NUTRITIONAL ASSESSMENT OF CEDAR SEEDLINGS (*Cedrela fissilis;* Vell.) GROWN IN A GREENHOUSE

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ABSTRACT: This work had the objective of investigate the nutritional requirements of Cedar (*Cedrela fissilis*) species. The experiment was performed in a greenhouse to assess effects of complete fertilization and of fertilization with missing nutrients on seedling development. The experiment consisted of 10 treatments and 5 replications in a complete randomized block design. Vases with a capacity for 5 kg of soil were used, with one plant unit per vase and a red-yellow latosol substratum of poor fertility, applying the following treatments: one complete treatment with N, P, K, Ca, Mg, S, B and Zn; eight treatments, each with one missing nutrient (-N, -P, -K, -Ca, -Mg, -S, -B and -Zn), and one control treatment with natural substratum. It was assessed shoot height, stem base diameter and dry matter yield at 110 days after planting. Results demonstrated that N and P are the most limiting nutrients for the development of the species. Considering these limitations and defining shoot dry matter yield in the complete treatment as a parameter, the nutrient requirements of cedar seedlings were as follows, in decreasing order: P > N > K > B > S > Ca > Zn > Mg.

Key words: Missing nutrient, Meliaceae, seedlings.

AVALIAÇÃO NUTRICIONAL DE CEDRO (*Cedrela fissilis;* Vell.) EM CASA DE VEGETAÇÃO

RESUMO: *Com a finalidade de conhecer as exigências nutricionais do Cedro (Cedrela fissilis) conduziu-se um experimento em casa de vegetação em que foram avaliados os efeitos da fertilização completa e da omissão de nutrientes no desenvolvimento de plântulas dessa espécie. O experimento foi constituído de 10 tratamentos e 5 repetições, em delineamento de blocos inteiramente casualizados. Foram utilizados vasos com capacidade 5 kg de solo, contendo uma planta por vaso e como substrato um latossolo vermelho amarelo de baixa fertilidade. Os tratamentos aplicados foram o completo com N, P, K, Ca, Mg, S, B e Zn; outros 8 tratamentos com omissão de um nutriente por vez (-N, -P, -K, -Ca, -Mg, -S, -B e -Zn) e um último tratamento com o substrato natural como testemunha. Avaliou-se altura da parte aérea, diâmetro do colo e produção de matéria seca aos 110 dias após o plantio. Os resultados encontrados nas condições desse estudo indicaram ser N e P os nutrientes mais limitantes para o desenvolvimento da espécie. Quanto à limitação, os nutrientes exigidos pelas plântulas, tomando como parâmetro a produção de matéria seca da parte aérea do tratamento completo, foram, em ordem decrescente, P > N > K > B > S > Ca > Zn > Mg.*

Palavras-chave: Elemento faltante, Meliaceae, mudas.

1 INTRODUCTION

Cedar (*Cedrela fissili*s, Vell.) from the Meliaceae family is one of the most important forest species of Tropical America. Its wood is highly valued due to easy workability and long-lasting properties (CARVALHO, 1994). It occurs in dry tropical forests *mata seca*, in coastal moist forests *restinga* and also in riparian forests extending from Pará state to Rio Grande do Sul state (LORENZI, 1992). It is categorized as an early- and late-secondary species and is recommended for timber production and urban forestry as well as for recovery of degraded areas and riparian forests (CARVALHO, 1994).

Seedling production and later forest planting demand knowledge of the specific nutrition requirements of each species (D'AVILA *et al.* 2001), although few studies have been performed on nutrition of tropical native species. Authors Tucci *et al.* (2007) and Silva *et al.* (2008) studied

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nutritional aspects of mahogany *(Swietenia macrophyla)* and sumaúma *(Ceiba pentandra)* respectively.

