Morphological response and nutritional deficiency symthoms in ipe seedlings (*Tabebuia serratifolia*)

Respostas morfológicas e sintomatologia de deficiência nutricional em mudas de ipê (*Tabebuia serratifolia*)

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ABSTRACT

The yellow ipe (*Tabebuia serratifolia* Vahl Nich.), is a forest species of relevance in Brazil, with characteristics of timber, medicinal, ornamental and cultural interest, in addition, the species stands out in reforestation activities in degraded areas. Mineral nutrition directly affects the production of seedlings, being a very important factor in the productivity of forest stands. Based on that, the present work aimed to evaluate the morphological responses, accumulation of dry matter, quality of seedlings, as well as the characterization of the symptoms of nutritional deficiencies in seedlings of yellow ipe (Tabebuia serratifolia), under individual omissions of macronutrients and micronutrient iron. The design was used in randomized blocks, adopting eight treatments: Complete solution, and individual omission of N, P, K, Ca, Mg, S and Fe, with three repetitions each. The omissions of N and Ca were those that most compromised the dry matter accumulation of the yellow ipe seedlings. The omissions of nutrients limited the relative growth of the seedlings, presenting the following order of growth: N<Ca<Mg<S<K. Omissions of N, Ca, Mg, S and Fe promoted a reduction in the chlorophyll index, besides manifesting deficiency symptoms. The omission of K manifested symptoms of deficiency, but did not affect the variables assessed. No effect of the omission of P was observed in the seedlings of yellow ipe.

Keywords: Seedling production, visual diagnosis, hydroponics.

RESUMO

O ipê amarelo (*Tabebuia serratifolia* Vahl Nich.), é uma espécie florestal de relevância no Brasil, possuindo características de interesse madeireiro, medicinal, ornamental e cultural, além disto, a espécie se destaca em atividades de reflorestamento em áreas degradadas. A nutrição mineral afeta diretamente a produção de mudas, sendo um fator muito importante para produtividade de povoamentos florestais. Com base nisso, o presente trabalho teve como objetivo avaliar as respostas morfológicas, acúmulo de matéria seca, qualidade de mudas, bem como a caracterização das sintomatologias de deficiências nutricionais em mudas de ipê amarelo (*Tabebuia serratifolia*), sob omissões individuais de macronutrientes e do micronutriente ferro. O delineamento utilizado foi em blocos casualizados, adotando-se oito tratamentos, sendo estes: Solução completa, e omissão individual de N, P, K, Ca, Mg, S e Fe, com três repetições cada. As omissões de N e Ca foram as que mais comprometeram o acúmulo de matéria seca das mudas de ipê amarelo. As omissões de nutrientes limitaram o crescimento relativo das mudas, apresentando a seguinte ordem de crescimento: N<Ca<Mg<S<K. As omissões de N, Ca, Mg, S e Fe promoveram redução no índice de clorofila, além de manifestarem sintomatologias de deficiência. A omissão de K manifestou sintomatologia de

deficiência, contudo não afetou as variáveis avaliadas. Não foi observado efeito da omissão de P nas mudas de ipê amarelo.

Palavras chave: Produção de mudas, diagnose visual, hidroponia.

1 INTRODUCTION

The yellow ipe (*Tabebuia serratifolia* Vahl Nich.), is a forest species of relevance disseminated in several regions of Brazil, with characteristics of timber, medicinal, ornamental and cultural interest (Carvalho, 1994; Goulart et al., 2017). Furthermore, the species has characteristics that qualify it for use in reforestation activities in degraded areas (Vidal-Tessier, 1988), However, the indiscriminate exploitation of the species has significantly reduced its population (Silva et al., 2011), thus the establishment of stands is becoming necessary to ensure the perpetuation of the species.

Among the stages of implementation of forest stands, the production of seedlings is the one that most affects the success of this activity, and the mineral nutrition provided to the plants in the seedling stage is essential for it to express its productive potential in the field (Tucci et al., 2009; Corcioli et al., 2016). However, not much is known about the nutritional requirements of yellow ipe plants in the seedling stage (Goulart et al., 2017).

