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Nitrogen, phosphorus and potassium nutrition on ornamental *Ipomoea purpurea* growth

Nitrogênio, fósforo e potássio no crescimento ornamental de *Ipomoea purpurea*

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Abstract: The study aimed to evaluate the effect of nitrogen, potassium, and phosphorus on *I. purpurea* growth. Plants were weekly fertilized with 50 mL of Hoagland & Amon (1950) modified nutrient solution as follow: Nitrogen solution with 0, 0.0888, 0.2001, 0.6003 or 1.801 g L^{-1} of ammonium nitrate; Phosphorus solution with 0, 2.1, 5.5, 10.3 or 13.5 mL L^{-1} phosphoric acid, and Potassium solution with 0, 0.3728, 1.1183, 1.8638 or 2.2065 g L^{-1} potassium chloride. *I. purpurea* showed high demand for N, reflected on an increase of leaf area. Higher concentration of N promoted preferential investment in photosynthetic areas, as confirmed by the leaf/root ratio. *I. purpurea* is responsive P fertilization, mainly to promote stem and root growth. *I. purpurea* was not responsive to K fertilization. The results showed that fertilization with 0.2001 g L^{-1} ammonium nitrate and 5.5 mL L^{-1} phosphoric acid is recommended for *I. purpurea* cultivation.

Keywords: Floriculture. Morninglory. Mineral nutrition. NPK.

Resumo: O estudo objetivou avaliar o efeito de nitrogênio, fósforo e potássio no crescimento de *I. purpurea*. As plantas foram fertilizadas semanalmente com 50 mL de solução nutritiva modificada de Hoagland & Amon (1950): Nitrogênio com 0; 0,0888; 0,201; 0,6003 ou 1,801 g L^{-1} de nitrato de amônio; Fósforo com 0; 2,1; 5,5; 10,3 ou 13,5 mL L^{-1} de ácido fosfórico e Potássio com 0; 0,3728; 1,1183; 1,8638 ou 2,2065 g L^{-1} de cloreto de potássio. *I. purpurea* apresentaram alta demanda por N, que resultou em aumento da área foliar. A maior concentração de N promoveu investimento preferencial nas áreas fotossintéticas, confirmado pela relação folha/raiz. *I. purpurea* é responsiva a fertilização com fósforo, principalmente para promover o crescimento de caule e raízes. *I. purpurea* não respondeu à fertilização com K. Os resultados do estudo recomendam a fertilização com 0,2001 g L^{-1} de nitrato de amônio e 5,5 ml L^{-1} de ácido fosfórico no cultivo de *I. purpurea*.

Palavras-chave: Floricultura. Ipomoea. Nutrição mineral. NPK.

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Introduction

The Brazilian market of Floriculture and Ornamental Plants has acquired a remarkable importance and visibility, constituting itself as an eminent segment for national and regional economies. Production of the sector are estimated to be of R$ 7.2 billion or US$ 1.9 billion in 2017 (IBRAFLOR, 2017). The identification and valorization of native species with ornamental potential is an important target for research in floriculture (Junqueira & Peetz, 2018).

The *Ipomoea* genus (Convolvulaceae) have many species with high ornamental potential, such as *Ipomoea alba*, *Ipomoea purpurea* and *Ipomoea quamoclit*, which has produced attention in international floriculture market, motivated by morphological aspects such as lush foliage and flowers that extend along the stem and are adapted to various environments (Fischer *et al*., 2007). The use of these species in plant ornamentation and landscape has been overlooked in Brazil; with few studies investigating new technologies for *Ipomea* cultivation. The main studies on *Ipomoea* highlight the importance that some species present as invasive plants in agronomic systems or as a potential bioindicator of atmospheric pollutants (Ferreira *et al*., 2012).

Considering the fundamental role that balanced fertilization provides for the growth and development of plants, especially with the supply of macronutrients such as nitrogen (N), phosphorus (P) and potassium (K). Plants cannot synthetize DNA, RNA, enzymes, ATP and many other key components, in the lack of nitrogen and phosphorus and potassium is an important regulator of plant responses and tolerance to abiotic stress (Galembeck *et al*., 2019). This study aimed to answer the following questions: are plants of *I. purpurea* (L). Roth biometrically more responsive to N, P or K supplies? What is the optimum concentration of these nutrients to promote the biometric growth of this species? The study aimed to determine the best fertilizer dose to cultivate *I. purpurea*; thus, biometric responses of *Ipomoea purpurea* fertilized with concentrations of N, P or K were evaluated.

