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The Effect of Different Substrates on the Growth of *Enterolobium contortisiliquum*

A. Q. Batista[1], Carla Figueiredo Coelho[1,2], Ires Paula de Andrade Miranda[1,3], Edelcílio Marques Barbosa[1] & Thiago de Paula de Andrade Miranda[1]

[1] Laboratório de Pesquisas em Palmeiras (LABPALM), Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Amazonas, Brazil

[2] Postgraduate Program in Tropical Agronomy, Federal University of Amazonas, Manaus, Amazonas, Brazil

[3] REDE PPG/BIONORTE Postgraduate Program, Manaus, Amazonas, Brazil

Correspondence: Carla Figueiredo Coelho, Laboratório de Pesquisas em Palmeiras (LABPALM), Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, Amazonas, CEP: 69067375, Brazil. Tel: 55-92-9603-7995. E-mail: carlacoelhofigueiredo@gmail.com

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Abstract

Brazilian origin species *Enterolobium contortisiliquum* (Vell.) Morong (Fabaceae) is distributed from north to south of the country. The species is a pioneer and important in the manufacture of furniture, boats and canoes, and presents easy handling also being significant for degraded areas recovery programs. As a result, management plans are necessary for the survival of this species. In the context of reforestation and recovery of degraded areas, the production of seedlings of native forest species occurs in nurseries and the quality of these plants depends on several factors, among which, the composition of the substrates is a factor of great importance for having its physical, chemical and biological characteristics directly linked to the growth of the seedlings. The study was based on obtaining knowledge and potential applicability in seedling production, subjecting it to different substrates, in order to evaluate their growth in height, diameter, number of leaves and biomass. The behavior presented by the species suggests its potential for reforestation turned to production and conservationism, since it revealed tolerance to the various types of substrates and better results with the use of organic matter added to the substrate.

Keywords: Amazon, dicotyledonous, substrate, growth, tropical

1. Introduction

Enterolobium contortisiliquum (Vell.) Morong (Fabaceae) is commonly known as tamboril, tamburé, monkey ear, timbaúva, timbó or black timbaúva. It is distributed throughout Brazil and also occurs in Bolivia, Paraguay, Argentina and Uruguay (Corandin, Siminski, & Reis, 2011). The propagation mechanism of this species happens through seeds and also vegetatively. It is a heliophile species of rapid growth, rustic, with regenerative potential in degraded areas and suitable for reforestation areas. Its wood is light and soft, used mainly in the manufacture of canoes (boats), general caskets, toys and plywood. It is dispersed in several forest formations, occurring in the northern, central-western and southern areas of the country (Lorenzi, 2002).

In the context of reforestation and recovery of degraded areas, the production of seedlings of native forest species occurs in nursery and the quality of these plants is dependent on several factors, among which, the composition of the substrates is a factor of great importance for having their physical, chemical and biological characteristics directly linked to the growth of the seedlings (Oliveira, Accioly, Santos, Flores, & Barbosa, 2014; Ferreira, Rocha, Gonçalves, Alves, & Ribeiro, 2009).

In Brazil, the practice of liming is present in all quadrants of the country, commonly in areas with the predominance of yellow latosols. Generally, these soils are acidic, with low base saturation, with high exchangeable aluminum contents, hugely deep, small and have strong granular structure; however, it offers good yields when its fertility is corrected (Furtini Neto, Vale, Faquin, & Fernandes, 1999; Silva, Tucci, Lima, Souza, & Venturin, 2007; Tucci, Lima, & Lessa, 2009).

Most ground soils in the Amazon are featured by low fertility, high acidity, low cation exchange capacity and high aluminum saturation. These conditions can be harmful to most forest species. To correct low fertility and high acidity, fertilizers and limestones are required, which allow neutralization of aluminum and other undesirable soil characteristics (Zenero et al., 2016).

