WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.10 (1): 937-940. 2012 *www.world-food.net*

Visual symptoms and growth parameters linked to deficiency of macronutrients in young *Swietenia macrophylla* plants

Ismael de Jesus Matos Viégas *, Allan Klynger da Silva Lobato, Max Franck da Silva Rodrigues, Raimundo Lázaro Morais da Cunha, Dílson Augusto Capucho Frazão, Cândido Ferreira de Oliveira Neto, Heráclito Eugênio Oliveira da Conceição, Elaine Maria Silva Guedes, Gustavo Antonio Ruffeil Alves and Sávia Poliana da Silva

*Núcleo de Pesquisa Vegetal Básica e Aplicada, Universidade Federal Rural da Amazônia, PA 256 Km 06 - S/N Caixa Postal 284, Paragominas, Para, Brazil. *e-mail: ismael.viegas@ufra.edu.br, candido.neto@ufra.edu.br*

Received 18 November 2011, accepted 3 January 2012.

Abstract

The aim of this study was to characterize the symptoms linked to deficiencies of macronutrients in young *Swietenia macrophylla* plants, evaluating effects produced by nutrient omissions on macronutrient level in leaf and growth parameters such as dry matter of leaf, petioles, stem and root and total dry matter using missing element technique. Plants were grown in nutrient solution of Bolle-Jones, the treatments consisted in omission of some nutrients like N, P, K, Ca, Mg and S, as well as control treatment used was complete nutrient solution. The experimental design was completely randomized with 7 treatments (N, P, K, Ca, Mg and S deficiencies, and control) and 5 replicates. The omission of all macronutrients resulted in the expression of visual deficiency symptoms, reduction of dry matter and leaf contents of these nutrients. The order in limiting the production of dry matter in leaves, stems and roots, and total dry matter were N>P>Ca>Mg>K>S, and in petiole N>Ca>P>K>Mg>S. In control treatment nutrient levels were N 20.9, P 2.2, K 15.7, Ca 9.2 Mg 2.6 and S 4.3 g kg^{-1}, while in treatments with deficiency N 15.1, P 1.4, K 3.4, Ca 4.3, Mg 0.6 and S 1.3 g kg^{-1}.

Key words: Mahogany, *Swietenia macrophylla*, mineral nutrition, nutritional deficiency.

Introduction

Brazil is considered one of the countries with most biodiversity in the world, taking its natural resources constantly threatened linked to the illegal removal of wood without any management system. In the last two decades many plant species have become extinct in Brazil as a result of intense exploration without any control coming from the opening of agricultural frontiers in the Amazon [1].

Because of its high commercial value and wide acceptance in the international market, *Swietenia macrophylla* is at risk of disappearing with that arise the necessity for adoption of alternative production systems such as agroforest systems in degraded pastures in the Amazon in order to recover deforested areas and preserve this species. On the other hand, *Swietenia macrophylla* can be exploited in a rational way and there is a need of the occurrence of the conception of information and technologies through various research actions, among which those related to soil fertility and plant nutrition, because little is known about the nutritional requirements of *Swietenia macrophylla* plants. In the last decade, some research in soil fertility and nutrition in this species have been made [2-6]. In addition, the diagnosis of nutritional problems through observation of visual symptoms has great practical importance, because it allows making quick decisions in the field on correct deficiencies and consequent action of fertilization. However, it is necessary to develop controlled research in greenhouse using nutritive solution and applying the missing element technique thus enabling the advancement of knowledge in plant mineral nutrition.

Symptoms of deficiencies for certain elements may differ from culture to culture so that knowledge of the deficiency syndrome in a species provides little help in identifying the deficiency in other species [7]. In this way, this study aimed to characterize the symptoms of deficiencies of macronutrients, evaluating effects produced by nutrient omissions on macronutrient level in leaf and growth parameters, such as dry matter of leaves, petioles, stem and root and total dry matter using young *Swietenia macrophylla* plants.

Materials and Methods

Experimental conditions and plant material: Experiment was conducted under greenhouse conditions at Embrapa Amazônia Oriental, Belém City, Pará State, with temperatures oscillating from 24°C to 30°C. *Swietenia macrophylla* seeds came from Empresa Brasileira de Pesquisa Agropecuária (Embrapa) located in Belterra City, Pará State.

