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Visual symptoms, growth and nutrients of *Alpinia purpurata* plants exposed to N, P, K, Ca, Mg and S deficiencies

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Abstract

Aim of this study was to evaluate effects induced by nitrogen, phosphorus, potassium, calcium, magnesium and sulphur deficiencies on visual symptoms and growth and nutrient levels in *Alpinia purpurata* plants (cv. Jungle King). Experimental design was entirely randomized with 7 treatments (N, P, K, Ca, Mg and S deficiencies and control) and 5 replicates. Qualitative parameters measured were visual symptoms and quantitative parameters dry matter of leaves, stem, shoot and root and total dry matter, as well as macronutrients (N, P, K, Ca, Mg and S) in leaves and whole plant. Symptoms linked to nitrogen deficiency were shown in evaluation carried out in 90th day after treatment implementation with old leaves presenting symptoms such as yellow-green leaf colour. Leaf, stem, shoot, root and total dry matter was affected by nutrient deficit, potassium being probably more limiting. Nutrient levels in leaves of control and deficient treatments were 25.1 and 17.6 g kg^{-1} for nitrogen, 5.1 and 1.4 g kg^{-1} for phosphorus, 36.1 and 16.2 g kg^{-1} for potassium, 5.9 and 1.0 g kg^{-1} for calcium, 5.6 and 1.3 g kg^{-1} for magnesium and 4.1 and 1.8 g kg^{-1} to sulphur, respectively. Deficiencies also limited nutrient levels in whole plant, compared with control. Results obtained in this study reveal that potassium and magnesium were nutrients that presented first symptoms after calcium, nitrogen, phosphorus and sulphur.

Key words: *Alpinia purpurata*, mineral nutrition, macronutrients, nutritional deficiency.

Introduction

Agribusiness linked to tropical flowers and ornamental plants in Brazil is increasing, this activity generates financial resources and jobs to this country. Positive effects are also found in other economy sectors due to accessory acquisitions, agricultural supplements and services.

Pará State is located in northern region of Brazil, it exercises influence in Brazilian market of ornamental plants, as well as presents edaphoclimatic conditions favourable to cultivate flowers and ornamental plants. The market in this region moves about 18 million dollars in global commercialization and services [5]. Based in this situation, the flower culture in Pará State represents an alternative to farmers and industries that produced sub-products derived of ornamental plants.

Currently, there is few research related with nutrition in tropical ornamental plants; among these, *Alpinia* gender in edaphoclimatic conditions of Pará State. This fact reflects scarce of results and information aiming increase of yield and quality of flowers. During cultivation of *Alpinia* plants, the determination of nutrient amount is important aiming to obtain growth and development adequate, and consequently the plant will have maximum yield.

Chemical analysis of plant tissue to determine nutrient levels can indicate simple form and fast plant nutritional states, besides it reveals exigencies to plant normal development and negative consequences induced by nutrient deficiencies. Plants are cultivated in nutritive solution in order to evaluate the relation between growth and nutrient level in tissues, being plants exposed to adequate and absence nutrient amounts in solution, in which are considered control and deficient, respectively.

The objective of this study was to evaluate effects induced by nitrogen, phosphorus, potassium, calcium, magnesium and sulphur deficiencies on visual symptoms and growth and nutrient levels in leaves and whole plants of *Alpinia purpurata* (cv. Jungle King).

Materials and Methods

Experiment conditions and plant material: Experiment was carried out under greenhouse conditions in Embrapa Amazônia Oriental, Belém City, Pará State. Temperature interval during study was 24 and 30°C. Plant material used was 15-cm rhizomes of *Alpínia purpurata* (cv. Jungle King).

Rooting: Rhizomes were placed to rooting in substrate composed of sand and sawdust in proportion of 3:1, respectively. Rooted cuttings of 30-cm height were selected and removed. After rooting, they were washed with distillated water aiming to eliminate substrate residues.

Plant acclimation: Rooted cuttings were transplanted to plastic pots with capacity of 5 l containing washed silica (type zero). Silica was washed with distilled water to avoid contamination by organic residues and micro-organisms. Rooted cuttings were acclimated by period of 75 days in nutrient solution of Hoagland and Arnon [4]. Subsequently, all plants were subjected to control and deficiency treatments with pH solution adjusted to 5.5 using HCl or NaOH, when necessary. Nutrient solution was changed in regular intervals of 15 days.

Experimental design: Experiment was entirely randomized with 7 treatments (N, P, K, Ca, Mg and S deficiencies and control), being composed by 5 replicates and 35 experimental units.