Organic fertilization is an alternative to the use of chemical fertilizers, as well as providing nutrients, improves soil aeration, enhances permeability, aggregate stability and water retention capacity, and decreases soil compaction (Oliveira et al., 2014) and good results can be obtained in the production of seedlings.

The use of organic materials, such as crop residues, industrial waste and animal manure, has been increasingly attracting farmers and technicians. This is due to the aforementioned advantages and the availability and easy access to these materials.

The sustainable cultivation of *E. contortisiliquum* under natural conditions requires studies related to silvicultural aspects, such as aspects of seedling production and monitoring. Favoring a greater possibility in the perpetuation of the species and establishment of progenies. The study aims to evaluate the initial growth of seedlings in function of different substrates.

2. Methods

2.1 Place of Study

The study was carried out in a greenhouse at the Department of Agricultural and Soil Engineering (DEAS) of the Faculty of Agrarian Sciences (FCA), Federal University of Amazonas (UFAM), located in the city of Manaus, AM, with Latitude South 03°06′05″ and Longitude West of 59°58′30.67″, average elevation of 82 m asl.

2.2 Installation of the Experiment to Monitor Seedlings

Seeds were sown in sand, washed with 80% of germination, previously submitted to dormancy breaking by the seed (cutting) next to the seed, where the cotyledon (germinating part) is started, favoring the imbibition process (Brazil, 2009).

Twenty days after sowing, the most vigorous seedlings, with uniform height (10 cm), were transplanted individually into polyethylene bags with dimensions of 20 × 30 cm, containing three kilos of the following substrates:

T1 = Yellow Latosol

T2 = Yellow latosol with cattle manure (2:1)

T3 = Yellow latosol with organic compound (2:1)

T4 = Yellow latosol with liming

The Yellow Latosol was collected in an area of secondary forest in the superficial layer of 0-20 cm of depth. Soon after the collection, the soil was dismantled and placed to dry in the open air for a period of 96 hours, after which it was passed through a 4 mm aperture mesh sieve.

The cattle manure used was tanned outdoors and dried and homogenized, being mixed uniformly to the soil. The dosage of manure corresponded to the proportion 2:1 by volume, being two parts of soil, for a part of dung, according to Carvalho Filho, J. Blank, and M. Blank (2004).

The organic compound was decomposed for six months, manufactured in the form of piles of one meter high by one meter wide. The components for the manufacture of organic compost contained in this work were: cattle manure, fruits, vegetables, pruning of grams, pruning of branches and fish waste, used in fairs and markets in the city of Manaus, Amazonas. The dosage of the compound corresponded to the ratio 2:1 by volume, being two parts of soil and one part of compound. The limestone dose was equal to 10.5 g of $CaCO_3$ per experimental unit (CFSEMG, 1999).

2.3 Parameters Evaluated

The evaluated parameters were height, diameter and number of leaves during 84 days after the transplant of the seedlings; and ratio of dry shoot and root dry mass (MSPA/MSR) at the end of the experiment.

2.4 Experimental Design and Statistical Analysis

The experimental design was completely randomized, consisting of four treatments (substrates), with five replicates, each seedling being a replicate. Data regarding height, diameter and number of leaves were submitted to regression analysis. The data related to the biomass were submitted to analysis of variance and test of means by the test of Tukey to 5% of probability. The statistical program used was ASSISTAT Version 7.5 beta (2008) (Silva & Azevedo, 2009).

3. Results and Discussion

Plant growth is dependent on changes in physiology, which can be measured by the rate of assimilation and/or plant morphology (Hunt, 1982). In this work, a morphological parameter was studied, measuring the diameter, height and number of leaves. Significant differences between treatments were verified from 42 days after transplanting.

E. contortisiliquum seedlings showed better results in number of leaves, height and diameter in the substrate Yellow Latosol with organic compost, followed by Yellow Latosol with cattle manure, Yellow Latosol with liming and only Latosol as substrate (Figures 1, 2 and 3).

