Comparison of postharvest commercial products in two varieties of spray chrysanthemum on the Bogota Plateau

Comparación de productos comerciales usados en la poscosecha de dos variedades de pompón en la sabana de Bogotá

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ABSTRACT

The ornamental quality of chrysanthemum (*Dendranthema grandiflorum* (Ramat.) Kitamura) is affected by postharvest premature senescence of foliage. The longevity of the flower stem is limited by yellowing of the foliage while the flower itself maintains ornamental value. The objective of this research was to compare the efficiency of anti-senescence and hydrating commercial products used in postharvest handling of the chrysanthemum varieties Polaris and Yellow Polaris. The variables floral longevity, relative water content (RWC) and chlorophyll content were measure. Flowering spray chrysanthemum stems underwent vase life evaluation for 10 days. In the beginning, there were differences between treatments in the content of chlorophyll; however, the onset of premature senescence symptoms on the foliage can be delayed through the application of treatment RVB clear (hydrating and bactericide, it's contains a complex of biocide, organic acidifying and surfactant) in a hydration solution or in a mixture with the SVB treatment (foliar anti-senescence based on hormones). We determined a total chlorophyll content of 0.011 mg g^{-1} of leaf fresh weight as a threshold, above which no symptoms of yellowing foliage are visible in spray chrysanthemum. For the variable RWC, a differential effect of the treatments was not seen for the tested varieties. There was also no correlation between hydration status and chlorophyll content in the foliage.

Key words: senescence, *Dendranthema*, chlorophyll degradation, floral longevity.

RESUMEN

La calidad ornamental del pompón (*Dendranthema grandiflorum* (Ramat.) Kitamura) en poscosecha se ve afectada por la senescencia prematura del follaje. La longevidad del tallo floral está limitada por el amarillamiento del follaje mientras la flor se mantiene con valor de ornato. El objetivo de esta investigación fue comparar la eficiencia hidratante y antisenescente de productos comerciales empleados en el manejo poscosecha de las variedades de pompón Polaris y Yellow Polaris. Las variables evaluadas fueron longevidad floral, contenido relativo de agua (CRA) y contenido de clorofila. Los tallos florales de pompón fueron sometidos a evaluación en florero durante 10 días. En los primeros días se observaron diferencias entre los tratamientos en cuanto al contenido de clorofila; sin embargo, la forma prematura de aparición de síntomas de senescencia en el follaje puede ser retardada a través de la aplicación del tratamiento RVB clear (hidratante y bactericida que contiene un complejo de biocidas, acidificante orgánico y surfactante) en la solución de hidratación o en mezcla con el tratamiento SVB (antisenescente foliar a base de hormonas). Se determinó el contenido de clorofila total de 0,011 mg g^{-1} de masa fresca foliar como umbral, por encima del cual no se manifiestan síntomas visibles de amarillamiento del follaje de pompón. Para la variable CRA no se encontró un efecto diferencial de los tratamientos en las variedades evaluadas. Tampoco se encontró correlación entre el estado de hidratación y el contenido de clorofila en el follaje.

Palabras clave: senescencia, *Dendranthema*, degradación de clorofila, longevidad floral.

Introduction

Chrysanthemums are native from China and Japan, countries which give a high cultural value to these flowers and rank the flowers as economically representative. Japan leads production with 2 billion stems per year. Colombia is the third largest producer of chrysanthemums in the world with a production volume of 600 million stems annually (Teixeira da Silva, 2003).

Spray chrysanthemums present problems for longevity and decorative quality due to yellowing foliage while the flower stays fresh; the rate at which these symptoms begin to occur is due to factors specific to the species, variety and agronomic and postharvest factors (Yakimova *et al*., 1996). Some varieties demanded by the market, such as Polaris and Yellow Polaris, show yellowing and premature leaf senescence, which affect quality and duration of the flower vase life.

