Growth and nutrient uptake by potted foliage anthurium[(1)]

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ABSTRACT

Nutrient uptake study is important to understand the plant nutritional requirements during its growth and to identify periods of increased nutrient demand and, thus to establish fertilization program. The objective was to determine the growth and the nutrient uptake by potted foliage anthurium. The experiment was carried out in a greenhouse and the experimental design was completely randomized with ten times of plant sampling (0; 30; 60; 90; 120; 150; 180; 240; 300; and 360 days after transplanting) and five replicates. *Anthurium maricense* Nadruz & Mayo seeds were germinated in polyethylene trays filled with commercial substrate and the seedlings were transplanted into plastic pots (1.16 L capacity) when reached four leaves. Plant height, leaf number and foliar area were determined every sampling. Blades with petioles, stem, inflorescence and roots were collected and dry mass and nutrients accumulation were determined. Foliage anthurium plants showed initial development but from the 180 days of planting, which corresponds with the beginning of the inflorescence emission, there was a marked increase in height, leaf area, and dry mass and nutrient accumulation. Nutrient accumulation after 360 DAT followed the decreasing order: K > Ca > N > Mg > P > S > Mn > Fe > Zn > B > Cu.

Keywords: *Anthurium maricense*, ornamental plants, nutritional status.

RESUMO

Crescimento e absorção de nutrientes por antúrio para folhagem cultivado em vaso

A determinação da marcha de absorção de nutrientes é importante para entender as necessidades nutricionais das plantas durante o seu crescimento, identificar os períodos de maior demanda de nutrientes e, posteriormente, estabelecer um programa de adubação. O objetivo deste estudo foi determinar o crescimento e a absorção de nutrientes pelo antúrio para folhagem cultivado em vaso. O experimento foi conduzido em casa de vegetação e o delineamento experimental foi inteiramente casualizado, com dez épocas de amostragens de plantas (0; 30; 60; 90; 120; 150; 180; 240; 300; e 360 dias após o transplantio) e cinco repetições. Sementes de *Anthurium maricense* Nadruz & Mayo foram germinadas em bandejas de polietileno preenchidas com substrato comercial e as mudas foram transplantadas em vasos plásticos (capacidade de 1,16 L) quando apresentavam quatro folhas. A altura das plantas, o número de folhas e a área foliar, foram determinados a cada amostragem. Lâminas com pecíolos, caule, inflorescência e raízes foram coletadas e o acúmulo de massa seca e de nutrientes foram determinados. O antúrio para folhagem apresentou desenvolvimento inicial lento, mas a partir dos 180 dias de plantio em vasos, que correspondeu ao início da emissão da inflorescência, houve aumento acentuado na altura de plantas, área foliar e acúmulo de massa seca e de nutrientes. O acúmulo de nutrientes aos 360 DAP seguiu a ordem decrescente: K > Ca > N > Mg > P > S > Mn > Fe > Zn > B > Cu.

Palavras-chave: *Anthurium maricense*, plantas ornamentais, estado nutricional

1. INTRODUCTION

On the one hand we have the mega diverse Brazilian flora, with a large reservoir of species with ornamental potential (CASTRO et al., 2010), and on the other hand the market of ornamental plants is avid for the introduction of novelties, and so in this context the introduction of native species in cultivation, may be a future alternative of differentiated products for Brazilian floriculture. The green potted plant are in fashion, represents 15% of the European market of floriculture products, is the second more commercialized, behind only cut flowers and foliage (EUROPEAN COMMISSION, 2017).

Among the factors have led to increased demand, we highlight that consumers are looking for plants that are easy to maintain (easy to care) and the convenience of having a more durable product at home. It was observed by the increase in the demand for other channels of distribution of these products, like the self-service type as supermarkets (NEVES and PINTO, 2015).

There are several species with great ornamental potential, conserved in public or private germplasm collections (MORAIS et al., 2017). Among these species are selections or varieties that are already ready for commercialization, others still lack some technological contribution for large-scale cultivation or propagation, and

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there are also some promising materials that need to be selected and finalized.

