INICIAL DEVELOPMENT OF *Tectona grandis* L.f UNDER NUTRICIONAL RESTRICTION

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Resumo

Desenvolvimento inicial de mudas de Tectona grandis L.f sob restrição nutricional. No processo de produção de mudas, a nutrição das plantas pode melhorar a sua qualidade. Dentre as espécies florestais, a teca destaca-se pela madeira resistente e sua rusticidade. O conhecimento das necessidades nutricionais de mudas de teca vem a favorecer seu desenvolvimento com reflexo na produção a campo. O objetivo desta pesquisa foi realizar a omissão de nutrientes em mudas de teca e verificar os efeitos no crescimento das plantas em vasos. O experimento foi conduzido em casa de vegetação com mudas seminais plantadas em vasos de 3 litros; como substrato, utilizamos terra de subsolo. Os tratamentos foram divididos em: controle, solução completa, omissão de N, omissão de P, omissão de K, omissão de Ca, omissão de Mg, omissão de Si. Para avaliar os efeitos dos tratamentos nas plantas, mediu-se altura total e diâmetro do coleto, com seis leituras quinzenais. As observações foram submetidas à análise de variância e as médias foram comparadas pelo teste de Tukey a 5%. Posteriormente, foram ajustados os modelos de regressão linear, contendo, como variável independente: tempo de desenvolvimento; e variável dependente: altura e diâmetro do coleto por tratamento. Não houve diferença significativa entre tratamentos na variável altura total de plantas, apenas em diâmetro de coleto, no qual o tratamento completo foi detentor das maiores médias. Foi possível notar nos primeiros meses de desenvolvimento da teca um desempenho suficiente nas variáveis avaliadas, entretanto deve-se realizar adubação para uma produção satisfatória contendo principalmente os macronutrientes N, P, K.
Palavras-chave: Silvicultura, teca, adubação mineral.

Abstract

In the process of seedling production plant nutrition can improve the quality. Among the forest species, the teak stands out for the resistant wood and its rusticity. The knowledge of the nutritional needs of teak seedlings favors its development with reflex in the field production. The experiment was conducted in a greenhouse with seedlings planted in 3 liter pots, as substrate we used underground soil. The treatments were divided into: control, complete solution; omission of N, omission of P, omission of K, omission of Ca, omission of Mg, omission of Si. To evaluate the effects of treatments on plants, we measured total height and stem diameter, with six biweekly readings. The observations were submitted to analysis of variance and the means were compared by Tukey test at 5% probability. Subsequently, linear regression models were adjusted, containing as independent variable: development time; and variable dependent height and diameter of the collection per treatment. There was no significant difference between treatments in the variable total height of plants, only in stem diameter where the complete treatment had the highest mean values. In the first months of development of teak, it was possible to observe a sufficient performance in the evaluated variables, however, fertilization should be carried out for a satisfactory production, mainly containing the macronutrients N, P, K.
Keywords: Forestry, teak, mineral fertilization.

INTRODUCTION

The nutricional deficiency or imbalance is common among plants, because they do not always find the necessary elements, much less, in the adequate concentrations (LARA, 1991), however the lack or excess of the available elements results in malfunctions that compromise mainly its rate of growth (CRUZ *et al*., 2012). The handling of the forest nutrition is determining in the productivity management, thus, the availiability of nutrients must be modified by the forest managers according the necessity of the cultivation (MOYA *et al*., 2014a).

The process of forestry seedling production requires studies that aim to improve its efficiency (STORCK *et al*., 2015), in which morphological characteristics are used more frequently in the determination of the quality, and those are influenced by environment and maintenance of fertility in the utilized substrate (ELOY *et al*., 2013;

ROWEDER *et al*., 2015). The fertilisation of the substrate is important to favour the growth and quality of plants, respecting traits such as quality of the nutrients, type of subtrate and the species used to obtain the best possible development (NAVROSKI *et al*., 2016).