Recipients and plant obtaining: Seeds were placed in recipient with dimensions of 40 cm × 20 cm × 10 cm (length×width×height, respectively), containing a mixture of sand and sawdust in the ratio of 3:1. Twenty days after germination, seedlings were transplanted to plastic bags. Plants to reach approximately 35 cm in height were selected. Their roots were washed with running water and subsequently with distilled water to eliminate any residue of the substrate and transplanted into plastic pots with a

capacity of 10 L containing washed silica (sort zero thick). The vessels were drilled next to the base and painted externally with aluminized paint to reduce the direct passage of sunlight, thus avoiding algae blooms within these containers. A segment of flexible plastic hose was connected to the drilling of each pot connecting the inside of each one with the entrance of the plastic bottles with a capacity of 1 L, and also painted with aluminized paint, and all bottles were placed in a lower level of the vessels.

Experimental design: The experimental design was completely randomized with 7 treatments (N, P, K, Ca, Mg and S deficiencies, and control) and 5 replicates. These treatments were composed by complete nutrient solution for control and omissions of individual nutrients for nitrogen, phosphorus, potassium, calcium, magnesium and sulphur.

Plant acclimation: Plants were initially acclimated for a period of thirty days in nutritive solution of Bolle-Jones [8] diluted in the proportion of 1:10, having salts as source for analysis. Young *Swietenia macrophylla* plants were treated with nutrient solution 1:1 supplied by leaching in plastic pots renewing the solution every 15 days, with pH retained around ±5.5. Daily, the level of the solution in the glass collectors was observed, filling until 1 L for each plant.

Qualitative parameter and harvest: The symptoms of deficiencies in macronutrients were characterized, described and photographed. The plants were collected and separated in leaves, petioles, stems and roots. The collected material was washed with deionised water, packed in paper bags and placed in drying oven with forced air at 60°C until constant weight.

Growth parameters: After drying the material was weighed on digital scale; measuring dry matter of leaves, petioles, stem and root and total dry matter. After weighing, the material was ground in Wiley mill type to perform chemical analysis of plant tissue.

Nutrient determination: Macronutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S) were determined using methods described by Malavolta [9]. Considering data obtained from leaf dry weight and nutrient contents results of accumulation of nutrients were calculated.

Data analysis: Data were analyzed by computer software Stat for analysis of variance and F test. When results were obtained significance, Tukey's test at 5% probability was used, comparing means between treatments on each variable.

Results and Discussion

Visual symptoms promoted by nitrogen deficiency: Symptoms of nitrogen (N) deficiency emerged in young *Swietenia macrophylla* plants in older leaves, which showed pale green or yellowish green uniform causing pallor and the withering of the same (Fig. 1). The light green colour is associated with lower production of chlorophyll with changes in chloroplast shape. Omission of nitrogen also markedly reduced plant height, as well as lower in size and number of leaves, when compared to control treatment (Fig. 2). Nitrogen participates in the reaction of protein synthesis, inhibition of this synthesis will reduce the process of cell division, thereby resulting in plant growth [10]. Visual symptoms of nitrogen deficiency observed in *Swietenia macrophylla* are similar to those described by Barroso *et al.* [11] in *Tectona grandis*, by Silveira *et al.* [12] investigating *Eucalyptus* gender, Sarcinelli *et al.* [13] in *Acacia holosericea*, as well as Carvalho and Viegas [14] in *Schizolobium amazonicum*.

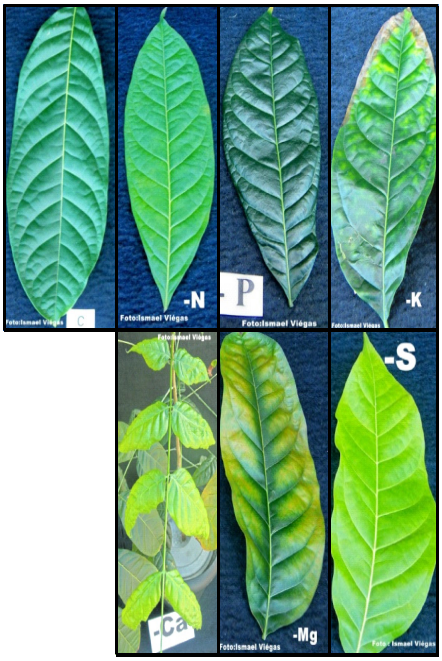

Figure 1. Visual symptoms linked to deficiencies of macronutrients (-N, -P, -K, - Ca, -Mg and -S) in leaf of young *Swietenia macrophylla* plants.

