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Fertilization for potted foliage anthurium

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ABSTRACT

Anthurium maricense Nadruz & Mayo is one of the anthurium species with potential for commercialization as a foliage. The objective of this study was to evaluate the NPK rates and the frequency of nitrogen foliar fertilization for pot cultivation of *Anthurium maricense*. The experimental design was completely randomized, in a split-plot scheme, with 04-14-08 NPK rates applied in the substrate (0; 3; 6; 9 and 12 kg m^{-3}) as the main treatments and the frequency of nitrogen foliar fertilizer (no foliar fertilizer; once and twice a month at urea concentration of 20 g L^{-1}) in subplots, with ten replicates. Ten months after planting the seedlings in the pots, the following evaluations were made: height, average plant diameter, number of leaves and inflorescences, leaf area and dry mass (leaves, inflorescence, shoots, roots and total). In the absence of nitrogen foliar fertilizer, maximum leaf area and leaf, shoot and total dry masses were obtained with NPK rates varying from 4.7 to 5.4 kg m^{-3}. With application of nitrogen foliar fertilizer as urea, twice a month, there is no need for NPK application in the commercial substrate used in the cultivation of foliage anthurium in pots.

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Anthurium maricense Nadruz & Mayo; fertilizers; nitrogen; phosphorus; potassium; ornamental plants

Introduction

Ornamental plants have been gaining prominence in the flower sector due to the great diversity of species and varieties. The foliage of Anthurium is especially appreciated for its high durability and different leaf blades (Morais et al. 2017). Among the anthuriums with ornamental potential, *Anthurium maricense* Nadruz & Mayo has good prospects for the insertion in the market of ornamental flowers (Castro et al. 2010). In addition, they are perennial, terrestrial plants that grow well in shady environments, have simple oblong to lanceolate leaves and in nature do not exceed 30 cm in length (Valadares and Sakuragui 2016).

The demand of the consumer market for quality and high value-added products requires growers to change the form of production, whether in technical or economic efficiency. Foliage potted plants should be cultivated under optimal growing conditions, for rapid growth and high-quality characteristics. Quality is directly related to the nutritional aspects, that is, the plant needs to be well nourished to exhibit attractive visual characteristics in a controlled development (Ferrante et al. 2015). According to Dufour and Guérin (2005), fertilization and chemical composition of nutrients are the main factors affecting *Anthurium* development and yield.

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The substrate is the most important component of the potted cultivation of plants. It should have good water retention capacity and drainage and should provide adequate nutrient and aeration for the plant. The determining factors for choosing a substrate are cost and availability, which could compromise the fertilization and nutrition of plants (Sanghamitra et al. 2019). In many cases, producers use only commercial substrates with their pre-established standards, resulting in over-fertilization or often deficient fertilization, which decreases the quality of the plant and increases the cost of marketing. Hardly any information is available about nutritional needs of N rates in Anthurium, which makes it difficult to define the fertilization rate and the frequency of fertilization.

Fertilization with NPK rates or foliar fertilization can supply the nutrient deficiency of the substrates used for the production of *Anthurium* plants. For Wendling et al. (2002), foliar fertilization has been used to obtain rapid plant responses, but it is not recommended as the sole source of fertilization. Producers normally tend to consider N application as a solution for their income, but unintentionally, they end up exceeding the rate, and the results are higher costs for production and high environmental costs through the leaching and runoff of NO_3^- into ground and surface waters. According to Chang et al. (2012), the effects of N on plant growth and flower yield are different at different stages of growth.

In order to reduce production and environmental costs, in addition to obtaining plants with high quality, more attention should be paid to the fertilization of ornamental plants. Considering the lack of information about fertilization, the aim of this study was to evaluate NPK rates and frequency of nitrogen foliar fertilization for the cultivation of foliage *Anthurium maricense* in pots.

Material and methods

The experiment was carried out in a greenhouse located at Embrapa Agroindústria Tropical (Fortaleza, Ceará State, Brazil). The experimental design was randomized, in split-plot scheme with ten replicates, totaling 150 pots. The main treatments consisted of five rates (0; 3; 6; 9 e 12 kg m^{-3}) of mineral fertilizer 04-14-08 NPK evaluated in the plots and three frequency of the nitrogen foliar fertilizer application (no foliar; once and twice a month) that was evaluated in the subplots.