Anthurium is recognized for its ornamental importance, and among species with potential for use as pot plant, *Anthurium maricense* Nadruz & Mayo is described as a beautiful, durable, small and easy care plant. Perennial and terrestrial plants that grows well in shady environments; have a sympodial growth stem, single leaves, oblong to lanceolate leaf blade, and in nature does not exceed 30 cm in length (VALADARES and SAKURAGUI, 2016).

A desirable interior foliage plant must have the ability to maintain a high aesthetic value while exhibiting a greater longevity in an interior environment. According to Chen et al. (1999) the adaptability to interior conditions and its versatility as a potted plant, do the *Anthurium* a true interior-flowering foliage plant.

Mainly for ornamental plants, the appearance and the production are primordial factors for their insertion in the flower market. The quality of the plants is associated with their physical characteristics, which are dependent on the chemical nutrition, that is, the adequate nutritional balance, resulting in the appearance of the plants and the standards definition for the commercialization (MARSCHNER, 2012).

Plant development and growth is restrained in pots due to the limited substrate volume and restricted root growth. Understanding the nutritional requirement is important to synchronize the timing of fertilizer applications with plant nutrient demand, improving the plant quality and decreasing the production costs (FURTINI et al., 2015).

The objective of this study was to determine the growth and the nutrient uptake in potted foliage anthurium (*Anthurium maricense*).

2. MATERIALS AND METHODS

The experiment was carried out in a greenhouse located at the Embrapa Agroindústria Tropical (Fortaleza, Ceará State, Brazil). The greenhouse covering was a black shade cloth of 50% of shading.

The experimental design was completely randomized with ten times of plant sampling (0; 30; 60; 90; 120; 150; 180; 240; 300 and 360 days after transplanting) and five replicates. *Anthurium maricense* seeds were collected from Embrapa Tropical Flowers germplasm collection and germinated in 162 cells polyethylene trays filled with commercial substrate (mixture of composted pine bark, peat and vermiculite).

Seedlings were transplanted into plastic pots number 15 (1.16 L of capacity: 10.5 x 14.5 x 11.0 cm) filled with the same commercial substrate as described above when reached four leaves (approximately four months after sowing). Five grams per pot of controlled release fertilizer (15-09-12) were mixed to commercial substrate prior the seedlings transplanting. Pots were watered daily through an overhead sprinkler irrigation system. During the experiment was not given any pesticide sprays and weeds were manually removed.

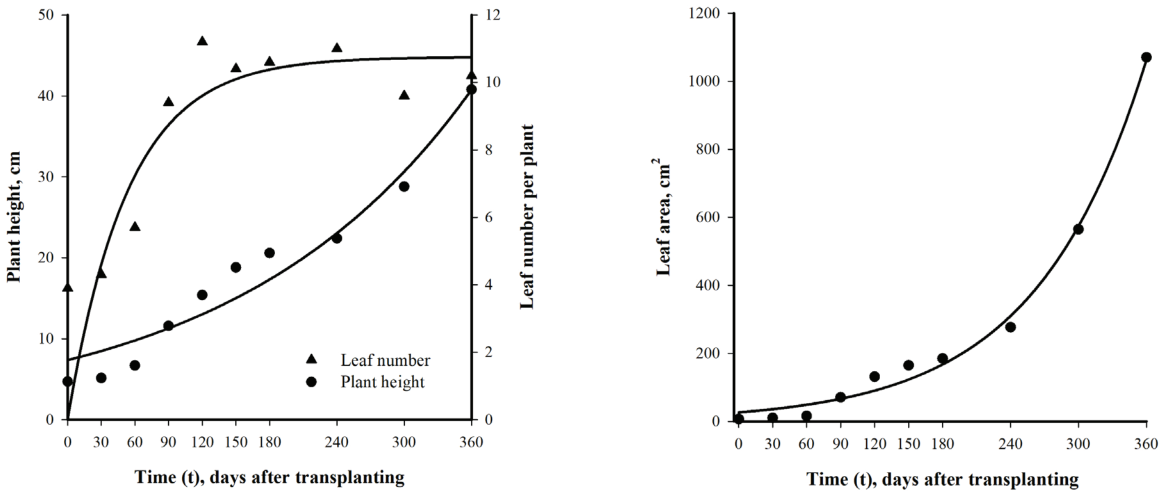
Plant height, leaf number, leaf area, shoot system blades with petioles, stem and inflorescences, when there were) and roots dry mass were determined at every evaluation time. Leaf number was determined by counting all living leaves per plant. Plant height was measured from substrate surface to the longest leaf tip. Leaf area was determined using electronic integrator (LI-3100C, LI-COR). Shoot systems and root systems were separated, washed with hydrochloric acid solution 3% (v:v) and deionized water and dried in an oven at 65 °C until constant weight. Afterwards, shoots and roots dry mass were determined and grounded up to pass through a 1.0 mm sieve.

