornamental 'Sol Vermelho'. O delineamento experimental adotado foi o inteiramente casualizado arranjado em esquema fatorial 2 × 4 (ponto de colheita × comprimento de haste), com uso de hastes colhidas no estádio R4 e R5.5 e em quatro comprimentos de 50, 60, 70 e 80 cm. Os resultados demonstram que a colheita precoce (estádio R4) das hastes florais de girassol ornamental 'Sol Vermelho' é uma alternativa viável que possibilita maior durabilidade pós-colheita e consequentemente a comercialização das hastes por um período de tempo maior. Além disso, as hastes colhidas no estádio R5.5 (flores abertas) com comprimentos de 50 e 60 cm podem ser recomendadas para comercialização em regiões próximas aos locais de produção.

Palavras-chave: flor de corte; durabilidade; ponto de colheita; *Helianthus annus*; semiárido

* Shayne Rodrigues de Moura - E-mail: shaynermoura@gmail.com (Corresponding author)
Associate Editor: Mário de Andrade Lira Júnior

Introduction

Floriculture has always been characterized as one of the most promising segments of intensive horticulture and seen as an important socio-economic activity in the market, in the generation of employment and income; and, also valuing the social inclusion of important parcels and segments of small properties and family agriculture, especially the female labor force. Even with the crisis of the Covid-19 pandemic, the Brazilian market of flowers and ornamental plants moved in 2020 around R$9.6 billion, a growth of 10% compared to 2019 (Ibraflor, 2021), and it was no different in 2021 (Ibraflor, 2022). These numbers confirm the sector as an attractive, strategic, and economically profitable activity, especially in small agricultural areas (Schwab et al., 2014; Junqueira & Peetz, 2018). In this market, more than 2,500 species of flowers and ornamental plants are currently cultivated, and of this total, 15% of the area is occupied by cut flowers for arrangements (Ibraflor, 2022).

Among the ornamental species cultivated, in recent years there has been a significant increase in the use of ornamental sunflowers (*Helianthus annuus* L.) for both cut and potted flowers. The ornamental sunflower has stood out for its beauty, rustic appearance, easy propagation and handling, and, short cycle, which allows its cultivation and production in different regions, becoming an excellent alternative for small producers (Nascimento et al., 2019; Ezz et al., 2021).

However, as a cut flower, it has shown short vase life characteristics, which depending on environmental conditions and cultivar characteristics can range from 4 to 12 days (Sanches et al., 2019; Kılıç et al., 2020). A large part of the cut flowers used in Brazil come from the state of São Paulo (Ibraflor, 2021) and, therefore, in order to increase the time between harvest and commercialization in the different regions of the country, it is important to implement adequate postharvest management techniques that provide better quality and durability of the floral stems, or that the crops are close to the consumer centers (Nascimento et al., 2019; Sanches et al., 2019).

Cut flower quality and post-harvest longevity depend on factors such as handling, environment, stage of development, hormonal balance, carbohydrate content, and the water relations that constitute one of the main factors that play a critical role in regulating cut flower senescence (Costa et al., 2021). The stage of development of cut flowers directly influences the total durability. To this end, the harvest point is variable between species and cultivars and should be considered according to the physiology of flower development and the proximity of the consumer market (Curti et al., 2012; Nascimento et al., 2019; Costa et al., 2021).

In the case of ornamental sunflower for cut flower harvesting is usually done at the intermediate stage, which can range from the R4 stage when the inflorescence begins to open and points out the ligulate flowers (Naik et al., 2018) to R5.5, when the chapter is fully open and with 50% of the disc flowers open (Schneiter & Miller, 1981; Curti et al., 2012). Another characteristic that interferes with the quality of stems is their length, and it is suggested to harvest at the longest possible length to ensure greater longevity (Curti et al., 2012).

Determining the harvest point is fundamental to define the relationship between the production site and the consumer market. Studies on this theme enable the introduction of methodologies or management techniques to achieve greater longevity and post-harvest quality, especially when grown in different soil and climate conditions than in regions traditionally producing flowers and ornamental plants. In this regard, it was aimed to evaluate the optimal harvest point and stem length for harvesting ‘Sol Vermelho’ ornamental sunflower for cut flower.

Materials and Methods

The ornamental sunflower stems came from an open-air cultivation in the Floriculture Sector of the Universidade Federal do Vale do São Francisco, Petrolina, PE, Brazil. Seeds of the commercial ornamental sunflower cultivar ‘Sol Vermelho’ (Isla©) were used. It is described as a multi-crop cultivar, with a cycle around 70 days, with chapters that can reach up to 18.0 cm and the average stem height of 2.5 m. During the reproductive phase, flowering was managed by removing the axillary or lateral buds, leaving only the apical chapter to obtain unicapped stems.

