Potential use of germicides in vase solutions for gladiolus 'White Friendship' [1]

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ABSTRACT

Gladiolus (*Gladiolus* x *hortulanus*) is one of the most important crops for cut flowers worldwide, however having a short longevity. Usually, stems are harvested at the bud stage and need water and carbohydrates to support inflorescence development and to ensure flower quality. Vase solutions can supply these elements. However, sugars may benefit bacterial proliferation, which eventually can block xylem vessels. Bactericides potentially inhibit microorganism proliferation and new compounds are being tested constantly. This experiment was conducted to evaluate 'White Friendship' cut gladiolus performance in vase solutions with sodium dichloroisocyanurate dihydrate (Na-DCC), 8-hydroxyquinoline (8-HQ) or polymeric biguanide (PB). Inflorescences harvested at commercial maturity were placed in distilled water with 4% w/v of sucrose plus the germicides and kept under ambient conditions. Vase life, inflorescence postharvest development, fresh mass, membrane stability index and water relations were evaluated. There were no visual symptoms of toxicity in the treatments. The highest values of vase life, fully-open flowers, fresh mass and water balance were obtained with the Na-DCC treatment. Inflorescences treated with 8-HQ exhibited the highest values of solution uptake and wilting flowers. PB had a limited effect in gladiolus postharvest since the obtained results were similar to the sucrose alone. There was no effect of germicides on membrane stability index and its reduction was due to flower senescence progress only. Vase solution with Na-DCC plus sucrose improved water balance, increased open flowers, reduced wilting of flowers and fresh mass loss. Therefore, vase solutions with sucrose 4% w/v and Na-DCC enhance postharvest quality of cut gladiolus inflorescences.

Keywords: antimicrobial agents, flower quality, postharvest conservation, vase life.

RESUMO

Potencialidade do uso de germicidas em solução de manutenção para gladíolos 'White Friendship'

O gladíolo (*Gladiolus*x *hortulanus*) é uma das culturas mais importantes para flores cortadas em nível mundial, possuindo curta longevidade após o corte. Normalmente, as hastes são colhidas ainda no estádio de botão e precisam de água e carboidratos para sustentar o desenvolvimento pós-colheita da inflorescência e garantir a qualidade das flores. Para suprir essas necessidades são utilizadas soluções de vaso. No entanto, os açúcares presentes podem favorecer a multiplicação das bactérias, que bloqueiam os feixes vasculares. O uso de bactericidas evita o crescimento e a proliferação de microrganismos. O objetivo deste trabalho foi avaliar o comportamento pós-colheita do gladíolo 'White Friendship' mantido em soluciones de vaso com: dicloroisocianurato de sódio dihidratado (Na-DCC), 8-hidroxiquinolina ou biguanida polimérica (PB). Inflorescências com botões fechados foram colocadas em solução de água destilada com 4% w/v de sacarose, acrescida dos germicidas e armazenadas em condição de ambiente. Foram avaliadas vida de vaso, desenvolvimento pós-colheita da inflorescência, massa fresca, índice de estabilidade da membrana e relações hídricas. Não houve sintomas visuais de toxicidade nos tratamentos. Os maiores valores de vida de vaso, flores totalmente abertas, massa fresca e melhor equilíbrio hídrico, foram obtidos com Na-DCC. As inflorescências tratadas com 8-HQ apresentaram os maiores valores de absorção de solução e de flores murchas. O maior número de flores fechadas e menor equilíbrio hídrico foram obtidos com PB e sacarose só. A PB teve efeito limitado sobre a pós-colheita do gladíolo porque os resultados obtidos foram semelhantes aos obtidos com a solução de sacarose só. Não teve efeito dos germicidas no índice de estabilidade da membrana e sua diminuição deveu-se ao avanço da senescência da flor. A solução de vaso com Na-DCC mais sacarose melhorou o balanço hídrico, aumentou o número de flores abertas, reduziu as flores murchas e a perda de massa fresca. Assim, soluções de vaso com sucrose 4% w/v e Na-DCC favorecem a qualidade pós-colheita de gladíolos.