An efficient method for detecting the nutrition requirements of a species for purposes of fertilization is the missing element technique (BRAGA *et al.* 1995). This technique informs what nutrients are deficient, the relative importance of such deficiency, and the fertility reduction rate in the soil (CHAMINADE, 1972).

Using the missing nutrient technique, Renó *et al.* (1997) demonstrated that seedlings of jacaré (*Piptadenia gonoacantha*), pau-ferro (*Caesalpinia ferrea*) and canafístula (*Senna multijuga*) had their vertical growth constrained by missing nutrients P, S and N. In a similar experiment using low fertility soil in an area of savanna vegetation, Braga *et al.* (1995) observed that *Tibouchina granulosa* presented high nutrition requirements, responding to application of all macro- and micronutrients. *Acacia mangium* only responded to P, N and S, while pau-pereira (*Platycyamus regnellii)* responded to N, P, Ca and S, and *Aspidosperma polyneuron* responded to P, K and S.

Working with aroeira-do-sertão (*Myracrodruon urundeuva*), Mendonça *et al.* (1999), detected harmful effects on plants in the absence of all elements except for S. Missing P and missing Ca were found to be the most limiting to seedling development. Venturin *et al.* (1999) listed the nutrient requirements of *Peltophorum dubium* as follows, in decreasing order: P, N, S, Ca, Mg, K and B.

In a study with *Trema micrantha*, Venturin *et al.* (2000) concluded that N was the most limiting nutrient to its vertical growth, while N, P and B were the most limiting nutrients to diameter. The complete treatment affected species development due to the toxicity of nutrient Zn.

Souza *et al.* (2006) demonstrated that nutrients P and N should be prioritized in the fertilization of species ipê-roxo *(Tabebuia impetiginosa)*, followed in decreasing order by S, B, Zn, Mg, Ca and K.

Given the overall importance of cedar *(Cedrela fissilis)* and the lack of existing information on its nutritional aspects, this work aimed at to assess the nutritional requirements and effects of missing nutrients on the development of greenhouse-grown cedar seedlings, using the missing nutrient technique.

2 MATERIAL AND METHODS

The experiment was conducted in a greenhouse in the Department of Forest Sciences, belonging to the Federal University of Lavras (UFLA). The substrate used was a red-yellow latosol of naturally poor fertility collected in the municipality of Itumirim at a depth of 20 to 40 cm, thus avoiding the fertile layer of the soil which might mask the effect of fertilizers. The soil was air-dried, put through a 5mm sieve and stored in plastic bags. Following it was sampled for determination of its physical and chemical properties, before and after adding the nutrients (Table 1). The physical analysis was conducted at the Laboratory of Soil Physics of the Federal University of Lavras and consisted of determination of particle texture and density.

The routine chemical analysis followed EMBRAPA guidelines (1997) and included pH in water; P and K extraction using HCl 0.05 mol L^{-1} + H_2SO_4 0.0125 mol L^{-1} (Mehlich 1); Ca, Mg, Al extraction using KCl 1 mol L^{-1}, and S extraction using $Ca(H_2PO_4)_2$, 500mgL^{-1} P in HOAc 2 mol.L^{-1}. Potential acidity (H + Al) was extracted using Ca acetate 1N at pH 7.0 and organic carbon according to Raij *et al.* (1987). Micronutrients Cu, Fe, Mn and Zn were extracted using Mehlich 1 method. B was extracted by the hot water method and determined by the curcumin method, according to Jackson (1970). Physical analysis involved granulometric determination of air-dried fine earth by the pipette method with NaOH 0.1 mol L^{-1} as dispersant and rapid stirring.

Cedar seeds were collected in the field from selected trees and left to germinate in a substratum comprising a third of sterilized soil, a third of carbonized rice husk and a third of sand. At the stage where seedlings had produced four pairs of leaves, they were replanted into vases with a capacity for 4 liters of soil, two seedlings per vase. After 30 days they were thinned and only one plant was left in each vase.

