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RESEARCH ARTICLE

Maintenance solutions for the conservation of sunflower inflorescences

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ABSTRACT

The sunflower (*Helianthus annuus* L.) is an ornamental plant of great acceptance in the market, however, as cut flower has its limited useful life, about 3 to 5 days at room temperature. In order to prolong shelf life and preserve post-harvest quality was evaluated the effect of maintenance solutions on sunflower cv. Oasis for 10 days storage at 25 °C. O experimento foi conduzido em delineamento inteiramente casualizado em arranjo fatorial 5x6, correspondendo a cinco tratamentos/soluções de manutenção (distilled water (control), sucrose, citric acid, gibberellic acid and benzylaminopurine to 5%) and six evaluation times (0, 2, 4, 6, 8 and 10 days). The effect of treatments on fresh mass, inflorescence turgescence, stem curvature, relative petal water content, respiratory rate and carbohydrate content was investigated. The results showed that the solutions with sucrose and gibberellic acid significantly ($p<0.05$) preserved the quality of the inflorescences as a function of the control of respiratory activity and water absorption, thereby reducing the physiological processes related to senescence. It is recommended to use sucrose 5% as a maintenance solution due to the low cost to producers and consumers.

Keywords: Cut flower; Gibberellic acid; *Helianthus annuus* L; Sucrose

INTRODUCTION

The sunflower (*Helianthus annuus* L.) belonging to the family Asteraceae is a species native to the United States and Mexico, and in recent years has been increasing its use as an inflorescence of cut and pot due to the edafoclimatic amplitude that favors the cultivation of the species in the most several regions of Brazil (Neves et al., 2005, Arruda et al., 2010; Curti et al., 2012).

As an ornamental plant, it has great potential of commercialization, because it has short cycle and of easy propagation (Anefalos e Guilhoto, 2003; Coutinho et al., 2014). The inflorescence is very attractive, being the part more used commercially to compose diverse types of ornamental arrangements (Neves et al., 2005; Jesus et al., 2013).

However, as cut flower, the sunflower has a short shelf life, about 3 to 5 days under room temperature condition (Curti et al., 2012), thus, the knowledge of the physiological changes between the harvest and the complete senescence is fundamental to establish strategies of preservation of the useful life. These physiological processes are characterized by the exhaustion of reserves through respiratory activity, the loss of turgescence and occlusion of the stem after cutting leading to obstruction of conducting vessels, as well as changes in the color and brightness of the petals, among others (Almeida et al., 2008; Pellegrini, 2009; Vieira et al., 2012).

An alternative to delay these processes and prolong the life of cut flowers occurs in the use of maintenance solutions consisting, especially, of sugars, acids, phytohormones, germicides, among others (Durigan et al., 2013), being used after harvesting, during transport or storage.

The understanding of postharvest conservation metabolism is of great importance for flowers and tropical ornamental

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plants to reach the consumer without changes in their aesthetic aspect and quality. In this sense, this work had as objective to evaluate solutions of maintenance on the useful life and the quality of inflorescences of sunflower.

MATERIAL AND METHODS

Plant material

The inflorescences of yellow sunflower cv. BRS Oasis were harvested in the morning and the chapters presented 50 % of the flowers. These were transported under refrigeration (15 °C) to the Technology Laboratory of the Federal University of Pará, Campus Altamira-PA where they were washed with distilled water, standardized in size of 40 cm and submitted to maintenance solutions.

Treatments with maintenance solutions

The inflorescences were conditioned in beakers (1L) containing the following solutions: distilled water (control), sucrose, citric acid, gibberellic acid and benzylaminopurine in the amount of 50 ml and then the volume was filled to 1L with distilled water obtaining the concentration of 5 %. The control solution was formed only by distilled water. The inflorescences were maintained in the respective solutions at room temperature (25 ± 3 °C) and 85 ± 5 % relative humidity for a period of 10 days.

Quality analysis

Quality analyzes occurred every two days on the following variables:

Fresh mass: determined by the difference between the initial weight and the weight of the inflorescences on the day of analysis and the results expressed as % (Imsabai et al., 2013; Sanches et al., 2016).

Turgescence of inflorescences: determined through subjective analysis through hedonic scale of 4 points where: 4 = turgid; 3 = slightly wilted; 2 = withered and 1 = totally withered (Pietro et al., 2012).

