Universidade Federal Rural do Semi-Árido
Pró-Reitoria de Pesquisa e Pós-Graduação
https://periodicos.ufersa.edu.br/index.php/caatinga

ISSN 0100-316X (impresso)
ISSN 1983-2125 (online)
http://dx.doi.org/10.1590/1983-21252023v36n314rc

Wastewater and substrates on the growth of *Anadenanthera colubrina* L. seedlings

Água residuária e substratos no crescimento de mudas de angico

Nelson J. V. Macumbi[1]*, Nildo da S. Dias[1], Raimundo F. de Brito[2], Miguel Ferreira Neto[1], Jucicléia S. da Silva[3], Raniere B. de Lira[4], Hozano de S. Lemos Neto[5]

[1]Center for Agrarian Sciences, Universidade Federal Rural do Semi-Árido, Mossoró, RN, Brazil. [2]Empresa de Assistência Técnica e Extensão Rural, Assú, RN, Brazil. [3]Embrapa Semiárido, Petrolina, PE, Brazil. [4]Cooperativa de Assessoria e Serviços Múltiplos ao Desenvolvimento Rural, Mossoró, RN, Brazil.[5]Universidade Federal do Piauí, Floriano, PI, Brazil.

ABSTRACT - The production of seedlings of forest species for reforestation of biomes is a practice that restores the conditions of the environment, but water and substrates that favor the growth of seedlings are required. However, in the semi-arid region, water is a limiting factor, requiring the use of alternative sources such as treated domestic sewage. In this context, the objective was to evaluate the growth of *Anadenanthera colubrina* L. seedlings produced in substrates (soil + bovine manure and soil + coconut fiber) fertilized with treated domestic sewage effluent diluted in public-supply water in proportions (100, 75, 50 and 25% of domestic effluent) and using water from the supply network as a control. The treatments were arranged in a completely randomized design, in a split-plot with three replicates. The treated domestic effluent (TDE) used in the experiment came from the domestic sewage treatment plant of the decanter-digester type of the Projeto de Assentamento Milagre Apodi/RN. The study was conducted in a seedling production nursery at UFERSA, with growth and vigor evaluations at 30, 60, 90 and 120 days after transplanting. The production of seedlings fertigated with domestic effluent caused differences in all growth variables, with improvement in phytomass production. Seedlings fertigated with a dilution of 50% TDE and 50% water supply showed better results when produced with substrate composed of soil and coconut fiber. The seedlings showed good quality, and those cultivated with 50% and 75% of wastewater showed better quality after 120 days of cultivation.

Keywords: *Anadenanthera colubrina* L. Forest species. Domestic sewage. Coconut fiber. Seedling production.

RESUMO - A produção de mudas de espécies florestais para reflorestamento de biomas é uma prática que restaura as condições do meio, porém é necessário água e substratos que favoreçam o crescimento das mudas. Entretanto, na região semiárida a água é um fator limitante sendo necessário uso de fontes alternativas como os esgotos domésticos tratados. Neste sentido, objetivou-se avaliar o crescimento de mudas de angico produzidas em substratos (solo + esterco bovino e solo + fibra de coco) fertigadas com efluente de Esgoto Doméstico Tratado (EDT) e diluídos em água de abastecimento nas proporções (100, 75, 50 e 25% do EDT) e água de abastecimento (testemunha). Os tratamentos foram dispostos em delineamento inteiramente casualizado, em parcelas subdivididas com três repetições. O efluente EDT utilizado no experimento foi proveniente da estação de tratamento de esgoto doméstico do tipo decanto digestor do Projeto de Assentamento Milagre Apodi/RN. O estudo foi realizado em viveiro de produção de mudas da UFERSA, sendo realizadas avaliações de crescimento e vigor aos 30, 60, 90 e 120 dias após o transplantio. A produção de mudas fertigadas com efluente doméstico promoveu diferenças em todas as variáveis de crescimento com melhoria na produção de fitomassa. As mudas fertigadas com diluição de 50% do EDT e 50% água de abastecimento proporcionaram melhores resultados quando produzidas com o substrato composto por solo e fibra de coco. As mudas apresentaram-se como de boa qualidade e as cultivadas com 50% e 75% de água residuária mostraram-se com maior qualidade aos 120 dias de cultivo.