Material and Methods

Seeds of *Ipomoea purpurea* were purchased from a commercial supplier and sown in plastic pots containing 500 mL of $^{1}/_{3}$ soil (Ferralsol - WRB, 2014) and $^{2}/_{3}$ of washed sand. Plants with two pairs of fully expanded leaves were used in the experimentation. The experiment was carried out in an experimental greenhouse (23º39'10"S-46º 42'42"W) with 30% shading at Universidades Nove de Julho, São Paulo State, Brazil. During experimentation the average of temperature was 19.3 ºC, and relative humidity was 76%. Plants were daily irrigated during all experimentation period.

Plants were weekly fertilized for four months with 50 mL of Hoagland & Amon n.1 (Hoagland & Amon , 1950) modified nutrient solution as follow: Nitrogen solution (N) with 0 g L^{-1} (T0), 0.0888 g L^{-1} (T1), 0.2001 g L^{-1} (T2), 0.6003 g L^{-1} (T3) or 1.801 g L^{-1} ammonium nitrate (T4); Phosphorus solution (P) with 0 ml L^{-1} (T0), 2.1 ml L^{-1} (T1), 5.5 ml L^{-1} (T2), 10.3 ml L^{-1} and 13.5 ml L^{-1} phosphoric acid, and Potassium solution (K) with 0 g L^{-1} (T0), 0.3728 g L^{-1} (T2), 1.1183 g L^{-1} (T2), 1.8638 g L^{-1} (T3) and 2.2065 g L^{-1} potassium chloride (T4). The experimental design was completely randomized in a 3 x 4 factorial scheme with 10 plants per parcel, repeated 3 times and totalizing 360 plants.

After four months of experimentation the plants were sectioned on shoot and root systems and the biometric parameters of plant height (g) and the main root length (cm) were evaluated, and leaf area index (cm^2) were calculated according to the model proposed by Bianco *et al*. (2007): LAI = 0.6211*width*length (leaf).

Data were analyzed using a multivariate analysis of variance (MANOVA) followed by Tukey post hoc test, considering the nutrient applied and concentration with statistical significance at $p \leq 5\%$, and presenting the effect size (η2) of the interaction. All variables were standardized using *Z* transformation to standardize the metrics before the analysis, using the SPSS statistical software, version 20.

Results and Discussion

The effect of N, P or K concentrations or the nutrients in vegetative development of *I. purpurea* was evaluated by MANOVA, considering shoot and root biometry (Table 1). The interaction between concentration and nutrient was significant for plant growth ($p \leq 0.001$), accounting for 31% of the observed multivariate variance. In addition, the factors of the interaction have a main effect over the biometry of the species, once its effects were significant in all conditions. Biologically, the analysis showed that N, P or K application promotes differentiation on *I. purpurea* growth, as well as the concentrations of each nutrients will reflect the specie vegetative development. Fertilization determines electron transport in the light phase of photosynthesis; thus, it can be manifested on *I. batatas* by an increase in yield, plant resistance to abiotic stress, changing the shape of tubers (according to industry standards), and modification of crop quality (Sawicka *et al*., 2015). Several authors have already reported the increase in productivity of herbaceous species of economic interest after nitrogen fertilization (Santi *et al*., 2006, Almeida-Oliveira *et al*., 2011); however, it should be considered that some species of *Ipomoea* genus present morphological adaptations that permit to have high productivity even in low nutritional availability (Echer *et al*., 2009).

Table 1. Multivariate variance analysis (MANOVA) of *Ipomoea purpurea* shoot and root biometric parameters evaluating the complete model of the effects of factors nutrients and concentration and analysis of the main effects on the interaction of these factors.