Curvature of the stems: evaluated by following the scale of notes: 4 = straight rod; 3 = wilted rod, little inclination; 2 = wilt stem tilted up to 30 ° and 1 = completely wilted, inclined rod. For the analyzes of turgescence and curvature of the stems note 3 was considered as commercial limit (Durigan et al., 2013)

Relative water content: determined by the destructive method using the petals of three inflorescences, as described by Durigan (2009), and the results expressed as a percentage (%), by the following formula:

$$RWC = FM – DM/TM - DM \times 100$$

Where: RWC = relative water content; FM = fresh mass; DM = dry mass; TM = turgid mass.

Respiratory rate: Determined by placing three inflorescences of each maintenance solution in a 5 L hermetically sealed plastic container for a period of 1 hour (25 °C and 85 % U.R) at room temperature. Aliquots (0.3 ml) of the contents of the atmosphere inside the containers were taken before and immediately after this period with an appropriate syringe (Exmire Microseringe, Ito Corp.). The aliquots had their CO_2 levels determined in a chromatograph (GC Finnigan 9001), with Porapak-Q packaged column. The column temperature was 50 °C and the nitrogen was the entrainment gas used with flow rate of 35 mL/min. The injector temperature was 100 °C and 150 °C for the detector. The results were expressed in mg de $CO_2.kg^{-1}.h^{-1}$.

Inflorescence coloring: The readings were performed with Minolta colorimeter, model CR-400 using six petals per repetition. Two readings were performed on each petal, one on the outer face and one on the inner face, and the foam results calculated based on the parameters a* and b*, and expressed in luminosity and color angle.

Total carbohydrate content: determined using the method proposed by Albalasmeh et al. (2013) and with reading in spectrophotometer apparatus and absorption in UV length at 315 nm. The frozen petals of three inflorescences of each maintenance solution were used and the results expressed in g of glucose 100 g^{-1} of fresh mass.

Total carbohydrate content: The extraction was performed by the method proposed by Albalasmeh et al. (2013) and the quantification was determined according to Franzen et al., (2016) with spectrophotometric reading and absorption at UV length at 315 nm. The frozen petals of three inflorescences of each maintenance solution were used and the results expressed in g glucose of 100 g^{-1} fresh mass (FM).

Experimental design and Statistical analysis

The experimental design was completely randomized in a 5x6 factorial arrangement with five maintenance solutions (distilled water - control, sucrose, citric acid, gibberellic acid and benzylaminopurine) and six days of evaluation (0, 2, 4, 6, 8 and 10 days) with five replications and the experimental plot composed of three inflorescences. Data were submitted to analysis of variance (ANAVA) and Tukey test at 5% probability ($p<0.05$) using statistical software SISVAR 4.3.

RESULTS AND DISCUSSION

The reduction in the fresh mass of the inflorescences occurred in all the treatments applied, especially after

the fourth day, when the average percentage was equal to/greater than 5 % (Fig. 1). At the 10 days of storage, there was an increase of this loss, around three treatments containing sucrose, citric acid, gibberellic acid and benzylaminopurine five times in the control treatment.

It was observed that inflorescences maintained only in distilled water (control) suffered the greatest accumulated loss of fresh mass (23.51 %) at the end of 10 days, differing significantly ($p<0.05$) in relation to the other treatments (Fig. 1). On the other hand, solutions containing sucrose (12.51 %) and gibberellic acid (11.84 %) resulted in inflorescences with lower mass loss at the end of the storage period, which may be due to sucrose ability to increase water absorption (Finger et al., 2004; Schmitt et al., 2013) and gibberellic acid in delaying senescence by maintaining tissue turgorence (Guimarães et al., 2014; Marsala et al., 2014).

The loss of turgescence of cut flowers occurs as a consequence of excessive water loss through transpiration, limiting longevity. In this study, there was a significant effect of the maintenance solutions ($p<0.05$) on the inflorescence turgescence (Fig. 2).

In summary, inflorescence turgescence was compromised with storage time, especially in those of the control treatment, which were characterized as 1.0 (completely wilted) on the 10 day. On the other hand, the solutions with sucrose and gibberellic acid preserved the turgescence, that is, being characterized with a note 3.0 (slightly wilted) at 10 days, differing significantly ($p<0.05$) in relation to the others treatments (Fig. 2).

In studies with white chrysanthemums (Silva e Silva, 2010) and roses (Pietro et al., 2012) greater longevity of the flowers (turgescence) was observed when kept in solution containing sucrose, independent of the concentration used. In anthuriums (Marsala et al., 2014) observed a positive effect on the turgescence of this cut flower when treated with gibberellic acid (200 $mg.L^{-1}$). The turgor of gladiolus was preserved when 25 $mg.L^{-1}$ of gibberellic acid was used as the maintenance solution (Saeed et al., 2014).