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Chrysanthemums have a long vase life when the flower is handled properly, sometimes lasting 20 to 30 d; this has been attributed to low ethylene production during senescence (Teixeira da Silva, 2003). The main problems encountered in postharvest are related to insufficient hydration of the stems after cutting, which causes premature wilting and yellowing of the foliage. That is, proper hydration is vital for a long vase life in chrysanthemums in general (Reid, 2004).

Studies have been conducted (Yakimova *et al*., 1996; Van Doorn and Vaslier, 2002; Çelikel and Reid, 2002; Reid, 2004) with the application of sugars, hormones and hydration potentiators used in solutions with the aim of solving postharvest problems presented in this ornamental species.

The postharvest hydrating treatments are specifically designed to maintain the water balance of the plant; this balance can be influenced by the rate of transpiration and water flow in the vascular bundles. According to Paulin (1997), dehydration losses that exceed 7% of the floral weight are sufficient to cause a considerable loss of longevity in vase life.

Water flow can be affected by conductive vessel occlusion as a physiological response to cutting of the stem in order to seal the wound with callose which impedes the adequate hydration of the flower. The reduction in the quality of the cut flower has also been attributed to the formation of air embolisms which can partially or completely block the transport of water or hydration solutions to the rest of the stem, resulting in water stress. However, occlusions in the xylem result in physiological oxidation due to the peroxidase and catechol oxidase activities (Yakimova *et al*., 1996).

Obstruction of the stem is located at the lower end; the occlusion segment length is defined by the time at which the stem has been exposed to air. Van Doorn and Vaslier (2002) reported a decrease of vascular obstruction with the application of treatments with oxidase inhibitors such as catechol and hydroquinones which are peroxidase inhibitors. The effect of oxidase inhibitors delays the onset of symptoms of foliage yellowing and senescence and drives the increase in phenoloxidase activity, limiting the development of the occlusion. They also concluded that, in the case of chrysanthemum, when the stem remains exposed to air for longer than 180 min, the rate of water uptake did not recover and remains low. It has also been estimated that after a period of 60 min in air after being harvested, flower stems have the ability to recover the optimum rate of hydration. When the flower remains for short periods of time without hydration, the leaves do not wilt and recover their turgidity when removing segments of obstruction in the basal part of the stem.

The conducting vessel blockage is also due to microbial growth. Microorganisms in the water break down plant material, forming mucilages that clog the vascular bundles. NaOCl (chlorine bleach) is used as a bactericide which increases the vase life of chrysanthemums and generally for cut flowers. In comparing distilled water management with the presence of a bactericide in the vase solution, Celikel and Reid (2002) observed that vascular occlusion is reduced, permitting normal hydration of the flower.

Hydration with solutions containing 6-benzyl adenine, a cytokinin, was effective for delaying foliage yellowing in some varieties of chrysanthemum; however, these treatments are not yet commercially used. The foliage yellowing of some varieties is specific and is caused by poor handling in the field, inappropriate storage or use of preservative solutions at higher doses than recommended (Reid, 2004). According to Yakimova *et al*. (1996), postharvest treatment with cytokinin in cut flowers retards senescence processes. The response to the application of these hormonal compounds depends on the cultivar, stage of flower development and type of cytokinin.

The postharvest flower senescence rate is defined by the reserves of carbohydrates and sugar content which allow the stem to remain without symptoms (Yakimova *et al*., 1996). The oxidation of sugars seeks to maintain energy sources to withstand the stress of the cut flower. Yakimova *et al*. (1996) reported that treatment with sucrose and chlorsulfuron, a phenylurea with cytokinin activity, affects the activity of the enzymes α-amylase and invertase. These enzymes decompose glucose molecules and therefore are associated with the appearance of the first symptoms of senescence in chrysanthemum.