Palavras-chave: agentes antimicrobianos, conservação pós-colheita, qualidade floral, vida de vaso.

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1. INTRODUCTION

Gladiolus is one of the major commercial bulbous crops produced for cut flower worldwide. The value of the flower bulb industry is estimated to be over $1 billion. Seven of the most popular genera (*Crocus*, *Gladiolus*, *Hyacinthus*, *Iris*, *Lilium*, *Narcissus*, and *Tulipa*) represent about 90% of the production area devoted to geophytes (BENSCHOP et al., 2010).

Vase life is a standard for postharvest longevity of cut flowers and longer vase life is an important target for improving flower characteristics (YAMADA et al., 2003). Gladiolus cut inflorescences have a short vase life, ranging from 3 to 5 days, depending upon the cultivar (SEREK et al., 1994; KUMAR et al., 2012). Wilting of the petals, senescence of half- and fully-opened florets cause early senescence in flower spikes and limit the acceptability of cut gladiolus in national and international trade (MEMON et al., 2012).

Vase solutions supply water and sugars that support inflorescence postharvest development and enhance flower quality and they are particularly useful when flowers must be harvested and transported in bud stage and flower opening occurs afterwards (SINGH et al., 2008).

Exogenous supply of sucrose, the most commonly sugar used in cut flower postharvest, provides substrates for respiration; maintains flower turgidity and improve water balance in cut flowers. However, sugar can stimulate the bacteria proliferation, which eventually leads to block xylem vessels (KNEE, 2000; PUN and ICHIMURA, 2003).

Biocides addition in floral preservatives maintains transparency in the solution and prevent blockage of xylem elements by controlling microorganism growth (KNEE, 2000). In gladiolus cut flowers, some chemical compounds have been used to control proliferation of microorganisms in vase solutions (PAL and SIROHI, 2007; KUMAR et al., 2012). However, antimicrobial substances, when used at concentrations that adequately control microbe growth, may be toxic to cut flowers, dangerous to human health and/or pollute the environment (DAMUNUPOLA and JOYCE, 2008).

Quinoline compounds may act as antimicrobial agents that delay wilting, help to reduce stem plugging and minimize losses in chlorophyll and carbohydrates content (EGILMABI and AHMED, 2009; KUMAR et al., 2012). Sodium dichloroisocyanurate dihydrate is an alternative slow-release chlorine compound that contains much more free available chlorine (FAC) that sodium hypochlorite, it is slightly toxic, not corrosive or carcinogenic, and does not bioaccumulate (CLASEN and EDMONSON, 2006). It has been successfully used in vase solutions for cut flowers like roses, miniature roses and orchids (KETSA and CHINPRAYOON, 2007; KETSA and DADAUNG, 2007; SATTAYAWONG et al., 2010).

New antimicrobial compounds are being developed and tested, and some of those can be nontoxic to cut flowers (VAN DOORN, 2012). Polymeric biguanides are active compounds with widespread antimicrobial action, reduced foam formation, highly soluble in water, allowing transparent solutions and, different from another disinfectants, like chlorine, organic material presence has no effect on its activity (FRANZIN, 2007).

The aim of this work was to evaluate 'White Friendship' cut gladiolus postharvest in vase solutions with the germicides: sodium dichloroisocyanurate dihydrate (Na-DCC), 8-hydroxyquinoline (8-HQ) and polymeric biguanide (PB)

2. MATERIAL AND METHODS

Inflorescences of gladiolus (*Gladiolus* x *hortulanus*) 'White Friendship' at commercial harvest stage, i.e. completely closed flowers, were obtained from a commercial producer in November, 2012 in Vargem Grande do Sul (21º50'28" S and 46º53'59.81" W, at an altitude of 710 m), São Paulo state, Brazil. They were transported in tap water, kept at vertical position and air conditioned to the laboratory, within 6 hours of harvest. Spikes were cut under water (80 cm long) and placed in the following vase solutions:

- Sucrose 4% w/v
- Sucrose 4% w/v + 0.66 mg L^{-1} Sodium dichloroisocyanurate dihydrate 6.25% (Sumaveg®) (Na-DCC)
- Sucrose 4% w/v + 200 mg L^{-1} 8-Hidroxiquinoline (Sigma-Aldrich) (8-HQ)
- Sucrose 4% w/v + 1500 mg L^{-1} Polymeric Biguanide 8% (Nippo-Lat IB®) (PBI)
- Sucrose 4% w/v + 3000 mg L^{-1} Polymeric Biguanide 8% (Nippo-Lat IB®) (PBII)

Flowering stems were kept in these solutions for the experimental duration and the environmental conditions consisted of 21.0±0.3 °C, relative humidity of 37±4 % and 12-h of ceiling fluorescent light. Evaluations were made every three days considering the following variables:

Inflorescence vase life. Days until complete wilting of third flower from the bottom of each inflorescence (SEREK et al., 1994).

Inflorescence postharvest development. Counting of tight buds, fully-open, wilting (SEREK et al., 1994) and tight flowers.

Inflorescence fresh mass (FM). Determined by weighing the three inflorescences in each repetition (IMSABAI et al., 2013).

Membrane stability index (MSI). Five tepal discs (1 cm^2) of the third floret from the basal end of the spike were carefully rinsed in deionized water prior to incubation in 5 mL of deionized water in test tubes. After 3 hours at room temperature, electrical conductivity (value A) was measured. Tubes were boiled for 15 min to kill the tissue. After cooling to room temperature, electrical conductivity (value B) was measured again. Potassium chloride (0.01 mM) was used as standard, which gives specific conductance of 1.41 dS m^{-1}. MSI was calculated by using the formula:

$$MSI\ (\%) = \left[1 - \left(\frac{value\ A}{value\ B}\right)\right] \times 100$$

(SINGH et al., 2008)

Water relations. Solution uptake was obtained by difference between initial and each evaluation day volume recorded using graduated cylinder. Water loss (transpiration estimate) was assessed by weighing. The water balance (difference between the rate of solution uptake and water loss) was calculated from the solution uptake and water loss data (IMSABAI et al., 2013).

A complete randomized 5x4 factorial design was used, comprehending 5 solutions and 4 evaluation times, with three replications and three inflorescences per replication. Data were subjected to analysis of variance and means were compared by Tukey test at 5% probability, using the analytical software Statistix for Windows version 8.0.

3. RESULTS AND DISCUSSION

Inflorescence vase life

There was no effect of germicides in gladiolus vase life. The longest vase life recorded was with Na-DCC treated stems and the shortest when 8-HQ was used, 11.3 and 9.0 days, respectively, but these values had no statistical differences to the sucrose solution alone. Inflorescences in vase solutions with polymeric biguanide had similar vase life that those in the sucrose solution alone, 9.7 and 10.7 days, respectively (Figure 1). Visual symptoms of toxicity were not observed in all the treatments during the experiment.

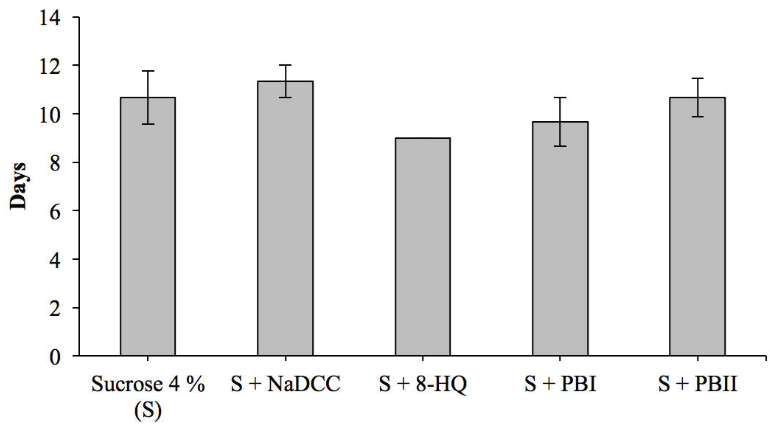

Figure 1. Vase life (days) for gladiolus'White Friendship' inflorescences in holding solutions with sucrose (4%) and different germicides. Data are means (n=9) ± SE.
S: Sucrose 4%; NaDCC: Sodium dichloroisocyanute dihydrate; 8-HQ: 8-Hidroxyquinoline; PBI: Polymeric biguanide 1500 mg L^{-1}; PBII: Polymeric biguanide 3000 mg L^{-1}