The stem curvature was significantly affected ($p<0.05$) by maintenance solutions with storage time (Fig. 3).

In general, the curvature of the rod was affected after the fourth day, especially in samples kept in distilled water (control). With the storage time the inflorescences maintained in sucrose and gibberellic acid showed steeper stems being characterized with a mark above 3.0 (wilted stem, little slope), differing ($p<0.05$) from the other

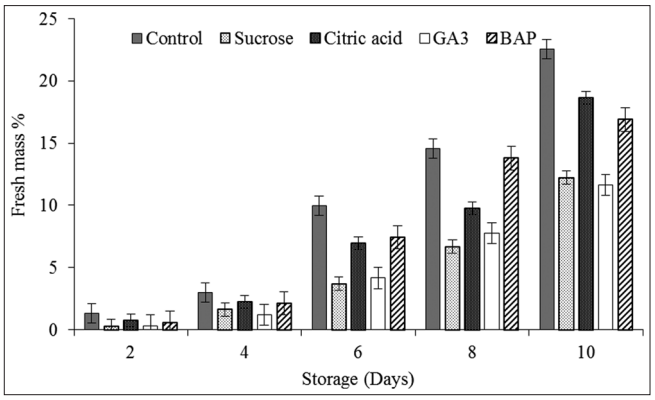

Fig 1. Fresh mass of inflorescences of yellow sunflower cv. BRS Oasis maintained maintenance solutions (5%) during 10 days storage at room temperature (25 ± 3 ° C). GA3 = gibberellic acid; BAP = benzylaminopurine.

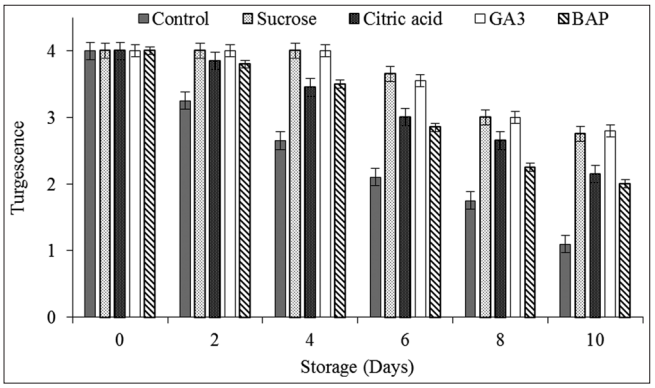

Fig 2. Turgescence of yellow sunflower inflorescences cv. BRS Oasis maintained in maintenance solutions (5%) during 10 days storage at room temperature (25 ± 3 °C). GA_3= gibberellic acid; BAP= Benzylaminopurine.

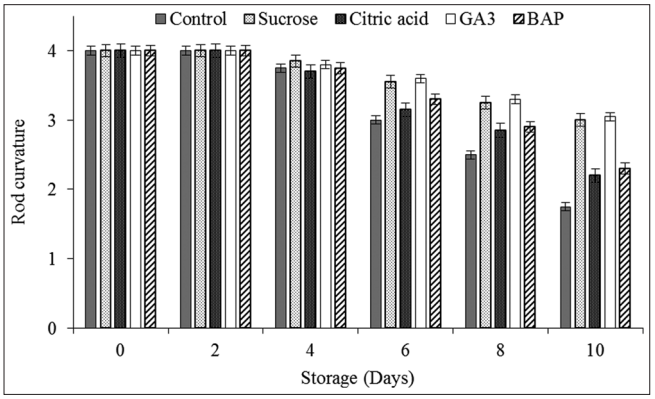

Fig 3. Rod curvature in yellow sunflower inflorescences cv. Oásis treated with maintenance solutions (5%) during 10 days at room temperature (25 ± 3 °C). GA_3= gibberellic acid; BAP= Benzylaminopurine.

solutions (Fig. 3) in accordance with the turgescence of the inflorescences (Fig. 2).

Exogenous application of growth regulators, such as gibberellins (gibberellic acid) reduce the damaging action of the endogenous/exogenous ethylene on the rods

(Gonzaga et al., 2001; Durigan, 2009) and the sugars (sucrose) present in the solution increase the osmotic concentration, improving the water absorption capacity and the water balance in the maintenance of the stems turgidity (Dias-Tagliacozzo et al. 2006). This fact justifies the lower curvature index of the stem observed in the inflorescences of sunflower when maintained in the solutions of sucrose and gibberellic acid. In addition, from the commercial point of view, the maintenance of the turgescence of the stems is directly associated to the longevity and the acceptance by the consumers.