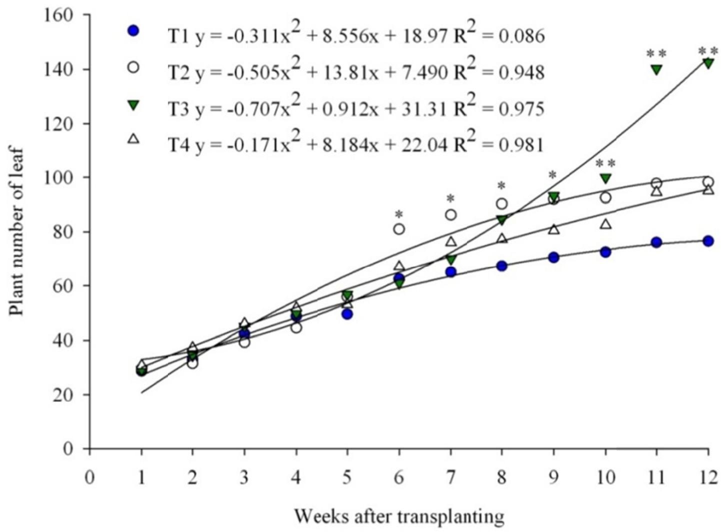

Figure 1. Number of leaves (*E. contortisilicum*, Fabaceae) in four treatments. T1: Yellow Latosol; T2: Yellow Latosol + cattle manure (2:1); T3: Yellow Latosol + organic compound (2:1); T4: Yellow latosol + liming

Note. **, * Significant at 1 and 5% probability, respectively.

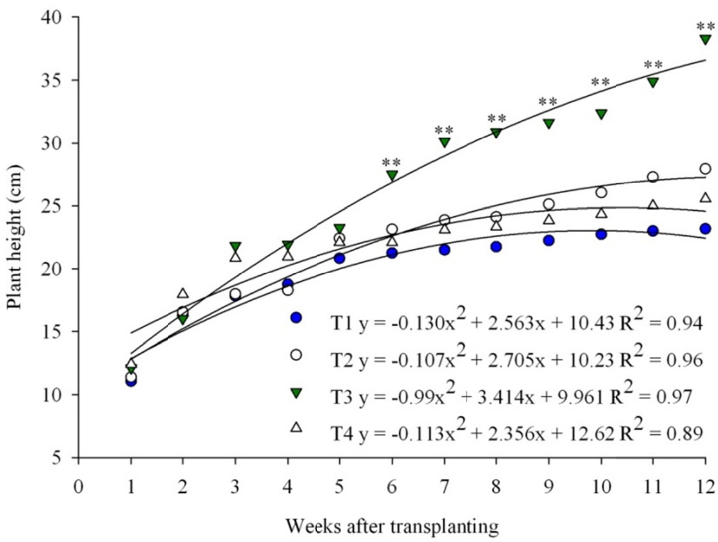

Figure 2. Height of seedlings (*E. contortisiliquum*, Fabaceae) in four treatments. T1: Yellow Latosol; T2: Yellow Latosol + cattle manure (2:1); T3: Yellow Latosol + organic compound (2:1); T4: Yellow latosol + liming

Note. **, * Significant at 1 and 5% probability, respectively.