For seedling production, the seeds were grown in polystyrene trays (expanded polystyrene) filled with a substrate composed of fine sand and tanned goat manure in a 1:1 ratio and were kept for 15 days under a screen with 50% shading. After this period, the seedlings were transplanted to 15.0 × 1.3 m beds, in full sun, with a spacing of 30 cm between plants and 30 cm between rows. Fertilization was performed using chemical fertilizer (NPK 10-10-10) and organic fertilization with 30 kg of tanned goat manure incorporated into the bed. The plants were irrigated daily to field capacity using the drip irrigation system and weed control was performed manually.

At 60 days after planting, harvesting of the floral stems at the R4 (Naik et al., 2018) and R5.5 (Schneiter & Miller, 1981; Curti et al., 2012) harvesting points began (Figure 1). The R4 stage was characterized by the appearance of the first ligulate flowers (ray flowers) showing color, but closed (angle less than 90°); and R5.5 stage, in which the inflorescences had the ligulate flowers expanded and with 50% of the tubular flowers (disk flowers of the capitulum) open.

The harvest was done early in the morning, and after being cut, the stems were immediately put in buckets with water and taken to the Seeds and Flora Management Laboratory (LASMAF/CCA/UNIVASF) where the stems were standardized in length (0.80, 0.70, 0.60, and 0.50 m), separated, identified according to the treatments, and evaluated. The stems were then weighed and distributed into individual containers containing 1 L of water and 2% NaClO.

The stems were kept throughout the evaluation period in a room with a controlled temperature of ± 22 °C, with a constant light source provided by cold fluorescent lamps

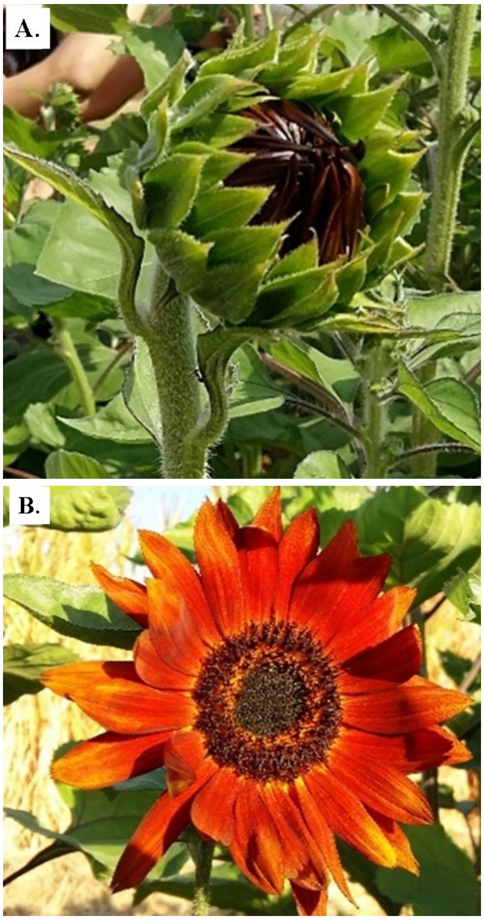


Figure 1. Harvest points of ornamental sunflower inflorescences 'Sol Vermelho': (A) R4 and (B) R5.5.

(General Electric F400 Extralife, 40 W) and the average relative humidity was approximately 60%. The water used to maintain the stems had an average pH of 8.2 and an electrical conductivity of 74.93 uS cm^{-1}.

Every three days after storing the stems in the containers, evaluations were performed: external diameter of the capitulum (EDC, mm, measured from ligule to ligule with a digital caliper); fresh mass of floral stem (FMFS, g, determined by weighing the stems) to calculate the variation in floral stem fresh mass loss (FML, %). For this variable, the initial fresh mass weight was assigned a value of 100% (He et al., 2006). The variation in fresh mass weight was estimated as a percentage in relation to the initial weight of the stems. The stems were weighed always at the same time, on scales with 0.01 g precision (Sartorious©) and kept out of the water for the shortest time possible (20-40 seconds). Water uptake by the floral stems (WUFS, mL) was determined by weighing each container with the maintenance water, disregarding the floral stems. The initial weight of each container was taken before storing the stems. In order to cancel the effects of evaporation, the upper end of the containers was wrapped with PVC film in 3 layers.

Destructive analyses were performed on floral stems stored under the same conditions as the stems for non-destructive analysis. The dry mass of the stems was measured on the day of storage and when they reached grade 3 on the senescence scale, the initial and final dry mass of floral stems were obtained ($DMFS_i$ and $DMFS_f$, g), which were determined from drying the material in an oven at 70 °C until reaching constant weight).

Total soluble carbohydrate content (TSC, mmol g^{-1} MF) was quantified on the day of harvest (TSC_h) and when the inflorescences reached grade 3 (TSC_3) (according to the floral senescence scale). The quantification of carbohydrates was performed using the method proposed by Chantrachit (1999), using 2 g of ligulate flowers (petals), and the contents of soluble carbohydrates were determined using the method proposed by Dubois et al. (1956), using 10 mL of phenol-sulfuric acid instead of 8 mL of buffer solution, as recommended by the authors.