Reyes-Arribas *et al*. (2001) observed the behavior of chrysanthemum cv. Boaldi, a functional mutant with the ability to retain chlorophyll and soluble proteins that can maintain its green color foliage longer. The functional phenotypes called stay-green show a reduction in the rate of senescence, suggesting that foliage yellowing can be regulated by the expression of genes involved in this process.

According to Hortensteiner (2006), the degradation reactions of chlorophyll initially present steps common to all plants and it's been identified plants with mutations in the genes encoding the enzymes responsible for this process, such as chlorophyllase (CLH), pheophorbide α oxygenase (PAO) and catabolite ruductase (RCCR).

Importantly, one mole of chlorophyll contains four moles of nitrogen, but chlorophyll provides only 2% of the total nitrogen in the cell. Therefore, the degradation of chlorophyll does not involve significant amounts of nitrogen in plant senescence and foliar discoloration. The correlation between this process and the degradation of other proteins was also highlighted (Hortensteiner, 2006).

Postharvest problems in cut flowers include premature wilt due to contamination in the vase solution and curvature of the stem in response to ethylene. It has been shown that the longevity of flowers increases with the application of a pretreatment with silver thiosulfate or with 1-methylcyclopropene, which inhibit the effect of ethylene on the petals and abscission of foliage (Çelikel and Reid, 2002).

Woltering (1987) reported no effect of ethylene on chrysanthemum senescence at concentrations below 15 mL L^{-1}. Ethylene can accelerate the loss of chlorophyll in leaves in higher concentrations for some varieties of chrysanthemum sensitive to the presence of the hormone. However, the chrysanthemum is considered a species with low ethylene production during senescence (Teixeira da Silva, 2003) and insensitivity to this hormone (non-climacteric species) and so, in commercial production, anti-ethylene treatments are not considered to protect the quality of the flower.

'Polaris' and 'Yellow Polaris' are handled commercially as spray type chrysanthemums and are susceptible to premature foliage yellowing but remain in the market due to high demand for its colors and the impossibility of being replaced by other less susceptible varieties. The present study aimed to evaluate and compare the efficiency of anti-senescence and hydrating commercial products used in postharvest handling of these varieties of chrysanthemum; and sought to determine the relationship between premature foliage yellowing and the hydration status of the chrysanthemum stems.

Materials and methods

The field essay was developed in the growing area of a commercial leader in the production of export type chrysanthemum, located in the municipality of Madrid (Cundinamarca), at 2,550 m a.s.l., with an average temperature of 14°C and 75% relative humidity. Flowering stems were harvested from plants grown under greenhouse conditions. 'Polaris' and 'Yellow Polaris', white and yellow respectively, were evaluated, which are managed commercially as spray type chrysanthemums.

Treatments were commercial products used in the postharvest hydration of cut flowers, their dosage and characteristics are presented in Tab. 1.

After cutting, the flower was hydrated in the field with the treatment solutions and held for three hours in a cool environment (15°C); bunches of 10 floral stems were fitted with a cap and immediately placed in hydration solutions and transported to the postharvest area where hydration was completed. Then transport was simulated. The bunches were packed in cardboard boxes of the type used for export and covered with transparent plastic. The box remained uncovered in a pre-cooled room for about 30 min, internal

TABLE 1. Description of the evaluated treatments with hydrating and foliage anti-senescence activity, applied at postharvest in the hydration solution for the spray chrysanthemums 'Polaris' and 'Yellow Polaris'.

Treatment	Dose	Product characteristics
RVB clear*	5 mL L^{-1} of water	Hydrating and bactericide, contains a complex of biocide, organic acidifying and surfactant
SVB*	1 pill per 3 L of water	Foliar anti-senescence based on hormones
Professional #2*	10 mL L^{-1}	Mixture of hydrating (70%) and carbohydrates (30%)
BVB*	0.15 mL L^{-1} of water	Floral anti-senescence based on hormones, bactericide.
CVBn powder*	0.04 mL L^{-1} of water	Slow release chlorine and strong biocide.
SVB + BVB		Mixed at full dose
SVB + Professional #2		Mixed at full dose
BVB + RVB clear		Mixed at full dose
BVB + Professional #2		Mixed at full dose
Floríssima 525	3 mL $L^{-1}$of water	Hormones (gibberellins)
Floríssima Experta	10 mL L^{-1} of water	Strong bactericidal
Farm treatment		Iodine solution (bactericide y fungicide). Contains surfactant
Absolute Control		Potable water