Vases were kept moist using deionized water at 60% of field capacity and daily checks, as proposed by Freire *et al.* (1980). Vase bottoms were sealed to prevent nutrient loss.

The experiment included ten treatments, arranged in a complete randomized block design with five replications, one vase per replication and one plant per vase. Treatments were as follows: T (Control treatment, natural substrate), C (Complete treatment containing all nutrients: N, P, K, Ca, Mg, S, Zn and B, -N (Complete except for nitrogen), -P (Complete except for phosphorus), -K (Complete except for potassium), -Ca (Complete except for calcium), -Mg (Complete except for magnesium), -S (Complete except for sulfur), -Zn (Complete except for zinc) and -B (Complete except for boron). Complete fertilization consisted of: N=150 mg kg^{-1} of soil, P=200 mg kg^{-1}, K=150 mg kg^{-1}, Ca=75 mg kg^{-1}, Mg=15 mg kg^{-1}, S=50 mg kg^{-1}, B= 0.5 mg kg^{-1},

Table 1 – Chemical and physical components of untreated soil and soil after fertilization with macro- and micronutrients.

Tabela 1 *– Componentes químicos e físicos do solo ao natural e após a adubação com macro e micronutrientes.*

Parameters	Untreated soil	Complete fertilization
pH (1)	5.3	5.6
Org. Mat. (g dag^{-1}) (2)	0.3	0.4
Total N (mg m^{-3}) (3)	3.0	21.0
P (mg dm^{-3}) (4)	1.0	56.0
K (mg dm^{-3}) (4)	11.0	28.0
S (mg dm^{-3}) (5)	1.4	12.0
Ca ($cmol_c$.dm^{-3}) (6)	1.0	2.0
Mg ($cmol_c$ dm^{-3}) (6)	0.10	0.3
Al ($cmol_c$ dm^{-3}) (6)	0.10	1.8
H + Al ($cmol_c$ dm^{-3}) (6)	1.30	1.6
Zn (mg dm^{-3}) (8)	1.35	3.0
Cu (mg dm^{-3}) (8)	20.8	28.0
Fe (mg dm^{-3}) (8)	11.3	15.0
Mn (mg dm^{-3}) (8)	1.4	1.6
B (mg dm^{-3}) (7)	0.2	0.6
Sand (g dag^{-1}) (9)	66.0	66.0
Silt (g dag^{-1}) (9)	10.0	10.0
Clay (g dag^{-1}) (9)	24.0	24.0

(1)H_2O 1:2.5 Ratio ; (2) Walkley and Black method; (3) Kjeldahl method by steam distillation; (4) Extractant HCl 0.05 mol_c L^{-1} + H_2SO_4 0.25 mol_c L^{-1}; (5) Extractant Ca $(H_2PO_4)_2.H_2O$ + 500 ppm P; (6) Extractant KCl 1 mol_c L^{-1}; (7) Hot water; (8) Extractant HCI 0.05 mol_c L^{-1} + H_2SO_4 0.025 mol_c L^{-1}; (9) Pipette method.

Cu=1.5 mg kg^{-1}, Zn=1.4 mg kg^{-1}, Mn= 20 mg kg^{-1}, and Fe= 25 mg kg^{-1}. The nutrient sources were $NH_4H_2PO_4$; KH_2PO_4; NaH_2PO_4; KCl; $MgSO_4.7H_2O$; $NaSO_4$; $CaCl_2$. $2H_2O$; KNO_3; $Ca(NO_3)_2.4H_2O$; NH_4NO_3; $MgCl_2.6H_2O$; $ZnSO_4.7H_2O$; $ZnCl_2$; H_3BO_3; $CuSO_4.5H_2O$; $FeSO_4.7H_2O$-EDTA; $MnCl_2.4H_2O$ and $H_2MoO_4.H_2O$.