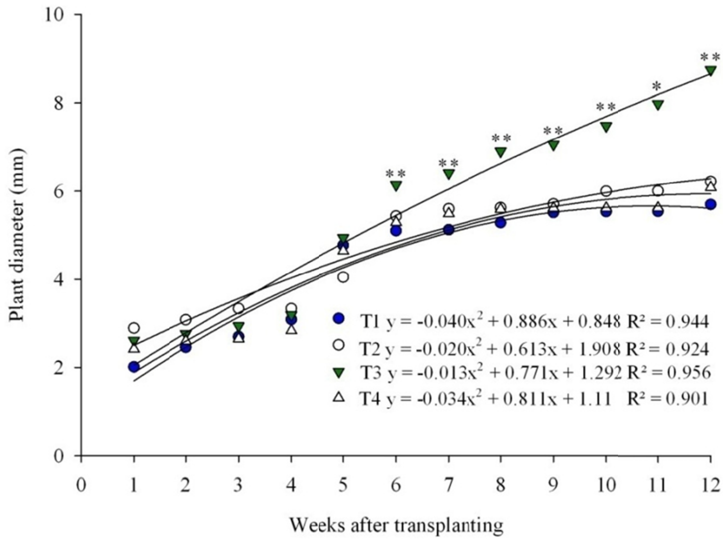

Figure 3. Diameter of seedlings (*E. contortisiliquum*, Fabaceae) in four treatments. T1: Yellow Latosol; T2: Yellow Latosol + cattle manure (2:1); T3: Yellow Latosol + organic compound (2:1); T4: Yellow latosol + liming

Note. **, * Significant at 1 and 5% probability, respectively.

The same result was found with respect to the accumulation of biomass, with the exception of the last two treatments, which did not differ statistically between them. It is possible to observe that there was a greater increase of biomass in the root with respect to the aerial part in the treatments with inferior results for the other parameters (Figure 4).

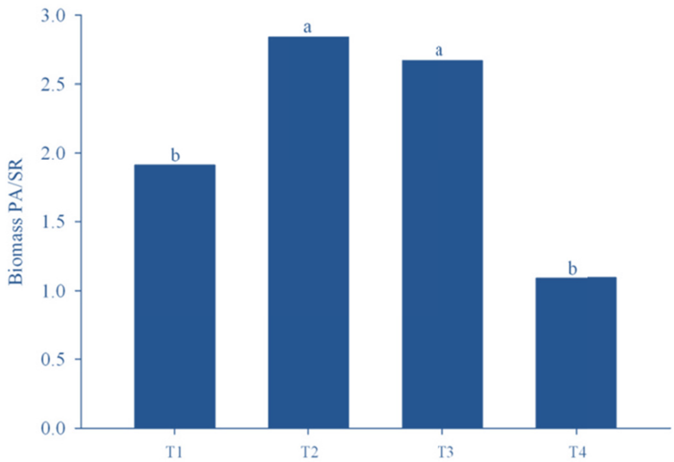

Figure 4. Allocation of biomass PA/SR (aerial part/root system) of *E. contortisiliquum* seedlings, Fabaceae, in four treatments. T1: Yellow Latosol; T2: Yellow Latosol + cattle manure (2:1); T3: Yellow Latosol + organic compound (2:1); T4: Yellow latosol + liming

Note. Equal letters do not differ statistically at the 5% probability level by the Tukey Test.

This result was expected by the lower presence of nutrients in the soil, confirmed by soil analysis (Tables 1 and 2). In a condition of nutrient deficiency, plants invest energy to develop the root system as a strategy to exploit a larger volume of soil to try to supply their nutritional demand (Carlos et al., 2014).

Table 1. Result of chemical analysis of the substrates used in the production of *Enterolobium contortisiliquum* seedlings

Substrates	pH H_2O	C	M.O.	P	K	Ca	Mg	Al	H+Al	t	T	V
		----- g/dm^3 -----		-- mg/dm^3 --		---------------------- cmol$_c$/dm^3 ----------------------						-- % --
T1	4.37	32.5	55.9	13	21	0.27	0.08	2.16	10.07	2.58	10.5	4.02
T2	6.2	51.35	88.32	475	180	4.38	2.56	0	5.08	7.47	12.6	59.51
T3	5.58	76.97	132.4	79	300	5.08	1.88	0	6.98	7.81	14.8	52.82
T4	5.8	30.66	52.74	10	25	1.92	1.32	0	4.32	3.32	7.64	43.45

Note. T1: Yellow Latosol; T2: Yellow Latosol + cattle manure (2:1); T3: Latosol yellow + organic compound (2:1); T4: Yellow latosol + liming.