Macronutrients and micronutrients were determined as described in Miyazawa et al. (2009). Nitrogen was determined by micro Kjeldahl; phosphorus, potassium, calcium, magnesium, sulfur, copper, iron, manganese and zinc by inductively coupled plasma optical emission spectroscopy (ICP-OES) and boron by azomethine-H method. Nutrient uptake was calculated by multiplying the nutrient content determined in each plant part by the respective dry mass production.

The data obtained were subjected to variance analysis using SAS program and means were adjusted to exponential models (SAS, 2012).

3. RESULTS AND DISCUSSION

Foliage anthurium grown in plastic pots showed slow initial growth and development until 120 days after transplanting. During this period there was slight increase in height, leaf area, and shoot system and root system dry mass production (Figure 1 and 2). On the other hand, in this period there was a considerable increase of number of leaves per plant, and followed by stabilization of this variable (Figure 1).

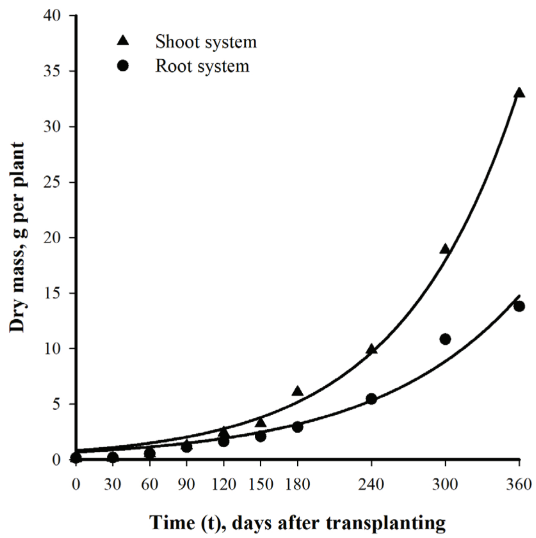


Height: H = 7.35*$e^{(0.0048*t)}$ (R^2 = 0.940**)
Leaf number: LN = 10.76*(1-$e^{(-0.0186*t)}$) (R^2 = 0.654**)

Leaf area:LA = 26.28*$e^{(0.0103*t)}$ (R^2 = 0.992**)

Figure 1. Foliage anthurium (*Anthurium maricense*) height, leaf number (1A) and leaf area (1B) over 360 days of cultivation in pots. ** Significant at 0.01 probability level.

The average leaf number, approximately 11 per plant, is similar to that reported by Morais et al. (2017) in a study with four accessions of foliage anthurium for cutting. These authors also claim that slow growth is advantageous for potted plants due to the need for replacement by larger containers as the plant grows.



Shoot: S = 0.8029*$e^{(0.0104*t)}$ (R^2 = 0.994**)
Root: R = 0.6911*$e^{(0.0085*t)}$ (R^2 = 0.965**)

Figure 2. Foliage anthurium (*Anthurium maricense*) shoot system and root system dry mass production over 360 days of cultivation in pots.

