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Original Article

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Economic and Financial Analysis of Tree Seedling Production Using Composted Biosolids Substrate

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ABSTRACT

The aim of this study was to evaluate production profitability of *Croton urucurana* and *Cytharexyllum myrianthum* seedlings produced in substrates composed of mixtures of composted biosolids and carbonized rice husk in different concentrations of nutrient solution. Seedlings were subjected to three doses of fertigation solutions. In order to check quality standards which indicated production cycle, the height, stem diameter and root quality were evaluated. Economic viability was determined by indicators of economic attractiveness commonly used for investment projects. Production costs of seedlings varied according to the production cycle, substrate compositions and nutritional management. The substrate with higher volume of composted biosolids and lower concentrated fertilizer was the one with the highest profitability and the lowest production cost.

Keywords: profitability, sewage sludge, nursery.

1. INTRODUCTION

The use of organic materials in substrate composition is a good alternative for waste disposal as well as a source of plant nutrients which can reduce input high costs required for production of forestry seedlings (Trazzi et al., 2013).

Biosolids is an example of such material from sewage treatment waste or wastewater and varies according to its origin (industrial or sanitary). It contains organic matter and nutrients for plant uptake like nitrogen, phosphorous, calcium and magnesium (Singh & Agrawal, 2008). Many studies have showed suitable results of this residue on the plants profitability.

Simões et al. (2012), testing different substrate compositions via seminal seedling production of *Eucalyptus grandis* × *Eucalyptus urophylla*, observed that the shorter time of seedling in nursery influenced the reduction of seedling production costs, thus suggesting the use of substrates which allow a higher development and quality of seedlings within a shorter period.

The cost of eucalyptus seedlings at planting and replanting was 14.63% of the implementation cost of a reforestation area in Bahia state, according to Virgens et al. (2016). Vasconcelos et al. (2012) analyzed the costs of four forestry nurseries and concluded that the effective cost management is important for the success of the venture, which demands accurate cost control as well as investment plans.

When carrying it out, the investor will have the overview on costs and incomes generated by production system, time and amount of investment or profit from a project as incomes; thus, making it possible to measure when production activities will be carried out and the real cost flow, as well as profits, during the analysis period and final investment balance.

Within forestry area, Sant'Anna & Leonel (2009) and Virgens et al. (2016) advise the use of tools which consider the variation of capital along time, such as Net Present Value (NPV), Internal Return Rate (IRR) and Equivalent Uniform Annual Cost (EUAC). Furthermore, it can also be considered Benefit/Cost Ratio (B/C R) (Rezende & Oliveira, 2008), Breakeven Point (BEP) and Equivalent Uniform Annual Value (EUAV) (Silva & Fontes, 2005).

Croton urucurana Baill. and *Cytharexyllum myrianthum* Cham. are tree species with a wide geographical distribution in Brazil, found in the Atlantic Forest, Cerrado and Pantanal Biome (Carvalho, 2014; Saueressig, 2014). They are used in the recovery of degraded riparian forests because of their fast growth and rusticity. Certainly, nurseries have produced these species because they are indicated for ecological restoration projects in São Paulo state, according to Instituto de Botânica (São Paulo, 2015).

Considering the above aspects, this study aimed at analyzing the economic and financial aspects of *Croton urucurana* and *Cytharexyllum myrianthum* seedlings produced in alternative substrates composed of biosolid mixtures and carbonized rice husk in different fertilizer concentrations in nutritive solution.

2. MATERIAL AND METHODS

The experiment was conducted in Forestry Seedling Nursery at São Paulo State University (UNESP), School of Agriculture, Botucatu, São Paulo state, located in geographical coordinates of 22°51' South latitude and 48°25' West longitude, with average altitude of 786 meters above sea level. According to Köppen classification the climate is under Cfa type, characterized as warm temperate (mesothermal) humid, with an average annual rainfall of 1508.8 mm and average temperature of the warmest month is above 22 °C (Cunha & Martins, 2009).

The experiment had a randomized distribution in a 3 × 3 factorial design (3 substrate and 3 fertilizer dosages), totalizing 9 treatments, each one consisting of 4 plots of 12 subjects with 8 working individuals for quality assessment.

Tested substrates were composed of composted biosolid and carbonized rice husk mixtures, and the control group was a commercial substrate composed of peat, vermiculite and roasted rice husk. Composted biosolid was collected from Botucatu Sewage Treatment Plant. The compounds were: S1 - commercial substrate; S2 - substrate composed of composted biosolids and carbonized rice husk (2:1, v/v); S3 - substrate composed of composted biosolids and carbonized rice husk (1:2, v/v).