N was applied in installments, 1/3 at the moment of planting and the rest in equal amounts on day 20, 50 and 80, while K was applied in a single dose on day 20 after transplantation, both using irrigation water**.**

On day 110 the following measurements were taken: stem base diameter, shoot height, yield of shoot dry matter and yield of root dry matter. The diameter was measured on the transitional zone between stem and root, and the height was measured from ground level to the utmost tip of the plant. After taking diameter and height measurements, we cut the seedlings even with the ground and weighed them. Following, we separated root system and soil, washing and weighing each plant unit. Roots and shoots were dried in a forced air oven operated at 70°C to a constant weight. Macro- and micronutrient concentrations in shoot dry matter were also determined as described by Sarruge and Haag (1974). Analyses were performed at the Laboratory of Plant Mineral Nutrition of the Federal University of Lavras (UFLA). The data obtained were submitted to analysis of variance and to Tukey test at the level of 5% of probability.

3 RESULTS AND DISCUSSION

3.1 Plant growth

The most limiting nutrients to cedar seedling development were P followed by N (Table 2). Missing N provided a lower relative yield in relation to the complete treatment of 69.1% for height, 49.1% for diameter; 18.8% for SDM and 16.3% for RDM, while missing P provided relative yields of 63.5% for height, 48.0% for diameter; 17.0% for SDM and 7.3% for RDM.

The control treatment did not differ from the previously mentioned treatments (Table 2), with relative yields of 56.1% for height, 34.5% for diameter; 8.3% for SDM and 6.3% for RDM, all in relation to the complete treatment.

Several authors have reported similar results with other species. While working with *Copaifera langsdorffii*, *Acacia mangium* and *Trema micrantha*, respectively, Duboc *et al.* (1996b), Braga *et al.* (1995) and Venturin *et al.* (2000) found P and N to be the most limiting nutrients. Venturin *et al.* (2005) observed that missing N affected both diameter and vertical growth in candeia plants *(Eremanthus erythropappus)*. Silva *et al.* (2005) observed lower SDM yield in seedlings of umbu *(Spondias tuberosa)* under conditions of missing N and P, followed by missing Ca. In a study conducted in the Amazon region, Tucci *et al.* (2007) noted that application of corrective phosphate and fertilization with N, P and K resulted in higher nutrient contents in mahogany plants *(Swietenia macrophiyla* King*)*, which in turn promoted growth.

Better plant development was obtained with the complete treatment and with the missing K, missing Ca and missing Mg treatments, with relative vertical growth of 100.0%, 98.2%, 91.0% and 110.3%, and with relative diameter growth of 100.0%, 96.1%, 86.8% and 108.5% respectively (Table 2). After analyzing the data, we concluded that Mg requirements in cedar plants were low, since even where availability of Mg was low (Table 1) it nonetheless proved sufficient to promote better growth in all parameters. With missing K and missing Ca, however, despite the statistical similarity, a slight decrease was noted in diameter and height in relation to the complete treatment and to the missing Mg treatment.

The missing Mg treatment also provided higher SDM and RDM values, with relative development of 157.8% for SDM and 104.5% for RDM in relation to the complete treatment. Observing these figures, we noted that the complete treatment and the missing Mg treatment promoted better plant development in all parameters (Table 2). As fertilization with Mg reduced height, diameter, SDM and RDM parameters by 10.3%, 8.5%, 57.8% and 4.5%, it can be inferred that this type of fertilization generated a slight nutritional imbalance considering the species requirements.

Still in Table 2, we can observe a lower R/S ratio with the missing Mg treatment in comparison to the complete and to missing N, S, B, and Zn treatments. In eucalyptus plants, Paula *et al.* (2003) observed a decrease in the R/S ratio with increasing levels of P and attributed that to a tendency for plants in suboptimal conditions to

Table 2 – Height, diameter, yield of shoot dry matter (SDM), yield of root dry matter (RDM), and root/shoot ratio (R/S) in seedlings of *Cedrela fissilis* as a function of missing nutrients.