The teak (*Tectona grandis* L.f) is a exotic cultivation of economic impact and relevance in the forest scenario (CHAIYASEN *et al*., 2017), it has as one of the main properties the ornamental beauty, resistance to the attack of external agents and, mostly, good mechanics (MOYA *et al*., 2014b), which guarantees the quality of the wood and enables its use to many purposes such as naval constructions, general carpentry, among others (KOZGAR *e* SHAHZAD, 2012; TEWARI *e* MARISWAMY, 2013).

The planting with teak expand signifcantly in Brazil, resulting in demand and valuation in the international scenery (TONINI *et al*., 2010), mainly by the indian and chinese markets (QUINTERO-MÉNDEZ *e* JEREZ-RICO, 2017; ZHOU *et al*., 2017), thusd, studies that favour the production as well the knowledge of the nutricional requirements of the species are necessary, after all, it will reflect on the field.

The objective of this research is to conduct tests with omission of mineral nutrients in teak seedlings, aiming to analyse the effects caused in the growth of the plants accoring to the time in the greenhouse.

MATERIAL AND METHODS

The seedling used in the experiments were from seminal origin, obtained in the property Estância Santa Rita, in Cáceres-MT, derived of a population with approximately 14 years of age, located in the geographic coordinates 15º 58’ 25.49” S e 57º 34’ 36.11” O. After the harvest, the seeds were conducted to the break of dormancy, where they were kept bagged in tow and immersed in running water for 24 hours. Later, the seeds were placed in washed sand box only as support to the initial stage of germination. The irrigations, daily, in two periods, and, then, after two weeks, the emerging seedlings were selected and transplanted to non-toxic polypropylene tubes with volume of 290 cm^3, filled with vermiculite substrate and basement soil in the proportion of 2:1.

Within 20 days of development, the seedling were taken to the greenhouse, located in the Instituto Federal de Mato Grosso – *Campus* Prof. Olegário Baldo (IFMT), Cáceres-MT, and transplanted to 3 liter pots, internally covered with newspaper to avoid loss of soil by drainage and filled with basement soil substrate. The greenhouse had systematization with ventilators to the conservation of temperature, plastic canvas coating for umidity control and automatic irrigation four times a day.

One week after the transplant the levelling fertilization was conducted on all the experimental seedlings, with ¼ of the composition of the complete treatment, aiming to improve adaptation and initial development. The utilized nutrients were of mineral origin and diluted in water for better homogeneity. The treatments were composed by: T1 (control treatment); T2 (complete solution); T3 (solution with nitrogen omission (N)); T4 (solution with phosphorus omission (P)); T5 (solution with potassium omission (K)); T6 (solution with calcium omission (Ca)); T7 (solution with magnesium omission (Mg)); T8 (solution with silicium omission (Si)) (Table 1).

Tabela 1. Fontes minerais e concentrações utilizadas na formulação dos tratamentos para adubação de mudas de teca.

Table 1. Mineral sources and concentrations used in formulation of treatments for fertilization of teak seedlings.

Mineral source	Treatment (mg dm^{-3})						
	Complete solution	- N	- P	- K	- Ca	- Mg	- Si
Ureia	-	-	-	0.60	0.60	-	-
$Ca(NO_3)_2$	1.688	-	1.69	-	-	1.69	1.69
KH_2PO^{-4}	0.462	0.462	-	-	0.46	0.46	0.46
H_2PO^{-4}	-	-	-	1.31	-	-	-
KCl	0.037	0.037	0.30	-	0.04	0.04	0.04
H_3BO_3	0.100	0.100	0.10	0.10	0.10	0.10	0.10
$MgSO_47H_2O$	1.667	0.271	1.67	1.67	1.67	-	1.16
Silicato Ca	0.220	0.621	0.22	0.31	-	0.22	-
AgriSil	0.139	0.628	0.14	0.12	0.18	0.14	-
Zn $SO_4.H_2O$	0.071	0.071	0.07	0.07	0.07	0.07	0.07
Calcário dolomítico	-	0.628	-	-	-	-	0.23

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Each pot received 20 ml of solution of its respective treatment with the help of a automatic pipetter. To assure the efficiency of the treatments. the fertilizations were conducted in two steps. seven days after levelling and two months after (Figure 1). In the greenhouse. the plants received irrigation through sprinkler nozzles four times a day.