The missing element technique represents a quick, practical and economical alternative to know the nutritional requirements of species (Moretti et al., 2011), since it is a semi-quantitative evaluation, showing the influence of each element on growth and quality of seedlings, in order to establish reference parameters for nutritional demand and fertilization needs (Malavolta, 2006). However, this technique has some limitations, because the symptoms of nutritional deficiencies are easily confused with disorders caused by biotic or abiotic factors (Sampaio et al., 2019).

Based on this, this work aimed to evaluate the morphological response, dry matter accumulation, seedling quality, as well as the characterization of symptoms of nutritional deficiencies in yellow ipe seedlings (*Tabebuia serratifolia*), under omissions of macronutrients and iron (Fe).

2 MATERIAL AND METHODS

The experiment was carried out under greenhouse conditions in the Soil Science Area, located at the Institute of Agricultural Sciences of the Federal Rural University of the Amazon, campus Belém, geographical coordinates 48° 26’ 14’’ W and 1° 27’ 22’’ S, with 6.37 m of latitude. The region's climate, according to the Koppen, is Af, with an average annual temperature of 26.8°C and average annual precipitation of 2.537 mm (Alvares et al., 2013).

For the test, yellow ipe seedlings were used, which were produced by direct sowing in 0.15 x 0.25 m seedling bags containing soil-based substrate and organic compound in the proportion of 3:1 (v v-1). After one year of conducting the seedlings, a selection of a stand of 30 seedlings was made based on the parameters of height and number of leaves, in order to standardize the experimental units.

The seedlings were transplanted, in a proportion of one seedling per 4 L pot, containing crushed and sterilized silica. During the transplant procedure, the roots were washed with running water to remove the substrate attached to the root surface. The silica was sterilized by immersion in 1% HCl (hydrochloric acid) solution for seven days. After the immersion period, the silica was washed with distilled water to remove possible residues of acid or other contaminants. After transplantation, the seedlings received a standard nutritional solution from Hoagland & Arnon (1950), at 50% ionic strength, for a period of 14 days for aclimatation. After this period, the treatments were submitted.

The design used was in randomized blocks, adopting eight treatments: Complete solution, and individual omission of N, P, K, Ca, Mg, S and Fe (Table 1). Each treatment was composed of three repetitions. An experimental unit was considered as a pot containing a yellow ipe seedling.

Table 1 – Nutrient solution composition and treatments.

Stock Solution	Concentration	Treatments (ml L^{-1})							
	(M)	C. S.	-N	-P	-K	-Ca	-Mg	-S	-Fe
KH_2PO_4	1	1	1			1	1	1	1
KNO_3	1	5		5		5	5	5	5
$Ca(NO_3)_2$	1	5		5	5		5	5	5
$MgSO_4$	1	2	2	2	2	2			2
KCl	1		5	1					
$CaCl_2$	1		5						
$NaNO_3$	1				1	10			
NaH_2PO_4	1				1				
$(Na)_2SO_4$	1				5		2		
$MgCl_2$	1							2	
Fe-EDTA*		1	1	1	1	1	1	1	
Micronutrients**		1	1	1	1	1	1	1	1

*26,1 g EDTA disodium in 286 ml of NaOH (1 M), mixed with 24,9 g of $FeSO_4.7H_2O$.
** H_3BO_3 2,86 g; $MnCl_2$: 1,81 g; $ZnSO_4.7H_2O$: 0,22 g; $CuSO_4.5H_2O$: 0,08 g; $H_2MoO_4.H_2O$: 0,02g.

During the experiment, the pH of the nutritional solutions was monitored by using a HANNA pocket pH meter, GroLine model - HI98118. The pH was maintained in the range of 5.5 to 6.5, with corrections being performed when necessary, utilizing a 0.1 N citric acid solution or 1N sodium hydroxide (NaOH). Aeration was carried out manually through daily recirculation of nutritional solutions, which were drained in the late afternoon and replenished in the next morning.