Seedling grown under these substrates were submitted to three different fertigation solutions (Table 1).

Table 1. Macro- and micronutrients content and electrical conductivity of nutrient solutions.

Nutrient	Nutritive Solution (mg L^{-1})		
	A1	A2	A3
N	483.60	725.40	967.20
P	444.00	666.00	888.00
K	400.50	600.75	801.00
Ca	312.00	468.00	624.00
Mg	72.20	108.30	144.40
S	101.11	151.67	202.22
Fe	16.25	24.38	32.50
Mn	3.12	4.68	6.24
Cu	0.33	0.50	0.66
B	4.59	6.89	9.18
Zn	1.20	1.80	2.40
EC (dS m^{-1})	1.91	2.18	2.90

A1 = standard nutritive solution; A2 = nutritive solution 50% more concentrated than A1; and A3 = nutritive solution 100% more concentrated than A1; EC = average electrical conductivity; Macronutrients = N, P, K, Ca, Mg and S; Micronutrients = Fe, Mn, Cu, B and Zn.

Table 2. Steps for seedling production of *Croton urucurana* and *Cytharexyllum myrianthum*.

Structure	Nozzle flow (L $hour^{-1}$)	Length of stay (days)	Received full irrigation (mm)
Greenhouse	7	45	168
Shade House	105	14	147
Nursery	200	86	860
Outdoor bed	108	31 (S2 and S3)	477
		55 (S1)	681

S1 = commercial substrate; S2 = substrate composed by composted biosolids and carbonized rice husk (2:1, v/v); S3 = composted biosolids and carbonized rice husk (1:2, v/v).

Tested species were *Croton urucurana* Baill. and *Cytharexyllum myrianthum* Cham., respectively known as sangra-d'água and pau-viola. Seeds were harvested at the beginning of March 2012 and sown at the end of the same month in tubes of 120 cm^3 distributed in trays with 450 plants per square meters, as shown in Table 2.

One hundred and twenty days after sowing (DAS), nine standard fertilizations were conducted to all subjects for seedling showed nutritional deficiency signs. Fertilization consisted of calcium nitrate (15% N and 20% Ca); urea (45% N); purified monoamoniophosphate (MAP) (60% P_2O_5 and 12% N); potassium chloride; and magnesium sulphate (9.5% Mg and 13% S). It was also added 1mL L^{-1} of micronutrients solution of boric acid (17% B); manganese sulfate (26% Mn, 11% S); zinc sulfate (20% Zn and 9% S); copper sulfate (18% S and 13% Cu); sodium molybdate (39% Mo); and iron (Fe 13%). All these fertilizers provided macronutrients in dosages of 310, 240, 240, 530, 160 and 38 mg L^{-1} of N, P, K, S, Ca and Mg, respectively, and micronutrients in dosages of 0.92, 0.065, 0.62, 0.31, 0.06 and 3.25 mg mL^{-1} solution of B, Cu, Mn, Zn, Mo and Fe, respectively.

After this period, different nutritive solutions were used for fertigation, three times a week. Used fertilizers were calcium nitrate; purified monoamoniophosphate (MAP); urea; potassium nitrate; magnesium sulphate; and micronutrient solution at a concentration of 5 mL L^{-1}.

Appropriate seedlings for field plantation were those reached at least 22 cm of shoot height, 3 mm of stem diameter (Fonseca et al., 2002), and score 2 as quality assessment of root system (Simões et al., 2012). For evaluation it was used a score scale ranging from 1 to 3, being: 1 – unstructured root system, little white roots and unfit for field planting; 2 – structured root system, with white roots, unsteady clod but suitable for

Figure 1. Score scale to assess root quality.

field planting, thus requiring greater care; 3 – structured root system, many white roots, steady clod and suitable for planting (Figure 1).

Production costs were estimated according to Hoffmann et al. (1987) methodology and expressed in American commercial dollar for being an international reference currency, according to Simões et al. (2012). For exchange rate it was considered the price of official foreign currency of Brazilian Central Bank for sale price, measured in units and fractions of the national currency, which was R$ 3.2986 on June 12, 2017 (BCB, 2017).

Gross revenue was estimated considering the sale price charged by the forestry market of US$ 0.6029 for each produced seedling. It was considered a discount rate of 12.8% per year for evaluation of the investment project, calculated by the Capital Asset Princig Model (CAPM), according Assaf et al. (2008).