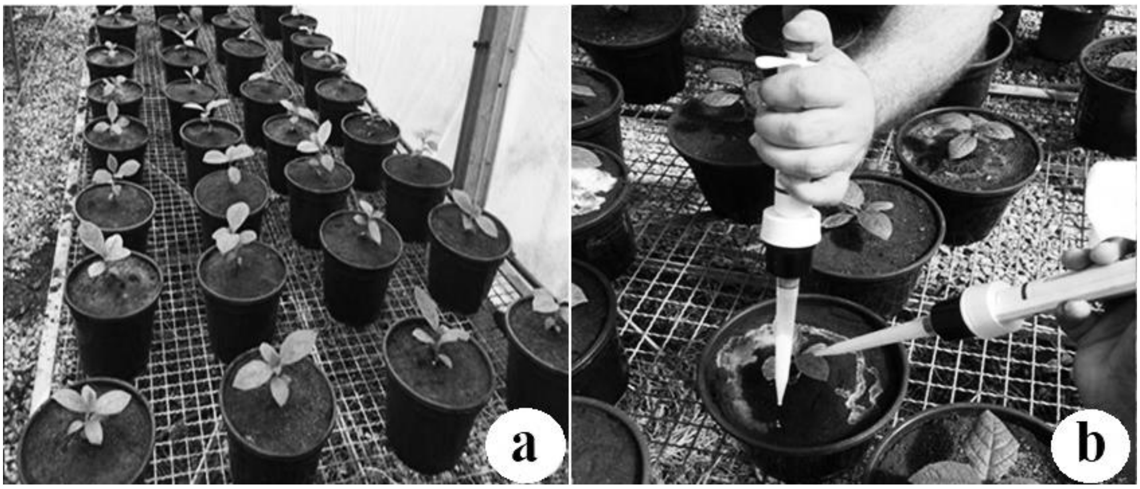

Figura 1**.** Mudas de teca utilizadas no experimento: (a) mudas dispostas nas parcelas experimentais; (b) aplicação dos tratamentos nas parcelas. Casa de vegetação – IFMT. Cáceres. MT. 2016.

Figure 1. Teak seedlings used in the experiment: (a) seedlings arranged in the experimental plots; (b) application of the treatments in the plots. Greenhouse – IFMT. Cáceres. MT. 2016.

To determinate the development of the seedlings. the measured variables were corresponding to the heigh (Ht) and stem diameter (Dc). with the help of a scaled ruler of 30 cm and digital pachymeter. respectively. Six measurements were performed. the first one before the application of the treatments. of which. after 30 days. were realized the others in biweekly intervals. completed 90 days after the application of the treatments.

The observations were submitted to the variance analysis (ANOVA). analysing the experiment im entirely designed delineation (DIC). with eight treatments and five repetitions. with 40 portions in total. Upon finding significant differences between the obtained averages of the variable responses (Ht and Dc). those were compared by the Tukey test at 5% of probability of error.

With the intent to analyse the development of the seedling according to the treatments. the data were adjusted through the linear regression model. containing as independent variable: development time of the seedlings (biweekly); and dependent variable: measurements of the variable responses (height (cm) and stem diameter (mm)). The significances of the adjusted regression were obtained through the test of the null hypothesis in which the angular coefficient of regression is zero. to the choice of the adequate polynomial equation. the regression with lower probability and high coefficient of determination (R^2) was considered. The analysis of the regression were conducted through the software R (CORE TEAM. 2018).

RESULTS

It is possible to determinate that the treatments influenced in the growth of the seedlings. because. since the first measure. a differentiated growth was noted between treatments and according to the control (witness). The treatment of complete solution obtained the higher growth at the period of analysis. although only after 45 days after the application of the treatments showed higher growth. Regarding the control. it is possible to note lower growth. obtaining the lower average at the end of the measurements (Table 2).