The symptoms of nutritional deficiencies were described throughout the experimental period (ninety days). After ninety days of treatment submission, morphological evaluations of plant height (using a ruler graded in centimeters), and diameter (using a pachymeter graded in mm) were performed. The relative chlorophyll index (RCI) was measured using a SPAD-502 (Konica, Minolta) chlorophyll meter. Three readings were taken on the second pair of leaves in the direction of the apex to the base.

After this, the seedlings were removed from the pots and compartmentalized into leaves, stem and root and stored in paper bags, which were stored in a forced circulation oven at 65° C until constant weight, to determine the dry matter of leaves, stem and root. Based on the dry matter values, the quality of the seedlings was determined using equation (Eq. 1) of the Dickson Quality Index - DQI (Dickson et al., 1960).

$$DQI: \frac{TDM}{\frac{Height\ (cm)}{Diameter\ (mm)} + \frac{SDM\ (g)}{RDM\ (g)}} \qquad \text{Eq. 1}$$

The ratio of aerial part and root (S/R) was calculated by the ratio of the dry masses of aerial part to the dry mass of root, as well as the relative growth (RG) of the seedlings using as reference value the total dry mass of the seedlings cultivated in complete solution (Viégas et al., 2008).

The data obtained were submitted to analysis of variance (F test) and when significance between treatments was observed, the means obtained were compared through the Dunnett test using the Statistical Analysis System - SAS statistical software (SAS, 2002).

3 RESULTS AND DISCUSSIONS

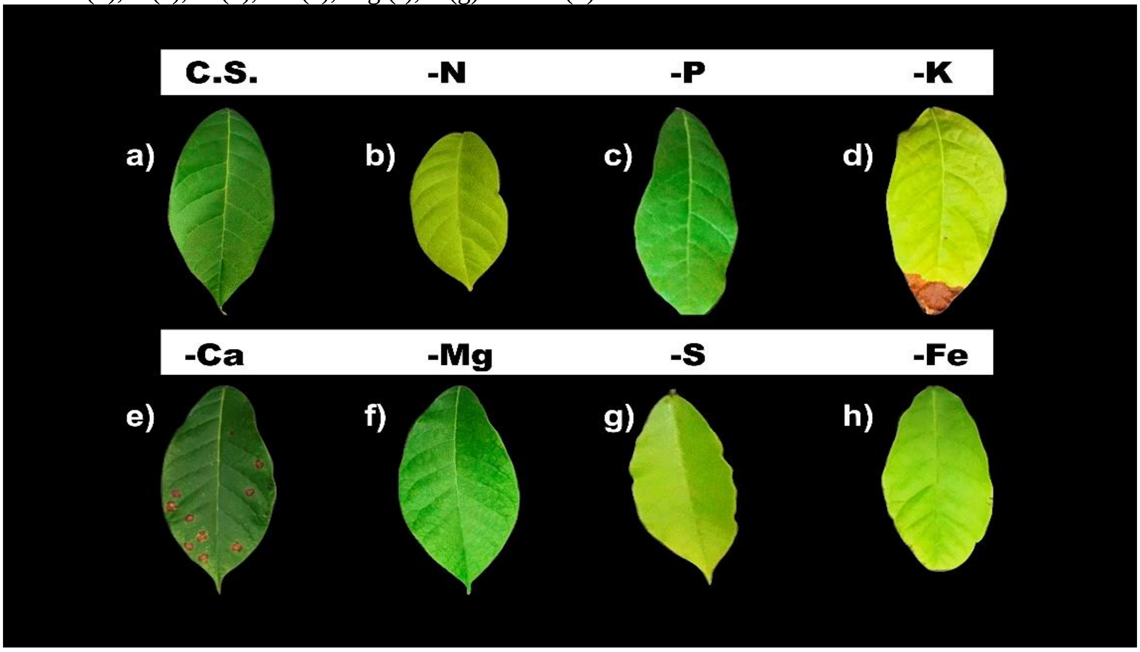
The ipe seedlings cultivated under individual omissions of N, K, Ca, Mg, S and Fe expressed deficiency symptoms (Figure 1), however, only the omissions of N and Ca caused significant reductions in growth. Regarding RG, it was observed that the individual omissions of N, K, Ca, Mg and S obtained a lower performance when compared to the complete solution, presenting the following growth order: N<Ca<Mg<S<K. However, no reduction of RG was observed in the omissions of P and Fe, which presented similar behavior to plants cultivated under complete solution.