Palavras-chave: *Anadenanthera colubrina* L. Espécies florestais. Efluente de esgoto doméstico. Fibra de coco. Produção de mudas.

Conflict of interest: The authors declare no conflict of interest related to the publication of this manuscript.

Received for publication in: October 25, 2021.
Accepted in: January 19, 2023.

***Corresponding author:**
<n.macumbi@gmail.com>

INTRODUCTION

Water scarcity imposes abiotic stresses, which are the most important factors in the limitation of the plant's production capacity, so the artificial supply of water, via irrigation, is an important instrument to reduce or mitigate the impacts of climate fluctuations on production (TORRES et al., 2019).

The main advantage of using treated domestic effluents in agriculture is the recovery of a resource of great importance for agriculture – water; the constituents of these effluents are products that can increase soil fertility for containing nutrients that are essential to plants, due to the organic matter added to it, with the consequent formation of humus (OLIVEIRA, 2012).

Gaspar, Bezerra and Mota (2020) observed that the use of treated effluents in domestic sewage treatment plants promoted better growth of citronella (*Cymbopogon winterianu*) seedlings when compared to the use of public-supply water and that the behavior of plants followed the same trend, making use of the nutrients available in the treated effluents to increase their growth rate.

The use of substrate composed of bovine manure and coconut fiber is of paramount importance for seedling development, as it provides conditions for the root system to develop until the moment the seedling is transplanted to the field.

Anadenanthera colubrina is an arboreal legume that belongs to the Fabaceae family and has an economic importance, besides being widely used in conservation plantations (LORENZI, 1998). For belonging to the Fabaceae family, it has potential for biological nitrogen fixation and is a significant option to be introduced in forest restoration areas or agroforestry systems (SOUZA et al., 2012). Thus, the objective of this study was to evaluate the effect of treated domestic sewage effluent and substrates on the growth of *A. colubrina* seedlings.

MATERIAL AND METHODS

The experiment was carried out in a greenhouse of the Department of Agronomic and Forestry Sciences of the Federal Rural University of the Semi-Arid Region (UFERSA), in Mossoró, RN, Brazil (5º 11' S, 37º 20' W and 18 m altitude), from January to June 2019.

The treatments were distributed in a completely randomized design, arranged in split plots with three replicates. The factors tested were five irrigation solutions (public-supply water – PSW, treated domestic effluent - TDE and the mixtures of 75% TDE + 25% PSW, 50% TDE + 50% PSW and 25% TDE + 75% PSW) and two growing substrates (S_1 - 75% soil + 25% bovine manure and S_2 - 75% soil + 25% coconut fiber).

Anadenanthera colubrina seeds were collected from vigorous trees of spontaneous occurrence within a radius of 50 m, in the municipalities of Apodi-RN and Governador Dix -Sept Rosado, beside the Apodi/Mossoró river.

The materials used to make up the two substrates were: soil, aged bovine manure and coconut fiber. The soil used was collected from the subsurface layer (20 - 40 cm) of a *Latossolo Vermelho-Amarelo* (Oxisol) under Caatinga, located in the rural area of the municipality of Mossoró/RN. The bovine manure used was acquired in the rural area of the municipality of Governador Dix-Sept Rosado/RN. The coconut fiber used was a commercial type, which contains as basic raw material the residue from *Cocos nucifera* industrialization, in which the shell is milled.

After preparing the growing substrates used in the experiment, samples were collected for physical-chemical characterization at the Soil Fertility Laboratory (LASAP) of UFERSA (Table 1).