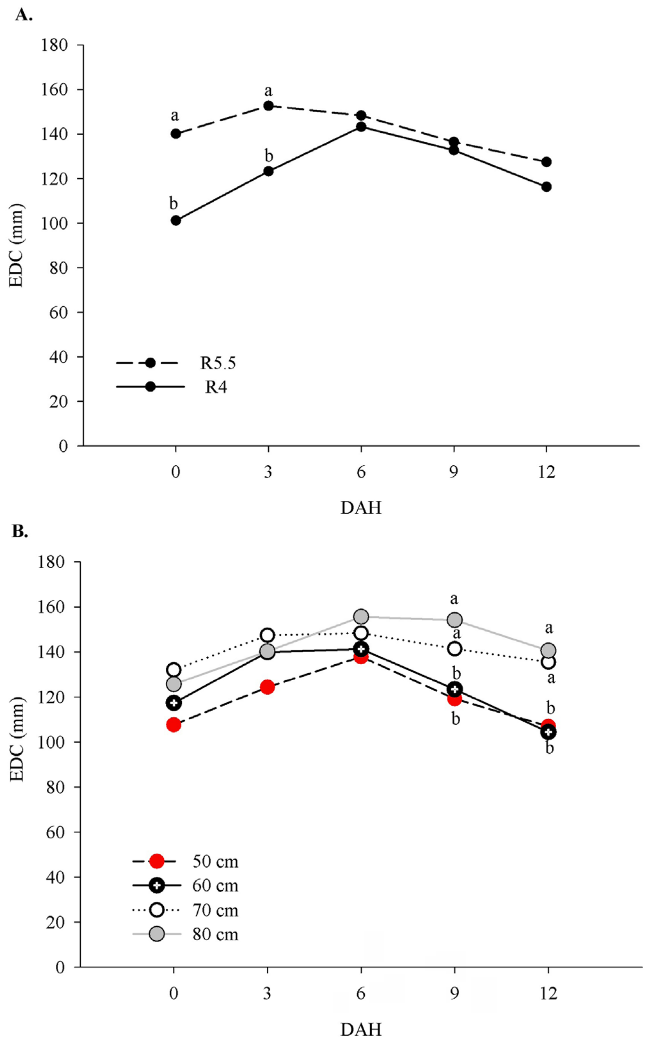
Commercial longevity of floral stems (LongC, days) followed the senescence scale developed by Curti (2010), assigning the following scales (N): N5 = overall excellent aspect, presence of brightness, well-opened flowers; N4 = overall good aspect, presence of brightness, open flowers, slight drooping of the flower stem; N3 = beginning of capitulum deterioration, slightly opaque color, stamens visible, ligulate ray flower facing downwards or into capitulum. With this, LongC was obtained, counted by the days in which the stems last showed a grade 3, considered the limit for commercialization.

The experimental design adopted was entirely randomized design (DIC) distributed in a 2 × 4 factorial scheme (two harvesting points and four lengths of floral stems) and four repetitions of twelve stems per plot were used (4 stems destined for non-destructive evaluations and 8 for destructive evaluations). The data obtained were subjected to analysis of variance by the "F" test at 5% probability and for diagnosis of significant effect, the treatments were compared among themselves by Scott-Knott test at 5% probability using the statistical software R Version: 3.5.1 (R Core Team, 2018).

Results and Discussion

The external diameter of the capitulum (EDC) of ornamental sunflower 'Sol Vermelho' was influenced by harvest point and length of floral stems. It can be seen that stems harvested at the R5.5 stage compared to stems at R4 obtained significantly higher values at 0 and 3 days after harvest (Figure 2A), equaling each other in the following days after harvest. This result was expected, since the stems harvested in R4 were still closed and during the post-harvest period they gradually opened until they showed similar EDC values starting on the sixth day. The results further show that regardless of the harvest point and stem length there was a trend of increasing EDC until the sixth day after harvest (Figures 2A and 2B).

Stem length significantly influenced EDC at 9 and 12 days after harvest. Stems with shorter lengths (50 and 60 cm) showed lower EDC values (Figure 2B). This result is an indication that the shorter stem length may have presented lower availability of carbohydrate reserves affecting the distribution between the stem and inflorescence. Consequently, with less reserve



Averages followed by the same letter do not differ by the Scott-Knott test (p ≥ 0.05).

Figure 2. External diameter of the capitulum (EDC) as a function of harvest point (A) and stem length (B) of ornamental sunflower 'Sol Vermelho' at 0, 3, 6, 9, and 12 days after harvest (DAH).

availability, the capitulum size may not have pronounced its maximum opening. Chen et al. (2020) points out that stem length for vegetables directly affects the uptake of endogenous hormones and the distribution of reserve compounds and consequently can cause a change in biomass allocation and therefore should be considered during the storage or post-harvest stage. Therefore, this change in the biomass allocation pattern can impair the quality of the final product.