* Products of Chrysal Colombia.

temperatures recorded between 3 and 4°C. The boxes were carried to a cold room (range 5-8°C), where they remained for 13 d. Next, the boxes were taken to the area of floral longevity assessment, where the stems were placed in vases for observation of the evaluated variables for 10 d.

Evaluated variables

Floral longevity

Floral longevity was measured by the number of days in which both the flower and foliage held ornamental characteristics. During this evaluation, qualitative measurements were taken for the state of the flower and foliage. For the flower, the characteristics observed were opening, size, color and floral hydration status. For foliage, observations were taken regarding the presence of chlorosis, hydration status, leaf mottling and presence of pests and diseases. The scored was based on a scale of values from 0 to 10, where 0 represents the lowest score for a feature.

Chlorophyll content

The chlorophyll quantification was done with fresh plant material obtained from flower stems during the floral longevity assessment. The measurement was based on Novoa and Villagran (2002); basically, a foliage sample of 3 g was placed in a mortar and macerated with a solution of 10 mL of 80% acetone. Next, the obtained solution was placed in a Falcon tube and centrifuged for 15 min at 3,000 rpm. Then, 1 mL of supernatant was taken and measured in a spectrophotometer, at absorbance of 663 nm and 645 nm for chlorophyll a and b, respectively, with a transmittance of 100 for both readings. The total chlorophyll amount in mg of chlorophyll per g fresh weight was obtained with Eq. [1]. There were four sampling points on days 0, 3, 6 and 10 after unpacking.

$$\text{Total chlorophyll} = \frac{(20{,}2 * D_{645}) + (8{,}02 * D_{663}) * V}{1000 * W} \quad (1)$$

Where D = optical density, V = volume of extract used in the determination of the optical density, W = weight of initial tissue (3 g foliar tissue).

Relative water content

The relative water content (RWC) was calculated from fresh foliar material obtained in four sampling points during the evaluation of floral longevity. The procedure consisted of taking leaf samples and after measuring fresh weight (Fw), the sample was hydrated at 4°C for 24 h in order to obtain turgid weight (Tw). Finally, the sample was exposed to 80°C until constant weight and the dry weight (Dw) was obtained. The value of RWC is given by Eq. [2].

$$RWC = \frac{Fw - Dw}{Tw - Dw} * 100 \quad (2)$$

Where, Fw = fresh weight, Dw = dry weight, and Tw = turgid weight

During the floral longevity evaluation RWC, was measured on days 0, 3, 6 and 10; and in the second phase of the trial, it was also measured at the time of the cutting, at 1.5 and 3 h of the start of the treatment .

This research was conducted in two phases, in which we considered the variables described above. In the first, from a group of thirteen treatments (Tab. 1), those with the best obtained results in both varieties were selected; and in the second phase, we evaluated the effect of the treatments that showed greater effectiveness for hydrating and foliage anti-senescence action in the previous phase. Also, the farm and absolute controls were evaluated, plus the combination RVB clear + SVB to consider a promising mixture based on the results from Phase I.

We used a completely randomized design and the data were statistically analyzed with the SAS® 9.0 software (Statistical Analysis System).

Results

Quantitative evaluation

Based on a correlation coefficient of r^2 = -0.24, it was determined that the chlorophyll content in spray chrysanthemum leaves is not related to the RWC, therefore it is inferred that premature yellowing foliage is not determined by the state of hydration of the flower stem. However, the turgidity state of the leaves formed part of the assessment for the vase evaluation, as a parameter of floral quality rating.

