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Effect of the concentration of the nutrient solution on the nutrient content of chrysanthemum (*Dendranthema grandiflorum* (Ramat.)

Quevedo-Ortiz Betsy[1]; Juárez-Hernández Ma. de Jesús[1*]; Magdaleno-Villar, J. Jesús[1]; Pérez-Vivar, Marcelino[1]; Valdez-Hernández, Edna Fabiola[1]; Mejía-Muñoz, José Merced[1]

[1] Universidad Autónoma Chapingo, Departamento de Fitotecnia, Carretera México-Texcoco Km 38.5, Texcoco, Estado de Mexico. C.P. 56230

* Correspondence: juarezhma@yahoo.com.mx

ABSTRACT

Objective: Evaluate the nutrient concentration at the foliar level of chrysanthemums grown in tezontle sand using three concentrations of the Steiner Universal Nutrient Solution.

Design/Methodology/Approach: A completely randomized design was used, each treatment represented a concentration of the nutrient solution and each concentration had 11 repetitions, the study variables were: foliar concentration of nutrients: N, P, K, Ca, Mg and S, plant height (AP), stem diameter (DT), number of leaves (NH), flower diameter (DF), fresh weight (PF) and dry weight (PS).

Results: The results showed this order of extraction K>N>Ca>P>Mg>S, for all concentrations, the foliar N content was low in the three treatments (<3.35%), the P was found in high concentrations. (>0.63%), K was higher in the 100% concentration treatment, Mg (>0.44%) was in sufficient levels, in Ca the 100% concentration had greater absorption and finally the S content was only the adequate in the concentration of 100%, in the morphological variables there were no significant differences.

Limitations of the study/Implications: High temperatures helped the proliferation of pests; therefore, it would be good to have a better control of temperatures inside the greenhouse.

Findings/Conclusions: Therefore, using different concentrations of the nutrient solution in chrysanthemums grown in tezontle sand affects the nutrient content at the foliar level but not necessarily its morphology.

Keywords: leaf analysis, tezontle sand, Universal Steiner.

INTRODUCTION

Mexico is considered one of the countries with the longest floricultural tradition due to its climate, soil, and labor characteristics, presenting growth potential in flower production (Flores-Ruvalcaba *et al.*, 2005). One of the most popular flowers is the chrysanthemum, native to East Asia; currently, the State of Mexico grows almost 90% of all the flowers sold in the country (Tejeda-Sartorius *et al.*, 2015). According to information from the Agro-Food and Fisheries Information Service (SIAP, 2020), chrysanthemums obtained 11 million 312 thousand 281 grosses, the State of Mexico contributed 1,587 million pesos, 87.8% of the

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national value, it should be noted that the State de Puebla has a planted area of 102.5 ha, which gives a production of 528,312.76 t, a yield of 5,154.27 t ha^{-1} with an average rural price of $174.32 per t.

On the other hand, we know that, for hundreds of years, agriculture in Mexico has offered a wide range of crops to satisfy human needs. However, in the case of food and industrial crops, the misuse of technologies, such as irrigation and fertilization, has caused such soil degradation that currently thousands of hectares cannot be cultivated. In the last sixty years, work has been done on the development of new systems that help solve these problems. Hydroponics is one of the alternatives according to Solís (2016) it is considered as an agricultural production system, which is of great importance within the ecological, economic and social context. Soilless crops are usually classified into hydroponic crops (grown in water plus nutrients or on inert materials) and substrate crops (grown on chemically active materials with cation exchange capacity). In addition, soilless crops can function as an open system, a lost solution (non-cyclic) or as a closed system, with circulation of nutrient solutions (San Martin, 2011). Among the substrate crops is the red, yellowish or black tezontle sand cultivation system of very porous volcanic origin, also known as volcanic tuff, abundant in various regions of Mexico, very popular as a horticultural substrate. It is considered a chemically inert material, it has a neutral to slightly alkaline pH, very low CEC, high total porosity, although its physical properties depend greatly on the size of the particles, it maintains its structure unchanged over time (Martínez & Roca, 2011).