Qualitative parameter determination and harvest: Visual symptoms were photo- documented to each treatment. At harvest plants were divided in leaves, stem and root, being plant parts placed to dry in a oven with forced air circulation at temperature of 70°C by period of 72 hours.

Determination of quantitative parameters: Dry matter of different parts and whole plant was measured and determined. Afterwards, these plant parts were triturated aiming chemical analysis.

Macronutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S) in leaves and whole plant were determined according to Malavolta *et al.* [7]. Nutrient concentrations were measured in function of nutrient level and leaf dry matter or plant dry matter.

Data analysis: Data were submitted to variance analysis, and when significant differences occurred, Tukey's test was applied at 5% level of error probability. Statistical analysis was carried out with the software ESTAT®.

Results and Discussion

Visual symptoms promoted by nitrogen deficiency: Symptom linked to nitrogen deficiency was shown 90 days after treatment applications. Compared to control (Fig. 1A) old leaf presenting symptom more intense and yellow-green colour (Fig. 1B). This colour is probably related with low chlorophyll production and modifications in chloroplasts [8]. Data obtained to plant height, leaf number and leaf size were reduced, when compared to control plants. These changes are similar to other ornamental genders, such as *Rosa* [3].

Consequences of phosphorus deficiency in leaf: Plants exposed to phosphorus deficiency presented symptoms with 90 days after experiment implementation. Old leaves are showed in Fig. 1C. This colour is more intense due to higher chlorophyll concentration and, according to Mengel and Kyrkby [10], by the decrease in protein synthesis linked to anthocyanin. In vegetative organ of the plant, such as leaf, occurs an increase in carbohydrate amount and this higher sugar concentration is favourable to anthocyanin synthesis in leaf. Plants with phosphorus deficiency also presented reduction in plant height, leaf size and leaf number, if compared to control plants. Similar symptoms promoted by phosphorus deficit were also reported by Lima and Haag [6] and Nogueira *et al.* [12].

Consequences of potassium deficiency in leaves: Plants exposed to potassium deficit presented quickly symptoms (Fig. 1D), if compared to other treatments (Fig. 1A), 11 days after treatment implantation. Clorosys process was showed in apical region of old leaves with development in direction to leaf extremity, and necrosis occurs due to deficiency intensification. Plants presented also reduction in height and leaf number. Normally, symptoms linked to potassium deficit promote initially clorosys and after necrosis in apical and extremity regions of old leaves as reported in this study. This fact is related with putrescine accumulation [13, 8].

Calcium deficiency symptoms: Calcium deficit presented light clorosys in apical region of young leaves; and subsequently these symptoms were shown in all leaf extremity. The deficiency evaluated in this study produced a necrosis also in ribbing, and these symptoms were shown 53 days after experiment execution (Fig. 1E). Young leaves with hard extremities and lightly directed up were reported in *Chrysanthemum* by Lima and Haag [6] due to calcium restriction. Young leaves and other tissues develop characteristic symptoms linked to calcium deficiency because this nutrient is not mobilized in plant. Deficit in young tissues can promote creamy aspect in apical region of leaf and in growth points, these observations are due to necessity of calcium pectate formation in cell wall [9].

Magnesium deficiency symptoms: Initial symptoms were manifested by plants under magnesium deficiency on the 29th day after experiment implementation. There was a decrease in plant height, leaf number and leaf size. Magnesium deficiency in old leaves was characterized initially by yellow chlorotic pits in leaf blade, which were extended between ribbing and later on by all