Effect	Wilks λ value	F	Hypothesis degrees of freedom	Error degrees of freedom	Significance	Parcial η^2
Complet Model	0.022	4,741.824	4	432	0	0.978
Nutrient	0.594	32.141	8	864	0	0.229
Concentration	0.354	33.379	16	1,320	0	0.228
Interaction	0.227	24.693	32	1,595	0	0.31
			Principal Effects			
			Concentration			
T0	0.631	27.997	8	864	0	0.206
T1	0.428	57.087	8	864	0	0.346
T2	0.856	8.765	8	864	0	0.075
T3	0.933	3.805	8	864	0	0.034
T4	0.567	35.445	8	864	0	0.247
			Nutrient			
N	1.092	40.818	16	1,740	0	0.273
P	0.68	22.284	16	1,740	0	0.17
K	0.148	4.171	16	1,740	0	0.037

The leaves of *I. purpurea* showed high demand for N, and the supplementation of the nutrient reflected on an increase of leaf area. The plants of T4 (N) treatment showed averages of approximately 60.0 cm^2, corresponding about 40% higher than other concentrations (Figure 1A). However, T4 (N) treatment decrease length of shoot and roots (Figures 1B and 1C). The results point out that the higher concentration of N promoted preferential investment in photosynthetic areas, as confirmed by the leaf/root ratio (Figure 1D). *Ipomoea* plants would invest its energy demand for leaf development instead of root development with higher N availability in soil. This state is consistent with the resource optimization hypothesis, which affirms “in general with increasing availability of nutrients in soils plants spends less effort to acquire this resource; thus, plants allocates lower resources in roots (Ågren & Franklin, 2003). However, when N is in lower concentrations as on T1 (N) treatment, occurs greater root growth in detriment of leaf area. Our results showed that N availability control the balance between shoot and root systems in *I. purpurea*.