Jiménez (2015) mentions that, in hydroponics, a large part of the success is to use the adequate nutrient solution, since the substrates and the water do not provide the necessary nutrients for the optimal development of the plants. A complete nutrient solution must have macroelements and microelements, Steiner Universal Nutrient Solution has a mutual relationship between the anions NO_3^-, $H_2PO_4^-$ and SO_4^-, and between the cations of K^+, Ca^{2+} and Mg^{2+}. It was since that a nutrient solution must be regulated in its macronutrients contained in the mentioned ions. The nutritive relationship consists not only in the absolute amount of each element provided but also in the quantitative relationship established between the anions on the one hand and the cations on the other. Steiner (1961) indicated that when the nutrient solution is applied continuously, plants can absorb ions at very low concentrations, however, it is likely that, at too low a concentration, the minimum demand for certain nutrients is not covered. Therefore, the objective of the present investigation was to evaluate the nutrient concentration at the foliar level of the chrysanthemum crop in tezontle sand using three concentrations of the Steiner Universal Nutrient Solution. The nutrient concentration at the foliar level has already been studied by several authors Osorio (2012), studied the adequate levels of soil fertility and foliar analyzes for chrysanthemum, establishing adequate levels for each element.

MATERIALS AND METHODS

This work was carried out in a 71.56 m^2 glass chapel-type greenhouse of the Graduate Program in Horticulture. It was during the period of December 2021 and ended in April 2022. It began with the sifting of the red tezontle substrate, to obtain granulometries of 2 to 4 mm (fine) and 5 to 8 mm (coarse), it was disinfected with sodium hypochlorite, leaving it to rest for 24 hours, after which time it was rinsed with water to avoid residues and allowed to dry. The pots that were used were recycled, with a diameter of 20 cm, height of 18 cm and a volume of 4.5 liters, perforated at the bottom to drain the nutrient solution, of the total volume only 3.5 liters of its capacity were used, placing them in 1/3 of the thickest substrate in the lower part and 2/3 of the fine substrate in the upper part, separated by tulle-type fabric, finally, they were placed on a base with a slope of 1% in three rows corresponding to the treatments. In addition, 3" PVC tubes cut in half were used to capture the drained nutrient solution, which was stored in 5-liter buckets for each treatment. The plant material used was a yellow pompom-type chrysanthemum. The nutrient solution was not recirculating. Based on the Steiner Universal Nutrient Solution, the respective calculations were made according to the three concentrations 85%, 100% and 115% with an EC of 2.2, 2.4 and 2.8 dS/m depending on the concentration, maintaining a pH of 6.0-6.5. The irrigations were automated with the use of analog timers, each hour there was an irrigation with a duration of 15 minutes distributed by means of tapes with drippers every 20 cm that threw 286 ml per minute, therefore a nutrient solution was prepared every third day once the experiment has been set up. During the first six weeks, night lighting was provided from 7:00 p.m. to 01:00 a.m. the following day with 100-watt incandescent light bulbs. After the second week, the weeding activity was carried out, with crop management. The experimental design used was completely randomized (DECA), three concentrations of Steiner Universal Nutrient Solution (85%, 100% and 115%) were evaluated, each with 11 repetitions. The variables that were evaluated were the foliar concentration of the elements: nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur, taking the foliar samples before harvest. The morphological variables were taken during the harvest: plant height (AP), stem diameter (DT), number of leaves (NH), fresh weight (PF) and dry weight (PS), root, stem + leaves and flower. Subsequently a means test was performed with the Tukey test ($P \leq 0.05$).

RESULTS AND DISCUSSION

After analyzing the data, the following results were obtained:

Table 1 shows the results of the means tests of the morphological variables AP: plant height, NH: number of leaves, DT: stem diameter and DF: flower diameter, noting that there are no significant differences ($P \leq 0.05$) between concentrations. Numerically, the plants supplied with the 115% nutrient solution reached higher AP, in the NH the concentrations of 100 and 115% had one more leaf than those of 85%, the DT was higher in the 85% concentration reaching 0.79 cm, for Finally, the DF was higher in the concentration of 100%.

In the following Table 2, the values of (PF) fresh weight and (PS) dry weight are observed, which also do not present significant differences, numerically there was a higher total PF in the most concentrated nutrient solution (115%) and greater accumulation of dry matter in the lowest concentration (85%).

Analyzing the data obtained from the laboratory samples Table 3, the nitrogen content was higher in the concentration of 115 %, however, the levels fall below the intervals proposed by Osorio (2012), despite that they were not observed. deficiency symptoms. It is

Table 1. Comparison of means of the three concentrations of the Steiner Solution on the morphological variables: AP, NH, DT, DF.