The public-supply water used in the experiment to irrigate the seedlings came from the hydraulic network of the UFERSA campus. On the other hand, the domestic sewage effluent came from the Domestic Sewage Treatment Plant of the Projeto de Assentamento Milagre Apodi (RN), composed of 20 residences and approximately 90 people, producing a daily volume of 20 m^3 of domestic wastewater. To estimate the amount of nutrients supplied to the plants through the depths of domestic sewage (DE) and public-supply water (PSW), samples were collected for physical-chemical characterization (Table 2).

The seedlings were manually irrigated, twice a day, using a graduated cup to measure the amount of water applied, and the volume used was sufficient to maintain the maximum water capacity of the substrate in the pot, with a volume of 3 L. The maximum water capacity in the substrate inside the growing container was determined twice a week by means of tensiometry and water retention curve for each treatment. Irrigation was performed by gradually adding water to the substrate and collecting the drained water.

The evaluations of growth and development of *A. colubrina* seedlings were carried out at 30, 60, 90 and 120 days after transplantation (DAT), determining the following variables: a) Plant height (PH, cm) - obtained by the distance from the stem to the insertion of the last leaf in development, using a graduated ruler; b) Stem diameter (SD, mm) - measured at 2.0 cm from the collar, with a digital caliper; c) Root length (RL, mm) - obtained by measuring from the plant collar to the tip of the root, with a graduated ruler; d) Number of leaves - obtained by simply counting the fully expanded leaves; e) Plant fresh matter: determined by individual weighing of roots, stem and leaves of the plants (g $plant^{-1}$); f) Plant dry matter - determined by individual weighing of roots, stem and leaves of the plants after drying in an oven with forced air circulation at 70 °C until reaching constant mass (g $plant^{-1}$); g) Dickson Quality Index (DQI) - determined as a function of plant height (PH), stem diameter (SD), shoot dry matter (SDM) and root dry matter (RDM), according to Dickson, Leaf and Hosner (1960).

The data were subjected to analysis of variance by the F test at 5% significance level, and the means were compared by Tukey test at 5% significance level, using the statistical program Sisvar® (FERREIRA, 2011).

Table 1. Physical-chemical attributes of the growing substrates.

Substrates	pH	OM	EC	C/N	P	K^+	Na^+	N	B	Cu	Zn	Ca^{2+}	Mg^{2+}	Al^{2+}	SB	CEC	m
		g kg^{-1}	dSm^-		……………mg dm^{-3}……………										cmol$_c$ dm^{-3}		%
S_1	6.4	12.4	1.6	24:1	39	240	125	28.3	0.1	0.7	3.1	2.1	0.6	0.0	3.1	4.0	0.0
S_2	5.6	10.5	1.7	73:1	36	181	120	23.1	0.3	0.9	0.5	1.8	0.6	0.0	2.7	3.2	0.0

S_1 – soil + bovine manure; S_2 – soil + coconut fiber. EC - Electrical conductivity of soil saturation extract; N - nitrogen; OM - Organic matter; P - phosphorus; K^+ - Potassium; Cu - copper; Zn - Zinc; Ca^{2+} - Calcium; Mg^{2+} - Magnesium; Al^{3+} - Exchangeable aluminum; Al - Potential acidity; SB - Sum of bases; CEC - Cation exchange capacity; m – aluminum saturation.

Table 2. Physical-chemical characterization of treated domestic effluent (TDE) and public-supply water (PSW) obtained from artesian well.