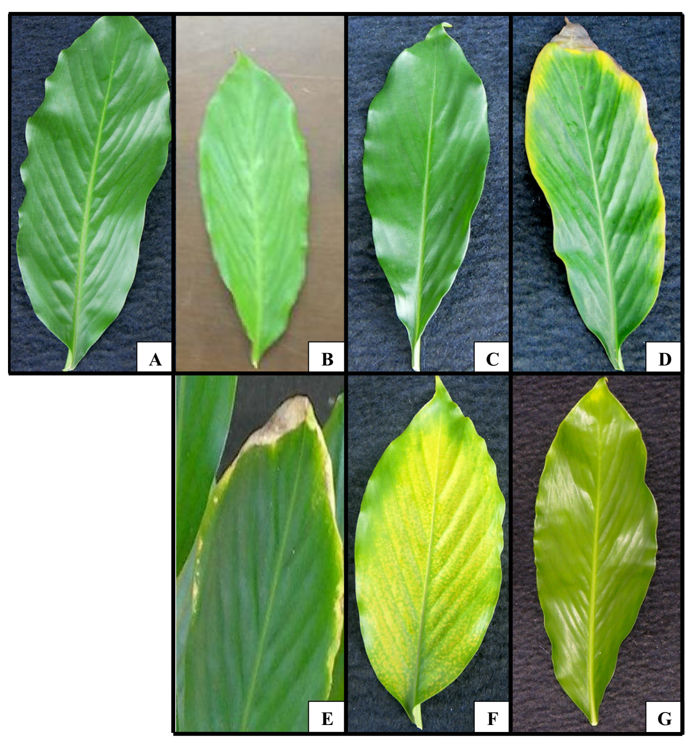

Figure 1. Visual symptoms in plants of *Alpinia purpurata* (cv. Jungle King) exposed to N, P, K, Ca, Mg and S deficiencies.

leaf, occuring several symptoms linked to magnesium deficieny in leaves (Fig.1F). Clorosys between ribbing, shown in this study, is due to chlorophyll in vascular bundle kept without alteration by longer periods if compared with chlorophyll in cells located between bundles [14]. Clorosys between ribbing in old leaves are reported by Lima and Haag [6] in *Chrysanthemum* plants.

Symptoms of sulphur deficiency: Symptoms induced by sulphur deficiency were shown only with 207 days after experiment implantation; however, it was not clearly defined. Sulphur deficiency caused reduction in plant height and young leaves presented clorosys (Fig. 1G). Visual symptoms of sulphur deficiency are less visible and can be explained by supplying this macronutrient through solution available to plants during adaptation stage. Clorosys in young leaves induced by sulphur deficit was shown in *Anthurium* ornamental plants [12].

Dry matter accumulation: Treatments induced to nutrient restriction limited dry matter production in several plant parts investigated (Table 1), in relation to control plants. Based in control plants, the dry matter content in leaves was higher than in root and stem. Total dry matter of plants induced to nutrient deficiency presented reduction in leaf, stem and root dry matter. Nutrients which affected production of total dry matter were nitrogen, potassium and magnesium with decreases of 53%, 49% and 48%, respectively; compared with control plants. Total dry matter presented behaviour linked to limitation expressed as N>P>Mg>K=Ca>S. Decrease in stem dry matter of *Heliconia psittacorum* was reported by Castro *et al.* [1] studying nitrogen and potassium deficiencies. Ferreira and Oliveira [2] described the benefit effect of nitrogen, phosphorus and potassium applications in *Heliconia* plants.

Macronutrient levels in leaves: In plants induced to deficiencies of N, P, K, Ca, Mg and S, levels of these nutrients in leaves were reduced , when compared to control (Table 2). Macronutrient levels in control plants presented behaviour as K>N>Ca>Mg>P>S, indicating that *Alpinia purpurata* is more exigent in potassium. Based on macronutrient levels, the values obtained were 25.1, 5.1, 36.1, 5.9, 5.6 and 4.1 g kg^{-1} in N, P, K, Ca, Mg and S of control plants, respectively. Plants exposed to deficiency presented macronutrients N, P, K, Ca, Mg and S values of 17.6, 1.4, 16.2, 1.0, 1.3 and 1.8 g kg^{-1}, respectively.

Plant nutritional state: Restrictions in each macronutrient promoted a lower value of nitrogen, phosphorus, potassium, calcium, magnesium and sulphur levels in whole plant, if compared to control treatment (Table 3). These results demonstrated nutrient importance in rational cultivation of *Alpinia* plants.

Additionally, control plants included N 1093.2, P 221.2 and K 1570.7 mg plant^{-1}. These results reveal that fertilization is important in this culture, since it indicates large accumulation of these nutrients in *Alpinia purpurata* plants.

Table 4 presents the comparison between macronutrient contents in leaves of control plants and level considered as adequate to *Alpinia* plants [11]. Only calcium presented lower nutrient level in leaf as it was indicated by Mills and Jones Jr. [11]. Nitrogen and sulphur were in the similar range; phosphorus, potassium and magnesium were at higher range. Nutrient levels in leaves present values next to adequate range proposed by Mills and Jones Jr. [11], and nutrients investigated in this study can be used to evaluate nutritional state of *Alpínia purpurata* plants.

Table 1. Leaf dry matter (LDM), stem dry matter (SDM), shoot dry matter (SHDM), root dry matter (RDM) and total dry matter (TDM) in plants of *Alpinia purpurata* (cv. Jungle King) exposed to N, P, K, Ca, Mg and S deficiencies.