Capitulum diameter is a fundamentally important characteristic for the commercialization of ornamental sunflower. The Instituto Brasileiro de Floricultura - Ibraflor, which provides quality standards, establishes that the consumer must be presented with an inflorescence with a minimum diameter of 60 mm for stems of up to 70 cm. For larger stems, the diameter should be at least 75 mm (Ibraflor, 2021). Thus, by the results obtained, these requirements are met, since the stems harvested regardless of the harvesting point and stem length showed EDC values with a minimum of 80 mm. However, it is important to emphasize that following this standardization depends on the characteristics of each cultivar and at the discretion of the market requirements, because for each region there are preferences regarding size and other characteristics concerning the chapter, such as color (Santos Júnior et al., 2016).

A reduction in fresh mass loss (FML) of floral stems was observed over time in both stems harvested at R4 and R5.5 (Figure 3A). For stems harvested at R4, we observed lower accumulated FML over the days after harvest (Figure 3A). Another important observation is that the stems in the different lengths showed increasing FML until the sixth day after harvest, with a subsequent reduction (Figure 3B). An indication that in the first six days the hydric state of the stems added water uptake elevated fresh weight, but as storage progressed, FML occurred and consequently led to senescence.

The FML of floral stems is directly affected by tissue water loss, indicating that stems with lower water content loss consequently maintain higher fresh mass. This ability to