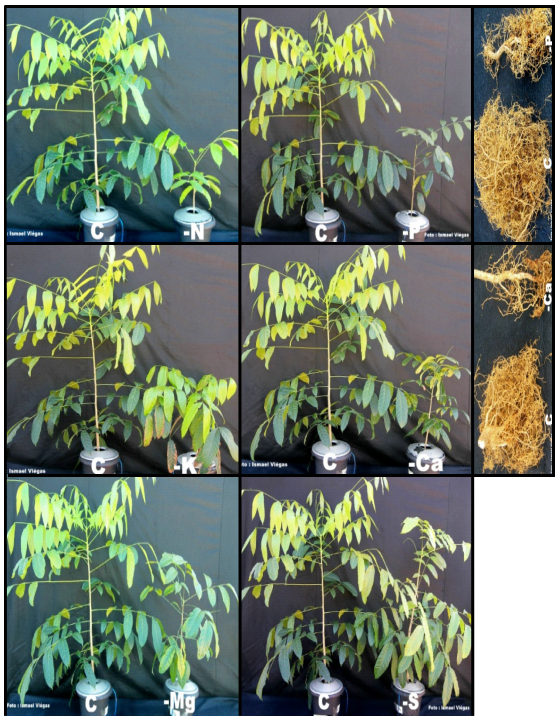

Figure 2. Visual symptoms linked to deficiencies of macronutrients (-N, -P, -K, - Ca, -Mg and -S) in shoot and root of young *Swietenia macrophylla* plants.

Consequences of phosphorus deficiency: In *Swietenia macrophylla* plants the phosphorus (P) deficiency was characterized by dark green colour in older leaves and a drastic reduction of plant height and root, comparing with the control treatment (Figs 1 and 2). This symptom is more intense green colour, according to Mengel and Kyrkby [15] it arises because of a decrease in protein synthesis, when the phosphorus is deficient, resulting in an increased amount of sugars in vegetative organs than in rest of the plant, promoting synthesis of anthocyanin in the leaves. Change in leaf colour from green to dark purple as a result of phosphorus deficiency was also observed in *Bertholletia excelsa* by Camargo *et al.* [16] and *Eucalyptus grandis* by Silveira *et al.* [12].

Consequences of potassium deficiency: A deficiency of potassium (K) started in older leaves with mild chlorosis. It starts at the apex of the leaf toward the edges, and the intensity of severe disability is a necrosis, and reduction of growth was also observed in *Swietenia macrophylla* plants, due to potassium omission (Figs 1 and 2). Characteristic symptoms of potassium deficiency, chlorosis and necrosis of shoot and margins of older leaves are related according to Silveira *et al.* [17] to accumulation of putrescine. These symptoms are similar to those described by Carvalho and Viegas [14] in *Schizolobium amazonicum* plants, as well as Silva *et al.* [18] working with *Jatropha curcas*.

Changes induced by calcium deficiency: Deficiency symptoms of calcium (Ca) were characterized by deformation of younger leaves that had bent to their ventral surface (Fig. 1), explained by the fact that the nutrient is needed in meristem growth of plants [19]. The omission of calcium also drastically reduced growth of roots and the plant (Fig. 2). Deformation in the new leaves, which curled as a result of calcium deficiency, was observed by Barroso *et al.* [11] in *Tectona grandis*.

Changes induced by magnesium deficiency: Plants that have grown in nutrient solution with the omission of magnesium (Mg) showed chlorosis between the veins of old leaves, the principal vein staying green, and with the severity of the disability necrosis occurred on older leaves, as well as a reduction in their growth (Figs 1 and 2). Magnesium deficiency showing yellowing between the veins of older leaves is quite common in forest species such as *Eucalyptus urophylla* [12] and *Schizolobium amazonicum* [14].