Relative water content

This variable was measured in order to monitor the hydration status of the foliage. At harvest time of the spray chrysanthemum stems, the soil moisture content in the growing beds was uniform, without restricting water to the development of plants. However, the overall mean RWC in the three measurements before the simulated transport was significantly higher in 'Polaris' (Tab. 2), as compared with 'Yellow Polaris' ($P \leq 0.05$).

This difference in water status may be attributed to characteristics of the varieties regarding their water retention capacity in the leaf tissue and not to field conditions or due to the effect of the treatments. In effect, there was no difference between treatments in each of the varieties, that is, no treatment immediately hydrated better or worse compared to the others. Consequently, all the flower stems entered the transport simulation in the same state of hydration.

TABLE 2. Averages of relative water content (RWC) in leaf tissue of spray chrysanthemum cvs. Polaris and Yellow Polaris, with three measurements during postharvest hydration prior to the start of the simulated transport.

Variety	Average RWC (%)		
	At cutting	1.5 h later	3 h later
Polaris	65.205 a	60.9487 a	66.334 a
Yellow Polaris	57.719 b	58.4137 b	58.310 b

Means followed by the same letter in the columns are not significantly different according to t test ($P \leq 0.05$).

In the first sampling point of RWC, after transport simulation (day 0), no difference was found in the state of hydration of the flowering spray chrysanthemum stems subjected to different treatments, but there was between varieties. 'Polaris' RWC obtained 57% and 'Yellow Polaris' 53%. Meanwhile, in the samples for days 3, 6 and 10 there were no significant differences between varieties for foliar hydration status (Tab. 3).

For sampling day 6, the application of RVB clear in the hydration solution had a RWC (73%) significantly higher compared to the farm control (RWC = 52%) (Tab. 3B). This result was observed for RVB clear (RWC = 80.4%) in phase I when compared to the absolute control (RWC = 69.8%). However, during phase I, treatment RVB clear showed significantly lower RWC values than those obtained with SVB + BVB (Tab. 3A). Although RVB clear is a hydrator, a better result was observed with hormone-based products, such as SVB and BVB, which maintain better hydrated flower stems during the first 3 d in a vase, but the qualitative evaluation found that these hormones based products generate a slight wrinkling of flower petals. At the end of the assessment (d 10), there were no differences in hydration of the stems subjected to different treatments.

Chlorophyll content

Due to the significant interaction between varieties and treatments, a double entry matrix analysis was carried out, which allow find a statistical difference between treatments for each variety. For this analysis, the referents were the best treatment and the control treatment at each sampling point (Tab. 5). For example, at day 0 the foliage stems of 'Polaris' (Tab. 5A) treated with RVB clear had a chlorophyll

TABLE 3. Averages of RWC in leaf tissue in four sampling points during the evaluation of the spray chrysanthemum flower longevity cvs. 'Polaris' and 'Yellow Polaris' subjected to different postharvest hydration and anti-senescence treatments. Data from two successive phases.

