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Growth and Quality of *Inga heterophylla* Willd Seedlings According to the Slow Release Fertilizer

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Abstract

Slow release fertilizers have become an alternative for better efficiency in substrate fertilization for seedlings production, however, there are not many studies approaching the use of such fertilizers in the production of native forest species seedlings. This work aimed to evaluate the effect of different doses of a slow release fertilizer (SRF) on the development and quality of the *Inga heterophylla* seedlings. The experiment was conducted in a vivarium with 50% of shade for a 150-day period. Randomized blocks were the chosen experimental design, constituted of four treatments and four replications, with twenty plants per experimental unit. The treatments were four doses of Osmocote® FLL (0, 4.1, 8.2 and 12.3 g dm^{-3}) in NPK 15-09-12 formulation, with evaluated variables being the height of the seedling (H), collar diameter (CD), number of leaf pairs (NLP), leaf area (LA), aerial part dry mass (APDM), root dry mass, total dry mass (TDM) and Dickson quality index (DQI). All the evaluated parameters responded significantly to the SRF doses and fit the positive quadratic polynomial model. For all of the analyzed variables, results show that the best averages were obtained by using the doses between 5.7 and 6.5 g dm^{-3}, but due to the quadratic response they presented a decrease in the mean values after doses which were superior to the maximum performance point of each characteristic.

Keywords: controlled release fertilizer, forest species, Osmocote®, substrate fertilization

1. Introduction

The secondary species *Inga heterophylla* Willd belongs to the legume family. Besides presenting abundant phytogeographic domain in the Brazilian Amazon (Gonçalves, 2012), it is part of a little-known native species group, even though it has high economic potential to be explored.

90% of Brazilian Amazon is composed of secondary forest, including *I. heterophylla* as one of the species with potential for handling and economically valued floristic composition for farmers in the region (Schwartz, 2007). In addition, it can be intercropped with other species which require a low amount of light, such as coffee and cocoa; it also has properties for phytotherapy use, power generation and human comsumption (Bilia et al., 2003).

Although *I. heterophylla* presents high occurrence in secondary forests and many characteristics of future economic value such as high production of vegetal biomass—an interesting feature in degraded areas under recovery process, as well as during the enrichment of initial secondary forests, there are no studies reported, so far, on the production of seedlings, which may be a limiting factor for seedlings success of such species in a secondary forest system¸ and also in commercial orchards and recovery of degraded areas.

Dutra et al. (2016) emphasize the importance of carrying out basic studies such as sustainability analysis—relevance of environmental, social, economic, political and health impacts—in little evaluated species, in order to provide information for their exploration and to improve techniques which aim to contribute to the production of good quality seedlings and to the success in forestry projects.

Information about factors which have influence over seedling production directly relates to quality, which interferes in the ability to adapt and grow after planting in field conditions (Garcia & Souza, 2015). Among those factors, the fertility of the substrate used in the production of seedlings, essential to greater plant resistance, stands out. Traditional fertilizers widely used in the seedling production of native species are highly soluble, allowing a great supply of nutrients to the plant, but also causing nutrient loss due to the leaching process, causing the need of nutritional replacement in a shorter period of time and risings in production costs (Dutra et al., 2016).

In this context, the use of fertilizers with controlled release of nutrients, such as Osmocote®, has shown greater efficiency in fertilization of substrates for seedling production, since it increases availability time for plant nutrients, reduces nutrient loss by leaching, reduces environmental impact, and is economically viable for forest businesses (Andiru et al., 2011; Cabrera, 1997; Merhaut et al., 2006; Mendonça et al., 2008).

Therefore, this study aimed to evaluate the effects of different doses of a slow release fertilizer (Osmocote ®) on the development of *Inga heterophylla* seedlings.

2. Method

The experiment was conducted in a vivarium with 50% of shade at Institute of Agrarian Sciences of the Federal Rural University of Amazonia-UFRA, located in the city of Belém, state of Pará at the geographical coordinates 1°27′12.6″ S and 48°26′33.5″ W with a 150-day follow-up period.