Symptoms of sulphur deficiency: The omission of sulphur (S) showed light green colour in young leaves (Fig. 1), which means that the chlorosis is very little marked, this is due to the low mobility of sulphur in the plant, occurring in the upper leaves and leading to reduced height (Fig. 2). Chlorosis in young leaves is a result of the omission of sulphur, it was also observed by Sarcinelli *et al.* [13] in *Acacia holocericea*.

Growth parameters: Omission of all macronutrients limited production of dry matter in the leaves, stems, petioles and roots, when compared to control treatment (Table 1). In solution with all nutrients (control) favourable response was shown to the dry mass production in different parts of the plant, in relation to omissions. Nitrogen omission was most limiting in relation to total dry matter, which was 8.4 times lower compared to control treatment. The omission of nitrogen has been considered a limiting factor linked to growth of several plants, such as *Ricinus communis* [20], *Schizolobium amzonicum* [21] and *Bertholletia excelsa* [16]. Importance of nitrogen for growth of young *Swietenia macrophylla* plants was observed by Tucci *et al.* [6], who studied the nitrogen fertilization in the substrate surface layer of sandy loam Oxisol. On the other hand, failure of phosphorus was the second most limiting, 4.9 times lower than in total dry matter of control treatment; and the third limiting factor was the omission of calcium, 3.41 times lower than in control. Increase in the growth of young *Swietenia macrophylla* plants in according to the phosphate fertilization was found by Santos *et al.* [5], indicating that species *a priori* are responsive to phosphorus. Souza *et al.* [22] found that phosphorus was the nutrient which most affected the growth of *S. macrophylla* on Oxisol soil of clay texture. The calcium was important in reducing the length of galleries produced by *Hypsipyla grandella* in this species [18]. The sulphur omission produced lower impact, if compared with other nutrients, just 1.4 times smaller than in control plants. Absolute values of descending order linked to total dry matter were observed as follows: Control>-S>-K>-Mg>-Ca>-P>-N treatments.

Macronutrient levels: Individual omissions of N, P, K, Ca, Mg and S reduced the leaf content of these nutrients, when compared to the control treatment (Table 2). Foliar levels for the control presented in the following order: N>K>Ca>S>Mg>P, indicating that *S. macrophylla* presents large demand in nitrogen. Leaf contents of macronutrients in control plants were 20.9, 2.2, 15.7, 9.2, 2.6 and 4.3 g kg^{-1} of N, P, K, Ca, Mg, and S, respectively, and in treatments under omission of N, P, K, Ca, Mg, and S leaf contents were 15.1, 1.4, 3.4, 4.3, 0.6 and 1.3 g kg^{-1}, respectively. Lima Júnior[23] found that the growth and nutritional status of young *S. macrophylla* plants in the substrate surface layer of typic loam affected by liming carried out before eight months, nitrogen levels oscillated from 12.1 to 16.2 g kg^{-1}, phosphorus from 0.5 to 1.8 g kg^{-1}, potassium from 5.7 to 9.1 g kg^{-1}, calcium from 2.1 to 2.6 g kg^{-1} and magnesium from 0.8 to 2.1 g kg^{-1}, which are lower values than those obtained in this study. Moreover, Cunha [24] evaluated biochemical and ecophysiological behaviour of *S. macrophylla* of 20 months age. He found adequate vegetative growth and absence of visual symptoms linked to deficiency, when leaf levels of N, P, K, Ca and Mg

Table 1. Leaf dry matter (LDM), petioles dry matter (PDM), stem dry matter (SDM), root dry matter (RDM) and total dry matter (TDM) in young *Swietenia macrophylla* plants.