Treatment	LDM	SDM	SHDM	RDM	TDM
Control	45.23 a *	22.45a	66.36 a	23.76 a	91.45 a
N deficiency	20.36 d	10.10d	30.16 d	12.71 cd	43.17 d
P deficiency	21.64 d	12.06cd	33.69 cd	12.79 cd	46.48 cd
K deficiency	24.16 c	11.36cd	35.26 cd	12.99 c	53.93 bc
Ca deficiency	27.38 b	13.22bc	40.56 c	13.30 c	53.90 bc
Mg deficiency	24.77 c	11.82cd	36.49 cd	11.57 d	47.08 cd
S deficiency	28.22 b	15.00b	50.80 b	16.57 b	59.96 b
C.V.	3.49	7.99	11.49	4.65	8.13
DMS	1.91	2.19	9.65	1.38	9.21

*Averages followed by the same letter within columns do not differ by the Tukey's test at 5% of probability.

Table 2. Macronutrient levels in leaves of *Alpinia purpurata* (cv. Jungle King) exposed to N, P, K, Ca, Mg and S deficiencies.

Treatment	N	P	K	Ca	Mg	S
	Macronutrient level in leaf (g kg^{-1})					
Control	25.16 b *	5.10 de	36.14 ab	5.92 c	5.64 c	4.16 d
N deficiency	17.64 c	5.60 cd	35.98 ab	5.26 c	5.00 d	6.12 a
P deficiency	25.28 b	1.40 f	37.94 a	8.16 b	4.32 e	3.52 e
K deficiency	27.98 a	7.14 a	16.22 c	16.80 a	12.22 a	5.12 b
Ca deficiency	26.84 ab	6.68 ab	35.48 ab	1.06 d	8.26 b	4.60 c
Mg deficiency	25.80 b	6.14 bc	36.68 ab	8.78 b	1.36 f	3.54 e
S deficiency	26.34 ab	4.64 e	32.96 b	8.60 b	4.46 de	1.86 f
C.V.	4.12	5.50	5.70	6.35	4.93	4.14
DMS	2.06	0.57	3.77	0.99	0.58	0.34

*Averages followed by the same letter within columns do not differ by the Tukey's test at 5% of probability.

Table 3. Macronutrient levels in plant of *Alpinia purpurata* (cv. Jungle King) exposed to N, P, K, Ca, Mg and S deficiencies.

Treatment	N	P	K	Ca	Mg	S
	Macronutrient mg plant $^{-1}$)					
Control	1093.21 a *	221.22 a	1570.73 a	258.45 bc	244.32 b	180.86 a
N deficiency	361.86 d	116.08 c	737.43 c	107.89 e	102.56 d	125.49 b
P deficiency	546.40 cd	30.27 d	820.28 c	176.52 d	93.34 d	76.01 c
K deficiency	668.58 c	170.62 b	387.96 d	401.81 a	292.01 a	122.26 b
Ca deficiency	717.87 bc	178.78 b	949.18 bc	27.97 f	220.18 b	122.86 b
Mg deficiency	618.10 c	147.27 bc	876.65 bc	209.15 cd	32.85 e	84.96 c
S deficiency	971.76 b	158.49 b	1127.27 b	294.21 b	152.66 c	64.03 c
C.V.	13.56	13.04	13.65	13.08	10.30	11.42
DMS	190.63	38.19	252.88	55.30	33.57	25.38

*Averages followed by the same letter within columns do not differ by the Tukey's test at 5% of probability.

Table 4. Comparison of leaf macronutrient levels in *Alpinia purpurata* (cv. Jungle King) reported in this study and proposed [11] to this species.

Nutrient (g kg^{-1})	In this study	Mills and Jones Jr.[11]
N	24.3 – 25.6	21.9 – 27.0
K	34.7 – 38.6	24.6 – 33.4
P	5.0 – 5.3	3.0 – 3.7
Ca	5.6 – 6.2	7.5 – 13.5
Mg	5.3 – 5.8	3.5 – 4.7
S	4.0 – 4.4	2.9 – 4.8

Conclusions

Results obtained in this study reveal that potassium and magnesium were nutrients that presented first symptoms, and thereafter calcium, nitrogen, phosphorus and sulphur. In addition, N, P, K, Ca, Mg and S deficiencies resulted in morphological changes, as well as symptoms related with nutritional deficit corresponding to each nutrient studied in *Alpinia purpurata* plants.

Leaf, stem, shoot, root and total dry matter was affected by nutrient deficit, being potassium probably more limiting due to first symptoms, if compared with other nutrients investigated. Restrictions in N, P, K, Ca, Mg and S supplies have as consequence the decrease in level and accumulation of macronutrients in leaves and plant of *Alpinia purpurata*.

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