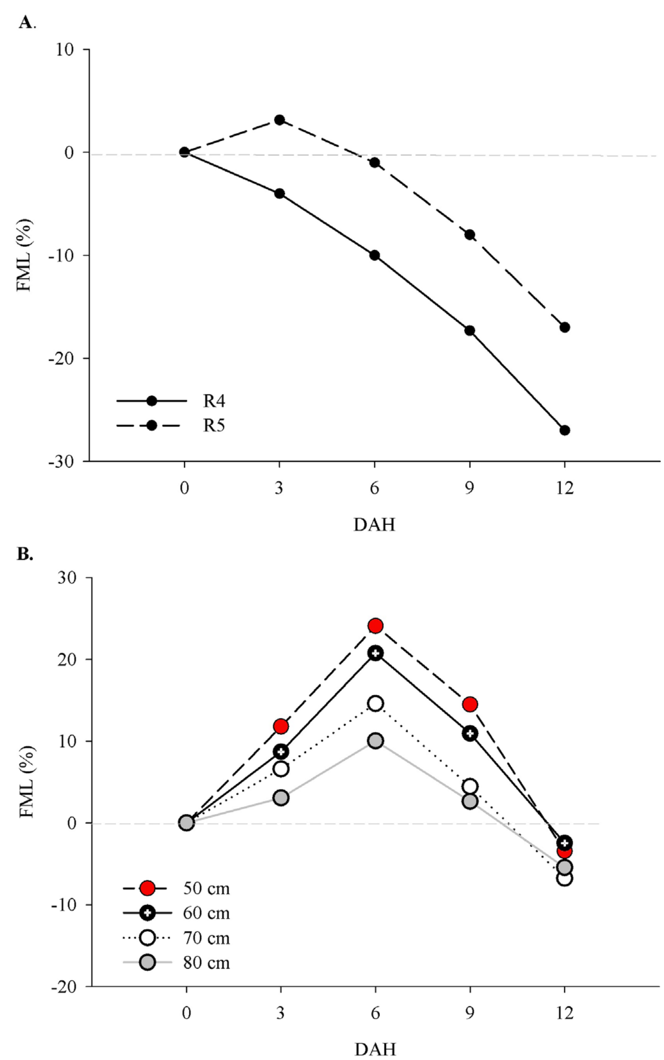


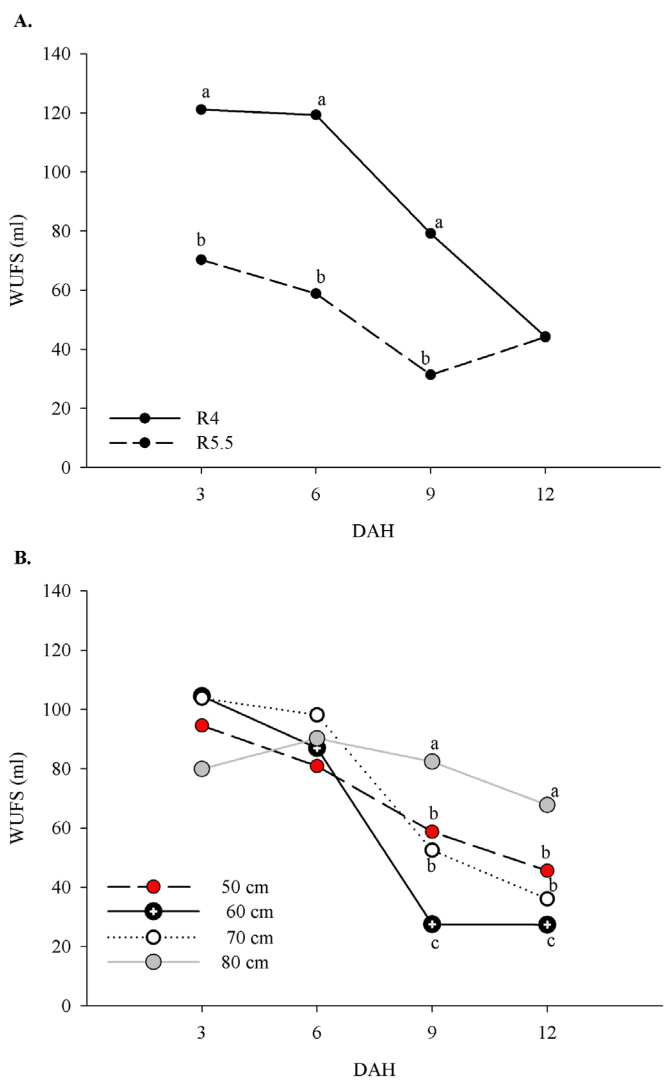
Figure 3. Cumulative variation of fresh mass loss (FML, %) as a function of harvest point (A) and stem length (B) of ornamental sunflower 'Sol Vermelho' at 0, 3, 6, 9, and 12 days after harvest (DAH).

maintain tissue hydration is an interesting characteristic that can be correlated to the degree of tolerance to drought stress conferring better quality and postharvest durability of the stems (Jedrzejuk et al., 2012). Several factors can contribute to maintaining the water balance of floral stems after harvest, such as the ability to absorb water. Therefore, the lower fresh mass loss of stems harvested at R4 and in the shorter length stems may be related to a higher water absorption capacity, showing a higher potential for absorption, as expressed in Figure 4A.

For water uptake by floral stems (WUFS) it was observed that stems harvested at R4 showed higher water uptake capacity, which resulted in a higher volume of absorbed water compared to stems harvested at R5.5 (Figure 4A).

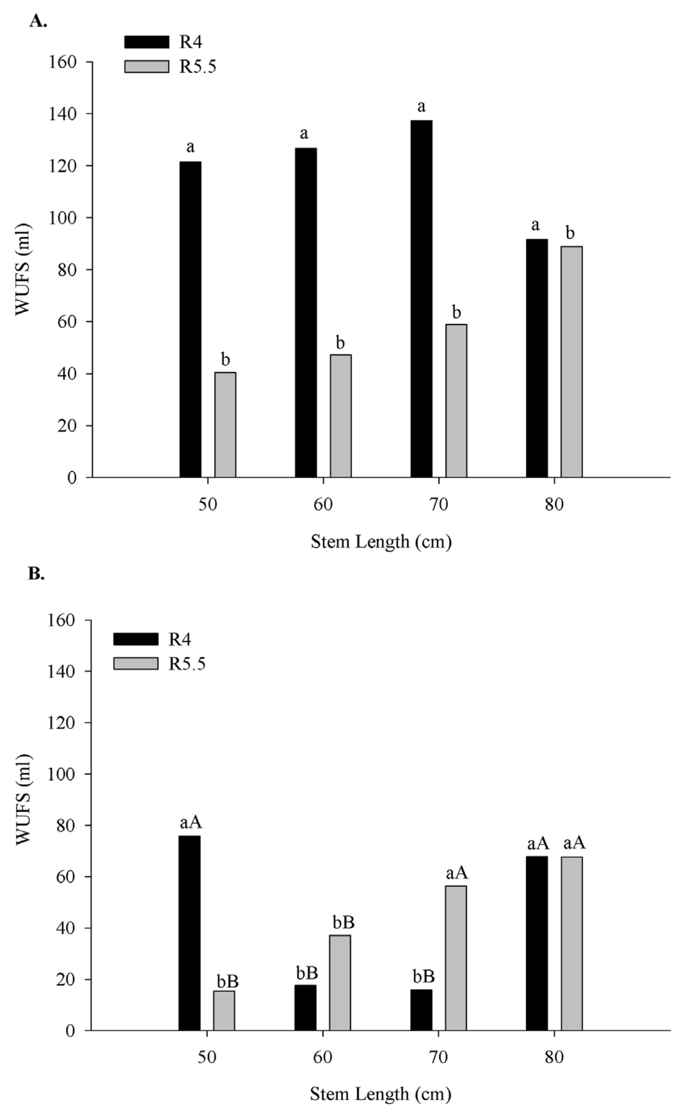
The interaction harvest point × stem length showed significant effect for the volume of water absorbed only on the 6th and 12th days after harvest. At 6 days, the volume of water absorbed by stems harvested at R4 were higher than at R5.5, but there was no difference as a function of stem length within each harvest point. There is a tendency, with more emphasis on the stems at R5.5, for the volume of water absorbed to be directly proportional to the stem size, indicating that the longer the length, the greater the volume of water absorbed by the stem (Figure 5A). This result corroborates with the lower FML (Figure 5B), because until day 6 there were no gains in mass, probably due to the greater water absorption that occurred until that date.