	Parameters (g. plant^{-1})				
Treatments	LDM	PDM	SDM	RDM	TDM
Complete C	44.39 a	13.54 a	68.14 a	41.66 a	167.73 a
Omission of N	6.53 g	1.63 fg	5.74 g	6.00 g	19.90 fg
Omission of P	10.31 f	2.72 ef	10.84 ef	10.12 ef	33.99 ef
Omission of K	22.63 c	4.00 d	32.37 cd	16.89 cd	75.89 cd
Omission of Ca	16.02 e	2.09 e	17.95 e	12.17 e	49.06 e
Omission of Mg	18.83 d	5.16 cd	23.23 cd	14.77 cd	61.98 cd
Omission of S	32.81 b	10.75 b	44.31 b	28.02 b	115.88 b
C.V	4.19	8.36	2.72	4.53	1.92
D.M.S	1.82	0.98	1.58	1.63	2.88

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

Table 2. Macronutrient levels in leaf of young *Swietenia macrophylla* plants.

Treatments	N	P	K	Ca	Mg	S
	Macronutrient level in leaf (g kg^{-1})					
Complete C	20.9 b	2.2 b	15.7 b	9.2 d	2.6 c	4.3 b
Omission of N	15.1 c	3.3 a	17.8 ab	16.9 a	2.6 c	5.7 a
Omission of P	26.4 a	1.4 c	12.6 c	8.4 d	2.9 c	4.4 b
Omission of K	23.6 ab	2.5 b	3.4 d	10.1 cd	3.6 b	3.9 b
Omission of Ca	23.4 ab	2.6 b	17.8 ab	4.3 e	4.3 a	5.2 a
Omission of Mg	24.0 ab	2.3 b	18.2 a	12.2 bc	0.6 d	4.4 b
Omission of S	15.3 c	1.4 c	12.9 c	13.4 b	2.7 c	1.3 c
C.V	10.63	8.65	7.42	9.30	9.91	8.03
D.M.S	5.2	0.4	2.4	2.3	0.6	0.8

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

were 22.5, 1.1, 12.5, 9.2 and 2.7 g kg^{-1}, respectively. With the exception of P, other values are similar to those obtained in this study.

Conclusions

Omission of macronutrients in the nutritive solution promotes the occurrence of visual symptoms of deficiency in young *Swietenia macrophylla* plants with a reduced leaf contents of these nutrients. In addition, the omission of macronutrients limits the production of dry matter in leaves, stem, petiole, roots and total plant of this species, when compared to complete treatment, nitrogen being the most limiting. In nutritive solution, the visual symptoms of macronutrients deficiency in young *S. macrophylla* plants was expressed by foliar concentrations of 15.1, 1.4, 3.4, 4.3, 0.6 and 1.4 g kg^{-1} of N, P, K, Ca, Mg and S, respectively.

References

[1]Grogan, J., Barreto, P., and Veríssimo, A. 2002. Mahogany in Brazilian Amazon: Ecology and Perspectives of Management. Belém, Brazil, 56 p.

[2]Barros, J. G. 2001. Fertilization and Liming for Formation of Young Mahogany (*Swietenia macrophylla* King) Plants. MSc. thesis, Universidade Federal do Amazonas, Brazil.

[3]Silva, A. R., Tucci, C. A. F., Lima, H. N. and Figueiredo, A. F. 2007. Growing doses of liming on mahogany (*Swietenia macrophylla* King) seedling formation. Acta Amazônica **37**:195-200.

[4]Silva, E. B., Tanure, L. P. P., Santos, S. R. and Resende Junior, S. 2009. Visual symptoms of nutrient deficiency in physic nut. Pesquisa Agropecuária Brasileira **44**:392-397.

[5]Santos, R. A., Tucci, C. A. F, Hara, F. A. S. and Silva, W. G. 2008. Phosphated fertilization to produce mahogany seedlings (*Swietenia macrophylla* King). Acta Amazônica **38**:453-458.

[6]Tucci, C. A. F., Lima, H. N. and Lessa, J. F. 2009. Nitrogen fertilization in the production of seedlings of mahogany (*Swietenia macrophylla* King). Acta Amazônica **39**:289-294.

[7]Epstein, E. and Bloom, A. J. 2005. Mineral Nutrition of Plants: Principles and Perspectives. 2nd edn. Sinauer, Sunderland, USA, 400 p.

[8]Bolle-Jones, E. W. 1954. Nutrition of *Hevea brasiliensis*. II. Effect of nutrient deficiencies on growth, chlorophyll, rubber and mineral contents of Tjirandji seedlings. Journal of the Rubber Research Institute of Malaya **14**:209-230.