Tabela 2. Desenvolvimento em altura (cm) das mudas de teca submetido aos tratamentos de adubação mineral em função de cada leitura mensurada.

Table 2. Height development (cm) of teak seedlings submitted to mineral fertilization treatments as a function of each measured reading.

Mineral source	Development of the seedlings (height in cm)					
	0	30	45	60	75	90
Control	8.0	11.7	13.9	14.4	14.8	15.7
Complete	7.3	13.1	15.5	16.1	17.1	18.1
- N	6.8	11.7	13.8	14.3	14.7	16.7
- P	6.8	11.5	12.8	14.0	14.7	16.1
- K	7.7	12.4	15.6	15.8	16.6	17.8
- Ca	8.2	12.2	15.3	15.5	16.4	17.3
- Mg	7.1	12.3	13.9	14.6	15.6	17.4
- Si	8.1	13.5	15.2	15.9	16.5	17.8
CV (%)	13.91	12.37	10.15	9.41	7.56	6.97
Pα	0.17^{ns}	0.41^{ns}	0.23^{ns}	0.19^{ns}	0.27^{ns}	0.06^{ns}

^{ns} Not significant; CV (%) coefficient of variation;

Regarding the substantial difference. the treatments presented significantly equal values in all the evaluations. and it is possible to see that. although the probability of error decreased along the time. were not meaningful to the level of 5%; thus. there was no necessity perform average testing. Another factor taken into consideration is the coefficient of variance (CV). that decreased along the analysis. showing that. during the evaluations. the seedlings started to have similar development between repetitions. decreasing the variability among samples and. over time. could occur substantial differences between treatments.

In the stem diameter. it was possible to note the differences in the increase according to treatments. Before the application of treatments. some seedlings. due to genetic matters. presented higher values of diameters of the neck. although. along the development. obtained lower values than the other treatments. as. for example. the witness of the first measure obtained the higher average value (4.2). however. in the last evaluation. it was the complete treatment that obtained the higher average value. obtaining the value of 10.8 (Table 3).

Tabela 3. Desenvolvimento do diâmetro do coleto (mm) das mudas de teca submetido aos tratamentos de adubação mineral em função de cada leitura mensurada.

Table 3. Development of the stem diameter (mm) of the teak seedlings submitted to mineral fertilization treatments as a function of each measured reading.

Mineral source	Development of the seedlings (stem diameter in mm)					
	0	30	45	60	75	90
Control	4.2	5.2	7.1	7.5 ab	8.6 ab	9.1 ab
Complete	3.8	6.4	7.8	9.3 a	10.1 a	10.8 a
- N	3.4	4.7	6.1	6.8 ab	7.2 b	7.8 b
- P	3.5	4.7	6.2	6.7 b	7.2 b	7.6 b
- K	4.1	5.1	6.9	7.4 ab	8.1 ab	9.1 ab
- Ca	3.9	6.1	7.1	7.8 ab	8.5 ab	9.3 ab
- Mg	3.6	5.0	6.7	7.4 ab	7.8 ab	8.8 ab
- Si	3.7	6.0	7.0	8.6 ab	8.9 ab	10.5 ab
CV(%)	16.49	14.81	14.93	14.80	14.01	12.47
Pα	0.45^{ns}	0.26^{ns}	0.24^{ns}	0.03^{*}	0.02^{*}	0.00^{*}

^{ns} Not significant; * significant 5 % error probability; CV (%) coefficient of variation; Averages followed by the same letter vertically do not differ statistically by the Tukey test at the level of 5% probability of error.

The substantial differences between treatments presented values statiscally different 60 days after the application of the treatments of which was possible to note significance values lower than 5% of probability of error, 0.03, 0.02 and 0.00 to the measures 60, 75 and 90 days respectively. It was found that the complete treatment obtained the higher average being statiscally different of the other averages. The treatments with absence of nitrogen (-N) and phosphorus (-P) were the most damaging to the development of the seedling because they presented the lower average values and still were statiscally inferior to the other treatments.