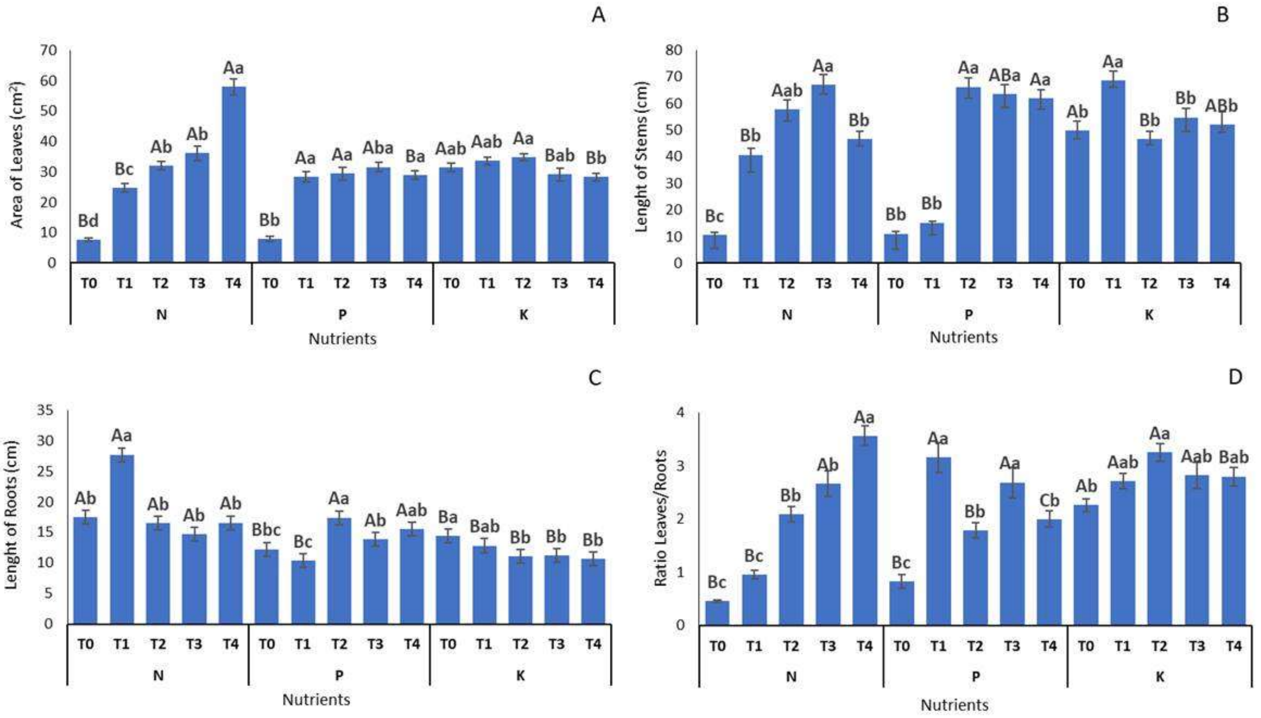

Figure 1. Area of leaves (cm^2), stem (mm), root (cm) and leaves/roots ratio of *Ipomoea purpurea* plants submitted to fertilization with Nitrogen (N), Phosphorus (P) and Potassium (K). Capital letters compares Nutrients and lowercase letters compare Concentrations at $p \leq 5\%$ significance.

I. purpurea plants were responsive to P fertilization. Phosphorus free treatments (T0) were lower than other treatments for all biometric parameters (Figures 1A, 1B, 1C, 1D). Length of shots and roots were not responsive to low concentration of P (T1, 0.3728 g L^{-1} P). Root growth also require a high P demand and the highest root growth were observed on T2 (P) treatment (Figure 1C). There is a lack of study of phosphorus fertilization on *Ipomoea* sp. since FAO (2005) not recommend phosphorus fertilization on *I. batatas*. Low tuberous yield from high phosphorous fertilization in *I. batatas* can be credited to a nutrient imbalance resulted from additional phosphorus nutrition through fertilizer application (Kareem *et al.,* 2020). Reductions in total and commercial yield in *I. batatas* with P_2O_5 above 191 kg ha^{-1} occurred due to the increased salinity in soil; thus, reducing roots growth and/or the unavailability of other nutrients (Costa Cruz *et al.,* 2016). However new studies are showing that *Ipomoea* spp. is responsive to phosphorus (Kareem et al., 2020; Kumar et al., 2016; Silva *et al.*, 2013). Yellowing of older leaves spreading from discrete interveinal stains on the blades are the visible deficiency symptoms of phosphorus on *I. batatas* plants (Makokha et al., 2019). Phosphorus fertilization augmented shoot and root dry matter, total and commercial productivity, and P accumulation in shoot, and tuberous roots of *I. batatas* (Costa Cruz *et al.,* 2016). Additionally, there is a positive association between phosphorus uptake and number of leaves produced by *I. batatas* plants (Kareem, 2013). There usually is no response of *I. batatas* grown in soils with available phosphorus; however, in soils with low of phosphorus such as the Brazilian “Cerrado” fertilization with phosphorus enhance *I. batatas* yield (Silva *et al.,* 2013).

I. purpurea did not require a high demand for K; consequently, high concentrations such as T3 (K) and T4 (K) treatments were detrimental to shoot and root development (Figures 1A-C). The T1 (K) treatment promoted greater height and root growth on *I. purpurea* and T2 (K) greater leaf development (Figures 1A and D). Comparing the three nutrients applied, K had the lowest contribution to *I. purpurea* vegetative development, especially for root growth. Duarte *et al*. (2008) studying the mineral nutrition of *Ipomoea nil* demonstrated that K was the greatest macronutrient accumulated in the specie, mainly after 77 days after emergency of the plants. The highest yield obtained for *I. batatas* was on parcels treated by inorganic fertilizer with high potassium content (NPK, 3-3-6; Koodi, *et al.,* 2017). However, *I. quamoclit* accumulated more N and had a lower requirement of macronutrients (Carvalho *et al*., 2009) than *I. nil* (Duarte *et al.,* 2008). The high fertilization rates (150 mg NPK L^{-1}) depressed *I. purpurea* growth (Gonçalves *et al*., 2019). These results suggest that within the *Ipomoea* genus there is an intraspecific variability for nutrients consumption, with higher requirement of some nutrient over another.

Conclusions

I. purpurea responsive to N and P fertilization. N fertilization enhance shoot, stems and roots growth, and fertilization with 0.2001 g L^{-1} ammonium nitrate is recommended for *I. purpurea*. Fertilization with 5.5 mL L^{-1} phosphoric acid is also recommended to meet *I. purpurea* requirements for P. *I. purpurea* was not responsive to K fertilization.

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