Investigation note

Yellowing on leaf and stem of Alstroemeria cv 'Olga' in greenhouse and post-harvest

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Abstract

The present investigation was carried out in a greenhouse, with rhizomes of Alstroemeria cultivar 'Olga' under hydroponic system, with universal Steiner solution until harvest. It consisted of two stages: greenhouse phase and vase life. In the greenhouse, foliar fertilization was applied to the crop under a completely randomized experimental design with five replications. Eight doses of $Ca(NO_3)_2$, $MgSO_4^-$ and FeEDTA fertilization were evaluated. The variables evaluated were chlorophyll, leaf length, stem diameter, number of leaves per stem, and stem length. In vase life it was carried out in September 2013. As a preservative solution, two concentrations of the universal Steiner solution were evaluated. Tap water, Chrysal Clear® commercial preservative solution, was used as a control. The experimental unit was a flower stem. The variables evaluated were chlorophyll, fresh biomass, indirect transpiration, total chlorophyll by the AOAC method, days in vase and flower opening. At 0, 2, 4, 6, 8 and 10 days after the cut. In the greenhouse phase, the length of stems, number of leaves per stem and length of leaves, was independent of the dose and frequency of application of foliar fertilizers. SPAD readings, the treatment that showed effect from the first evaluation was 5 with foliar application of $Ca(NO_3)_2$ 2 g L^{-1}, being different from the rest of the treatments. The stem diameter increased with the application, every 15 days of $Ca(NO_3)_2$ 1 g L^{-1} via foliar. In the vase life, the SPAD and total chlorophyll readings of treatments five and six showed higher values. It is possible to maintain the flower stems with a foliar fertilization of $Ca(NO_3)_2$ 2 g L^{-1} whose effect in post-harvest was different from that of the other treatments in relation to chlorophyll. This dose applied in pre-harvest plus the addition of a preservative product in post-harvest is important in preserving the green color of the leaves.

Keywords: chlorophyll, foliar fertilization, rhizomes, vase life.

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Alstroemerias have a high commercial value due to their wide and attractive range of colors, in addition to their long life in vase (King and Bridgen, 1990; Van Schaik *et al*., 2000; Akatsu and Sato, 2002). The main producers of *Alstroemeria* sp. They are the State of Mexico and Hidalgo, the first being the most relevant for the estimated value of its production. The area sown with alstroemeria is estimated to be 67.2 hectares and a yield of 7 902.39 t (SIAP, 2012).

Alstroemeria stems are marketed with leaves, which generally have a marked yellowing before the inflorescences reach senescence, this yellowing occurs differently in each cultivar. Therefore, the objective of this research was to evaluate postharvest quality in Alstroemeria and generate nutritional information on the crop that reduces or prevents premature yellowing during vase life.

Greenhouse phase

The experiment was carried out in a greenhouse of the Montecillo Campus of the Graduate College, floral stems of Alstroemeria *cv* Olga, obtained from rhizomes, were used under a hydroponic production system with drip irrigation and Steiner solution. A completely randomized experimental design with five repetitions was used. Three sources of foliar fertilizers were evaluated, two with three different doses and the last with two doses, obtained from a study conducted by Rodríguez (1997).

Each experimental unit was made up of a pot. The foliar fertilization sources used were: calcium nitrate (T1, T2, T3), magnesium sulfate (T4, T5, T6) and FeEDTA (T7, T8). Three applications were carried out, at 105, 120 and 135 DDT. Greenhouse evaluations were performed three days after each fertilization.

Four experimental stems were randomly selected per experimental unit, evaluating the following response variables: SPAD-502 readings, indirectly estimated the chlorophyll content in the leaves of the floral stems. Statistical analysis was performed with the Statistical Analysis System (SAS Institute 2002). An analysis of variance was performed (Anova $\alpha = 0.05$). Subsequently, a multiple comparison test (Tukey $\alpha = 0.05$) was applied, in order to define the best treatment.

Vase life phase

The floral stems obtained from treatments 4 and 5 were evaluated because they were the ones with the highest SPAD values, stem diameter and with optimum marketing characteristics. This evaluation was carried out on September 10, 2013 in the area of edaphology, Montecillo *Campus*. The floral stems were placed individually in glass jars of 350 ml capacity, containing the preservative solution at a pH of 3.5 with a volume of 250 mL. For 11 days (d) two concentrations of the Steiner universal nutrient solution (20 and 30%) obtained from the greenhouse phase were studied.