The economic and financial evaluation was based on discounted cash flow (DCF) structured in accordance to Assaf & Lima (2017), characterized as conventional, considering a 15-year lifespan according to the depreciation period of facilities and equipment. Considering that, the expenditure capital of US$ 1,608.87 was used to produce a thousand seedlings during a year; therefore, the revenue generated by the sales of forestry seedlings, production costs, linear depreciation and tax provision were calculated.

According to the National Classification of Economic Activities (Classificação Nacional de Atividades Econômicas – CNAE), the economic activity category is Seedling Cultivation in Forestry Nurseries (0210-1/06). Thus, considering that the production capacity of the nursery is 300 thousand seedlings per year, it was established that the tax policy for forestry nursery is the Simplified National Tax (Simples Nacional) with annual revenue up to US$ 54,568.60. Therefore, the rate of this simplified tax was 4.00%, which were distributed in tributes: 5.50% Corporate Income Tax (Imposto de Renda sobre Pessoa Jurídica); 3.50% Social Contribution on Net Profit (Contribuição para o Financiamento de Seguridade Social); 12.74% Contribution for Social Security Financing (Contribuição para o Financiamento da Seguridade Social); 2.76% Social Integration Plan (Programa de Integração Social); 41.50% Employer's Social Security Contribution (Contribuição Patronal Previdenciária – CPP); and 34.00% Tax on Operations related to the Circulation of Goods and on Services of Interstate and Intermunicipal Transport and Communication Services (Imposto sobre Operações Relativas à Circulação de Mercadorias e sobre Prestações de Serviços de Transporte Interestadual e Intermunicipal e de Comunicação – ICMS).

Economic attractiveness indicators were estimated based on thousands of produced seedlings as follows: Net Present Value (NPV) according to Noronha (1987); Internal Return Rate (IRR) according to Nogueira (2009); Equivalent Uniform Annual Value (EUAV) according to Casarotto & Kopittke (2010); discounted payback (Hirschfeld, 2007); Benefit/Cost Ratio (B/C R) according to Nogueira (2009); Accounting Breakeven Point, expressed in produced units (BEPq) as well as in US$ trade dollar (BEP$), according to Bruni (2008) methodology.

3. RESULTS AND DISCUSSION

Seedlings of all the treatments reached quality patterns. However, production cycle was different, which varied production costs and economic indicators.

Both species seedlings grew under substrate composed of composted biosolids (S2 and S3) reached quality patterns considered fit for planting (Fonseca et al., 2002; Simões et al., 2012) at 176 DAS. During this period, nine nutritive solutions were used.

On the other hand, seedlings under commercial substrate reached minimum shoot height and stem diameter for planting a week later. However considering root quality, they were unfit for planting (score lesser than 2).

Davis & Jacobs (2005) state that the root system may indicate more precisely the potential for establishment of seedling in the field, for new root emissions may minimize impact with seedling transplant mainly caused by water reduction. Thus nutritive solution usage continued until root assessment reached to equal or higher than score 2, which occurred at 200 DAS, totalizing 15 fertigation with nutritive solution.

3.1. Production costs of tree seedlings

Seedling production costs varied according to substrate compositions and nutritional management. The highest production cost was observed in S1A3 treatment resulting in USD 317.84 k^{-1}. This can be explained by higher nutritive concentration of A3 fertigation, as well as time spent in nursery due to S1 substrate show less nutritive input resulting in an increase in production cycle. Such increase resulted in greater amount of fertigation, irrigation, electricity and expenditures with manpower, among others.

Comparing to the lowest production cost treatment (S2A1), the difference was 17.9%. Seedlings produced under this substrate had a shorter production cycle, probably due to the higher amount of nutrients within composted biosolids for this substrate had a higher proportion of such compound. Generally, substrates with composted biosolids had the lowest average production costs of US$ 265.29 k^{-1}, which showed inferior cost differences between them, of 1.0%.

Simões et al. (2012), when testing different substrate compositions for seminal seedling production of *Eucalyptus urophylla* × *Eucalyptus grandis* in tubes of 50 cm^3, 92 days after sowing, observed an average cost of US$ 105.68 k^{-1}. It was concluded that seedling production cycle is crucial on production total cost (PTC) confirmed by the estimated values for the assessed species. These authors also emphasize that seedling cost and quality should be compatible, since in lower cost substrates seedlings with inferior quality were obtained, showing that they would need a longer time in nursery.