Table 2. Average values for micronutrients, contained in the substrate used for seedling production of *Enterolobium contortisiliquum*

Substrates	Fe	Zn	Mn	Cu
	--------------------------------------- mg/dm^3 ---------------------------------------			
T1	102	1.65	0.96	0.56
T2	93	3487	24.9	2.19
T3	85	11.46	32.4	0.92
T4	110	1.71	2.44	0.76

Note. T1: Yellow Latosol; T2: Yellow Latosol + cattle manure (2:1); T3: Latosol yellow + organic compound (2:1); T4: Yellow latosol + liming.

It is observed that the treatments promoted changes in the composition of the substrates. The Yellow Latosol presented high acidity, which is characteristic of this type of common soil in the Amazon region, the other substrates presented pH in the ideal range (5.6 to 6.2) for most crops (Silva et al., 2016).

All treatments presented medium iron content and low amount of copper (Dadalton & Fuliin, 2001) and high levels of phosphorus. Yellow Latosol + cattle manure presented higher levels of this last element. The Latosol substrate showed the lowest concentrations of calcium, magnesium and manganese when compared to the other substrates.

The highest amount of carbon, potassium, calcium and zinc was found in the substrates to which organic matter was added (Yellow Latosol + organic compound and Yellow Latosol + cattlemanure), the organic compound being richer in carbon than cattle manure.

Cattle manure, organic compost and liming, mixed with the Yellow Latosol, neutralized the aluminum that was in high concentration in this soil, reducing the potential acidity (H + Al), increasing the saturation of bases to levels appropriate to the crops (Dadalton & Fuliin, 2001).

Similar results were found in the cultivation of castor bean (*Ricinus communis* L.) seedlings, which were abuded with bovine manure and organic compound favoring the growth of height, diameter and larger number of leaves (Fernandes, Chaves, Dantas, & da Silva, 2009). Other works also prove that the addition of organic matter has an influence on soil structure modification, releasing nutrients and producing substances that stimulate growth (Miranda, Batista, Tucci, Almeira, & Guimarães, 2013; Oliveira et al., 2014; Cerqueira, Freitas, Maciel, Carneiro, & Leite, 2015).

With the addition of organic matter in the substrate there is a rapid mineralization and supply of the chemical element phosphorus, limiting the growth of the species, and others, such as: carbon, nitrogen and sulfur (Gomes, Couto, Leite, Xavier, & Garcia, 2002; Fernandes et al., 2009).

The relationship between height and diameter are routinely used as parameters in the quality evaluation of seedlings, since they reflect the accumulation of reserves by the plant, ensuring a higher resistance and a better fixation in the soil (Coelho, Miranda, Melo, & Barbosa, 2015; Da Silva Neto et al., 2015).

The positive effect on the growth of *Enterolobium contortisiliquum* seedlings produced in substrates containing organic compound may be related to the higher concentration of nutrients in these substrates. This behavior represents a favorable characteristic for the production of sustainable seedlings with purpose of use in the productive chain, since it allows the substitution of the organic fertilizers, that can be acquired at low cost. Thus, it is satisfactory in terms of meeting the nutritional demand of the plants and viable from an economic and environmental point of view (Fernandes et al., 2009).

The use of this species in reforestation programs has shown efficiency in function of being a species adapted to several biomes and their economic importance from the point of view of the use for the shipbuilding pole, furniture and constructions, besides reforestation programs in degraded areas in the Amazon.

4. Conclusion

Enterolobium contortisiliquum responded to the addition of organic matter.

The substrate Yellow Latosol + organic compound provided the highest growth of *Enterolobium contortisiliquum* seedlings.

Organic compost and cattle manure increase the soil carbon, potassium, calcium and zinc contents.

The organic compound provides an indication for increased productivity of *Enterolobium contortisiliquum*.

Enterolobium contortisiliquum is a species with potential for production of sustainable seedlings with purpose of use in the productive chain and in recovery of degraded areas.

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