Studies with chrysanthemum stems 'Dragon' (Spricigo et al., 2010) e tango (Fonseca et al., 2017) showed that the solution containing sucrose kept the stems more turgid when compared to other solutions, especially those maintained in distilled water (control), confirming the preservative power of this sugar.

The quality of the water in which the flowers are stored is a factor that influences the longevity of the stems being associated with factors such as the diffusion of solutes in the biochemical reactions, the temperature regulation and the sustentation of the vegetal tissues (Reichardt, 1985; Spricigo, Ferreira e Calbo, 2012).

Regarding the water content in the petals (Fig. 4), a significant effect of maintenance solutions ($p < 0.05$) was observed with storage time.

The transpiration of the inflorescences led to a reduction in the water content of the petals in all treatments, especially in the samples kept in distilled water (control), whose average reduction was over 60%, differing significantly ($p<0.05$) from the inflorescences maintained in solutions containing sucrose and gibberellic acid, whose reduction was about 30% over 10 days.

This lower loss of water of the petals observed in this study is due to factors such as inhibition in the synthesis of ethylene intermediated by gibberellic acid and osmotic balance stimulated by sucrose leading to a higher water uptake and, consequently, a lower rate of transpiration in the inflorescences.

Similar results were obtained on rose petals 'Carola' (Bastos et al., 2016) and gladiolus florets (Kumar e Gupta, 2014) where maintenance in solution with sucrose (1 %) and gibberellic acid (100 $mg.L^{-1}$) reduced the loss of water, respectively.

The respiratory rate of the inflorescences maintained in solution with sucrose and gibberellic acid remained lower ($p<0.05$) than the others during 10 days (Fig. 5), being

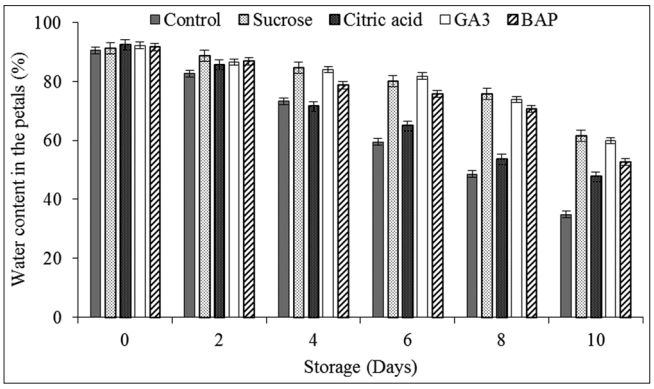

Fig 4. Relative water content in the petals of the yellow sunflower cv. Oásis treated with maintenance solutions (5%) during 10 days at room temperature (25 ± 3 °C). GA_3= gibberellic acid; BAP= Benzylaminopurine.

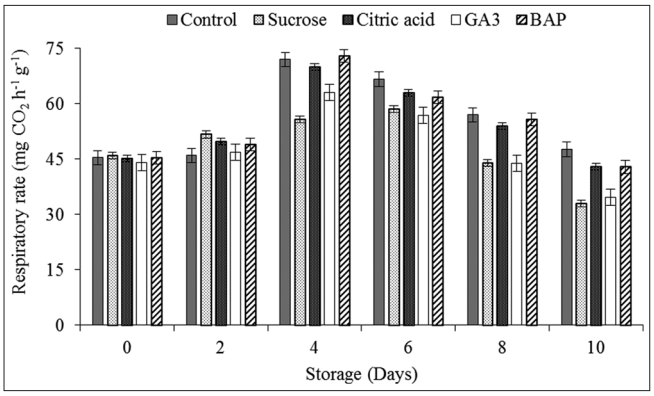

Fig 5. Respiratory rate of yellow sunflower inflorescences cv. Oásis treated with maintenance solutions (5%) during 10 days at room temperature (25 ± 3 °C). GA_3= gibberellic acid; BAP= Benzylaminopurine.

related to the lower reduction in the water content of the petals (Fig. 3).

According Pietro et al. (2010) the lower respiratory rate favors the increase in vessel life, which in this case is characterized mainly by the lower use of reserves as a respiratory substrate and, in turn, generates vital energy to them, positively influencing the qualitative characteristics of the flowers. In this work this effect was achieved by solutions with sucrose and gibberellic acid differing significantly ($p<0.05$) from the others (Fig. 5).