The individual omissions of N, Ca, Mg, S and Fe obtained a lower relative index of chlorophyll when compared to the plants that received complete solution, being this related to the visual symptoms manifested.

3.1 NITROGEN OMISSION

The seedlings of ipe cultivated under omission of N expressed as symptomatology the generalized chlorosis (Figure 1b), which started in the leaves closest to the base (mature leaves) and gradually evolved to the apical leaves (juvenile leaves), affecting all the leaves, as described by (Malavolta, 2006).

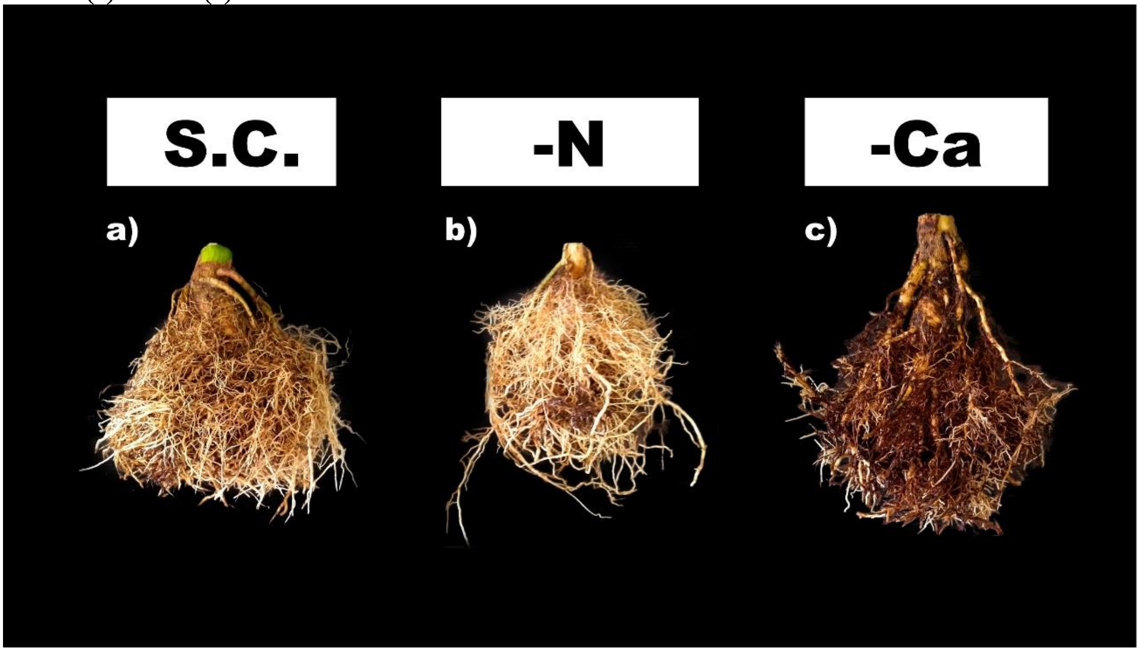
Figure 1 - Visual symptoms obtained from *Tabebuia serratifolia* leaves corresponding to complete solution (a), and omissions of N (b), P (c), K (d), Ca (e), Mg (f), S (g) and Fe (h).