Overall, we can point out that the water uptake behavior of flowering stems of ornamental sunflower 'Sol Vermelho' is dependent on the interaction between harvest point and stem length. Stems harvested at R4 have higher water uptake potential in shorter (50 cm) stem lengths. Whereas stems harvested at R5.5 showed higher water uptake potential in longer stems (70 and 80 cm) (Figure 5B). The fact that stems harvested at R4 showed a higher volume of water absorbed



Averages followed by the same letter do not differ by the Scott-Knott test (p ≥ 0.05).

Figure 4. Water uptake by floral stems (WUFS) as a function of harvest point (A) and stem length (B) of ornamental sunflower 'Sol Vermelho' at 3, 6, 9, and 12 days after harvest (DAH).



Averages followed by the same letter do not differ by the Scott-Knott test (p ≥ 0.05). Lower case and upper-case letters compare means between harvest point and stem length, respectively.

Figure 5. Effect of the interaction between harvest point and stem length of ornamental sunflower 'Sol Vermelho' for water uptake by floral stems (WUFS) at 6 (A) and 12 (B) days after harvest.

can be explained by the fact that flower opening is a process that involves high rates of cell division and expansion, and consequently requires high levels of water (Sanches et al., 2019).

For the dry mass data of floral stems on the day of harvest ($DMFS_i$) and at 12 days after harvest (when they reached grade 3 on the senescence scale) ($DMFS_f$), there was no significant effect of harvest point for both variables (Table 1). However, there was an effect of the length of the stems on the values of $DMFS_i$ and $DMFS_f$, in which the 70 and 80 cm stems showed higher values of dry mass compared to the 50 and 60 cm stems. This result was expected, since the size of the stem influences the final dry mass value and normally, the longer the length, the higher the dry mass.

For the content of total soluble carbohydrates (TSC), there was a statistical difference only for the harvest point factor in the stems evaluated on the first day of storage. It is observed that the highest value was obtained in stems harvested at R4; while for TSC_3 both harvesting points, were in a similar situation in carbohydrate reversal when they reached grade 3 (Table 1). It can be seen that the reduction in TSC content was more pronounced in stems harvested at R4 (44%) while for R5.5 only 23% of TSC was reduced from the day of storage until the day the stems lost their commercial characteristics, given by the grade 3. This fact highlights the high consumption of these reserve compounds for the continued development, flower opening, and maintenance of the floral stems.

The availability of carbohydrate reserves and their accumulation provides a potential osmotic effect favorable to water uptake, since the accumulation of carbohydrates decreases the water potential and increases water uptake, which is essential to the processes of division and expansion of the cells that form the petals, stimulating the opening of floral buds (Cho et al., 2001). This explains the better post-harvest performance of the stems harvested in R4, since they presented a greater accumulation of carbohydrates at the time of harvest and consequently presented a greater potential for water absorption of the stems over time, with the maximum volume of water absorbed at 6 days after harvest, a moment that coincided with flower opening. This same time interval (6 days after harvest) coincides with the minimum fresh mass loss of the stems (Figure 3A) and highest EDC (Figure 2A).

Table 1. Dry mass of floral stems (DMFS) at harvest ($DMFS_i$) and final (when grade 3 on the senescence scale, $DMFS_f$), initial total soluble carbohydrates (at the day of harvest, TSC_h) and upon reaching grade 3 (TSC_3) of ornamental sunflower stems 'Sol Vermelho' as a function of harvest points and stem length.

Source of variation	DMFS (g)		TSC (g $100g^{-1}$)	
	$DMFS_i$	$DMFS_f$	TSC_h	TSC_3
Harvest points (HP)	0.8556ns	0.7556ns	0.0155*	0.4592ns
R4	28.81	28.11	38.18 a	21.36
R5.5	27.79	26.90	29.94 b	23.06
Stem length (SL)	0.0416*	0.0411*	0.7354*	0.3934ns
50	23.17 b	22.17 b	36.54	20.35
60	24.75 b	22.15 b	34.51	22.32
70	29.75 a	29.15 a	31.63	26.07
80	35.99 a	34.71 a	33.55	20.09
HP × SL	0.5818ns	0.5811ns	0.2069ns	0.3707ns
CV (%)	16.09	16.09	25.97	17.12

Averages followed by the same letter in the column do not differ by the Scott-Knott test ($p \geq 0.05$). * Significant ($p < 0.05$); ns - not significant, by the F test ($p \geq 0.05$).