Also according to Fig. 5, it was observed that the solution with distilled water (control) had the highest respiratory rate, and coincided with the results of lower turgidity of the inflorescences, stem curvature and water content in the petals (Fig.s 2, 3 and 4), respectively, possibly due to the use of reserves alone to maintain the metabolism.

In general, the use of the solutions kept the inflorescence respiratory rate lower than the control treatment. The

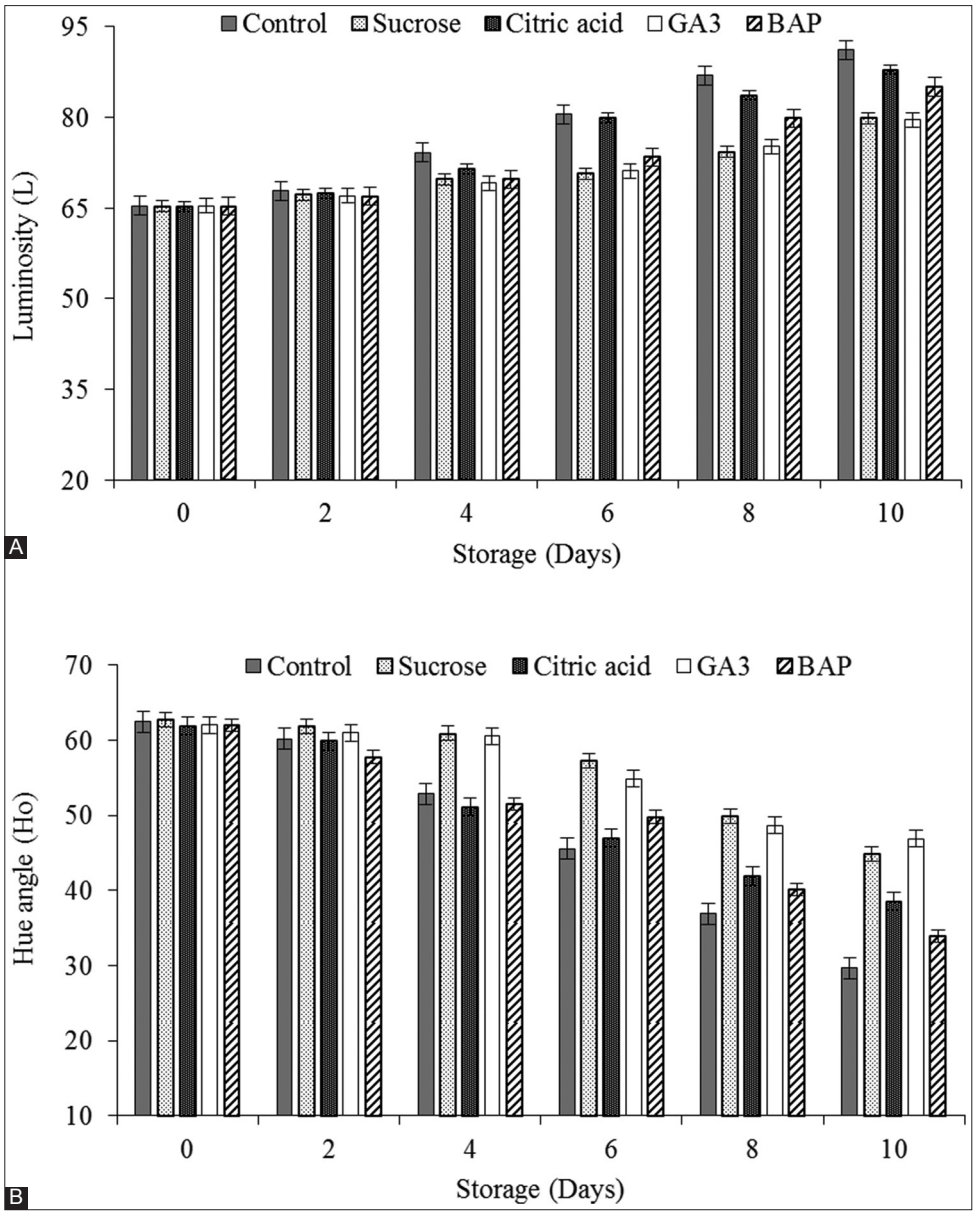

Fig 6. Luminosity (A) and hue angle (B) of yellow sunflower inflorescences cv. Oasis treated with maintenance solutions (5%) during 10 days at room temperature (25 ± 3 °C). GA_3= gibberellic acid; BAP= Benzylaminopurine.

use of solutions such as methyl jasmonate in 'Vega' roses (Pietro et al., 2012) and 8-hydroxyquinoline in 'Suzanne' gerberas (Durigan et al., 2013) resulted in less respiratory activity and prolonged shelf life in 4 and 5 days, respectively, relative to the control (distilled water). These results corroborate the potential of use of maintenance substances on quality and useful life as used in this study.