Randomized blocks were the chosen experimental design, constituted of four treatments and four replications, with twenty plants per experimental unit. The treatments consisted of four doses of Osmocote® slow release fertilizer (0; 4.10; 8.2 and 12.3 g dm^{-3}). This fertilizer has NPK 15-09-12 formulation, plus 1.3% Mg, 5.9% S, 0.02% B, 0.05% Cu, 0.46% Fe, 0.06% Mn, 0.02% Mo and 0.05% Zn, with nutrient availability time of approximately 5 to 6 months.

The fruits of *Inga heterophylla* were harvested in parent trees located in the city of Belém, state of Pará. After seed treatment, sowing was carried out in beds of washed sand and when the seedlings reached the "match sticks" stage, they were transplanted into polyethylene bags filled with 2 liters of Tropstrato® substrate (Table 1), into which the slow release fertilizer was manually mixed.

Table 1. Feature of the Tropstrato® comercial substrate used in *I. heterophylla* seedling production

Feature	Unity	
Maximum humidity	%	60
Water retention capacity	%	130
pH in water	-	5.8 (±0.5)
Density	kg m^{-3}	200
Electric conductivity	dS cm^{-1}	0.5 (±0.1)

The adopted cultural treatments to the seedlings consisted of daily irrigation—according to their need—and manual control of pests and diseases when necessary. After 150 days of sowing, the following parameters were measured: height of the seedling (H), obtained with a ruler graduated in centimeters from the soil surface to the end of the last leaf; collar diameter (CD), obtained with a digital pachymeter near the soil surface; and number of leaf pairs (NLP).

After those measurements, a sample of 40 plants of each treatment was collected to obtain the leaf area (LA; cm^2), with the help of a leaf area reader, model LI-3100C area meter. In addition, there were data about the aerial part's dry matter (APDM) in g $plant^{-1}$, root dry mass (RDM), in g $plant^{-1}$ and total dry mass (TDM), obtained from APDM + RDM, g $plant^{-1}$, which were all previously subjected to drying in an oven with forced air circulation at 60 °C until reaching constant weight and then weighed in a precision analytical balance.

After achieving parameters, the Dickson quality index (DQI) of the seedlings was also obtained, as recommended by Dickson et al. (1960) using the following formula:

$$DQI = [TDM\ (g)]/\{[H\ (cm)]/[CD\ (mm)] + [APDM\ (g)]/[RDM\ (g)]\} \quad (1)$$

The results achieved in the experiment were previously submitted to the normality analysis under the Shapiro-Wilk test and the homogeneity of the data was evaluated by the Levene test at 5% probability using the InfoStat software (Di Rienzo et al., 2014). Analysis of the variance of the data was performed at 5% probability under the F test. The effect of the Osmocote® doses was analyzed by a regression study, according to the methodology recommended by Banzatto and Kronka (1995), in which the points of maximum efficiency were obtained from the derivation of the equations.

3. Results

Analysis of variance (Table 2) indicated that all variables were significantly influenced by slow release fertilizer (SRF) doses. The ratio between the variables and the doses was adjusted to a positive quadratic polynomial model, through which it was possible to determine the point of maximum technical efficiency (MTE) by using the derivation of the equation.

Table 2. Summary of the analysis of variance for growth characteristics of *I. heterophylla* seedlings

Sources of variation	GL	H (cm)	CD (mm)	NLP	LA (cm²)	APDM (g/plant)	RDM (g/plant)	TDM (g/plant)	QDI
Osmocote®	3	27.0544 **	18.433 **	25.9790 **	78.1467 **	77.2841 **	43.2777 **	138.3950 **	46.8304 **
Block	3	1.6922 ns	2.4937 ns	0.0816 ns	0.3113 ns	3.7036 ns	1.1526 ns	3.8281 ns	0.7114 ns
Residue	9	17.15756	0.06683	2.92764	42.94517	0.00544	0.00083	0.00507	0.00013
CV%		15.86	8.3	17.89	15.98	17.89	25.76	13.59	25.77

Note. ** Significant at the 1% level of probability under the F test. CV%: coefficient of variation. H: height, CD: collar diameter, NLF: number of leaf pairs, APDM: aerial part dry matter, RDM: root dry matter, TDM: total dry matter, QDI: Dickson quality index.