The results further demonstrate that, commercial longevity was greater in stems harvested at R4 (Table 2). Therefore, ornamental sunflower 'Sol Vermelho' harvested at R4, with flower bud practically closed, showing the color of the ligules, continued its opening process (full opening at 6 days from harvest) and retained the desirable commercial characteristics for a longer period, when compared to the stems harvested at R5.5 (open inflorescences). In evaluating harvest points of sunflower 'Sunbright Supreme', Nascimento et al. (2019) also observed that stems harvested while still closed showed greater commercial durability. The greater longevity observed in stems harvested in R4 is a consequence of the greater potential for water absorption, retention, and transport in stem tissues, characteristics that have been pointed out as effective for obtaining greater postharvest durability of cut flowers (Nascimento et al., 2019; Costa et al., 2021).

On the other hand, the lower commercial durability of stems harvested at R5.5 may be associated with the more advanced maturity stage of these stems, since they would be closer to reaching the senescence stage. Therefore, early harvesting of ornamental sunflower flower stems, specifically at R4, is a viable alternative that allows for greater post-harvest durability and a longer period for stems to be sold, especially in regions far from the production site.

The factor length of floral stems also affected the commercial longevity of floral stems of sunflower 'Sol Vermelho' harvested mainly at R5.5, when it was found that the longer stems (70 and 80 cm) obtained shorter commercial longevity (Table 2). Although the stems harvested in R5.5 presented a lower commercial longevity, this result is also interesting and can be used by producers, especially when the destination of production is for local markets or closer to the producing region. The stems harvested at this point have maximum harvest quality and make it possible to market them immediately. In addition, stems harvested at R5.5 showed significantly greater commercial longevity when they had lengths of 50 and 60 cm, which understands market demands.

Table 2. Commercial longevity of floral stems (days) of ornamental sunflower 'Sol Vermelho' as a function of harvest point (R4 and R5.5) and stem length (50, 60, 70, and 80 cm).

Harvesting points	Commercial longevity of floral stems – Stem length (cm)			
	50	60	70	80
R4	13.25 aA	10.5 aB	12.25 aA	14 aA
R5.5	11 aA	12.0 aA	7 bB	10 bA

* Averages followed by the same letter do not differ by the Scott-Knott test ($p \geq 0.05$). Lower case letters compare the levels of the harvest point factor, while upper case letters compare the levels of the stem length factor.

Conclusions

The early harvest (stage R4) of ornamental sunflower stems 'Sol Vermelho' is a viable alternative that allows for greater post-harvest durability and consequently the commercialization of stems for a longer period of time.

Flower stem length does not affect the commercial longevity of stems harvested at the R4 stage.

Ornamental sunflower stems 'Sol Vermelho' harvested at R5.5 with lengths of 50 and 60 cm are recommended for marketing in regions near the production sites.

Compliance with Ethical Standards

Author contributions: Conceptualization: MZBC; Formal analysis: MZBC; RRS; Investigation: SRM, CMAS, JCC; MSMB; Project administration: MZBC; Supervision: MZBC; Validation: MZBC, SRM; Writing - original draft: SRM; Writing – review & editing: RRS; MZBC.

Conflict of interest: The authors declare that there is no conflict of interest (professional or financial) that could influence the article.

Financing source: The CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico, Grant Number 456690/2014-0).

Literature Cited

Chantrachit, T. Postharvest physiology of red ginger inflorescence. Honolulu: University of Hawaii, 1999. 192p. Dissertation PhD. https://core.ac.uk/download/pdf/211323295.pdf. 07 Dec. 2021.

Chen, Y.; Song, X.; Guo, Y.; Zhang, Y.; Li, L.; Wang, L.; Yun, L.; Liu, S.; Zhang, X.; Ma, Y. Stalk length should be considered for storage quality of broccoli heads based on the investigation of endogenous hormones metabolismo. Scientia Horticulturae, v.267, e109338, 2020. https://doi.org/10.1016/j.scienta.2020.109338.

Cho, M.S.; Celikel, F.; Dodge, L.; Reid, M. Sucrose enhances the postharvest quality of cut flowers of *Eustoma grandiflorum* (Raf.) Shinn. Acta Horticulturae, v.543, p.305-315, 2001. https://doi.org/10.17660/ActaHortic.2001.543.37.

Costa, L. C.; Araujo, F. F.; Ribeiro, W. S.; Santos, M. N. S.; Finger, F. L. Postharvest physiology of cut Flowers. Ornamental Horticulture, v.27, n.3, p.374-385, 2021. https://doi.org/10.1590/2447-536X.v27i3.2372.

Curti, G. L. Caracterização de cultivares de girassol ornamental semeados em diferentes épocas no Oeste Catarinense. Pato Branco: Universidade Tecnológica Federal do Paraná, 2010. 76p. Thesis Master. http://repositorio.utfpr.edu.br/jspui/handle/1/242. 07 Dec. 2021.