There was a significant effect of the maintenance solutions ($p<0.05$) on the color of inflorescences luminosity and hue angle (Fig.s 6A and 6B), respectively.

For the luminosity variable (Fig. 6A) there was a gradual increase in the values with storage time in all treatments. This increase in luminosity evidences greater darkening of the petals, which changed from light yellow to orange-yellow, especially in the control inflorescences (91.17), citric acid (87.92) and benzylaminopurine (85.07) at the end of 10 days. On the other hand, the maintenance of these solutions with sucrose (79.85) and gibberellic acid (79.56) ensured a lower luminosity index differing significantly ($p<0.05$) from the others, indicating less darkening of the petals.

In studies with gerberas (Durigan et al., 2013) also observed an increase in the luminosity of flowers when kept only in distilled water and citric acid. On the other hand, the maintenance of these in solution with sucrose and gibberellic acid kept the values of luminosity stable, that is, the petals maintained the light yellow coloration

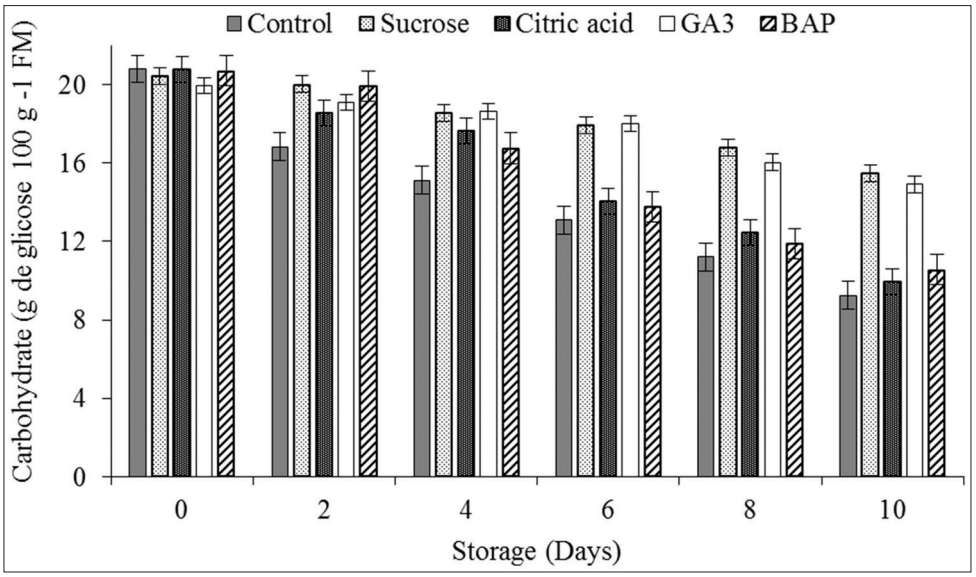

Fig 7. Carbohydrate content in inflorescences of yellow sunflower cv. Oasis treated with maintenance solutions (5%) during 10 days at room temperature (25 ± 3°C). GA_3= gibberellic acid; BAP= Benzylaminopurine.

for a longer period of time similar to that observed in this study.

In a study with gerberas (Durigan et al., 2013) an increase in the luminosity of the flowers was observed when kept only in distilled water and citric acid (6 $g.L^{-1}$). On the other hand, the maintenance of these in solution with 8-hydroxyquinoline kept the values of luminosity stable, that is, the petals remained pale yellow for a longer period of time similar to that observed in this study with the use of sucrose and gibberellic acid, that is, favoring a slower metabolism.

The angle hue, or color, expresses the maintenance of color in the evaluated products. In this sense, there was loss in the color of the inflorescences since there was reduction in the values with the storage time in all the treatments (Fig. 6B).

In summary, the lowest reduction occurred in the inflorescences maintained in sucrose and gibberellic acid, mean values of 44.88 and 46.76, respectively, differing significantly from the others ($p<0.05$), which averaged around 30.00 at 10 days. This result demonstrates efficiency of these solutions in maintaining the coloration of the petals, possibly by the control in the synthesis of ethylene, in the water balance, energy and in the preservation of the pigments that compromise the commercialization by interfering in the visual aspect of the inflorescences.