Concentration of the nutritive solution (%)	AP cm	NH cm	DT cm	DF cm
85	72.72 a	23 a	0.79 a	6.83 A
100	71.95 a	24 a	0.77 a	6.96 A
115	82.58 a	24 a	0.76 a	6.86 A

AP: plant height, NH: number of leaves, DT: stem diameter, DF: floral diameter. Values with the same letter within the columns are equal according to Tukey's test at P≤0.05.

Table 2. Comparison of means of different concentrations of the Steiner Solution on the fresh weight and dry weight of different organs of the chrysanthemum plants.

Organ of the plant		Stem+leaves		Root		Flower	
		PF g	PS g	PF g	PS g	PF g	PS g
Concentration of the nutritive solution	85%	56.875[a]	16.245[a]	18.168[a]	7.725[a]	13.853[a]	1.86[a]
	100%	52.128[a]	14.62[a]	23.203[a]	7.058[a]	15.764[a]	1.9275[a]
	115%	55.94[a]	14.758[a]	21.098[a]	7.378[a]	14.968[a]	2.08[a]
DMS		18.933	5.7347	10.5	5.155	3.6347	0.4764

Values with the same letter within the columns are equal according to Tukey's test at P≤0.05. PF: fresh weight, PS: dry weight, DMS: minimum significant difference.

Table 3. Nutrient content in yellow pompon chrysanthemum leaves due to the concentration of the nutritive solution.

Concentration of the nutritive solution (%).	Nitrogen %	Phosphorus %	Potasium %	Sulfur %	Calcium %	Magnesium %
85	2.18 B	0.69 A	7.4 S	0.24 B	2.28 S	0.38 A
100	3.5 B	0.63 A	8.55 S	0.37 A	2.38 S	0.46 A
115	3.08 B	0.86 A	5 A	0.16 B	1.98 A	0.32 A

Data with letter B represent low levels, with letter A high levels and with letter S they represent sufficient values, based on what was obtained by Osorio (2012): N (4.5-5.5), P (0.3-0.6), K (4.0- 6.5), S (0.3-0.7), Ca (1.0-2.0), and Mg (0.3-0.6Data in red color represent low levels, blue high levels and black sufficient, based on what was obtained by Osorio (2012): N (4.5-5.5), P (0.3-0.6), K (4.0-6.5), S (0.3 -0.7), Ca (1.0-2.0), and Mg (0.3-0.6).

said that the deficiency favors the lignification of the stems which reduces the flow of water after the harvest, thus decreasing the vase life.

The phosphorus content was higher in the treatment with the concentration of 115%, the three treatments having a sufficient to very high concentration, a restricted availability of phosphorus produces shorter and/or more compact plants.

The most absorbed nutrient by the plant was K, reaching up to 8.55% in the 100% concentration, Anuradha *et al.* (1990), mentions that the increase in potassium extraction before harvest may be due to its participation in the synthesis of anthocyanins and other pigments, producing a greater intensity of the color of the inflorescence in cempasúchil

(*Tagetes erecta* L.). Sulfur was higher in the 100% concentration, but in the 115% concentration the levels fell below those required. In the plant, sulfur is concentrated in greater quantities in mature leaves than in young leaves, this is due to its greater metabolic maturity, which probably could have happened, since the leaves from the middle part of the plant were taken (INTAGRI, 2001).

The calcium content at the foliar level was found to be high to sufficient in the three treatments, being higher in the concentration of 100%, followed by that of 85% and finally that of 115%. Regarding magnesium, optimal levels were obtained, its concentration at the foliar level is sufficient for the three treatments. The concentration of 100% and 85% presented a higher percentage, although these data agree with those obtained by Pineda *et al.* (1998) and Carrillo (2009), who reported higher levels in the treatments with lower concentrations in chrysanthemums.

CONCLUSIONS

In the morphological variables, as well as in the fresh weight and dry weight, there were no significant differences ($P \leq 0.05$) between the concentrations of the nutrient solution. Instead, the foliar analysis reflected better absorption of most of the nutrients in the 100% concentration, except for phosphorus. An effect of the different concentrations of the nutrient solution on the foliar nutrient content was found, but this did not alter the morphological characteristics of commercial interest in the chrysanthemum plants.

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