Tabela 2 – *Altura, diâmetro, produção de matéria seca da parte aérea (MSPA) e do sistema radicular (MSSR), e relação raiz/parte aérea (R/PA) de mudas de Cedrela fissilis, em função da omissão de nutrientes.*

Treatment	Height (cm)	Diameter (mm)	SDM (g)	RDM (g)	R/S
Complete	23.62a	16.40a	10.64a	8.24a	0.75a
Control	13.24c	5.66c	0.88c	0.52c	0.64b
- N	16.32c	8.06c	2.00c	1.34c	0.69a
- P	15.00c	7.88c	1.81c	0.60c	0.33c
- K	23.20a	15.76a	7.80b	4.35b	0.62b
- Ca	21.50a	14.24a	9.56b	5.25b	0.53b
- Mg	26.06a	17.80a	16.79a	8.61a	0.52b
- S	19.80b	13.10b	8.91b	6.03b	0.73a
- B	18.98b	13.18b	8.06b	6.63b	0.82a
- Zn	20.74b	15.88a	10.91a	8.31a	0.77a
Mean value	19.85	12.80	7.74	4.99	0.64
CV%	20.43	32.55	63.94	63.85	22.73

Different letters within a column differ by the Tukey test, at the level of 5% of probabilityl. SDM = shoot dry matter, RDM = root dry matter and R/S = root/shoot ratio.

designate greater growth potential to the root system. According to Clarkson (1985), stronger development of roots in relation to shoots is a strategy of the plant for extracting as much as possible in the way of soil nutrients under conditions of low fertility.

In this study, the lower R/S ratio was due to stronger shoot growth in the missing Mg treatment, reinforcing the signs of nutritional imbalance caused by addition of Mg.

Similarly to this study, Venturin *et al.* (2005) found that missing Mg, followed by K, Ca and B, produced lower root/shoot ratio in seedlings of *Eremanthus erythropappus*.

The missing Zn treatment was similar to the complete treatment for diameter, SDM and RDM parameters, though it presented lower vertical growth (Table 2), demonstrating the need to apply this nutrient in smaller quantities than was used.

Other authors, including Duboc *et al.* (1996a), arrived at similar conclusions in works with jatobá *(Hymenaea courbaril)*. Working with *Trema micrantha*, Venturin *et al.* (2000) concluded that the complete treatment was unsuitable, while the missing zinc treatment promoted better growth. No signs of toxicity could be detected in this work, only nutrient deficiency and signs of imbalance with use of Mg in fertilization. Opposing to our results, Renó *et al.* (1997) argued that missing Mg was a limiting factor for growth of *Caesalpinia ferrea* and cedar.

Based on yield of shoot dry matter, the most limiting nutrients to growth of cedar plants were found to be as follows, in decreasing order: P> N> K> B> S> Ca> Zn> Mg.

3.2 Mineral nutrition in cedar

Higher concentrations of N were observed in the missing P treatment, not differing statistically from the missing K, S, B and Ca treatments (Table 3). This treatment provided higher concentrations for all nutrients in question, indicating a clear concentration effect, given the lower accumulation of shoot dry matter (Table 2). Nitrogen absorption was affected by the complete treatment, by the control treatment, and by the missing Mg and Zn treatments (Table 3), other than by the missing N treatment, which produced the lowest concentrations. In a study with *Copaifera langsdorffii*, Duboc *et al.* (1996b) observed that missing P reduced absorption of N, opposing to results in this study.

Only in missing Mg, Zn and N treatments was the concentration of N below the critical level of 15.2 g/kg proposed by Dias *et al.* (1991), though probably for different reasons. In the case of Mg, there seems to have been a dilution effect given the high yield of SDM, differing from Zn, which presented lower SDM values, while N presented a clear deficiency in the soil-plant system. Absorption of Mg is affected by the presence of K, as the latter is a competitive inhibitor of Mg (MALAVOLTA *et al.* 1989). With missing K, the absorption of Mg was higher, probably due to the absence of competitive inhibitor K.