Curti, G.L.; Martin, T.N.; Ferronato, M.L.; Benin, G. Girassol ornamental: caracterização, pós-colheita e escala de senescência. Revista de Ciencias Agrárias, v.35, n.1, p.240-250, 2012. https://doi.org/10.19084/rca.16179.

Dubois, M.; Gilles, K.A.; Hamilton, J.K.; Rebers, P.A.; Smith, F. Colorimetric method form determination of sugars and related substances. Nature, v.28, n.3, p.350-356, 1956. https://doi.org/10.1021/ac60111a017.

Ezz, T. M.; Weheda, B.M.; Gaber, M. K.; SallamA. M. Efficiency evaluation of pulsing solutions and cold storage on prolonging the vase life of *Helianthus annuus* L. cut flowers. Journal of the Advances in Agricultural Researches, v.26, n.2, p.53-59, 2021. https://doi.org/10.21608/jalexu.2021.171040.

He, S.G.; Joyce, D.C.; Irving, D.E.; Faragher, J.D. Stem-end blockage in cut Grevillea "Crimson Yul-lo" inflorescences. Postharvest Biology and Technology, v.41, n.1, p.78-84, 2006. https://doi.org/10.1016/j.postharvbio.2006.03.002.

Ibraflor - Instituto Brasileiro de Floricultura. O mercado de flores no Brasil. Holambra: Ibraflor, 2021. 4p. https://354d6537-ca5e-4df4-8c1b-3fa4f2dbe678.filesusr.com/ugd/b3d028_e002f96eeb81495ea3e08362b49881a3.pdf. 15 Nov. 2021.

Ibraflor - Instituto Brasileiro de Floricultura. Mercado de flores no Brasil. Holambra: Ibraflor, 2022. 4p. https://www.ibraflor.com.br/_files/ugd/b3d028_2ca7dd85f28f4add9c4eda570adc369f.pdf. 24 May 2022.

Jędrzejuk, A.J.; Rochala, J.; Zakrzewski, J.; Rabiza-Świder. Identification of xylem occlusions occurring in cut clematis (*Clematis* L., fam. Ranunculaceae Juss.) stems during their vase life. Scientific World Journal, v.2012, e749281, 2012. https://doi.org/10.1100/2012/749281.

Junqueira, A.H.; Peetz, M.S. Sustainability in Brazilian floriculture: introductory notes to a systemic approach. Ornamental Horticulture, v.24, n.2, p.155-162, 2018. https://doi.org/10.14295/oh.v24i2.1253.

Kılıç, T.; Kazaz, S.; Şahin, E. G. E.; Uran, M. Extension of the vase life of cut sunflower by different vase solutions. Ornamental Horticulture, v.26, n.1, p.45-50, 2020. https://doi.org/10.1590/2447-536X.v26i1.2108.

Naik, K. B.; Nataraj, S. K.; Shadakshari, Y.G.; Kumar, D. P.; Seetharamu, G. K. Standardisation of optimum stage of harvest for enhancing vase life in ornamental sunflower (*Helianthus annuus* L.). International Journal of Pure & Applied Bioscience, v.6, n.4, p.733-735, 2018. https://doi.org/10.18782/2320-7051.6453.

Nascimento, A. M. P.; Paiva, P. D. O.; Manfredini, G. M.; Sales, T. S. Harvest stages and pulsing in ornamental sunflower 'Sunbright Supreme'. Ornamental Horticulture, v. 25, n.2, p.149-157, 2019. https://doi.org/10.14295/oh.v25i2.1991.

R Core Team. R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing, 2018. https://www.r-project.org. 21 Apr. 2021.

Sanches, A. G.; Silva, M. B.; Moreira, E. G. S.; Cordeiro, C. A. M. Maintenance solutions for the conservation of sunflower inflorescences. Emirates Journal of Food and Agriculture, v.31, n.5, p.335-341, 2019. https://doi.org/10.9755/ejfa.2019.v31.i5.1950.

Santos Júnior, J.A.; Gheyi, H.R.; Cavalcante, A.R.; Dias, N. da S.; Medeiros, S. de S. Produção e pós-colheita de flores de girassóis sob estresse salino em hidroponia de baixo custo. Engenharia Agrícola, v.36, n.3, p.420-432, 2016. https://doi.org/10.1590/1809-4430-Eng.Agric.v36n3p.

Schneiter, A.A.; Miller, J.F. Description of sunflower growth stages. Crop Science, Madison, v.21, n.6, p.901-903, 1981. https://doi.org/10.2135/cropsci1981.0011183X002100060024x.

Schwab, N.T.; Streck, N.A.; Langner, J.A.; Ribeiro, B.S.M.R.; Uhlmann, L.O.; Becker, C.C. Aplicabilidade do termo antocrono para representar a velocidade de abertura de flores em inflorescência. Pesquisa Agropecuária Brasileira, v.49, n.9 p.657-664, 2014. https://doi.org/10.1590/S0100-204X2014000900001.