It was also possible to observe that the effect of the fertilizer after the MTE had a negative influence on the evaluated variables, evidencing that the excess of SRF can be harmful to seedling growth (Figures 1-3).

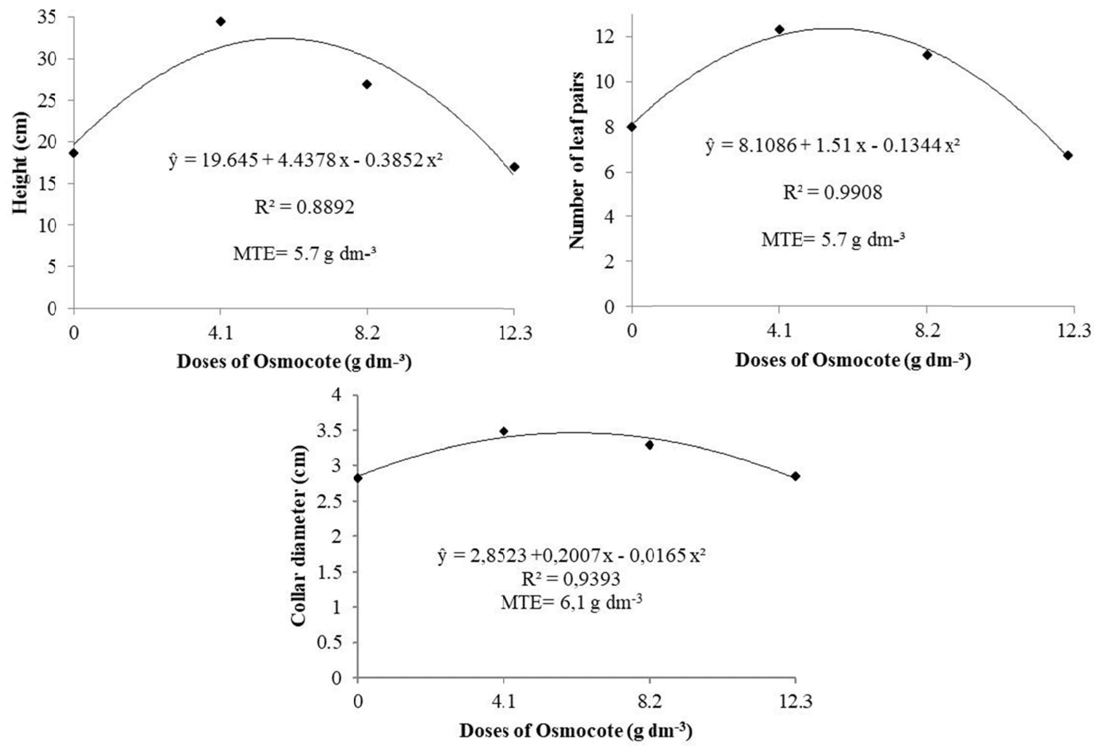

Figure 1. Graphic representation of regression equation of the height, number of leaf pairs and collar diameter as a function of the different doses of Osmocote®