As an absolute control, tap water was used, in addition to the Chrysal Clear® commercial preservative solution. A completely randomized design was used, with 8 treatments and 4 repetitions, with a factorial arrangement (AxB), in which factor A represents the selected

treatments in pre-harvest, factor B represents preservative solutions in post-harvest. To evaluate the effect of preservative solutions on vase life in floral stems of Alstroemeria *cv* Olga, the following variables were considered, a) SPAD readings, they were performed every third day; b) loss of wet biomass, it was recorded daily with a digital scale and was expressed as a percentage of biomass lost compared to the initial one; c) indirect perspiration rate, the initial and final water volumes in the vases were calculated daily; d) total chlorophyll concentration, the total chlorophyll concentration was quantified by the AOAC method (1980). For this purpose, the following equation was used: total chlorophyll= (8.2∗A663) + (20.2∗A645), for which a spectrophotometer (Spectronic2 1D, Milton Roy®) was used. The evaluation was carried out on the last day in vase life.

Greenhouse phase

SPAD readings

In Figure 1, it is observed that from the second and third evaluation the treatments did not have the same effect on the response variable (Pr> F< 0.05), there was a notable difference in the SPAD units of T1 and the other treatments; since these presented an exponential increase in SPAD units, while the T1 values remained constant with respect to the first evaluation.

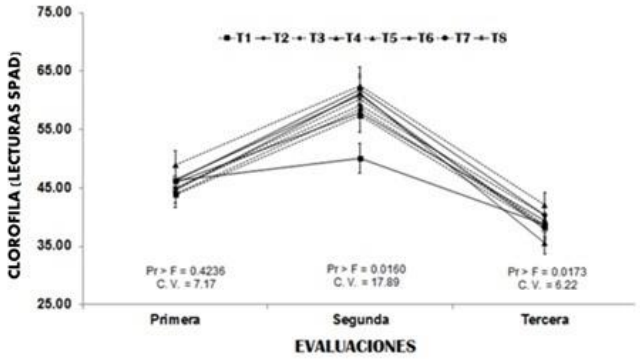

Figure 1. SPAD readings during the three evaluations three days after the greenhouse treatments. Pre-harvest management (T) treatments were T1= $MgSO_4$ 0.5 g L^{-1}; T2= $MgSO_4$ 1 g L^{-1}; T3= $MgSO_4$ 2 g L^{-1}; T4= $Ca(NO_3)_2$ 1 gL^{-1}; T5= $Ca(NO_3)_2$ 2 g L^{-1}: T6= $Ca(NO_3)_2$ 4 g L^{-1}; T7= FeEDTA 5 mg L^{-1}; T8= FeEDTA 10 mg L^{-1}.

The results obtained correspond to what was reported by Vilcox (1994), which indicates that as the days pass after the transplant and the plant develops, the nitrogen content in the leaves decreases to increase in the whole plant and in the fruit.

When the temperature rises in the range of 15 and 20 °C there is a strong increase in the chlorophyll concentration, while, above 20 °C, the rate of increase in the chlorophyll concentration decreases sharply with its increase (Dwyer *et al*., 1991). Therefore, the different average temperatures observed in this evaluation that were above 20 °C could be the cause of the decrease in SPAD readings. With respect to the other treatments evaluated, these presented values of 37.93 to 40.32, without significant differences between them.

Stems diameter

The treatments did not show the same effect on the response variable (Pr> F< 0.05). In the first evaluation, the best treatments were T4, T6 and T8, which had a stem diameter of 0.57, 0.57 and 0.55 cm, respectively. These treatments exhibited differences with respect to T5, T3 and T1 themselves that had a diameter of 0.47, 0.47 and 0.45 cm (Figure 2). In the second evaluation, T4 was the one with the largest stem diameter (0.64 cm), this treatment was different from T7, T2, T1, T5 and T3, which presented values from 0.52 to 0.56 cm. In the third evaluation, the treatments that presented the smallest stem diameter were T1, T2 and T5, highlighting that the best treatment was T4, which exhibited a stem diameter of 0.64 cm.