Parameters	TDE	PSW
EC (dS m^{-1})	1.2	0.52
pH	7.3	7.4
SS (mg L^{-1})	44	0.0
DS (mg L^{-1})	350	50
Fe (mg L^{-1})	0.60	1.4
Mn (mg L^{-1})	0.20	1.1
Ca^{2+} (mg L^{-1})	32.06	12.02
Mg^{2+} (mg L^{-1})	17.01	12.15
Cu (mg L^{-1})	0.06	-
Zn (mg L^{-1})	0.09	-
COD (mg L^{-1})	60.00	-
BOD (mg L^{-1})	19.40	-
N total (mg L^{-1})	72.00	0.0
P total (mg L^{-1})	7.5	-
K^+ total (mg L^{-1})	47.7	11.5
Na^+ (mg L^{-1})	161.61	10.57
N-NO_3^- (mg L^{-1})	0.10	0.0
TC (mmolc L^{-1})	2.40	-
ThermoC (MPN 100 mL^{-1})	$8x10^4$	0.0

SS - Suspended Solids; DS - Dissolved Solids; COD - Chemical Oxygen Demand; BOD - Biochemical Oxygen Demand; TC – Total coliforms; ThermoC – Thermotolerant coliforms.

RESULTS AND DISCUSSION

According to the results presented in Table 3, for plant height, *A. colubrina* seedlings showed significant difference from each other when produced in different substrates (soil + manure; soil + coconut fiber) when irrigated with the five different concentrations of wastewater. However, when comparing the five concentrations considering the Soil + Manure substrate they showed no significant difference from each other, and the means ranged from 12.34 cm for the concentration of 25% PSW + 75% TDE to 7.0 cm for the concentration of 75% PSW + 25% TDE.

Table 3. Means of plant height and stem diameter of *A. colubrina*, as a function of different wastewaters and types of substrate at 120 days after transplanting.

Wastewaters	Plant height			Stem diameter		
	Substrates		Means	Substrates		Means
	Soil + Manure	Soil + fiber		Soil + Manure	Soil + fiber	
100% PSW + 0% TDE	7.58 Ab	13.76 Ba	10.67	1.80 ABa	1.55 Ca	1.68
75% PSW + 25% TDE	7.00 Ab	12.93 Ba	9.96	1.32 Bb	1.75 Ca	1.53
50% PSW + 50% TDE	7.80 Ab	26.83 Aa	17.31	1.47 ABb	3.10 Aa	2.29
25% PSW + 75% TDE	12.34 Ab	20.94 ABa	16.64	1.87 Ab	2.48 Ba	2.17
0% PSW + 100% TDE	8.95 Ab	17.81 Ba	13.38	1.57 ABa	1.90 Ca	1.73
Means	8.73	18.45	-	1.61	2.16	-
CV (%) $_{plots}$	38.85			17.12		
CV (%) $_{subplots}$	28.59			19.31		

Means followed by the same lowercase letter in the rows and uppercase letter in the columns do not differ from each other, at 5% significance level by Tukey test.

In the production of seedlings using the Soil + Coconut Fiber substrate, plant height showed significant differences when comparing the concentrations of irrigation water; the combinations 75% PSW + 25% TDE and 50% PSW + 50% TDE differ from the others statistically with values of 20.94 cm and 26.83 cm, respectively.

In a study evaluating growth parameters and dry matter accumulation of *Calophyllum brasiliense* seedlings, Artur et al. (2007) recorded a decrease in height when bovine manure was added to the substrate. Different results were obtained by Silva et al. (2013), who recorded growth of *Ormosia arborea* after the addition of bovine manure to the substrate. *A. colubrina* seedlings probably prefer more porous substrates that allow better aeration to the roots, which favors their development.

For stem diameter, the means differed for the two substrates and the different water concentrations, with minimum of 1.32 cm (25% of wastewater) obtained with manure and maximum of 3.10 cm (50% of wastewater) obtained with coconut fiber. According to Pereira et al. (2017), shoot height combined with stem diameter, as well as dry biomass, are indicators of quality of seedlings of forest species.

Brito et al. (2017), in a study conducted with domestic effluent application and substrates on *Tabebuia aurea* seedlings, concluded that the application of domestic sewage in seedlings promoted a positive response in stem diameter. In the study, the lowest means were observed for stem diameter with irrigation using 25% PSW and 75% TDE, while the lowest means were observed when the seedlings were irrigated with 100% PSW.