After 360 days of cultivation in pots, the plants presented about 40 cm in height, which resulted in unbalance of ratio plant height/pot height. The plant size in proportion to the pot sizes is crucial to define appearance and to improve the capacity to store and transport, this ratio varies according to the species and shape of the product (MEGERSA et al., 2018). The plant height in relation to the pot size is one of the quality parameters established by the Veiling Holambra Cooperative (largest wholesaler of flowers and plants in America) for classification and commercialization of ornamental cultivars.

Quality parameters for *Anthurium* non-floriferous species have not yet been established. For some other species of ornamental aroids, marketed as potted foliage, the quality standard established for pot nº 15 (10 cm high), is a plant height depending on the species, between 12 to 25 cm, just over about half to two-third of the total height (plant + pot) (VEILING HOLAMBRA COOPERATIVE, 2018). Considering the minimum height established to *Dieffenbachia,* for an example, the plant height would be obtained around 125 days of transplanting.

From the 180 days of transplanting there was a marked increase in the growth and development of the plants, coinciding with the reproductive period and the emission of the inflorescences. In fact, foliage plants like *Anthurium maricense* are a segment of floriculture, wherein flowering is not attraction because the interest is only in the vegetative growth and plant morphogenesis. In a study of 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 detract the ornamental value of the plant. Other anthurium species also present potential for use as foliage, such as *Anthurium bonplandii subsp guayanum* (Bunting) Croat., *A. superbum* Madison and *A. magnificum* Linden. (DONSELMAN and BROSCHAT, 1988).

Although nutrient contents in the leaves varied according to the stage of plant development, leaf age, time of year, within species and even within cultivars, the nutrients contents obtained for foliage anthurium were comparable to cut flower anthurium. At the beginning of the inflorescence emission (180 days of transplanting) nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), copper (Cu) and iron (Fe) contents in foliage anthurium shoot system (leaves + stem + inflorescence) were within the range recommended to Tombolato et al. (1997) for mature and complete expanded anthurium leaf (Table 1).

Table 1. Macro and micronutrients contents in *Anthurium maricense* shoots (leaves + stem) at the beginning of the flowering (180 days after planting in pots).

N	P	K	Ca	Mg	S
------------ $g\ kg^{-1}$ ------------					
18.2 ± 0.4	2.3 ± 0.1	23.8 ± 2.7	12.7 ± 1.7	3.4 ± 0.4	2.3 ± 0.1
Cu	**Fe**	**Zn**	**Mn**	**B**	
------------ $mg\ kg^{-1}$ ------------					
10 ± 1	101 ± 21	74 ± 5	377 ± 20	19 ± 1	

Recommended nutrients contents in anthurium mature and complete expanded leaves according to Tombolato et al. (1997). N; P; K; Ca; Mg and S, in $g\ kg^{-1}$: 16-30; 2-7; 10-35; 12-20; 5-10 and 1.6-7.5, respectively. Cu; Fe; Zn; Mn and B in $mg\ kg^{-1}$: 6-30; 50-300; no information; 50-200 and 25-75, respectively.