Similar symptoms were observed in Brazilwood seedlings (Valeri et al., 2014), african mahogany - *Khaya ivorensis* e *K. anthotheca* (Viera et al., 2015; Corcioli et al., 2016) and cedar (Munguambe et al., 2017). Such symptomatology manifested in the leaves, according to Viégas et al., (2014), occurs due to the collapse of chloroplasts as a function of proteolysis, resulting in the degradation of chlorophyll molecules which promotes the yellowing of the leaves.

A notorious reduction in the root system was also observed (Figure 2b). Such symptoms occur due to the high mobility that N has in the plant phloem, being easily redistributed from source organs (roots and mature leaves) to draining organs (new leaves, apical meristem) (Marschner, 2012; Taiz et al., 2017). In such a way that, when submitted to deficiency conditions, plants are able to mobilize the N of the most mature leaves in the form of amino acids to meet the demand of the youngest organs (Silva Júnior et al., 2007).

Figure 2 - Visual aspect of the root system of *Tabebuia serratifolia* seedlings corresponding to complete solution (b), and omissions of N (a) and Ca (c).



Regarding the growth variables evaluated (Table 2), the omission of N was the most limiting, promoting significant reductions in height and relative growth, which showed a reduction of 72.0% and 65.3%, respectively, when compared to seedlings grown in complete solution. The omission of N did not affect the diameter of the stem of the ipe seedlings. Research assessing the nutritional status of african mahogany seedlings (Corcioli et al., 2016) and assai palm (Viégas et al., 2008) through the technique of the element missing in hydroponics verified that the N was the element that most affected the height and relative growth of the seedlings.

Table 2 – Plant height (g), diameter (mm) and relative chlorophyll index (SPAD units) and relative growth (%) of *Tabebuia serratifolia* seedlings growth under nutrient omission.

Treatment	Height	Diameter	RCI	RG
Complete Solution	70.33	1.97	44,85	100.00
-N	50.66*	1.53	23.17*	34.71
-P	64.33	1.67	43.43	100.00
-K	65.00	1.90	40.73	90.28
-Ca	63.00	1.91	33.20*	55.11
-Mg	61.67	1.73	34.10*	79.16
-S	62.00	1.82	30.03*	82.72
-Fe	64.67	2.03	22.00*	100.00
CV (%)	8.00	9.93	10.45	-

Means folowed by * in the column significantly difer by the Dunnett test ($p \leq 0.05$) when compared with control treatment (Complete solution)

Nitrogen is directly and indirectly related to vegetative growth, being responsible for the synthesis of structural proteins and also of enzymes, which act in several key reactions to plant metabolism, such as photosynthesis (Malavolta, 2006; Marschner, 2012), since N is one of the main components of chlorophylls (Taiz et al., 2017). Due to this, the individual omission of nitrogen was the one that most reduced the chlorophyll content in the leaves of the ipe seedlings. This decrease in chlorophyll content promotes an imbalance in the photosynthetic reaction, affecting the activity in the photochemical stage of the process, (Paul & Driscoll, 1997), and consequently enzymes such as ribulose bisphosphate carboxylase (RUBISCO), resulting from lower photosynthetic activity and consequently lower growth and mass accumulation (Fernandes et al., 2013).

Table 3 contains the values referring to the dry masses of leaves, stem and roots, DQI and S/R ratio of the ipe seedlings according to their respective treatments. Regarding the dry mass accumulation, significant reductions were observed only for N and Ca omissions. No differences were observed in the S/R parameter ($p>0.05$).

Table 3 – Leaves dry mass (g plant^{-1}), stem dry mass (g plant^{-1}), roots dry mass (g plant^{-1}), total dry mass (g planta^{-1}), Dickson's quality index and shoot/root ratio of *Tabebuia serratifolia* seedlings growth under nutrient omission.