The results obtained in this experiment are similar to findings in cut roses, miniature roses and orchids, where Na-DCC significantly increased the vase life, reduced total microbial count in vase solution and eliminated "bent neck", when compared with tap water, sucrose, 8-HQS and Physan-20, in different combinations and concentrations (KETSA and CHINPRAYOON, 2007; KETSA and DADAUNG, 2007; SATTAYAWONG et al., 2010).

It was found that use of quinoline compounds (8-Hydroxyquinoline sulfate or citrate) in pulsing or vase solution prolonged vase life in gladiolus 'White Prosperity' and cut roses, and that sucrose addition had a synergistic effect with germicides (SINGH and SHARMA, 2003; EGILMABI and AHMED, 2009; KUMAR et al., 2012). On the other hand, hidroxyquinoline solutions had no effects on flower longevity or quality maintenance of cut chrysanthemums (*Dendranthema grandiflora* T.) 'Calabria' (SILVA and SILVA, 2010) and Ketsa and Chinprayoon (2007) recorded significant differences in vase life as response to vase solutions with 8-HQS in some miniature rose cultivars. Therefore, reduced efficacy of 8-HQ in extend vase life of gladiolus 'White Friendship' may be associated with cultivar differences.

Inflorescence postharvest development

Germicides affected the following parameters: number of tight buds, fully-opened and wilting flowers (Table 1). Lowest values for fully-open and wilting flowers were obtained with polymeric biguanide (PBI and PBII) and sucrose solution only, indicating no positive effect of PB on gladiolus postharvest development.

Table 1. Fully-open, wilting flowers and unopened buds in gladiolus'White Friendship' inflorescences in holding solutions with sucrose (4%) and different germicides at three, six, nine and 12 days.

Treatment	Evaluationday			
	3	6	9	12
	------------ *Fully-open flowers* ------------			
Sucrose 4% (S)	0.4 Ab	2.0 Aab	3.3Ba	1.0 Bb
S + NaDCC	0.1 Ac	2.3 Ab	5.9 Aa	4.9 Aa
S + 8-HQ	0.1 Ab	3.9 Aa	4.3 ABa	4.4 Aa
S + PBI	0.3 Ab	3.1 Aa	3.0 Ba	1.2 Bb
S + PBII	0.0 Ac	2.3 Aab	3.3 Ba	1.3 Bbc
	------------ *Wilting flowers* ------------			
Sucrose 4% (S)	0.0 Ab	0.4 Ab	1.3 Bb	4.4 Ba
S + NaDCC	0.0 Ac	0.1 Ac	1.4 Bb	5.8 ABa
S + 8-HQ	0.0 Ac	0.1 Ac	4.0 Ab	6.4 Aa
S + PBI	0.0 Ac	0.8 Ac	3.0 Ab	6.4 Aa
S + PBII	0.0 Ac	0.2 Ac	2.8 ABb	5.2 ABa
	------------ *Unopened buds* ------------			
Sucrose 4% (S)	10.3 Aa	6.8 Ab	7.1Ab	6.9 Ab
S + NaDCC	9.8 Aa	5.1 ABb	3.8 BCc	3.0 BCd
S + 8-HQ	8,0 Aa	3.9Bab	2.2 Cb	1.8 Cb
S + PBI	9.4 Aa	4.6 ABb	4.9 Bb	3.7 BCb
S + PBII	9.9 Aa	5.6 ABb	5.4 ABb	5.8 ABb

Means followed by the same letter (capital in columns; minor in lines) are not significantly different according to Tukey test at a $\alpha \leq 0.05$.