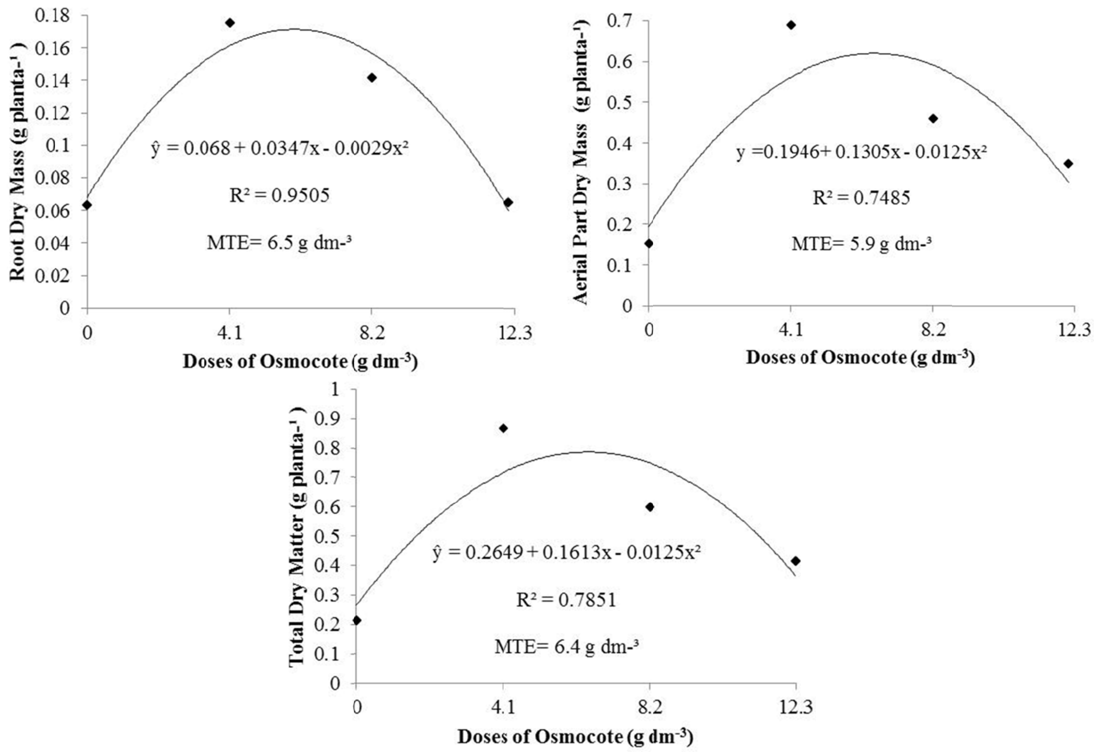

Figure 2. Graphic representation of regression equation of the root dry matter, aerial part dry matter and total dry matter as a function of the different doses of Osmocote®

Seedlings of *I. heterophylla* showed MTE in height (H) and number of leaf pairs (NPF) almost at the same dose, which was equivalent to 5.7 g dm^{-3}. As to collar diameter (CD), maximum growth was achieved at a dose of 6.1 g dm^{-3} FLL (Figure 1).

The optimum doses estimated for the best H, CD and NLP results, when compared to the treatment without addition of Osmocote®, provided significant gains of more than 60%, with a significant increase of 82% in CD.

The behavior of root dry mass (RDM), aerial part dry mass (APDM), total dry matter (TDM), leaf area (LA) and Dickson quality index (DQI) presented a similar response to the other variables. As a result, the maximum performance points were determined, in which the APDM values were achieved at the dose 5.9 g dm^{-3} and RDM and TDM at 6.5 and 6.4 g dm^{-3} respectively (Figure 2).

In relation to the parameters FA and IQD, *I. heterophylla* seedling production with the largest total leaf area and seedlings of better quality was observed at 6.2 g dm^{-3} of input (Figure 3).

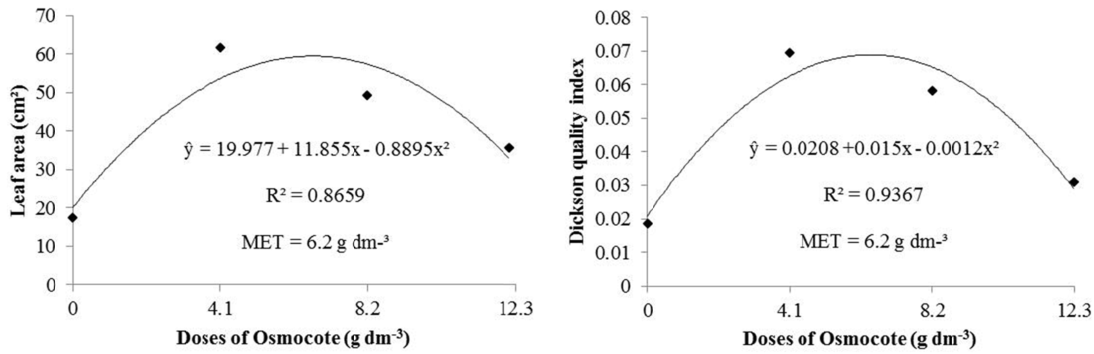

Figure 3. Graphic representation of regression equation of the leaf area and Dickson quality index as a function of the different doses of Osmocote®