Regarding the development of the seedlings. it was possible to adjust the linear models that explain the growth of the variables according to time. and. to the variable of height. the growth was better explained by the

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exponential function. of which was possible to note that all the equations and coefficients were statiscally meaningful to the level of probability inferior to 5%. In stem diameter. the models that better explained the growth were the ones of first degree functions. of which all the equations and coefficients were meaningful to 1% of probability of error (Table 4).

Tabela 4. Coeficientes das regressões lineares para estimativa do crescimento em altura (Ht) e diâmetro do coleto (Dc) das mudas de teca sob os tratamentos em função do tempo.

Table 4. Coefficients of the linear regressions to estimate growth in height (Ht) and stem diameter (Dc) of the teak seedlings under the treatments as a function of time.

Variable	Treatments	β_0	β_1	β_2	r^2	α-value
HT	Control	8.4047 **	0.1517 **	-0.0008 **	0.83	7.32_x10^{-11} **
	Complete	7.2886 **	0.2244 **	-0.0012 **	0.94	2.21_x10^{-16} **
	- N	6.5952 **	0.1794 **	-0.0008 *	0.85	1.72_x10^{-11} **
	- P	7.2738 **	0.1446 **	-0.0006 **	0.87	2.78_x10^{-12} **
	- K	7.9464 **	0.1857 **	-0.0009 *	0.82	1.21_x10^{-10} **
	- Ca	7.5654 **	0.2214 **	-0.0012 **	0.87	1.55_x10^{-12} **
	- Mg	7.9523 **	0.1717 **	-0.0008 **	0.91	1.84_x10^{-14} **
	- Si	8.8363 **	0.1991 **	-0.0011 **	0.81	4.24_x10^{-10} **
DC	Control	3.8721 **	0.0544 **	-	0.85	1.96_x10^{-12} **
	Complete	4.3315 **	0.0794 **	-	0.94	2.21_x10^{-16} **
	- N	3.2535 **	0.0504 **	-	0.69	2.26_x10^{-8} **
	- P	3.6784 **	0.0508 **	-	0.91	3.08_x10^{-15} **
	- K	3.9335 **	0.0505 **	-	0.65	1.11_x10^{-7} **
	- Ca	4.1773 **	0.0579 **	-	0.88	9.76_x10^{-14} **
	- Mg	3.5219 **	0.0564 **	-	0.85	1.94_x10^{-12} **
	- Si	4.2543 **	0.0735 **	-	0.87	1.71_x10^{-13} **

* Significant at the 5% probability level; ** Significant at the 1% probability level.

All the coefficients of determination (R^2) of the adjusted models to the height were superior to 0.81. exhibiting that the curve of growth to the adjusted equations present lower variability between the real and the adjusted values. For the variable of stem diameter. the values of the coefficient of determination presented low values in the adjustments of the treatments with absence of nitrogen and potassium (-N e -K). obtaining the values of 0.69 and 0.65. respectively. Values R^2. ranging 60 to 70%. can represent a intermediate estimate. However. in biological data cases. Oliveira *et al*. (2000) report that the differences between the R^2 to adjuested models in linear regression for biological studies are often derisory. because biological data presents high variability in which sometimes present abnormalities. thus. is it recomended the use of other parameters to the indicatives of the adjusted equations. such as significances of the adjusts.

The curve of growth proves that some the treatments presented similar behavior in the development according to time. and. even if the the control treatment presented always the lower rate of development. and. thus. noted that. even if some treatments presented absence of some element. those obtained the better development if compared to the control (Figure 2).