Anthurium maricense Nadruz & Mayo seeds were collected from Embrapa Tropical Flowers Germplasm Collection, germinated in polyethylene trays of 162 cells filled with commercial substrate (mixture of composted pine bark, peat and vermiculite) and acclimatized for four months. The substrate had the following characteristics: bulk density = 427.7 kg m^{-3}; pH H_2O = 5.1; electrical conductivity = 0.9 dS m^{-1}; organic carbon = 226.6 g kg^{-1}; total-N = 7.9 g kg^{-1}; Ca = 309 mg L^{-1}; Mg = 251 mg L^{-1}; K = 375 mg L^{-1}; Na = 82 mg L^{-1}; P = 124 mg L^{-1}; Cl = 709 mg L^{-1}; NO_3^--N = 225 mg L^{-1}; NH_4^+-N = 2.1 mg L^{-1}, and SO_4^{2-}-S = 125.5 mg L^{-1}.

Seedlings were transplanted into plastic pots number 15 (1.16 L of capacity: 10.5 × 14.5 × 11.0 cm), filled with the same commercial substrate and the NPK rates, when they reached about four fully expanded leaves (approximately four months after sowing).

Nitrogen foliar fertilization consisted of the application of urea solution at the concentration of 20 g L^{-1} using a 5-liter high-pressure sprayer. The device was adapted to apply 5 mL of solution containing N per plant and application. Treatment plots not receiving the nutrient solution spray was similary sprayed with an equal volume of water. Leaves were sprayed on both adaxial and abaxial sides and the substrate surface was not covered. After each foliar fertilization, extra care was taken to not perform irrigation in order to avoid leaf washing. No sprinkler irrigation was performed in the 48 hours after foliar fertilizer application. Foliar application started 30 days after planting the seedlings and extended for seven more months. The pots were placed in greenhouse with 50% shading and irrigated daily (two cycles of 10 min) by a sprinkler irrigation system

Table 1. NPK fertilizer on the commercial substrate and frequency of foliar nitrogen fertilizer in the development of potted *Anthurium maricense*.

Foliar fertilizer	Height	Diameter	Leaf number	Inflorescence number	Leaf area
	cm				cm²
No foliar	19.1 b[1]	22.0 b	9.0 a	3.0 a	456 c
Once a month	21.8 b	26.3 a	9.7 a	3.2 a	574 b
Twice a month	25.0 a	30.2 a	10.0 a	3.7 a	751 a
			F test[2]		
Via foliar (F)	13.489**	14.608**	2.715 ns	1.644 ns	47.292**
Via substrate (S)	1.030 ns	2.489 ns	0.572 ns	1.896 ns	2.916*
F x S	0.815 ns	1.964 ns	1.016 ns	1.267 ns	4.383**
CV $\%_{foliar}$	20.29	22.65	18.43	48.18	19.90
CV $\%_{substrate}$	16.49	18.32	24.61	39.64	20.22

[1] Mean values followed by the same lower-case letters for each variable did not differ statistically by Tukey's test ($P \leq 0.05$).
[2] ns; ** and *: Non-significant; significant at $P \leq 0.01$ and $P \leq 0.05$, respectively.

(rotating micro-sprinklers with flow rate of 52 L h^{-1} and operating pressure of 200 kPa). Environmental parameters were recorded throughout the experiment (May 2016 to March 2017) using a digital thermohygrometer: maximum and minimum daily temperatures (°C) and relative humidity (%) of 31.8 ± 0.5; 24.5 ± 0.6 and 76.2 ± 3.6, respectively. The average daylength was 12 hours and no supplemental lighting was provided. During the experiment, no pesticide sprays were performed, and weeds were manually removed.