NaDCC: Sodium dichloroisocyanute dihydrate; 8-HQ: 8-Hidroxyquinoline; PBI: Polymeric biguanide 1500 mg L^{-1}; PBII: Polymeric biguanide 3000 mg L^{-1}

The use of Na-DCC and 8-HQC on vase solutions resulted in the highest values for fully-open flowers and according to Singh and Sharma (2003) the use of 8-HQC plus sucrose improved gladiolus flower opening and significantly increased flower diameter.

Snapdragon, roses and orchids harvested in bud stage and kept in solutions with sucrose and bactericides (citric acid, 8-HQC, 8-HQS or Na-DCC) showed better development, revealing that opening is significantly enhanced when flowers are placed in appropriate preservative solution (DIAS and REDDY, 2004; SATTAYAWONG et al., 2010; VIEIRA et al., 2010).

The lowest value for tight flowers was observed for the 8-HQ vase solution on the 12th day of evaluation, i.e. 1.8 flowers, demonstrating a positive effect of this germicide on the postharvest development of inflorescences. Vase solutions including a suitable biocide can improve flower opening and prolong life beyond normal water or a sugar solution (KNEE, 2000).

The highest value for wilting flowers was recorded for the 8-HQ solution at the 9thday of evaluation, indicating that individual flowers from inflorescences treated with 8-HQ wilted faster than those treated with Na-DCC and sucrose alone. Treatment with sucrose solution alone showed the lowest value for fully-open flowers and for wilting flowers, i.e. 3.3 flowers at the 9th day of evaluation and 4.4 flowers at the 12th day of evaluation, respectively.

Highest number of tight buds was obtained in the sucrose solution alone, in accordance with Memon et al. (2012) who observed the highest value of tight flowers in cut gladiolus inflorescences kept in distilled water or sucrose without chemical preservatives.

For all the treatments, the highest number of tight buds was recorded at the 6th day of evaluation. At the 9th

day of evaluation was recorded the highest number of fully-opened flowers and at the 12th day, the highest value for wilting flowers.

Gladiolus performance in this experiment is according to Yamada et al. (2003) who described inflorescence development in gladiolus 'Traveler' as following: three days before flower opening, petals begin to be apparent between bracts (tight buds), and they are totally emerged one day before complete flower opening. When the gladiolus flower is fully open, first signals of wilting appear and three days later, flowers are completely wilted.

Inflorescence fresh mass (FM)

Inflorescences were weighed initially (day 0) and the fresh mass mean was 204.1g. Germicides had effect in FM of gladiolus cut inflorescences. Highest values were recorded in Na-DCC and 8-HQ treatments (Figure 2).

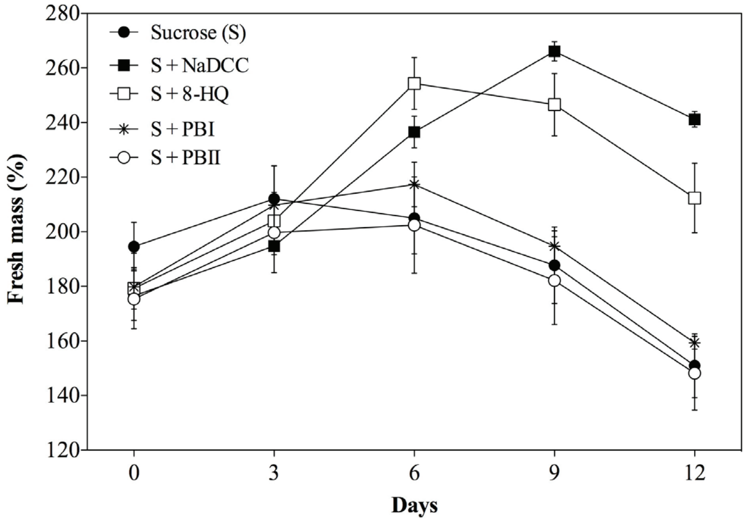

Figure 2. Fresh mass variation in gladiolus 'White Friendship' inflorescences in holding solutions with sucrose (4%) and different germicides at three, six, nine and 12 days. Data are means (n=9) ± SE. NaDCC: Sodium dichloroisocyanute dihydrate; 8-HQ: 8-Hidroxyquinoline; PBI: Polymeric biguanide 1500 mg L^{-1}; PBII: Polymeric biguanide 3000 mg L^{-1}