These results corroborate those found in the present study, where the highest means were obtained using 25% PSW + 75% TDE and 50% PSW + 50% TDE for the Soil + Manure and Soil + Coconut Fiber substrates, respectively. The waters with the lowest concentration of domestic effluent showed intermediate behavior for this characteristic, which can be attributed to high levels of N, P and K in the composition of the water with higher concentration of domestic effluent (Table 2).

In a study applying seven doses of treated domestic effluent in ‘sabiá’ (*Mimosa caesalpiniaefolia* Benth) seedlings and different substrates, Rebouças et al. (2018) concluded that, regardless of the fertilization management employed, the effluent proved to be an important source of nutrients, since it promoted increments in stem diameter and plant height, and these parameters are directly related to the seedling quality index. These findings corroborate those of the present study.

Table 4 shows the means of Dickson quality index and shoot dry matter of *A. colubrina* seedlings, as a function of different wastewaters and substrates.

Regarding the DQI, seedlings irrigated with water at the concentrations 50% PSW + 50% TDE and 25% PSW+75% TDE in the Soil + Coconut Fiber substrate were the ones with the highest means. This index is an indicator of seedling quality, as it considers the sturdiness and balance of biomass distribution through a balanced formula, including the relationships of morphological parameters, such as total dry biomass, shoot dry biomass, root dry biomass, shoot height and stem diameter.

Table 4. Means of Dickson quality index and shoot dry matter of *A. colubrina* seedlings, as a function of different wastewaters and types of substrate, at 120 days after transplanting.

Wastewaters	Dickson Quality Index			Shoot dry matter (g plant^{-1})		
	Substrates		Means	Substrates		Means
	Soil + Manure	Soil + fiber		Soil + Manure	Soil + fiber	
100% PSW	0.11 ABa	0.16 Ca	0.13	0.24 Ba	0.69 Ca	0.46
75% PSW + 25% TDE	0.07 Bb	0.20 BCa	0.14	0.21 Bb	1.03 BCa	0.62
50% PSW + 50% TDE	0.08 ABb	0.56 Aa	0.32	0.17 Bb	2.56 Aa	1.36
25% PSW + 75% TDE	0.20 Ab	0.29 Ba	0.25	1.07 Ab	1.75 ABa	1.41
100% TDE	0.10 ABb	0.25 BCa	0.17	0.35ABb	1.69 Ba	1.02
Means	0.11	0.29	-	0.41	1.54	-
CV (%) $_{plots}$	34.45			51.47		
CV (%) $_{subplots}$	38.92			48.73		

Means followed by the same lowercase letter in the rows and uppercase letter in the columns do not differ from each other, at 5% significance level, by Tukey test.

According to the criterion of Hunt (1990), DQI lower than 0.20 indicates that the seedlings do not have good final quality to be transplanted to the field, and the higher the DQI, the higher the quality of the seedling. Thus, the seedlings produced with Soil + Bovine Manure substrate and irrigated with 25% PSW + 75% TDE are on the threshold of DQI for good quality seedlings. Seedlings produced with coconut fiber had higher DQI, differing significantly from those produced with manure, except when irrigation was performed with public-supply water.

In relation to shoot dry matter, seedlings produced with Soil + Coconut Fiber substrate and irrigated with 50%

PSW+50% TDE differed from the others, with value of 2.56 g. This behavior indicates the preference of *A. colubrina* for the Soil + Coconut Fiber substrate when irrigated with public-supply water and with the same proportions of treated domestic sewage; this combination probably allowed better balance of nutrients for the seedlings.

Seedlings produced in the Soil + Bovine Manure substrate and irrigated with 25% PSW + 75% TDE had higher shoot dry matter production, differing significantly from the others. Biomass production is one of the best characteristics to evaluate the quality of seedlings, despite being destructive, because it reflects the net photosynthesis of the plant, that is, it is possible to analyze the growth in height and diameter obtained by the forest species during its permanence in the nursery and whether or not it is able to go to the field (ALVES; FREIRE, 2017).