A - Primary phase							
Sampling (d)							
0		3		6		10	
Treatment	RWC (%)	Treatment	RWC (%)	Treatment	RWC (%)	Treatment	RWC (%)
SVB+BVB	77.4 a	SVB+BVB	76.7 a	RVBclear	80.4 a	BVB	74.3 a
BVB	76.4 a	SVB+P2	72.0 ab	BVB	76.5 ab	RVBclear	73.3 a
P2	74.4 ab	BVB+P2	67.0 abc	FLOR5	75.2 ab	SVB	73.2 a
CVBN	73.5 ab	BVB+RVBclear	67.0 abc	CVBN	75.1 ab	TES	72.8 a
BVB+P2	70.4 ab	P2	65.0 abc	TESFIN	74.5 ab	TESFIN	70.4 a
SVB+P2	66.9 ab	BVB	65.0 abc	SVB	73.9 ab	P2	69.6 a
BVB+RVBclear	64.2 ab	FLORE	64.6 abc	BVB+P2	73.4 ab	FLOR5	68.7 a
TESFIN	63.7 ab	RVBclear	60.1 bc	BVB+RVBclear	72.2 ab	FLORE	68.5 a
SVB	61.7 ab	SVB	59.4 bc	SVB+P2	72.1 ab	BVB+P2	66.8 a
TES	60.6 ab	TESFIN	59.3 bc	SVB+BVB	72.1 ab	SVB+BVB	63.3 a
RVBclear	59.0 b	TES	57.7 c	FLORE	70.3 ab	BVB+RVBclear	63.0 a
FLOR5	58.4 b	CVBN	57.7 c	P2	70.2 ab	SVB+P2	62.9 a
FLORE	58.3 b	FLOR5	57.2 c	TES	69.8 b	CVBN	58.8 a
B - Second phase							
P2	60.0 a	SVB+RVBclear	88.8 a	RVBclear	73.1 a	P2	83.9 a
SVB+RVBclear	57.3 a	RVBclear	86.9 a	P2	66.4 ab	SVB+RVBclear	79.4 a
SVB	56.9 a	SVB+P2	86.2 a	SVB	65.2 ab	TESFIN	77.8 a
RVBclear	54.4 a	P2	83.9 a	TES	62.7 ab	SVB+P2	72.2 a
SVB+P2	54.4 a	SVB	83.6 a	SVB+RVBclear	56.9 ab	SVB	72.2 a
TESFIN	53.3 a	TESFIN	76.8 a	SVB+P2	55.2 ab	TES	71.0 a
TES	53.0 a	TES	75.8 a	TESFIN	51.7 b	RVBclear	69.2 a

P2 = Professional #2; CVBN = CVBn powder; FLOR5 = floríssima 525; FLORE = floríssima experta; TESFIN = farm control; TES = absolute control. Means in the same column followed by the same letter are not significantly different according Duncan's test ($P \leq 0.05$).

content of 0.02387 mg g^{-1} of fresh weight, producing the best treatment at the sampling point with no statistical difference with treatment professional # 2 (0.01968 mg g^{-1} of fresh weight). The RVB clear average was significantly higher as compared to the absolute control average. Overall, the RVB clear treatment had a positive effect as reflected in a 32% increase in chlorophyll content in the leaf tissue, as compared to the 'Polaris' control. In contrast, for 'Yellow Polaris', for the same day, the RVB clear effect was not different from the best treatment, in this case the SVB treatment (Tab. 5B).

Meanwhile, flower stems undergoing the Professional # 2 treatment (which contains a load of carbohydrates) exhibited no outstanding behavior regarding chlorophyll content during the flower longevity evaluation, except on day 0 in the Polaris variety (0.0197 mg g^{-1} of fresh weight). This is different to that observed in phase I, where Professional # 2 treatment initially (days 0 and 3) showed a higher chlorophyll content compared to treatments such as SVB + BVB, Floríssima expert, BVB + RVB clear and even the control (data not shown). According to Yakimova *et al.* (1996), the degradation of sugars seeks to maintain energy sources to withstand the stress subjected to a cut flower. The application of carbohydrates allows the flower to have a nutritious substrate in the absence of photosynthetic activity, thereby avoiding stress and increasing the longevity of the flowers. Considering this, the concentration of carbohydrates of Professional # 2 would not be sufficient to delay the onset of symptoms of senescence in the foliage. Thus, a treatment with doses higher than those evaluated in this study could maintain the anti-senescence effect manifested during the first days of the vase evaluation. In this regard, Reid (2004) reports that hydration solutions used in inadequate doses may increase the yellowing in chrysanthemum leaf tissue.