Lowest values were found with PB and sucrose solution alone, similar to Ketsa and Chinprayoon (2007), who found that FM of miniature cut roses placed in tap water, declined rapidly after 2-3 days when compared with those placed in vase solutions with sucrose and germicides. Thus, it is possible that PB had no germicide effect in vase solutions for cut flowers.

Increase of fresh mass in this experiment until the 9th day of evaluation indicates the non-toxicity of the tested compounds; the following decrease is a consequence of expected senescence. Knee (2000) affirms that toxicity of biocides in floral preservatives can be evidenced by flower opening inhibition and early decline in fresh mass.

FM increased in all the treatments until the 6th day of evaluation and then decreased, except in inflorescences in the sucrose only solution, where fresh mass decreased since the 3rd day of evaluation. Similar results were obtained by Ezhilmathi et al. (2007) and Waithaka et al. (2001) in gladiolus kept in distilled water plus sucrose 4% and 8-HQC solution, respectively. These results probably reflect cell expansion and the necessary manufacture of new cell walls and other components for the expanding cells (WAITHAKA et al., 2001).

Only inflorescences treated with Na-DCC, increased FM until the 9th day of evaluation. This fact may be due to a higher number of fully-open flowers found in this treatment. The Na-DCC use allowed higher fresh mass increase and delayed decline in cut roses and orchids, suggesting an absence of vascular blockage in the inflorescences (KETSA and DADAUNG, 2007; SATTAYAWONG et al., 2010).

Membrane stability index (MSI)

Use of germicides caused no significant effects in MSI values and it diminished only in consecutive evaluations (Figure 3), probably due to senescence process. Thus, it is possible that chemicals used as germicides caused no additional damages to membranes, probably indicating their low toxicity to cut gladiolus.

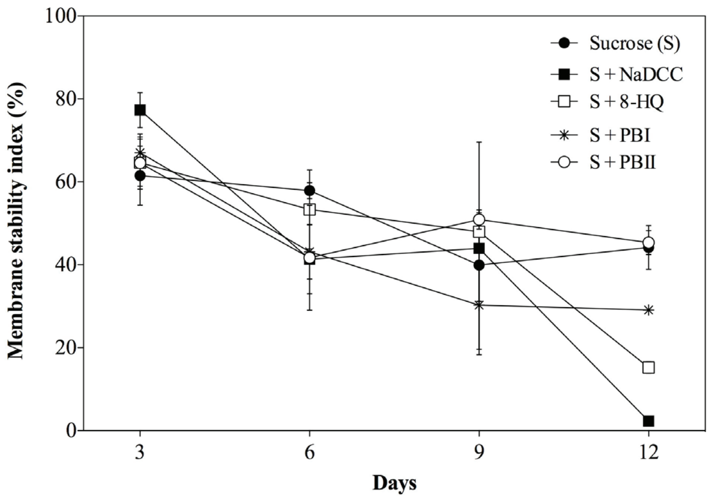

Figure 3. Membrane stability index in gladiolus 'White Friendship' flowers in holding solutions with sucrose (4%) and different germicides at three, six, nine and 12 days. Data are means (n=9) ± SE. NaDCC: Sodium dichloroisocyanute dihydrate; 8-HQ: 8-Hidroxyquinoline; PBI: Polymeric biguanide 1500 mg L^{-1}; PBII: Polymeric biguanide 3000 mg L^{-1}

The MSI reduction along the experiment was similar to Ezhilmathi et al. (2007), who observed that in gladiolus 'Green Willow', where the MSI varied little in the first stages of postharvest cut flowers, but thereafter decreased rapidly with the flower age, achieving the lowest value with flower senescence. During petal wilting, cellular membranes progressively lose their integrity, resulting in leakage of pigments, nutrients and electrolytes from the petal cells (RUBINSTEIN, 2000).