Carbohydrates are the main sources of carbon and energy for the maintenance of all biochemical and physiological processes of flowers after cutting (Antes et al., 2009). In this study the carbohydrate content was significantly ($p<0.05$) affected by the solutions with storage time (Fig. 7).

The carbohydrate content decreased with storage time in all treatments, however, inflorescences maintained in sucrose solution (15.67 g of glucose.$100g^{-1}$ MF) and gibberellic acid (14.91 g of glucose.$100g^{-1}$ MF) presented a significantly higher content ($p<0.05$) when compared to the other solutions whose average was around 10.0 g of glucose.$100g^{-1}$ MF after 10 days of storage. This reduction is probably due to the control of senescence of the inflorescences (sucrose and gibberellic acid), mainly in the carbohydrate consumption to maintain the respiratory metabolism as observed in Fig. 5.

CONCLUSION

Sucrose and gibberellic acid solutions preserve the quality of the inflorescences. It is recommended to use 5% sucrose as maintenance solution at the affordable cost to producers and consumers.

REFERENCES

Albalasmeh, A. A., A. A. Berhe and T. A. A. Ghezzehei. 2013. New method for rapid determination of carbohydrate and total carbono concentrations using UV spectrophotometry. Carbohydr. Polym. 97: 253-261.

Almeida, E. F. A., P. D. O. Paiva, L. C. O. Lima, M. L. Resende, J. Fonseca and T. S. Tavares. 2008. Pós-colheita de copo de leite: Efeito de diferentes conservantes comerciais e armazenamento a frio. Ciên Agrotec. 32: 1189-1194.

Anefalos, L. C and J. J. M. Guilhoto. 2003. Estrutura do mercado brasileiro de flores e plantas ornamentais. Agric. São Paulo. 50: 41-63.

Antes, R. B., C. R. S. Monteiro, S. Rieth, V. Duarte and R. J. Bender. 2009. Bloqueio vascular de hastes de gérberas cv. Patrizia. Rev. Biotemas. 22: 1-7.

Arruda, N. T., F. A. Oliveira, J. A. Batista, Ê. R. Menezes and A. F. Rodrigues. 2010. Taxa de crescimento e teores de nutrientes na planta da cultura do girassol submetido á aplicações de calcário e de fósforo. Rev. Agro. Des. Sust. 5: 179-184.

Bastos, F. E. A., M. C. Stanger, R. Allebrandt, C. A. Steffens, A. A. Kretzschmar and L. Rufato. 2016. Conservação de rosas "Carola" utilizando substâncias com potencial biocida. Rev. Bras. Orna. Hort. 22: 107-113.

Coutinho, I. B. L., R. J. Takane, C. F. Lacerda, A. B. Santos and K. F. L. Pivetta. 2014. Efeito do regulador daminozide e dos substratos fibra de coco e areia no cultivo em vaso de girassol ornamental. Cient. 42: 376-387.

Curti, G. L., T. N. Martin, M. L. Ferronato and G. Benin. 2012. Girassol ornamental: Caracterização, pós-colheita e escala de senescência. Rev. Ciên. Agr. 35: 240-250.

Dias-Tagliacozzo, G. M., F. L. Finger and J. G. Barbosa. 2006. Fisiologia pós-colheita de flores de corte. Rev. Bras. Hort. Orn. 11: 89-99.

Durigan, M. F. B. 2009. Fisiologia e Conservação Pós-colheita de Flores Cortadas de Gérbera (Tese Doutorado). Universidade Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias, São Paulo.

Durigan, M. F. B., B. Mattiuz, T. J. D. Rodrigues and C. F. M. Mattiuz. 2013. Uso de soluções de manutenção contendo ácido cítrico, cloro ou 8-HQC na conservação pós-colheita de flores cortadas de gérbera "Suzanne". Rev. Bras. Hort. Orn. 19: 107-116.

Finger, F. L., T. F Carneiro and J. G Barbosa. 2004. Senescência pós-colheita de inflorescências de esporinha (*Consolida ajacis*). Pesq. Agrop. Bras. 39: 533-537.

Fonseca, J. G., L. I. Choucair, V. C. Galati, R. Gimenes and C. M. A. Morgado. 2017. Maintenance solutions for postharvest conservation of tango. Sci. Electric. Arch. 10: 1-6.