In the case of nutrient S, a higher absorption occurred in the missing N and P treatments and a lower absorption occurred in the missing S treatment (Table 3). Renó *et al.* (1997) observed reduced concentrations of Mg and S in *Senna multijuga* and of several other nutrients in cedar and in *Caesalpinia ferrea* with missing N, noting that in these species N deficiency can be accompanied by other deficiencies.

Higher concentrations of B were found in missing N, P, Mg and Zn treatments, which did not differ statistically from each other. Likewise, lower concentrations were found in the control and missing B treatments (Table 4). Silva *et al.* (2005) detected higher concentrations of B in *Spondias tuberosa* with missing Ca and Zn, possibly due to a reduced interaction between these nutrients in the soil solution (MALAVOLTA *et al.* 1989). In the case of *Eremanthus erythropappus* seedlings, a higher concentration of B in the SDM was detected in the missing N treatment, due to a concentration effect (VENTURIN *et al.* 2005).

A higher absorption of Cu, Mn, Zn and Fe occurred in the missing P treatment (Table 4) due to a concentration effect, given the yield of dry matter illustrated in Table 2. According to Missio *et al.* (2004), phosphate enriched fertilization reduced leaf abscission in seedlings of grápia. Working with *Myracrodruon urundeuva*, Barbosa *et* a*l.* (1997) observed that application of increasing levels of P did not affect availability of Zn and vice-versa in the soil. Concentrations of Mg decreased in the shoot dry matter of cedar plants with the lack of that nutrient and yet they presented similar SDM yield in relation to the complete treatment (Table 2), confirming low requirements for this nutrient by cedar plants.

Treatments with missing Ca, K and Zn provided higher Mg contents in the SDM of *Spondias tuberosa* seedlings (SILVA *et al.* 2005). With *Eremanthus erythropappus* seedlings, the Mg content was favored by absence of K and Ca (VENTURIN *et al.* 2005), possibly due to competitive inhibition between the latter two and Mg (MALAVOLTA *et al.* 1989). The Mg content

Table 3 – Macronutrient contents in dry matter of *Cedrela fissilis.*

***Tabela 3** – Teores de macronutrientes na matéria seca de Cedrela fissilis.*

Treatment	N	P	K	Ca	Mg	S
	g kg^{-1}					
Complete	16.0b	1.4 a	12.0b	7.8b	1.5b	1.5b
Control	15.6b	0.9b	16.2a	6.0b	1.3b	1.2b
- N	5.9c	1.3 a	20.9a	9.8b	1.7b	2.5a
- P	26.9a	0.3c	22.8a	12.5 a	2.6 a	2.5a
- K	20.3a	1.5 a	6.7c	9.5b	2.3 a	2.0b
- Ca	17.8a	1.2 a	14.3b	14.3 a	1.6b	1.2b
- Mg	14.2b	1.1 a	11.7b	7.5b	0.8c	1.2b
- S	18.4a	1.1 a	13.6b	8.3b	1.6b	0.9c
- B	17.2a	1.3 a	14.3b	8.3b	1.0b	1.7b
- Zn	15.0b	1.1 a	13.0b	7.8b	1.6b	1.6b
Mean value	16.73	1.12	14.55	9.18	1.6	1.63
CV%	38.25	50.53	37.8	48.75	48.03	40.8

Different letters within a column differ from each other by the Tukey test, at the level of 5% of probability.

Table 4 – Micronutrient contents in dry matter of *Cedrela fissilis*.