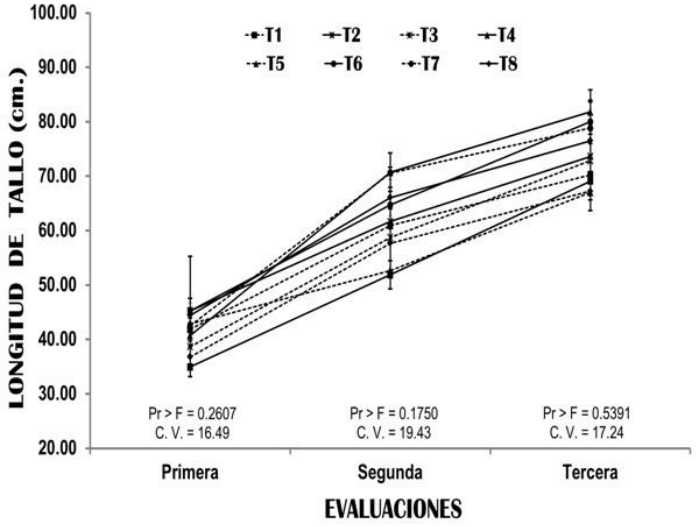

Figure 2. Length of stems during the three evaluations three days after the greenhouse treatments. Pre-harvest management (T) treatments were T1= $MgSO_4$ 0.5 g L^{-1}; T2= $MgSO_4$ 1 g L^{-1}; T3= $MgSO_4$ 2 g L^{-1}; T4= $Ca(NO_3)_2$ 1 gL^{-1}; T5= $Ca(NO_3)_2$ 2 g L^{-1}; T6= $Ca(NO_3)_2$ 4 g L^{-1}; T7= FeEDTA 5 mg L^{-1}; T8= FeEDTA 10 mg L^{-1}.

Vase life phase

Fresh biomass

From the second day of the application of the treatments, the fresh weight increased in all the treatments, this also agrees with that observed in other species, where the gain of the initial fresh weight of the floral wands results in an increase in turgor of the cells of the petals, necessary to achieve an adequate floral opening and a loss of the weight of the wand during senescence (Villaseca, 2005; Verdugo *et al*., 2006).

Fresh biomass began to decrease and was constant between treatments until the end of the experiment and there were no significant statistical differences (Figure 4).

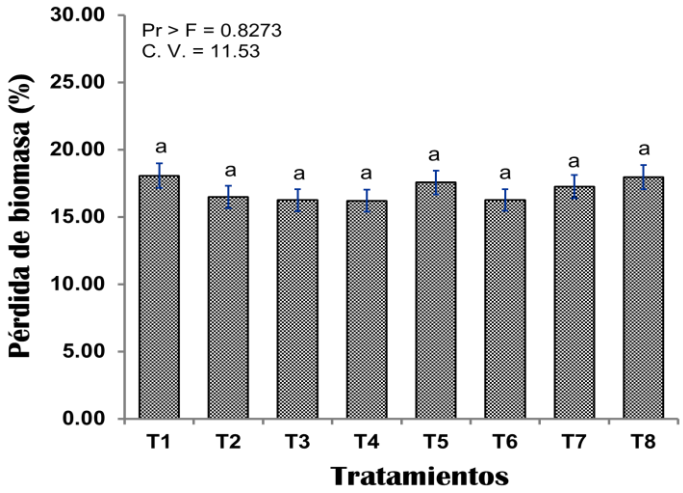

Figure 4. Percentage of wet biomass loss in floral stems of Alstroemeria cv Olga after 10 days of postharvest storage. Storage treatments (T) were T1 = $Ca(NO_3)_2$ 1 g L^{-1} + tap water (control); T2 = $Ca(NO_3)_2$ 1 g L^{-1} + Chrysal clear®; T3 = $Ca(NO_3)_2$ 1 g L^{-1} +30% nutritional solution; T4 = $Ca(NO_3)_2$ 1 g L^{-1} + 20% nutritional solution; T5 = $Ca(NO_3)_2$ 2 g L^{-1} + tap water (control); T6 = $Ca(NO_3)_2$ 2 g L^{-1} +Chrysal clear®; T7 = $Ca(NO_3)_2$ 2 g L^{-1} +30% nutrient solution; T8 = $Ca(NO_3)_2$ 2 g L^{-1} + 20% nutritional solution.