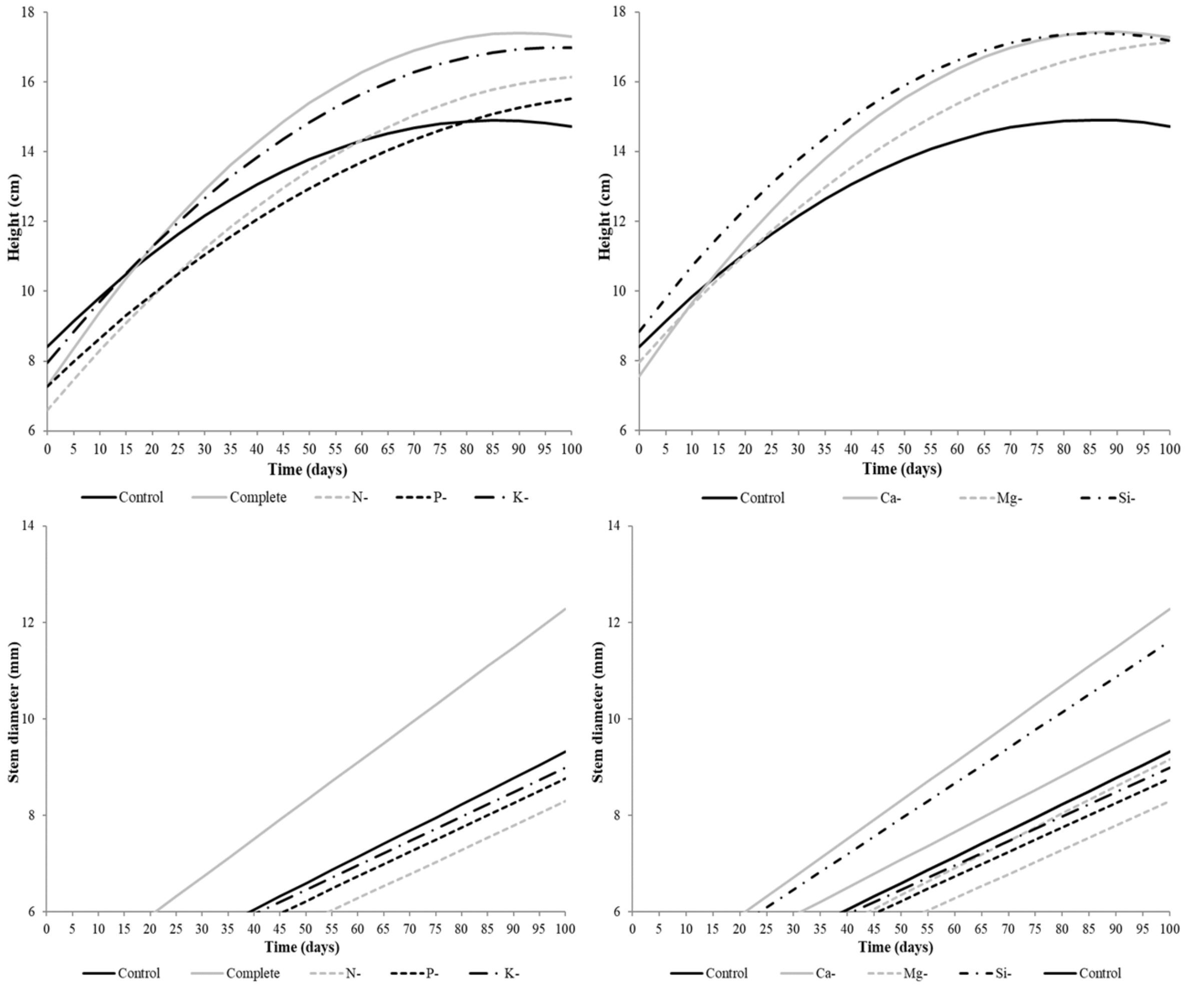

Figura 2. Curvas de crescimento das mudas de teca sob os tratamentos em função do tempo. (A) Altura: Tratamentos Controle. Completo. -N. -P e -K; (B) Altura: Tratamentos Controle. -Ca. -Mg e -Si;(C) Diâmetro do coleto: Tratamentos Controle. Completo. -N. -P e -K; (D) Diâmetro de coleto: Tratamentos Controle. -Ca. -Mg e -Si.