Chemical factors such as pH, EC, C/N ratio and high salt concentration in irrigation water may be determinant for plant development, as well as the preference of the species for a given growing environment.

The means of plant height showed no difference as a function of the application of the different wastewaters in the initial growth stage (30 and 60 DAS), while in the growth stage at 90 days after planting the combination 50% PSW + 50% TDE was superior, with 21.73 cm, and also at 120 days after planting stood out among the others with the highest height, 24.35 cm, under 25% PSW + 75% TDE (Table 5).

Table 5. Means of plant height (PH), stem diameter (SD), root length (RL) and Dickson Quality Index (DQI) of *A. colubrina* plants, irrigated with wastewater levels according to the evaluation times.

	Plant height (cm)			
	Evaluation times (days)			
Wastewaters	30	60	90	120
100% PSW	7.75 A	13.33 A	15.18 AB	12.07 C
75% PSW + 25% TDE	8.90 A	9.83 A	8.13 B	13.00 BC
50% PSW + 50% TDE	11.08 A	17.45 A	21.73 A	19.00 AB
25% PSW + 75% TDE	6.08 A	15.50 A	20.63 A	24.35 A
100% TDE	8.48 A	13.98 A	16.95 A	14.13 BC
Wastewaters	Stem diameter (mm)			
100% PSW	1.03 B	2.13 A	2.31 AB	1.25 C
75% PSW + 25% TDE	1.43 AB	1.83 A	1.63 B	1.25 C
50% PSW + 50% TDE	2.08 A	2.30 A	2.62 A	2.15 AB
25% PSW + 75% TDE	1.50 AB	2.08 A	2.63 A	2.50 A
100% TDE	1.13 B	1.75 A	2.30 AB	1.75 BC
Wastewaters	Root length (cm)			
100% PSW	17.75 A	21.25 A	20.18 A	14.45 B
75% PSW + 25% TDE	17.40 A	21.58 A	11.43 A	18.38 B
50% PSW + 50% TDE	19.58 A	22.00 A	18.88 A	23.25 AB
25% PSW + 75% TDE	20.75 A	22.58 A	19.75 A	28.83 A
100% TDE	20.05 A	27.50 A	21.50 A	21.20 AB
Wastewaters	Dickson Quality Index			
100% PSW	0.04 A	0.18 A	0.27 B	0.05 B
75% PSW + 25% TDE	0.07 A	0.18 A	0.20 B	0.09 B
50% PSW + 50% TDE	0.17 A	0.27 A	0.44 A	0.42 A
25% PSW + 75% TDE	0.08 A	0.17 A	0.32 AB	0.41 A
100% TDE	0.06 A	0.16 A	0.28 AB	0.20 B

Means followed by the same uppercase letter in the columns do not differ from each other, at 5% significance level, by Tukey test.

The height considered as ideal for forest species to leave the nursery stage for field conditions is still a controversial and highly debated subject. Schorn and Formento (2003) recommend height between 15 and 20 cm as appropriate for the seedlings to leave the nursery and be ready for the definitive field. In this study, reduced height was observed in seedlings irrigated with 100% PSW at 120 days of cultivation (Table 5). However, some Cerrado species have shown difficulty to reach this height standard, even after one year in the nursery, as reported by Pilon and Durigan (2013).

Regarding stem diameter, when *A. colubrina* seedlings were evaluated at 30 DAP, there was a difference between the applied waters, and the highest mean was equal to 2.08 mm, under 50% PSW + 50% TDE. Stem diameter is an important characteristic, since the higher its value, the greater the vigor, sturdiness and resistance of the plant (GUIMARÃES et al., 2009). Similar results were observed by Bezerra et al. (2005), with the increase in sewage sludge doses, for the stem diameter of colored cotton (*Gossypium hirsutum* L. r. latifolium Hutch).