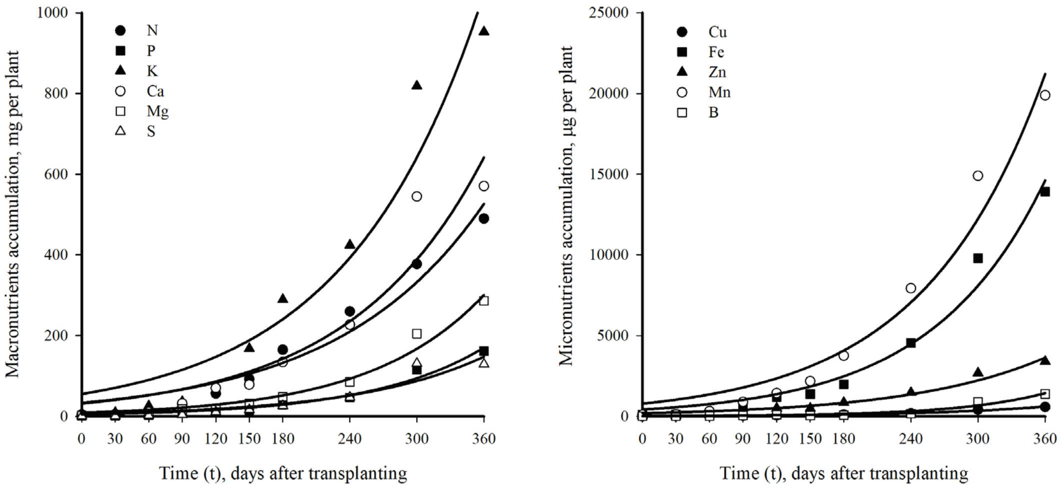
For *Anthurium maricense* the nutrients followed the descending order: K > N > Ca > Mg > P = S > Mn > Fe > Zn > B > Cu. In six *Anthurium x cultorum Birdsey* cultivars, fully expanded leaves presented macronutrients contents in the following decreasing order: K > Ca > N > P > S > Mg > Mn > B > Zn > Fe > Cu (KLEIBER et al., 2009a; 2009b). Ornamental plants normally demand potassium in higher quantity. This element is related to the maintenance of the osmotic balance in plant cells, enzyme activation, protein synthesis, photosynthesis, and stress resistance (MARSCHNER, 2012).

Magnesium (Mg) and boron (B) contents in the leaves were below the range considered adequate but no symptoms of deficiency of these nutrients were observed. Likewise, no symptoms of manganese (Mn) toxicity were observed in leaves. Magnesium deficient plants presents yellowing in older leaves and edges of younger leaves, followed by interveinal chlorosis and new leaves were light green and distorted (IMAMURA and HIGAKI, 1984). Symptoms of magnesium deficiency in *Anthurium andraeanum* reported in the literature range from 0.8 to 2.8 $g\ kg^{-1}$ (NOGUEIRA et al., 1980; IMAMURA and HIGAKI, 1984).

Boron sufficiency ranges in the anthurium leaves are quite varied: 11-27 (MILLS and SCOGGINS, 1998); 25-135 (UCHIDA, 2000) and 20-100 $mg\ kg^{-1}$ (CHEN et al., 2003). Kleiber and Komosa (2010) found boron content in the leaves ranging from 63.5 to 89.0 $mg\ kg^{-1}$ in six cultivars of *Anthurium cultorum* Birdsey. Boron omission, alone or in combinations with other micronutrients, caused changes in the leaf morphology and the decrease in *Anthurium andraeanum* cv. 'Jureia' leaves, stems, roots and inflorescence dry mass production (PINHO et al., 2012). According to these authors, symptoms of boron deficiency were characterized by decrease in growth, dark green and thick young leaves and then, shrouded leaves appearance.

The application of organic compost based on cattle manure and tea leaf residue resulted in manganese content of 370.1 $mg\ kg^{-1}$ in leaves and absence of toxicity symptoms, however, the authors attributed the lower development of the plants to high element concentration in the leaves of *A. andreanum* (Chang et al., 2010). Zinc (Zn) content in the leaves was within the range (28.6-87.4 $mg\ kg^{-1}$) found by Mills and Scoggins (1998) in young and mature leaves of four cultivars of *Anthurium andraeanum*. Kleiber and Komosa (2010) found zinc content in the leaves ranging from 60.3 to 67.6 $mg\ kg^{-1}$.