[9]Malavolta, E., Vitti, G. C. and Oliveira, S. A. 1997. Evaluation of the Nutritional State of Plants: Principles and Applications. 2nd edn. Potafos, Piracicaba, Brazil, 319 p.

[10]Malavolta, E. 2006. Manual of Plant Mineral Nutrition. Livroceres, São Paulo, Brazil, 638 p.

[11]Barroso, D. G., Figueiredo, F. A. M. M. A., Pereira, R. C., Mendonça, A. V. R. and Silva, L. C. 2005. Macronutrient deficiency diagnosis in teak seedlings. Revista Árvore **29**:671-679.

[12]Silveira, R. L. V. A., Moreira, A. M., Takashi, E. N., Sgarbi, F. and Branco, E. F. 2002. Deficiency symptoms of macronutrients and boron in hybrids clones of *Eucalyptus grandis* with *Eucalyptus urophylla*. Cerne **8**:107-116.

[13]Sarcinelli, T. S., Ribeiro Júnior, E. S., Dias, L. E. and Lynch, L. S. 2004. Symptoms of nutritional deficiency in seedlings of *Acacia holosericea* submitted to absence of macronutrients. Revista Árvore **25**:173-181.

[14]Carvalho, J. G. and Viégas, I. J. M. 2004. Characterization of nutrient deficiency symptoms in paricá (*Schizolobium amazonicum* Huber ex. Ducke). EMBRAPA, Belém, Brazil, 37 p.

[15]Mengel, K. and Kirkby, E. A. 1987. Principles of Plant Nutrition. 4th edn. International Potash Institute, Bern, Swiss, 687 p.

[16]Camargo, S. L., Muraoka, T., Fernandes, S. A. P. and Salvador, J. O. 2002. Nutritional diagnoses in young *Bertholletia excelsa* plants. Revista Agricultura Tropical **6**:81-96.

[17]Silveira, R. L. V. A., Malavolta, E. and Broetto, F. 2001. Effect of potassium on dry matter production and concentration of putrescine, spermidine and spermine in *Eucalyptus grandis* progenies. Scientia Forestalis **59**:13-25.

[18]Silva, S. A. S., Santos, M. M. L. S., Silva, G. R., Silva Junior, M. L., Ohashi, O. S. and Ruivo, M. L. P. 2009. Effect of the calcium in the control of the *Hypsipila grandella* in young mahogany cultivated in hydroponics system. Acta Amazônica **39**:273-278.

[19]Marschner, H. 1995. Mineral Nutrition of Higher Plants. 2nd edn. Academic Press, London, United Kingdom, 889 p.

[20]Lavres Junior, J., Boaretto, R. M., Silva, S. L. M., Correia, D., Cabral, C. P. and Malavolta, E. 2005. Deficiencies of macronutrients on nutritional status of castor bean cultivar Iris. Pesquisa Agropecuária Brasileira **40**:145-151.

[21]Marques, T. C. L. L. S., Carvalho, J. G., Lacerda, M. P. and Mota, P. E. F. 2004. Initial growthing of paricá (*Schizolobium amzonicum*) under nutrient omission and sodium in nutritive solution. Cerne **10**:184-195.

[22]Souza, C. A. S., Tucci, C. A. F., Silva, J. F. and Ribeiro, W. O. 2010. Nutritional requirements and growth of mahogany (*Swietenia macrophylla* King.) plants. Acta Amazônica **40**:512-522.

[23]Lima Júnior, E. C. 2005. Growth and Nutritional State of Mahogany (*Swietenia macrophylla* King) Plants in Relation to Liming. MSc. thesis, Universidade Federal Rural da Amazônia, Brazil.

[24]Cunha, R. L. M. 2010. Ecophysiology Behavior of Mahogany (*Swietenia macrophylla* King) and African Mahogany (*Khaya ivorensis* A. Chev.) Subjected to Potassium Fertilization, in Edaphoclimatic Conditions of Igarapé Açu-PA, Oriental Amazon. PhD. thesis, Universidade Federal Rural da Amazônia, Brazil.