Water relations

Solution uptake. Germicides affected solution uptake in gladiolus inflorescences. Maximum values were recorded for the 8-HQ solution and the lowest, in the sucrose solution alone (Figure 4a). Similar results were obtained with cut flowers of gladiolus 'White Prosperity' and miniature roses (SINGH and SHARMA, 2003; KETSA and CHINPRAYOON, 2007). Solution uptake was reduced on the experimental course, therefore, it is possible that germicides action decreased gradually too.

Asrar (2012) found that 8-HQS plus sucrose in vase solution was more effective in maintaining water uptake than 8-HQS or sucrose used alone, and suggested that germicide use increased fresh mass because the treatment prevent microorganism growth in xylem and thus, water uptake is maintained. The use of 8-HQS plus sucrose improved absorption of vase solution in gerbera cut flowers, reflecting the inhibitory effects of 8-HQS on bacterial colonization and clogging xylem vessels in cut surface of the flower stems (BANAEE et al. 2013). Inclusion of germicides in vase solutions helps to maintain high turgidity level in the gladiolus cut spikes, thereby prolonging their vase life (SINGH and SHARMA, 2003).

At the 3rd day of evaluation, solution uptake was the lowest in Na-DCC treatment and similar values were maintained until the 12th day of evaluation, possibly indicating a prolonged action of Na-DCC to inhibit bacterial growth and consequently, vessels clogging. In 8-HQ treatment, solution uptake increased until the 6th day of evaluation and then, it decreased rapidly. Results obtained in this experiment are different from Ketsa and Chinprayoon (2007), who registered higher solution uptake in 8-HQS, when compared to Na-DCC solution in cut miniature roses.

Solution uptake in polymeric biguanide and the sucrose solution alone decreased rapidly until the 12th day of evaluation, when all the treatments obtained values lower than Na-DCC solution (Figure 4a). A reduction in germicides efficiency during time allowing bacterial proliferation may explain these facts.

Na-DCC is a slow-release chlorine compound and its efficiency can be influenced by stem surface texture and number of stems in the vase (CLASEN and EDMONSON, 2006; XIE et al., 2008). Thus, it is possible that free available chlorine (FAC) of Na-DCC, a low number of gladiolus inflorescences per flask and/or its smooth (waxy) surface allowed this compound to act for a longer time.

Sucrose and germicides work primarily by improving solution uptake of cut flowers (KETSA and CHINPRAYOON, 2007) and this may explain fresh mass and postharvest development data of gladiolus 'White Friendship' inflorescences.

Water loss (transpiration estimative). Germicides affected water loss in gladiolus cut inflorescences. The lowest value was obtained in Na-DCC treatment and the highest, in 8-HQ treatment. Polymeric biguanide and sucrose alone solutions had similar water loss values (Figure 4b).