Nutrients accumulation in foliage anthurium followed the trend of total dry mass production, i.e. shoot system plus root system (Figure 2). Up to 180 days cultivation in pots, *Anthurium maricense* plants accumulated, in mg per plant: 242 of K; 144 of Ca; 131 of N; 52 of Mg; 31 of S; 29 of P; 4.0 of Mn; 2.5 of Fe; 0.8 of Zn; 0.2 of B; and 0.1 of Cu. With the beginning of the inflorescence emission there was a substantial increase in the nutrients accumulation. From 180 to 360 day of cultivation in pot there was a four-fold increase in nutrient accumulation. Nutrient uptake increases during the reproductive stage of potted gerbera was also observed by Ludwig et al. (2008); Guerrero et al. (2012) and Ludwig et al. (2013). At 360 day of cultivation, the accumulation followed the decreasing order: K > Ca > N > Mg > P > S (1059; 652; 515; 305; 171; and 148 mg per plant), while for micronutrients Mn > Fe > Zn > B > Cu (20.7; 14.9; 3.7; 1.4; and 0.6 mg per plant).



Nitrogen $N = 33.36*e^{(0.0076*t)}$ ($R^2 = 0.971**$)
Phosphorus $P = 5.02*e^{(0.0098*t)}$ ($R^2 = 0.970**$)
Potassium $K = 55.34*e^{(0.0082*t)}$ ($R^2 = 0.945**$)
Calcium $Ca = 31.71*e^{(0.0084*t)}$ ($R^2 = 0.935**$)
Magnesium $Mg = 8.97*e^{(0.0098*t)}$ ($R^2 = 0.973**$)
Sulfur $S = 6.45*e^{(0.0087*t)}$ ($R^2 = 0.923**$)

Copper $Cu = 21.55*e^{(0.0093*t)}$ ($R^2 = 0.976**$)
Iron $Fe = 421.20*e^{(0.0099*t)}$ ($R^2 = 0.970**$)
Manganese $Mn = 783.50*e^{(0.0091*t)}$ ($R^2 = 0.955**$)
Zinc $Zn = 191.10*e^{(0.0082*t)}$ ($R^2 = 0.966**$)
Boron $B = 15.82*e^{(0.0125*t)}$ ($R^2 = 0.937**$)

Figure 3. Macronutrients and micronutrients accumulation in foliage anthurium (*Anthurium maricense*) over 360 days of cultivation in pots. ** Significant at 0.01 probability level.

It was observed that the nutrients should be available on the substrate for the entire growing period. A commercial substrate like those found in supermarkets can supply the need for macro and micronutrients in the growth phase of potted *Anthurium maricense*. Potassium, nitrogen and calcium were the most accumulated nutrients. Calcium can be supplied via lime and mixed to the substrate at the pot fulfillment. Potassium and nitrogen fertilization, which are more susceptible to the losses should be split over the cultivation period and intensified with the beginning of reproductive phase.

At twelve months of cultivation, foliage anthurium plants had excessively developed shoot system for the pot used (capacity for 1.16 L), resulting in tipping. The roots, visually evident on the substrate surface, promoted the plastic pot deformation. Thus, long period of cultivation in pots, besides increasing the production costs, can result in detriment in the appearance of the commercial product. Therefore, for the production of anthurium for foliage (*Anthurium maricense*) in 1.16-liter pots, it is recommended to cultivate the plants for a maximum period of eight months.

4. CONCLUSIONS

Foliage anthurium plant showed very slow initial growth and development, but from the 180 days of transplanting, presented a marked increase in total dry mass production, which corresponded with the beginning of the inflorescence emission;

Nutrient accumulation at 360 DAT followed the decreasing order: K > Ca > N > Mg > P > S > Mn > Fe > Zn > B > Cu.

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AUTHORS CONTRIBUTIONS

C.A.K.T. 0000-0002-1280-8678**:** conception and design of the research, data interpretation, manuscript writing. **A.C.R.C.** 0000-0001-6441-9888**:** conception and design of the research, data interpretation, manuscript writing. **A.G.A.** 0000-0001-6009-2750**:** data interpretation, statistical analysis, manuscript writing. **T.S.M.** 0000-0002-4752-5256**:** conducting of the research, data collection, and laboratory analysis. **E.A.A.** 0000-0002-4405-2086**:** conducting of the research, data collection, and laboratory analysis.

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