***Tabela 4** – Teores de micronutrientes na matéria seca de Cedrela fissilis.*

Treatment	B	Cu	Mn	Zn	Fe
	mg kg^{-1}				
Complete	36.80b	6.08b	24.65b	16.67b	1106.32b
Control	16.90c	8.52b	31.10b	12.43c	2036.98b
- N	55.50 a	6.69b	34.92b	13.03c	1611.71b
- P	48.11 a	13.08 a	68.96 a	50.62 a	4819.72 a
- K	28.33b	9.13b	31.10b	26.07b	727.27c
- Ca	36.80b	8.21b	31.98b	29.40b	878.27c
- Mg	41.11 a	5.48c	29.05b	15.75b	659.48c
- S	44.62 a	6.69b	25.23b	15.46b	1226.5b
- B	10.57c	6.69b	21.71b	14.55b	807.40b
- Zn	39.99 a	6.08b	25.23b	9.09c	758.09b
Mean value	35.873	7.665	32.393	20.307	1463.174
CV%	46.18	63.72	60.11	61.47	42.1

Different letters within a column differ from each other by the Tukey test, at the level of 5% of probability.

in the SDM of cedar plants (Table 3) was higher in the missing P and missing K treatments.

P contents in the SDM were similar in all treatments except for the control and missing P treatments. Concentrations of P and Mg proved below the critical level of 4.5 g/kg and 3.4 g/kg (DIAS *et al.* 1990) respectively in all treatments.

Higher K contents in the SDM of cedar plants were found in the missing N and missing P treatments and also in the control treatment. The remaining treatments presented equivalent concentrations, except for the missing K treatment. In the case of *Senna multijuga*, higher concentrations of K were found in the missing Mg treatment (RENÓ *et al.* 1997). In the case of *Spondias tuberosa*, higher concentrations of K in the SDM were found in the missing Ca treatment (SILVA *et al.* 2005). The concentration of K in the shoot of cedar was found to be above the critical level of 4.0 g/kg suggested by Dias *et al.* (1991), in all treatments.

Higher concentrations of S in the SDM were found in the missing N and P treatments. The remaining treatments were equivalent, except for the missing S treatment (Table 3). This can be explained by a concentration effect, as they presented lower SDM yields (Table 2). Higher concentrations of S in the SDM of *Spondias tuberosa* were observed in the missing N and P treatments (SILVA *et al.* 2005). In *Eremanthus erythropappus*, a higher concentration of S was found with missing N (VENTURIN *et al.* 2005).

As regards *Copaifera langsdorffii*, the missing N, Ca and K treatments reduced absorption of S (DUBOC *et al.* 1996b).

The Ca content in the SDM of cedar plants was higher in the complete treatment (Table 3). This can be an indication that cedar plants have a high potential to extract Ca from the substratum even when availability is limited, or else it can be an indication of low physiological requirements for this nutrient. With *Hymenaea courbaril*, the missing Ca treatment and the complete treatment produced the same concentration of Ca in the SDM (DUBOC *et al.* 1996a). With cedar plants, absorption of Ca was favored by missing phosphorus (Table 3).

As regards *Spondias tuberosa* seedlings, a higher Ca content in the SDM was observed in the missing N treatment (SILVA *et al.* 2005), while with *Senna multijuga* seedlings higher concentrations of Ca and Mg were observed in the missing K and Mg treatments (RENÓ *et al.* 1997), suggesting competition between them (MALAVOLTA *et al.* 1989). With *Eremanthus erythropappus* seedlings, a higher Ca content was found in the missing Mg treatment (VENTURIN *et al.* 2005). The critical level of 0.69% for Ca was exceeded in all treatments, except for the control treatment.

4 CONCLUSIONS

Nutrients N and P should be prioritized in studies involving mineral fertilization of species *Cedrela fissilis*.

Taking the complete treatment as a comparison parameter, the most limiting nutrients to growth of shoot dry matter in cedar plants are as follows, in decreasing order: P> N> K> B> S> Ca> Zn> Mg.

Growth was obtained in diameter, height and SDM with the missing Mg, Complete, missing K and missing Ca treatments, in that order.

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