SPAD readings

From the third day, the SPAD units of T7 decreased significantly, while in T1 they decreased from the fifth day, these two treatments being the ones that presented the least amount of SPAD units at the end of the experiment. In the other treatments the SPAD values remained constant until day 11 (Figure 5). The T8 had the same effect in terms of chlorophyll degradation between days 3 and 7, while the rest of the treatments evaluated showed significant differences on both days of evaluation. Until day seven, T8 better preserved this pigment.

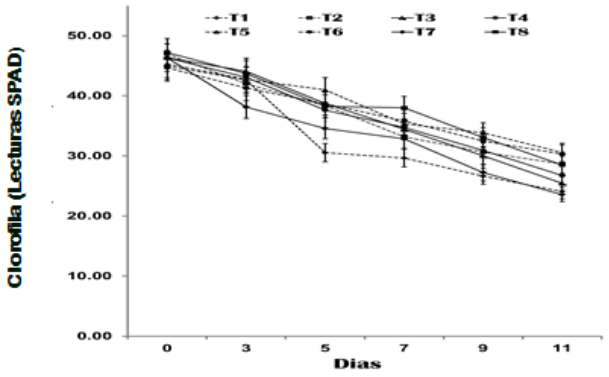

Figure 5. SPAD readings of floral stem leaves of Alstroemeria cv Olga after 10 days of postharvest storage. Storage treatments (T) were T1 = $Ca(NO_3)_2$ 1 g L^{-1} + tap water (control); T2 = $Ca(NO_3)_2$ 1 g L^{-1} + Chrysal clear®; T3 = $Ca(NO_3)_2$ 1 g L^{-1} +30% nutritional solution; T4 = $Ca(NO_3)_2$ 1 g L^{-1} + 20% nutritional solution; T5 = $Ca(NO_3)_2$ 2 g L^{-1} + tap water (control); T6 = $Ca(NO_3)_2$ 2 g L^{-1} +Chrysal clear®; T7 = $Ca(NO_3)_2$ 2 g L^{-1} +30% nutrient solution; T8 = $Ca(NO_3)_2$ 2 g L^{-1} + 20% nutritional solution.

Chloroplasts are converted to gerontoplasts when senescence signals begin, this plastid has an exclusively catabolic metabolism; they persist and remain intact through foliar senescence, then lose volume and density as a result of extensive losses of stromal and thylakoid components, and increase the number and size of lipophilic plastoglobes (Matile *et al*., 1999; Thomas *et al*., 2003).

Total Chlorophyll AOAC

The treatments did not show the same effect on total chlorophyll in Alstroemeria plant tissue at the end of the experiment (Pr> F< 0.05). The treatments T5 and T6 with values higher than 12 mg g^{-1} were those that presented the highest levels of total chlorophyll (Figure 6). This situation was similar to what was observed with SPAD.