In the second phase, the overall average chlorophyll content in the foliage on day 0 was 0.0172 and 0.0157 mg g^{-1} of fresh weight for 'Polaris' and 'Yellow Polaris', respectively. With these values, no visible symptoms of yellowing foliage had manifested. This difference between the varieties was not significant by the t-test (Tab. 4).

By day 3, the overall mean chlorophyll content was higher in 'Polaris' with 0.01330 mg g^{-1} of fresh weight as compared to 'Yellow Polaris' (0.01098 mg g^{-1} of fresh weight). At this time, there was no significant difference between varieties and the variety-treatment interaction. This is evident in the results where the farm control and the mixture of SVB + Professional # 2 had the best results in 'Yellow Polaris' (Tab. 5B) but not in 'Polaris', where RVB clear and SVB + RVB clear presented the highest averages (Tab. 5A).

TABLE 4. Total chlorophyll content in the foliage of spray chrysanthemum stems of 'Polaris' and 'Yellow Polaris' for the 0-day sampling of the floral longevity assessment.

Variety	Average total chlorophyll content (mg g^{-1} of fresh weight)
Polaris	0.01717 a
Yellow Polaris	0.01572 a*

Means in the same column followed by the same letter are not significantly different according t test ($P \leq 0.05$).

On day 6, there was a higher content of chlorophyll in the leaves from the stems of the Polaris variety treated with SVB + RVB clear (0.01707 mg g^{-1} of fresh weight, Tab. 5A). Although SVB appears with the highest average in 'Yellow Polaris' (0.0086 mg g^{-1} of fresh weight) for the same day (Tab. 5B), the chlorophyll content observed in all treatments was inferior to the minimum content proposed in this research which is the content where ornamental foliage retains acceptable quality (0.011 mg g^{-1} of fresh weight). For both varieties, RVB clear was not different from the absolute control.

On the last day, there was no difference in the effect of the treatments or the variety-treatment interaction.

Floral longevity

Qualitative observations of the flower and foliage of the flowering stems were performed on days 6 and 10. Regarding the rating given to the foliage, in both assessments, a significant difference was found between treatments but not between varieties. Without discriminating by variety, in both evaluations, top scores for foliage were obtained with treatments SVB + RVB clear, SVB + Professional # 2 and SVB (Tab. 6), however, these averages were below the grades accepted by the market and only the grade presented by the SVB + RVB clear foliage on day 6 (6.5) would be consistent with an acceptable rating.

From the results, the SVB treatment based on hormones together with RVB clear represents an alternative for the conservation of foliar chlorophyll. In this regard, Paulin (1997), reported significant action of hormones in this process, because applications from 150 to 200 mg L^{-1} of gibberellic acid delayed senescence and foliage yellowing in spray chrysanthemum. Flórez-Roncancio *et al.* (1996) also obtained satisfactory results, up to 8.5 d of flower longevity, with immersion of 'White Polaris' spray chrysanthemum foliage in a solution of 0.058 mol m^{-3} of GA_3.

TABLE 5. Total chlorophyll content (CHL) in mg g^{-1} of fresh weight of leaf tissue of spray chrysanthemum cultivars Polaris (A) and Yellow Polaris (B), subjected to different postharvest hydrating and anti-senescence treatments.