The results demonstrate that the best averages were obtained, with the evaluated parameters, when using a slow release fertilizer within a 5.7 to 6.5 g dm^{-3} range, that is, the range covering the maximum performance point of each feature.

4. Discussion

Despite using a different species, when evaluating the effect of different formulations and doses of the Osmocote® fertilizer in the quality and development of seedlings of *Peltophurum dubium* (Spreng.) Taub, Dutra et al. (2016) observed similar responses for height, root dry mass and total dry mass, for which maximum growth occurred at the doses of 5.3, 7.7 and 8.5 g dm^{-3} and, later, such doses had their mean values dropped.

Berghetti et al. (2016) verified the effect of Osmocote® doses (15-09-12) on *Cordia trichotoma* seedlings, and also observed equivalent results to the present study, since the dose range which provided the best performance for the evaluated parameters oscillated between 6.1 and 5.4 g dm^{-3}.

Collar diameter is one of the variables with a strong influence on the quality of the seedlings of forest species due to their high degree of relation with the DQI (Binotto, 2007). Rossa et al. (2015) reported that for *Eucalyptus grandis*, the 8 g dm^{-3} dose of the gradual release fertilizer resulted in an average increase twice as large as the treatment without addition of the SRF. Menegatti et al. (2017) obtained similar results in the production of *Aspidosperma parvifolium*, the maximum technical efficiency being estimated at 6.65 g dm^{-3} of the fertilizer for that feature.

Moreover, Menegatti et al. (2017) found that the influence of the SRF was significant in the number of leaf pairs and leaf area of *A. parvifolium*, resulting in MTE of 5.14 and 5.46 g dm^{-3} Osmocote® to those features, respectively. The number of leaves and size of the leaf area are extremely important for the species survival after planting in field conditions because they influence the photosynthetic capacity and consequently the productivity of the plant (Menegatti et al., 2017).

Seedling quality is also affected by the Osmocote® doses and can be analyzed through the Dickson Quality Index, which considers the morphological variables and biomass distribution. Pias et al. (2015) discuss that the DQI has shown exceptional performance as the main indicative in seedling quality of forest species. Massad et al. (2015), using Flamboyant seedlings, obtained the best quality when the maximum technical efficiency (MTE) was reached with 3.4 g dm^{-3} of osmocote. Rossa et al. (2015) report that, in the production of *E. grandis*, the highest DQI resulted in 12.9 g dm^{-3} of SRF, therefore it is noted that the *I. heterophylla* plants, in comparison to these works, behaves as a species with average nutritional requirement.

The frequency of SRF studies has increased and different doses of Osmocote® have been used in the production of seedlings of several species, with different responses regarding the quality and development of the plants. The results obtained in different studies show that most forest species present different nutritional requirements, which makes it more difficult to standardize the recommendation of fertilizers in a generalized way.

However, it is noteworthy that there is a similarity in the nutritional requirement of species of the same genus when comparing the results obtained with *I. heterophylla* to the works of Claudino (2015), in which MTE was calculated from several species of the genus Inga and showed similar requirements, predominantly within the range of 5 to 7 g dm^{-3} of a slow-release fertilizer.

5. Conclusions

The quality and development of *I. heterophylla* plants in the seedling production phase in the vivarium are influenced by the use of slow release fertilizers.

When it comes to the production of *I. heterophylla* seedlings under the experimental conditions evaluated, Osmocote® (15-09-12) should be used at the proportion of 5.7 to 6.5 g dm^{-3}.

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