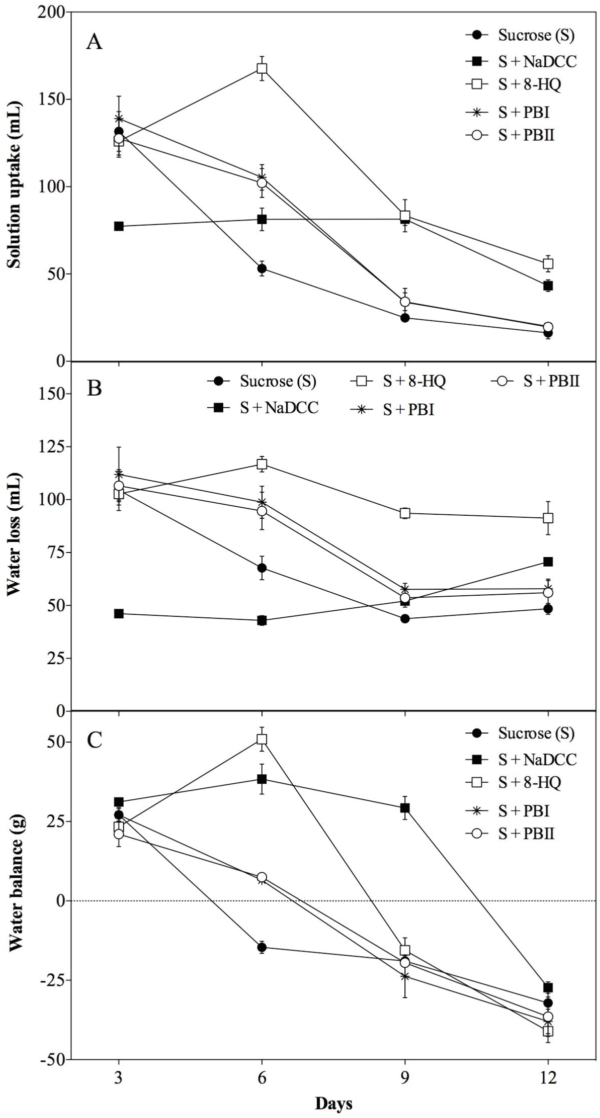

Figure 4. Water relations in gladiolus 'White Friendship' inflorescences in holding solutions with sucrose (4%) and different germicides at three, six, nine and 12 days. (a) Solution uptake; (b) Water loss; (c) Water balance. Data are means (n=9) ± SE. NaDCC: Sodium dichloroisocyanute dihydrate; 8-HQ: 8-Hidroxyquinoline; PBI: Polymeric biguanide 1500 mg L^{-1}; PBII: Polymeric biguanide 3000 mg L^{-1}

In general, water loss decreased during the time. It was higher at the 3rd day of evaluation and diminished up to the 12th day of evaluation, except for Na-DCC. Inflorescences in Na-DCC treatment had the lowest water loss up to the 6th day and these values were lower than solution uptake until the 12th day of evaluation. In the other treatments, water loss decreased rapidly up to 9th day. There are two ways to avoid early flower wilting: prevent the decrease in water uptake or reduce transpiration rate (VAN DOORN, 2012). In agreement with the results obtained, Na-DCC probably had positive effects on both of them and consequently, on flower turgidity and freshness.

Water balance. Germicides used had effect on water balance of cut gladiolus and it diminished rapidly along the experiment time too (Figure 4c). Inflorescences in the sucrose solution alone achieved negative balance earlier, followed by polymeric biguanide treatments, 8-HQ and finally, Na-DCC. These results showed that Na-DCC and 8-HQ had positive effects and enhanced water balance on gladiolus cut flowers. Results for cut snapdragon and roses suggested that 8-HQS and Na-DCC may reduce vase bacterial proliferation and improve water balance (ASRAR, 2012; KETSA and DADAUNG; 2007).

The lowest quantity of fully-open flowers in the sucrose solution alone and polymeric biguanide treatments, may have caused a lower solution uptake and a negative water balance, because water and carbohydrates are necessary for postharvest development of inflorescences (SINGH et al., 2008).

Use of Na-DCC caused significant reduction in water loss in all days of evaluation, facilitating a positive water balance of inflorescences. The water balance had similar performance to the fresh mass, in accordance with Imsabai et al. (2013) in cut lotus (*Nelumbo nucifera)*.

4. CONCLUSION

The Na-DCC improved water balance, increased open flowers and reduced wilting flowers and fresh mass loss, yet the combined positive effects above did not reflect in vase life extension compared to sucrose alone treated stems. Therefore, the treatment 4% w/v and Na-DCC is effective for enhancing postharvest quality of cut gladiolus inflorescences.

AUTHORS CONTRIBUTION

M.C.C.: Creation of the idea, literature review, laboratory analysis and data collection, statistical analysis of data, preparation of the basic text of the work. B.H.M.: Creation of the idea, obtaining of funds and materials, orientation and coordination of the work, important suggestions incorporated to the work. A.C.C.M.: Laboratory analysis and data collection, suggestions assimilated in the text. C.F.M.M.: Creation of the idea, orientation of the work, important suggestions incorporated to the work.

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