Treatment	LDM	SDM	RDM	TDM	DQI	S/R
Complete Solution	25.68	44.13	38.19	108.01	2.93	1.8
-N	7.24*	14.75*	15.50*	37.49*	1.08*	1.3
-P	25.94	43.43	39.51	108.87	2.69	1.7
-K	25.52	38.42	33.58	97.51	2.74	1.9
-Ca	12.59*	28.31	18.72*	59.52*	1.74	2.1
-Mg	20.23	36.01	29.26	85.50	2.26	1.9
-S	22.87	36.96	29.52	89.35	2.49	2.0
-Fe	27.57	46.35	36.31	110.23	3.26	2.0
CV (%)	14.65	18.90	26.35	16.58	23.21	45,01

Means folowed by * in the column significantly difer by the Dunnett test ($p \leq 0.05$) when compared with control treatment (Complete solution).

The nutrient that most limited the mass accumulation and quality of the yellow ipe seedlings was the N, as a reflection of the reduction in morphological variables, there was a significant decrease in dry matter accumulation, with reductions of 71.81%, 66.58% and 59.41% on leaves, stems and roots, respectively when compared to plants grown under complete solution. Such reductions represented 65.29% of the total dry mass of the ipê seedlings and consequently negatively affected their IQD.

Various cultures such as blackberry (Souza et al., 2015), mamorana (Camacho et al., 2013), cedar (Munguambe et al., 2017) and *Khaya ivorensis* (Corcioli et al., 2016) showed the same behavior, highlighting the importance of N in the accumulation of dry mass in the seedling stage.

The DQI is a parameter used to estimate the quality of the seedlings produced, as well as their performance and survival after definitive planting, thus, the higher the IQD obtained, the higher is the quality of the seedlings (Dickson et al., 1960; Gomes et al., 2002). According to Goulart et al. (2017), The recommended dose of N for seedlings of yellow ipe (*Tabebuia serratifolia*) with higher growth and DQI is 100 mg dm^{-1}, emphasizing the importance of adequate nutrition with this element in the production of quality seedlings and success of stands with this species.

N plays a key role in the growth and accumulation of biomass by plants, since it acts in the synthesis of enzymes and compounds that directly influence key processes, such as photosynthesis, ionic absorption, nutrient assimilation, carbohydrate metabolism, among others (Malavolta, 2006;

Marschner, 2012; Taiz et al., 2017). Justifying the limitation of seedling growth when in deficit of this nutrient.

3.2 PHOSPHORUS OMISSION

The seedlings of ipe submitted to omission of P, did not presented symptoms of nutritional deficiency (Figure 1c), neither reduction in height, diameter, relative chlorophyll, obtaining relative growth similar to the seedlings that received complete solution. Such results indicate the lower demand for P in this seedling phase, being the supply of P by the initial growing substrate and the complete solution during the acclimatization period to the hydroponic system sufficient to maintain the growth of the plants similar to the seedlings that received complete solution.

The results corroborate with those obtained in a similar essay with umbuzeiro culture, where the authors Gonçalves et al., (2006) attributed the non-expression of symptoms and growth reduction to the fact that the plant had accumulated P of reserve in the root structure, which was sufficient for the maintenance of the seedlings growth during the trial period.

3.3 POTASSIUM OMISSION

The seedlings under individual K omission presented as symptomatology chlorosis followed by necrosis, which started at the margins of the mature leaves, with a tendency to the center of the leaves (Figure 1d), as described by Malavolta, (2006). This symptomatology is explained by the high mobility of the K in the phloem and due to the absence of this element, a metabolic imbalance occurs that promotes increased activity of carboxylase enzymes, which leads to accumulation of compounds called putrescin (Vasconcellos et al., 1977), since K acts as a cofactor of some enzymes essential to plant metabolism (Malavolta, 2006).

Although the symptomatology was manifested, the seedlings of ipe amarelo did not present significant differences in height, diameter and relative chlorophyll content, however, there was a 9.7% reduction in the relative growth of the seedlings in relation to the plants that received complete solution. Similar results were obtained by Corcioli et al., (2016) and Gonçalves et al., (2006), in experiments with seedlings of *Khaya ivorensis* and umbuzeiro, respectively.