Franzen, F. L., N. S. P. Richards, M. S. R Oliveira, F. A. A. Backes, J. F. Menegaes and A. P. Zago. 2016. Caracterização e qualidade nutricional de pétalas de flores ornamentais. Act. Igua. 5: 58-70.

Gonzaga, A. R., L. A. Moreira, F. Lonardoni and R. T. Faria. 2001. Longevidade pós-colheita de inflorescências de girassol afetada por nitrato de prata e sacarose. Rev. Bras. Hort. Orn. 1: 73-77.

Guimarães, A. A., F. L. Finger, T. P. Silva and J. G. Barbosa. 2014. Avaliação da solução de pulsing com ácido giberélico na vida de vaso de *Heliconi*a *biha*i. Rev. Bras. Hort. Orn. 20: 171-178.

Imsabai, W, P. Leethiti, P. Netlak and W. G. Van Doorn. 2013. Petal blackening and lack of bud opening in cut lotus flowers (*Nelumbo nucifera*): Role of adverse water relations. Posth. Biol. Tech. 79: 32-38.

Jesus, F. N., A. C. Alves, A. R. Santos, G. S. Souza and T. T. Cerqueira. 2013. Mudas de girassol submetidas a doses de potássio. Enc. Biol. 9: 1554-1565.

Kumar, S and A. K. Gupta. 2014. Postharvest life of *Gladiolus grandiflorus* L. cv. Jessica as influenced by pre-harvest application of gibberellic acid and kinetin. J. Postharvest Tech. 2: 169-176.

Marsala, J., M. V. Ferraz, S. H. M. Silva and D. M. G. Pereira. 2014. Pós-colheita de folhagens de corte de *Anthuriu*m *andraeanu*m L. Cv. Apalai. Rev. Bras. Hort. Orn. 20: 137-142.

Neves, M. B., S. Buzetti, R. M. M. Castilho, S. F. Boaro. 2005. Desenvolvimento de plantas de girassol ornamental (*Helianthus annuus* L.) em vasos, em dois substratos com solução nutritiva e em solo. Rev. Cient. 33: 127-133.

Pellegrini, M. B. Q. 2009. O que você precisa saber sobre pós-colheita de flores. Rev. Cam. Neg. 5: 120-126.

Pietro, J., B. H. Mattiuz and C. F. M. Mattiuz. 2010. Influence of 1-MCP on postharvest conservation of roses cv. Vega. Ciên. Agrotec. 34: 1176-1183.

Pietro, J. D., B. H. Mattiuz, C. F. M. Mattiuz and T. J. D. Rodrigues. 2012. Quality of cut roses treated with natural products. Ciên. Rur. 42: 1781-1788.

Reichardt, K. 1985. Água: Absorção e translocação. In: Ferri, MG, editor. Fisiologia Vegetal. Vol. 1. São Paulo: Editora Pedagógica e Universitária Ltda, pp. 3-24.

Saeed, T., I. Hassan, N. A. Abbasi and G. Jilani. 2014. Effect of gibberellic acid on the vase life and oxidative activities in senescing cut gladiolus flowers. Plant. Grow. Reg. 72: 89-95.

Sanches, A. G., M. B. Silva, E. G. S. Moreira, J. M. Costa and C. A. M. Cordeiro. 2016. Stem cutting size and biofilm in longevity of ornamental ginger. Rev. Nativa. 4: 337-341.

Schmitt, F., V. Duarte, G. Shafer and R. J. Bender. 2013. Uso de sacarose nas soluções de manutenção de hastes florais de gérberas de corte. Rev. Bras. Hort. Orn. 19: 137-144.

Silva, L. R and S. M. Silva. 2010. Armazenamento de crisântemos brancos sob condição ambiente utilizando soluções conservantes. Sem. Ciên. Agr. 31: 85-92.

Spricigo, P. C., B. H. Mattiuz, J. Pietro, C. F. M. Mattiuz and M. E. M. Oliveira. 2010. Inibidor da ação do etileno na conservação pós-colheita de *Chrysanthemum morifoliu*m Ramat cv. Dragon. Ciên. Agrotec. 34: 1184-1190.

Vieira, M. R. S., D. C. Medeiros, P. N. Costa, C. M. G. Santos, R. A. Paes, L. M. S. Fernandez, N. G. Oliveira, N. G., A. Allan and F. Silva. 2012. Effect of refrigeration on post-harvest flowers. Afri. Jour. Biotech. 11: 13065-13068.