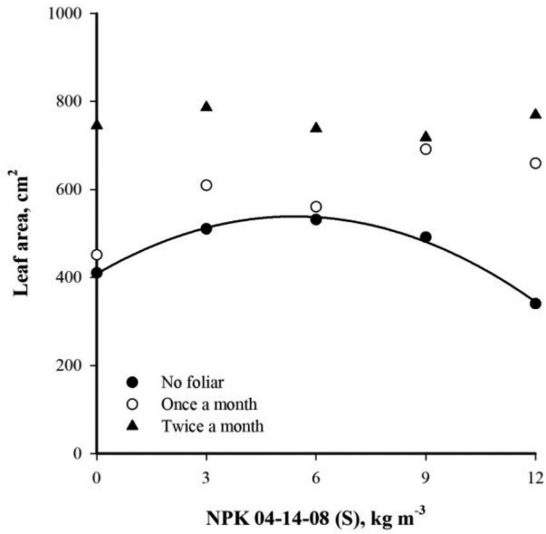
Ten months after planting (30 days after the last foliar application), the following evaluations were performed: plant height, diameter of the plants, number of leaves and inflorescences and leaf area. Plant height was measured from the substrate surface to the tip of the longest leaf. Plant diameter was measured in two directions and averaged with a measuring tape. Leaf and inflorescence number were determined by counting all living leaves and inflorescences per plant. Leaf area was determined using electronic integrator (LI-3100C, LI-COR). Afterwards, the plants were separated into leaves and inflorescences and roots, washed, and dried in a forced air circulation oven at 65 °C until constant weight to determine dry mass of leaves and inflorescences and roots.

The data were submitted to analysis of variance and the means of the NPK rates were compared by regression and the frequency of foliar fertilization by Tukey test using SAS Software (SAS Institute Inc 2012).

Results and discussion

NPK rates applied to commercial substrate did not influence the height and diameter of *Anthurium maricense* plants after ten months of cultivation in pots (Table 1). The lack of response to NPK application can be justified by the chemical composition of the commercial substrate used, which was a mixture of composted pine bark and vermiculite, enriched with lime and fertilizers containing macro and micronutrients. Positive response of growth and flowering characters were observed by Khawlhring, Patel, and Lalnunmawia (2019), *Anthurium andreanum cv.* Evita planted in cocopeat, charcoal and vermicompost in the proportion of 6.5:1:1 and fertilized with NPK (19-19-19) at 25 g/pot/year.

Compared to the control, the foliar fertilizer application twice a month increased the height and the diameter of the plants, but these increases did not depreciate their quality, i.e., the plant continues to exhibit attractive visual characteristics in the development. Plant quality is subjective but parameters like height, plant diameter, number of leaves and plant size:pot size ratio are considered. In addition, the growth in diameter of the plants receiving foliar fertilizer resulted in complete occupation of the container surface, which is desirable for potted plants.



No foliar $LA = -4.4683S^2 + 48.32S + 407.77$ ($R^2 = 0.994$**)

Once a month $LA=^{ns}$

Twice a month $LA =^{ns}$

Figure 1. Potted *Anthurium maricense* leaf area as affected by NPK and nitrogen foliar fertilizers. ^{2ns}; ** and *: Non-significant; significant at $P \leq 0.01$ and $P \leq 0.05$, respectively.

Despite the nonexistence of quality parameters for non-floriferous *Anthurium*, for other species marketed as potted foliage, plant height varies from 12 to 25 cm (Veiling Holambra Cooperative 2018). According to Megersa, Lemma, and Banjawu (2018), plant size in relation to pot size is crucial to define appearance and to improve the capacity to store and transport, and this ratio varies according to the species and shape of the product.

Fertilizers did not affect the inflorescence number but, unlike other anthuriums, in which the number, appearance and duration of inflorescences are criteria for use as potted plants, for *Anthurium maricense* the main attractions are the characteristic of its leaves and longevity. In a study with 21 anthurium cultivars for indoor use, Henley and Robinson (1994) classified 'Crystal Hope' as grown specifically for its showy foliage color pattern, and the non-showy inflorescence did not depreciate the ornamental value of the plant.

Although the NPK and nitrogen foliar fertilizers did not influence the leaf number, there was an interaction between them for the leaf area of anthurium plants. In the absence of foliar fertilization, the maximum leaf area was obtained with the NPK rate of 5.4 kg m^3 (Figure 1), indicating that this variable was probably limited by the nutrient present in lowest quantity in the 04-14-08 formulation, i.e., the nitrogen. With the application of foliar nitrogen, the effect of NPK fertilizer was suppressed and nitrogen limitation was overcome, which led to an increase in the leaf area of the plants. In the absence of NPK in the substrate, the application of foliar nitrogen once and twice a month increased leaf area by 10 and 81%, respectively. The application of Osmocote® at rate of 6.4 kg m^{-3} in *Anthurium maricense* plants increased leaf area by 11%, while higher rates caused a decrease in leaf area due to the possibly increased electrical conductivity (EC) (Campos et al. 2019).