A – 'Polaris'															
Sampling (d)															
0				3				6				10			
Treat.	CHL	M	T	Treat.	CHL	M	T	Treat.	CHL	M	T	Treat.	CHL	M	T
RVBC	0.02387	NS	*	RVBC	0.01338	NS	NS	SVB+RVBC	0.01707	NS	*	RVBC	0.01128	NS	NS
P2	0.01968	NS	NS	SVB+RVBC	0.01199	NS	NS	SVB	0.01316	*	NS	SVB+RVBC	0.00999	NS	NS
TES	0.01797	*	NS	SVB	0.01138	NS	NS	RVBC	0.01275	*	NS	TESFIN	0.00897	NS	NS
SVB+P2	0.01515	*	NS	TES	0.01103	NS	NS	TES	0.01188	*	NS	SVB+P2	0.00849	NS	NS
SVB	0.01465	*	NS	SVB+P2	0.01066	*	NS	SVB+P2	0.01114	*	NS	SVB	0.00806	NS	NS
SVB+RVBC	0.01446	*	NS	P2	0.00947	*	NS	TESFIN	0.00894	*	NS	TES	0.00794	NS	NS
TESFIN	0.01435	*	NS	TESFIN	0.00897	*	NS	P2	0.00853	*	*	P2	0.00750	NS	NS
B – 'Yellow Polaris'															
SVB	0.01958	NS	*	SVB+P2	0.01584	NS	*	SVB	0.00865	NS	*	SVB+P2	0.00878	NS	*
RVBC	0.01691	NS	NS	TESFIN	0.01512	NS	*	SVB+P2	0.00781	NS	*	RVBC	0.00875	NS	*
SVB+P2	0.01649	NS	NS	SVB	0.01396	NS	NS	TESFIN	0.00716	NS	NS	SVB+RVBC	0.00834	NS	*
TESFIN	0.01534	NS	NS	SVB+RVBC	0.01254	*	NS	RVBC	0.00660	NS	NS	P2	0.00763	NS	*
SVB+RVBC	0.01423	*	NS	TES	0.01226	*	NS	SVB+RVBC	0.00660	NS	NS	SVB	0.00715	NS	*
TES	0.01415	*	NS	P2	0.01171	*	NS	P2	0.00618	NS	NS	TESFIN	0.00485	*	NS
P2	0.01330	*	NS	RVBC	0.01170	*	NS	TES	0.00419	*	NS	TES	0.00326	*	NS

RVBC = RVBclear; P2 = Professional #2; TESFIN = Farm control; TES = Absolute control; M and T columns show the differences regarding the best treatment and the control, respectively. NS = Not significant * = significantly different ($P \leq 0{,}05$).

TABLE 6. Averages of quantitative grading of foliage of spray chrysanthemum stems of 'Polaris' and 'Yellow Polaris' in two assessments during the floral longevity evaluation.

Day 6		Day 10	
Treatment	Grade	Treatment	Grade
SVB+RVBclear	6.5 a	SVB+RVBclear	5.2 a
SVB+Professional #2	4.6 ab	SVB+Professional #2	5.2 a
SVB	4.6 ab	RVBclear	3.7 ab
RVBclear	4.1 bc	SVB	3.3 ab
Professional #2	3.0 bc	Professional #2	2.0 bc
Absolute control	3.0 bc	Absolute control	2.0 c
Farm control	2.3 c	Farm control	0.7 c

SVB = based on hormones treatment; RVBclear = hydrating and antibacterial treatment. Means in the same column followed by the same letter are not significantly differen according Duncan's test ($P \leq 0.05$).

Conclusions

No significant correlation was observed between the relative water content and the amount of chlorophyll, so premature yellowing of foliage in spray chrysanthemum stems is not defined by the state of hydration. However, due to the characteristics of the varieties, the relative water content was significantly higher in 'Polaris' as compared to 'Yellow Polaris'.

Although RVB clear is a hydrating product, during the first days in the vase, better results were observed with products based on hormones, such as SVB and BVB; however, it was found that these hormone based products generate a slight wrinkling of flower petals. At the end of the evaluation, no differential effect of treatments was found on water status of spray chrysanthemum flower stems in the tested varieties.

We determined a total chlorophyll content of 0.011 mg g^{-1} of foliar fresh weight as a threshold, above which no symptoms of yellowing foliage is visible in spray chrysanthemum cvs. Polaris and Yellow Polaris.

From the results, the SVB treatment (based on hormones) together with RVB clear (hydrating and antibacterial) represents an alternative for the conservation of foliar chlorophyll in 'Polaris' and 'Yellow Polaris' spray chrysanthemum.

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