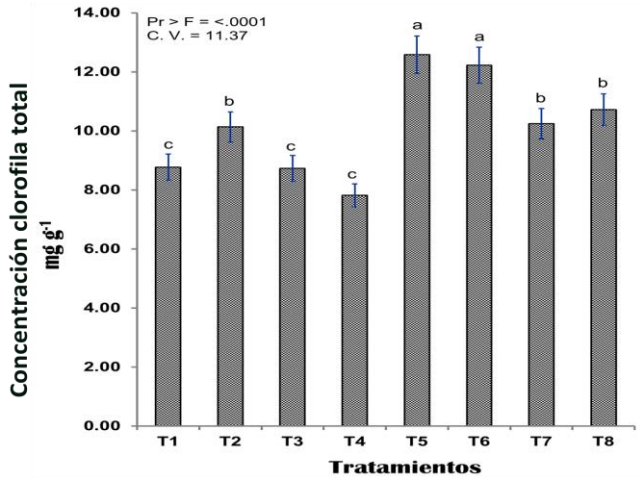

Figure 6. Total chlorophyll in Alstroemeria cv Olga leaves after 10 days of postharvest storage. Storage treatments (T) were T1 = $Ca(NO_3)_2$ 1 g L^{-1} + tap water (control); T2 = $Ca(NO_3)_2$ 1 g L^{-1} + Chrysal clear®; T3 = $Ca(NO_3)_2$ 1 g L^{-1} +30% nutritional solution; T4 = $Ca(NO_3)_2$ 1 g L^{-1} + 20% nutritional solution; T5 = $Ca(NO_3)_2$ 2 g L^{-1} + tap water (control): T6 = $Ca(NO_3)_2$ 2 g L^{-1} +Chrysal clear®; T7 = $Ca(NO_3)_2$ 2 g L^{-1} +30% nutrient solution; T8 = $Ca(NO_3)_2$ 2 g L^{-1} + 20% nutritional solution.

Indirect perspiration

The treatment that showed the lowest percentage of perspiration was T3 with a rate of 12.2% (Figure 7), agrees with Torre *et al*. (1999) where he mentions that it is frequently observed that the organs of plants that have low perspiration manifest disorders due to calcium deficiency. It is reported that cut roses, as well as fruits and tubers, fall into this category. Calcium in these organs is conducted within the plant generally by the xylem (Marschner, 1995) and therefore, low perspiration could result in less of the element transported to those organs.

It is worth mentioning that these treatments that showed an effect on perspiration were reflected in the floral stems that were treated with $Ca(NO_3)_2$ 2 g L^{-1} in a greenhouse based on foliar fertilization.

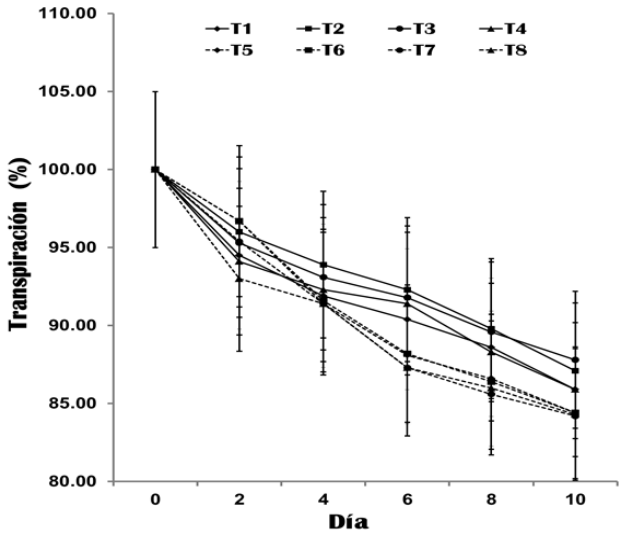

Figure 7. Percentage of loss of perspiration in cv Olga during 10 days of evaluation. Storage treatments (T) were T1 = $Ca(NO_3)_2$ 1 g L^{-1} + tap water (control); T2 = $Ca(NO_3)_2$ 1 g L^{-1} + Chrysal clear®; T3 = $Ca(NO_3)_2$ 1 g L^{-1} +30% nutritional solution; T4 = $Ca(NO_3)_2$ 1 g L^{-1} + 20% nutritional solution; T5 = $Ca(NO_3)_2$ 2 g L^{-1} + tap water (control); T6 = $Ca(NO_3)_2$ 2 g L^{-1} +Chrysal clear®; T7 = $Ca(NO_3)_2$ 2 g L^{-1} +30% nutrient solution; T8 = $Ca(NO_3)_2$ 2 g L^{-1} + 20% nutritional solution.

Conclusions

In the greenhouse phase the length of stems, number of leaves per stem and length of leaves, were independent of the dose and frequency of application of foliar fertilizers. The foliar application of $Ca(NO_3)_2$ 2 g L^{-1} favored the greenness index measured with SPAD. The stem diameter increased with the application of $Ca(NO_3)_2$ 1 g L^{-1} foliar route. In vase life, for the variable's fresh biomass and indirect perspiration, they were not modified by the application of foliar fertilizers in production or preservative solutions.

The SPAD readings in vase life, treatments five and six had a similar behavior, this result coincides with those obtained in the determination of the total chlorophyll concentration, highlighting the same treatments. Foliar treatment with $Ca(NO_3)_2$ 2 g L^{-1} in pre harvest plus the addition of a preservative product in post-harvest retain the green color of the leaves.

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