An increase in leaf area is interesting from the point of view of reducing the permanence time of the plants in the greenhouse, especially for potted foliage plants. In addition, leaves are organs

Table 2. NPK fertilizer on the commercial substrate and frequency of foliar nitrogen fertilizer in the dry mass production of potted *Anthurium maricense*.

Foliar fertilizer	Dry mass				
	Leaves	Inflorescence	Shoots	Roots	Total
	g per plant				
No foliar	5.66 b[1]	1.87 b	7.53 b	7.57 b	15.10 b
Once a month	6.92 b	1.92 b	8.83 b	7.70 b	16.53 b
Twice a month	9.34 a	3.57 a	12.91 a	10.31 a	23.22 a
			F test[2]		
Via foliar (F)	17.290**	11.335**	17.694**	12.839**	17.465**
Via substrate (S)	2.638*	1.015 ns	3.510*	4.768**	5.474**
F x S	2.290*	1.484 ns	3.217**	1.845 ns	3.297**
CV $\%_{foliar}$	33.69	64.09	37.40	27.77	31.06
CV $\%_{substrate}$	32.96	63.52	28.58	26.35	23.61

[1] Mean values followed by the same lower-case letters for each variable did not differ statistically by Tukey's test ($P \leq 0.05$).
[2] ns; ** and *: Non-significant; significant at $P \leq 0.01$ and $P \leq 0.05$, respectively.

that perform the function of intercepting and absorbing light, besides performing photosynthesis, gas exchange, and transpiration (Taiz and Zeiger 2009). Therefore, leaf area is an important parameter in plant development (Schmildt et al. 2016) and productivity indicator (Peksen 2007). Positive response of leaf area to nitrogen fertilizer was also observed by Freitas et al. (2010) in anthurium plants (*Anthurium affine* Schott) grown in pots. This is due to the fact that nitrogen is the main responsible for the vegetative growth, which is reflected in the leaf area index (Malavolta 2006). However, ornamental plants normally demand potassium in higher quantity than nitrogen. For potted *Anthurium maricense*, the accumulation of nutrients followed a descending order: K > N > Ca > Mg > P = S > Mn > Fe > Zn > B > Cu (Taniguchi et al. 2018).

NPK and nitrogen foliar fertilizers influenced dry mass production of *Anthurium maricense* (Table 2). Although the fertilizations did not increase the inflorescence number (Table 1), there was an increase in the inflorescence dry mass with foliar fertilization applied twice a month. Root dry mass was affected by NPK rates and foliar fertilizer frequency. Maximum root dry mass was obtained with NPK rate of 5.4 kg m^{-3}, which coincides with the NPK rate that resulted in the maximum leaf area value. Root development is often related to phosphorus availability in soil or substrate; however, this nutrient was not limiting since it was the most predominant element in the applied fertilizer. Root dry mass may have been limited by the lower nitrogen availability.

There was no significant difference in the leaf, inflorescence, shoot, root, and total dry masses between the plants that received foliar fertilization once a month in comparison to the control. Foliar fertilizer at the frequency of twice a month favored the accumulation of dry mass in potted anthurium plants (Table 2).

Leaf, shoot and total dry masses were influenced by NPK and nitrogen foliar fertilizers. In the absence of foliar fertilizer, the maximum values of leaf, shoot and total dry mass were obtained with the NPK rates of 5.1, 4.7 and 5.0 kg m^{-3}, respectively (Figure 2). NPK fertilizer associated with foliar fertilizer once a month promoted linear increases in leaf, shoot and total dry masses. Regardless of the NPK rate, foliar nitrogen fertilizer applied twice a month promoted an increase in leaf, shoot and total dry masses, suggesting that the commercial substrate provided nutrients, except for nitrogen, in sufficient quantities for the development of anthurium plants. Li and Zhang (2002) obtained high quality and maximum dry weight of anthurium plants that received N rates in the irrigation water at concentration of 20 mg L^{-1}. According to Shahin and Dergham (2018), potting plants that receive fertilization respond in growth and development due to the fact that the roots are restricted within the pot.