For *Khaya anthotheca*, the omission of K did not affect the morphological parameters as observed for ipe seedlings (Viera et al., 2015). This indicates a lower demand for K for the ipe plants, as expressed by other forest species in the seedling phase. Another hypothesis is the substitution of K^+ by Na^+ (Table 1) in the nutritive solution, causing the most efficient use of the K absorbed during the acclimatization of the seedlings, as demonstrated by Inocencio et al., (2014), in *Enterolobium contortisiliquum* and *Sesbania virgata* seedlings.

3.4 CALCIUM OMISSION

Ipe seedlings cultivated under Ca omission manifested chlorosis on the youngest leaves, which progressed to necrosis and subsequent petiole collapse and leaf fall (Figure 1e), as observed in mahogany seedlings *Swietenia macrophylla* (Wallau et al., 2008) and cedar *Acrocarpus fraxinifolius* (Munguambe et al., 2017) cultivated in nutritive solution suppressed from Ca.

Furthermore, the omission of Ca inhibited the development of the roots of the ipê seedlings, which exhibited an aspect of necrosis (Figure 2c), as reported by Munguambe et al., (2017) in cedar seedlings. Despite the appearance of symptoms which significantly affected root development, the omission of Ca did not interfere with the morphological variables of the yellow ipe seedlings, corroborating with results obtained for the *K. ivorensis* (Corcioli et al., 2016), *K. anthotheca* (Viera et al., 2015). The omission of Ca promoted a reduction in growth in the order of 44.9%, Ca after the omission of N being the element that most affected the relative growth of seedlings.

Ca deficiency is characterized by the reduction of meristematic tissues (new leaves and roots), since this element is considered immobile in the plants' phloem and acts on the composition of the cellular appearance and as a second messenger, stimulating plants' physiological responses to environmental or developmental alterations (Marschner, 2012; Raij, 2011).

Under Ca omission, as a reflex of the symptomatology of manifest deficiency, a reduction of 50.97% and 50.98% in the accumulation of dry mass in the leaves and root system, respectively, was observed, without, however, affecting the dry mass of the stem. Similar results were observed by the authors Viégas et al. (2014) in a similar test using ipeca seedlings, which had mass accumulation of the aerial part and root system limited by Ca omission.

Calcium performs beyond the structural function, constituting pectates of the medium lamella, which are responsible for the integrity of the cell wall, moreover, this nutrient acts on key enzymes such as phospholipases and nucleases (Marschner, 2012; Taiz et al., 2017). Although no significant reduction ($p>0.05$) has been observed for the IQD, attention should be paid to the nutrition of Ca in forest seedlings, since this element acts in the response of plants to biotic and abiotic stresses (Ranty et al., 2016), in such way, seedlings under this nutrient deficiency would be more susceptible to perish after transplanting, causing failures during the establishment of a forest stand.

The results obtained in this work corroborate with Barroso et al. (2005) e Gonçalves et al. (2006), where it was observed that the individual omission of the elements N and Ca were the most limiting for the accumulation of teak (*Tectona grandis*) and umbuzeiro seedling mass, respectively.

3.5 MAGNESIUM OMISSION

It was observed in the seedlings of ipe under the omission of Mg, the manifestation of symptomatology as described by (Malavolta, 2006), with the appearance of internerval chlorosis, which started on the mature leaves (Figure 1f), since the Mg has high mobility in the phloem of the plants, being therefore easily redistributed to meet the demands of growing regions (new leaves).

Regarding the morphological variables evaluated, similarly to what was observed for K, there was no difference in comparison with the seedlings cultivated in complete solution. It was noted, however, a reduction of 20.8% in the growth rate of the seedlings under omission of Mg. It was also observed a significant reduction for the relative index of chlorophyll. The Mg deficiency symptomatology and the relative chlorophyll content are closely linked, since about 35% of the plants Mg are stored in chloroplasts, especially in chlorophylls, where it plays a structural role, acting as a central ion of them (Cakmak & Yazici, 2010; Marschner, 2012).