Figure 2. Growth curves of the teak seedlings under the treatments as a function of time. (A) Height: Treatments Control. Complete. -N. -P and -K; (B) Height: Treatments Control. -Ca. -Mg and -Si; (C) Stem diameter: Treatments Control. Complete. -N. -P and -K; (D) Stem diameter: Treatments Control. -Ca. -Mg and -Si.

It is possible emphasize in this work that the complete solution demonstrated the better outcome in the both analysed variable (height and stem diameter). obtaining the higher rates of growth. thus. shows that to the acquisition of a better production of teak seedlings the full fertilization is essential. This informations are of great value to substatiate the importance of innicial fertilization in teak plants.

DISCUSSION

Although the difference in the height averages did not present meaningful values. the adherence of this variable. with the intention to estimate the quality of the of seedling in seedbeds. must be used since it is a easy measurable parameter. non-destructive. and can be related to other metrics. There are works accomplished by some researchers that also did not obtain substantial response to the height parameter. Cruz *et al*. (2004). testing different levels of liming and doses of N in ipê-roxo seedlings. also did not find statiscal difference between the averages of growth in height after 120 days of development in the greenhouse. Silva *et al*. (2017). testing the concentration of vermicomposts in the development of eucalyptus and pine seedlings. also did not find substantial difference in the height variable in the measures of 120 and 180 days of evaluation to each species respectively.

The favorable conditions offered in the greenhouse and genete inheritance of the plants could have favoured the inncial development of the seedling in the evaluated variables. Macedo *et al*. (2005) concluded on their work that the main factor that limit the innicial growth of the teak seedlings are the periods of insufficiency

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and/or rainfall irregularity and the high level of soil compaction. Busato *et al*. (2016) affirm that the quality of forest seedlings also depends on the chemical traits of the substrate used in cultivation. which should enable adequate nutrition and good formation of the root system. The height of the seedlings was an evident trait. because. even with the omission of essencial nutrients or with no fertilization. achieved to reach satisfactory averages. because. according to Paiva and Gomes (2000). seedling of arboreal species are fit to the planting in field when the height is between 15 and 30 cm.

When the stem diameter was evaluated. the lower values obtained in the treatments -N and -P were justified. because. according to Raij (2011). plants that lack this element present reduced development. In a work conducted by Souza *et al*. (2006). the authors pointed out that the lack of N and P were elements that blocked the full development of the Ipê-roxo (*Tabebuia impetiginosa*). establishing it as priority to the studies of mineral fertilizantion of this speciesd. With the control treatments and solutions with omission of K. Ca. Mg and Si. it was possible to note that the average of the diameter does not have substantial differences. thus. this trait can be related to all the treatments referred to contain addition of N and P. Jesus *et al*. (2016). testing the growth and chemical composition of the essencial oil of *Eucalyptus globulus* (Labill) seedlings with N and K fertilization. concluded that these elements influenced positively the innicial growth of the plants. because they are linked to the aerial development. acting in synergism in cellular structuring. as well as in the physiological functions of development.

Some treatments obtained lower rate of growth compared to the control. highlighting the treatments with absence of nitrogen and phosphorus and potassium (-N. -P e -K) that obtained the lower outcome. However. this treatments. in the height variable. presented higher values than the control. although seedling with higher height and lower stem diameter are considered inferior in the quality of production; according to Righi *et al*. (2008). are considered this way. even though it presents lower height.

Considering that in this research all the seedlings received levelling fertilization. this action might have caused favourable conditions to a uniform innicial take-off to all the seedlings. thus. it would need a longer period of measurement to analyze the statistical differences between the growth averages. Substantiated in literature. it is clear that the development of seedling in relation to height can not be used as the only variable to the parameter of quality. once it is not always possible to obtain substantial responses. making necessary to adopt other variables to analysis or even correlation between them.

CONCLUSIONS

- On the first months of development. when natural fertility soil with nutritional balance were used. the development of the seedlings can present sufficient output. although. later. it must be applied complete and balanced fertilization to a satisfactory development.
- It is essential the maintainability through mineral fertilization that contains the macronutrients N. P. K. because the absence of it may cause disorders in the development of the seedlings.

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