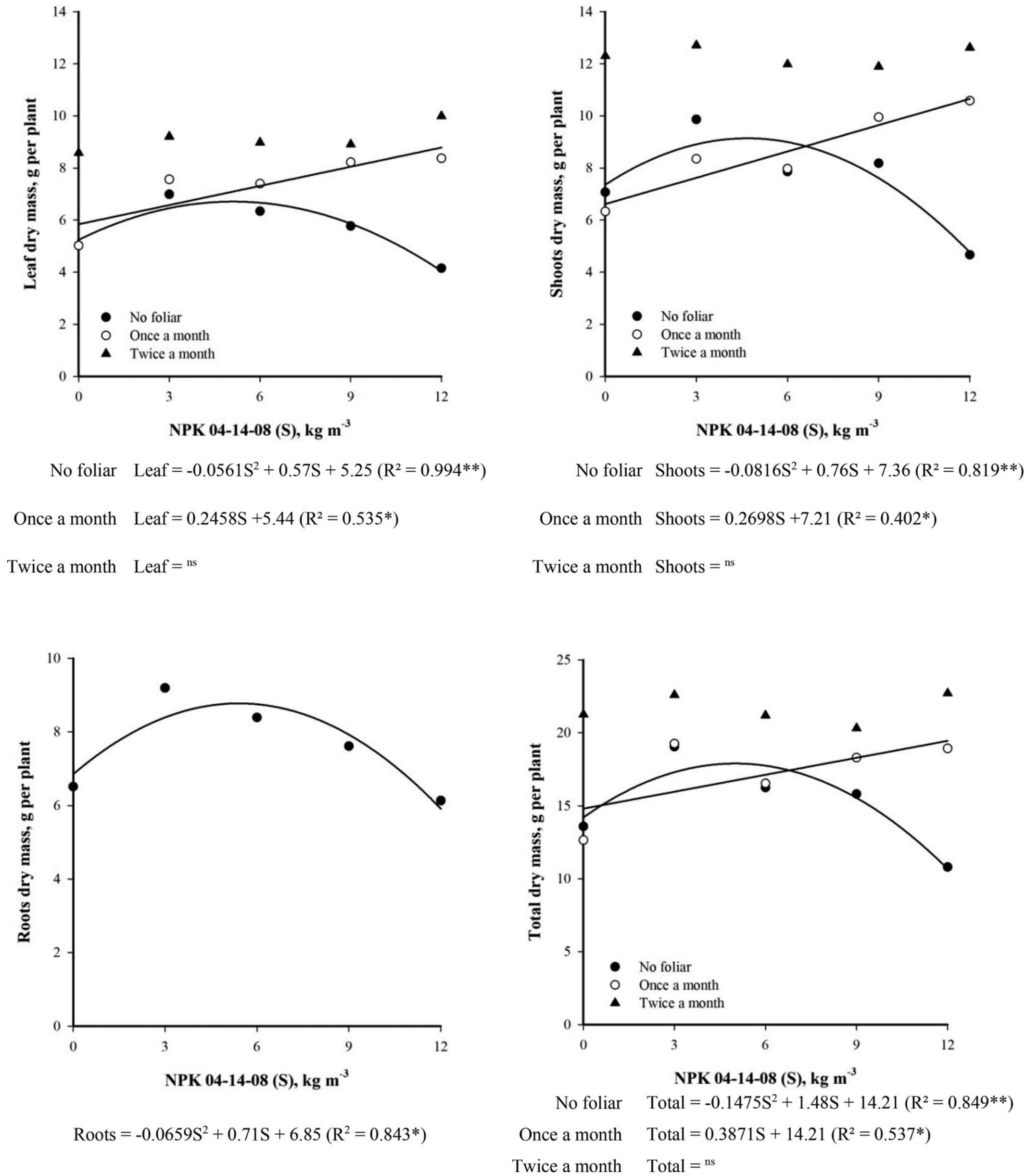


Figure 2. Leaf, shoots, roots and total dry mass production of potted *Anthurium maricense* as affected by NPK and foliar nitrogen fertilizers.
^{2ns}; ** and *: Non-significant; significant at $P \leq 0.01$ and $P \leq 0.05$, respectively.

Conclusion

With foliar application of urea, twice a month, there is no need for NPK application in the commercial substrate used in the cultivation of foliage anthurium in pots.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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