Magnesium deficiency in many cases causes reduction and even inhibition of photosynthetic activity, directly affecting the activity of the enzyme RUBISCO, as well as the accumulation of carbohydrates in mature leaves (Cakmak & Yazici, 2010; Farhat et al., 2016). According to Paul & Foyer, (2001), the accumulation of carbohydrates in the mature leaves promotes a change in the activity of the enzyme magnesium chelatase, resulting from an accumulation of protoporphyrin IX, a precursor molecule of chlorophyll, inducing the reduction of the transport of electrons and favoring the production of reactive oxygen species (ERO's), leading to the emergence of chlorosis (Walker & Weinstein, 1991; Hermans et al., 2005; Cakmak & Kirkby, 2008; Farhat et al., 2016).

3.6 SULFUR OMISSION

Under S omission, the ipe seedlings manifested widespread chlorosis on the youngest leaves, as described by Malavolta, (2006). Sulfur is, along with N, one of the nutrients that are involved in the constitution of essential amino acids, more specifically methionine and cysteine, thus, under conditions of deficit, there is inhibition of the synthesis of proteins and enzymes that contain these two amino acids (Viégas et al., 2014; Taiz et al., 2017).

Despite the symptomatology manifestation, the morphological variables did not present differences in relation to the seedlings cultivated under complete solution. Similar results were observed by Viera et al. (2015) in *Khaya anthotheca* seedlings crops under individual macronutrient omission. In comparison with the seedlings that received a complete solution, the seedlings under S omission showed a 17.3% reduction in relative growth.

The seedlings under S omission, showed significant reduction in the relative chlorophyll index. According to Viégas et al. (2014) that occurs when proteins are stored in chloroplasts and chlorophylls, thus the chlorosis caused by S deficiency is a result of the absence of these proteins, which also affect the chlorophyll contents.

3.7 IRON OMISSION

In the new leaves of the ipe seedlings under Fe omission, the reduction of the size of the leaves was observed, as well as the appearance of chlorosis which evolved from the edges to the center of the leaves, showing a whitish coloration. Similar symptomatology was described by Matos et al. (2013) in research evaluating the effects of omission of micronutrients in nutritive solution on the growth of *Bactris gasipaes* seedlings. However, in this study no reduction in morphological variables was observed, as well as in the relative growth of the seedlings.

This symptomatology occurs due to the low mobility of Fe in plants (Taiz et al., 2017), because of this, inhibition of photosynthetic activity occurs, since Fe participates in several enzymes such as ferredoxin, which acts in the transfer of electrons during the photochemical step of photosynthesis (Marschner, 2012). In addition, Fe is also related to enzymes that act directly on the metabolism of N and S, such as nitrate reductase, GOGAT and sulphite reductase. Explaining in this way the reduction marked in the relative content of chlorophyll in the leaves of ipe seedlings cultivated under omission of Fe.

Individual omissions of P, K, Mg, S and Fe did not affect the dry matter accumulation of the yellow ipe seedlings. A similar result was observed by Silva et al. (2011) in neem seedlings (*Azadiractha indica*) under individual omission of macronutrients in nutritive solution and by Sorreano et al. (2008), where the omission of iron in the nutritive solution did not affect the dry mass of seedlings of *Croton urucurana*.

Such results can be related to two factors: the advanced age of the ipe seedlings; and the period of acclimatization of the seedlings to the hydroponic system, in which all the seedlings received a complete solution. Favoring the accumulation and reserve of some of these nutrients, especially P, Mg, S and Fe, which are required in relatively smaller amounts in the seedling phase.

4 CONCLUSIONS

The omissions of N and Ca were the ones that most compromised the dry matter accumulation of the yellow ipe seedlings. The omissions of nutrients limited the relative growth of the seedlings, presenting the following order of growth: N<Ca<Mg<S<K. The omissions of N, Ca, Mg, S and Fe promoted a reduction in the chlorophyll index, besides manifesting deficiency symptoms. The omission of K manifested symptoms of deficiency, but did not affect the variables assessed. The omission of P did not manifest symptoms and also did not affect the analyzed variables.

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