Seedlings produced with lower nutritive solution once produced with composted biosolids (S2A1 followed by S3A1) had the lowest PTC (Table 3), and as a consequence they had the best commercial gross margin. Such costs come from the lowest cost of used compounds, lowest nursery time and lowest nutritive solution fertigation in relation to control substrate.

Table 3. Production total cost, commercial values and gross margin of 1,000 seedlings.

Treatments	PTC (USD k^{-1})	Commercial value (USD k^{-1})	Gross margin (%)
S1A1	305.24	584.80	91.6
S1A2	312.89	584.80	86.9
S1A3	317.84	584.80	84.0
S2A1	260.85	584.80	124.2
S2A2	264.37	584.80	121.2
S2A3	267.68	584.80	118.5
S3A1	262.46	584.80	122.8
S3A2	266.27	584.80	119.6
S3A3	270.09	584.80	116.5

S1 = commercial substrate; S2 = substrate composed by composted biosolids and carbonized rice husk (2:1, v/v); S3 = composted biosolids and carbonized rice husk (1:2, v/v); A1 = standard nutritive solution; A2 = nutritive solution 50% more concentrated than A1; and A3 = nutritive solution 100% more concentrated than A1.

What has caused the greatest impact on PTC in all treatments was the cost with manpower, varying between 58.3% and 62.3%. Simões & Silva (2010), carrying out an economic analysis of eucalyptus cuttings production in a large forestry nursery, have also observed that manpower overburdened the costs; nevertheless reaching lower percentual rates (37.5%) than those observed in this study, due to the high technology in nurseries studied by the authors.

3.2. Economic indicators

For cash flow, it was necessary to determine the amount of production cycles of each treatment for each year of the investment project lifespan. Thus, for S1A1, S1A2 and S1A3 treatments the estimated total capacity of production was 27 cycles, and for the other treatments, 31 productive cycles. After obtaining such values it was conducted the diagnosis for economic attractiveness indicators (Table 4).

The highest Net Present Value (NPV) was US$ 2,951.42 k^{-1} obtained from treatment S2A1. Thereby it is possible to state that this is the treatment that will provide the best financial return to investors due to the highest sum of estimated cash flow, when compared to the other treatments. Considering that an investor may choose S1A3 treatment, it shall have the lowest expected financial return for the investment project, with estimated value for the NPV of US$ 1,608.87. Nevertheless, this NPV is higher than different thinning management of *Tectona grandis* NPV, according Bezerra et al. (2011), or paricá-curauá agro forest system (*Schizolobium parahyba* var. *amazonicum* and *Ananas comosus* var. *erectifolius*) involving harvest of curauá's leaves and plantlets, which did not show economic feasibility after four years of cultivation (Cordeiro et al., 2009).

Regarding Internal Return Rate (IRR), the best rate obtained was 38.9%, also for S2A1 treatment. Such figure was higher than the discount rate and considered as Minimum Attractiveness Rate (MAR) used for the project (11.2%). If an investor chooses to produce tree seedlings under the conditions observed in this study, it is possible to have a higher financial profit than those of fixed income securities, as all treatments showed percentages above the rates within the financial market, even considering the 4.3% rate that currently represent country risk. Assaf (1992) stated that the acceptance of this method should be conducted comparing it to MAR, that is, if IRR is superior to MAR, the investment should be classified as economically attractive, otherwise the project should be rejected.

Analyzing EUAV, which corresponds to transform the investment project cash flow into equivalent uniform series for each assessed treatment (investment project), the best gain expectation was that of S2A1 treatment, resulting in US$ 413.84. According to Brigham & Houston (1999), it should preferably be chosen the investment project that shows the highest equivalent annuity, since periodical benefits are higher than periodical costs. Therefore, regarding this treatment

Table 4. Financial indicators used for *Croton urucurana* and *Cytharexyllum myrianthum* seedling production.

Treatments	NPV (USD)	IRR (%)	EUAV (USD)	B/C R	Discounted payback (years)	BEPq	BEP$
S1A1	1,783.10	27.8	250.02	1.45	4.6	608	355.70
S1A2	1,691.99	27.0	237.25	1.43	4.7	632	369.78
S1A3	1,608.87	26.3	225.59	1.40	4.8	654	383.01
S2A1	2,951.42	38.9	413.84	1.70	3.0	503	294.94
S2A2	2,893.82	38.4	405.77	1.67	3.1	515	301.31
S2A3	2,836.23	37.9	397.69	1.63	3.2	527	308.33
S3A1	2,918.14	38.6	409.18	1.68	3.1	510	298.38
S3A2	2,860.54	38.1	401.10	1.65	3.2	522	305.35
S3A3	2,802.95	37.6	393.03	1.62	3.2	534	312.43

S1 = commercial substrate; S2 = substrate composed by composted biosolids and carbonized rice husk (2:1, v/v); S3 = composted biosolids and carbonized rice husk (1:2, v/v); A1 = standard nutritive solution; A2 = nutritive solution 50% more concentrated than A1; and A3 = nutritive solution 100% more concentrated than A1; NPV = Net Present Value; IRR = Internal Return Rate; EUAV = Equivalent Uniform Annual Value; B/C R = Benefit/Cost Ratio; BEPq = Accounting Breakeven Point expressed in produced units; BEP$ = Accounting Breakeven Point expressed in USD trade dollar.

(S2A1), it was observed the highest net result for return on invested capital, comparing to the other treatments.

Benefit/Cost Ratio (B/C R) is another aspect confirming that S2A1 is the most profitable treatment. It was of 1.70, which indicates that the gains are 70% higher than the expenses, i.e., for every dollar invested in the project, the investment is covered and the return is US$ 0.70. In the lowest monetary return treatment (S1A3), this ratio was of 1.40. In spite of being the lowest ratio among the observed treatments, it was not so low compared to *Eucalyptus grandis* × *Eucalyptus urophylla* seedling production by mini-cutting in a midsize forestry company, in which Dias et al. (2011) observed a 1.37 ratio when seeds were sold at R$ 0.30. When ratio was of 1.60, selling price was of R$ 0.35. Moreover, in this study, for seminal seedling production the ratio ranged from 1.83 to 2.14. Although the seminal production showed a B/C R with higher values, decision taking on seedling production should not consider only the economic aspect in a short term, since plant propagation by seeds may propitiate heterogeneous forestry population regarding growth, production and wood quality.

Considering discounted payback, S2A1 treatment showed a shorter profitable term, estimated in 3.0 years due to lower PTC. Average paybacks of treatments were 3.6 years, which is considered relatively short when compared to other agricultural activities, as 6.24 years for seedling production of *Amburana cearenses*, *Albizia niopiodes*, *Hymenaea courbaril* and *Tabebuia alba* in Piauí state (Santos et al., 2013), and 2 to 5 years for mobile system for extraction of eucalyptus essential oil (Vivan et al., 2011).

For accounting breakeven point expressed in produced quantities (BEPq) and US trade dollar (BEP$) in S2A1 treatment with a production of 503 seedlings, there were attained the Breakeven Pont in units. So the Breakeven Point expressed in US trade dollar is 294.94 in order to balance the expenses with the earnings, because only from this point there will be profit. In S1A3 treatment, such amount increases to 654 seedlings, making it necessary to produce 151 more seedlings. This indicator is interesting to identify the moment in which the investor has to pay out in order to cover production costs.

All the treatments were economically viable for the evaluated conditions, that is, there is a monetary leftover after the payment of the production costs. The indicators corroborate this viability and also show that approximately 25% of the total useful life of the project is necessary for the recovery of the invested capital.

It is important to point out that the considered quantitative methods of investment analysis indicated that substrates composed by biosolids and lower doses of fertilizer presented better economic viability, mainly S2A1, followed by S3A1, S2A2, S3A2, S2A3 and S3A3. When comparing the treatments with alternative substrates, the difference occurred due to the costs of fertilizers; and when compared to commercial substrate, these differences are related to the shorter production cycle needed for seedling production and, consequently, lower costs with input and manpower.

Despite these results, it stands out that biosolids is still not a commercially utilized product for substrate production, which can influence technical issues that were not approached in research studies.

However, the utilization of biosolids as substrate for seedling production can be very promising, considering that the availability of this material tends to increase according to data from 2015, in which the treatment index was 42.7% of estimate sewage, whereas in 2012 it was 38.6% (Brasil, 2015). The Ministry of Agriculture, Livestock and Supply, through the Normative Instruction no. 5/2016, established the rules on the definitions, classification, specifications and warranties, tolerances, registration, packaging, labelling and advertisement for the commercialization of biosolid substrates for plants (Brasil, 2016).

4. CONCLUSIONS

Evaluated composted biosolids substrate, as well as commercial substrate, showed a profit gross margin above 84.0% regardless fertigation management, and it is an economically viable investment alternative.

Attractiveness indicators showed that composted biosolids substrates used for less concentrated fertigation were the most economically viable, especially substrates composed of two parts of biosolid for one part of carbonized rice husk.

Manpower costs for tree seedling production were approximately 60.6% of production total cost.

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