Regarding root length, there were no differences during all 90 DAP, and these results agree with Souza et al. (2012), who found no significant difference in root length for *A. colubrina*, 'sabiá', tamarind, 'jucá' and 'mulungú' when evaluating the production of seedlings of forest essences irrigated with public-supply water, reject brine and fish farming effluent. At 120 DAP, the seedlings irrigated with 25% PSW + 75% TDE showed higher mean and stood out from the others.

For the Dickson Quality Index, until 60 days, the waters led to the same behavior. At 90 days, seedlings irrigated with 50% PSW + 50% TDE had the highest means and the others had lower means. After 120 days, the waters 50% PSW + 50% TDE and 25% PSW + 75% TDE promoted the highest means, not differing from each other.

Significant correlations were found between DQI, plant height, stem diameter and days after emergence, indicating a satisfactory result because the evaluation of these variables is non-destructive, hence facilitating and enabling experimentation in forest nurseries. When studying the quality of *Trema micrantha* (L.) Blume seedlings, Fonseca et al. (2002) reported that DQI is highly correlated with all morphological parameters, corroborating the results in this study.

DQI is considered one of the most complete indices for assessing the quality of forest seedlings, as it includes in its calculation the relationships between the morphological parameters height, diameter, shoot dry matter weight and root dry matter weight, in addition to total biomass (ABREU et al., 2015).

According to José, Davide and Oliveira (2005), the higher the DQI, the higher the quality of the seedling, within that lot. DQI represents a good piece of information regarding the quality of seedlings, since it considers in its calculation the sturdiness and also the balance in biomass distribution in the seedlings (VIEIRA; WEBER, 2015).

For plant height, seedlings produced with the two types of substrate showed no differences when comparing the means at 30 days (Table 6). However, after this period the seedlings produced with Soil + Coconut Fiber obtained higher means than those produced with Soil + Bovine Manure.

Table 6. Means of plant height (PH), stem diameter (SD), root length (RL) and Dickson Quality Index (DQI) of *A. colubrina* plants, evaluated in different types of substrate in four evaluation times.

	Plant height (cm)			
	Evaluation times (days)			
Substrates	30	60	90	120
Soil + manure	6.75 A	9.68 B	9.29 B	9.21 B
Soil + fiber	10.16 A	18.35 A	23.75 A	21.55 A
Substrates	Stem diameter (mm)			
Soil + manure	1.23 B	1.86 A	1.93 B	1.40 B
Soil + fiber	1.63 A	2.17 A	2.66 A	2.16 A
Substrates	Root length (cm)			
Soil + manure	12.60 B	17.41 B	11.65 B	16.74 B
Soil + fiber	25.61 A	28.55 A	25.04 A	25.70 A
Substrates	Dickson Quality Index			
Soil + manure	0.05 A	0.16 A	0.12 B	0.11 B
Soil + fiber	0.11 A	0.22 A	0.48 A	0.36 A

Means followed by the same uppercase letter in the columns do not differ from each other, at 5% significance level, by Tukey test.

These results obtained in Table 6 are not in agreement with those reported by Kratka and Correia (2015), who evaluated the growth of *Myracrodruonur undeuva* Alemão in substrates prepared with sewage sludge, organic compost and bovine manure, and found that substrates with bovine manure showed excellent results. This is due to the supply of nutrients provided by this component for the seedlings, as well as the improvements of soil fertility and aeration, in addition to the water supply (CARVALHO et al., 2003).

In a study with production of *A. colubrina* seedlings using substrate of *Latossolo Distrófico* (Oxisol) at different base saturations, Bernardino et al. (2005) observed height ranging from 19.80 to 47.55 cm. The means obtained with Soil + Coconut Fiber were within this range.

The results of plant height in this experiment, regardless of the type of substrate, are consistent with those reported by Chaves, Carneiro and Barroso (2006), who evaluated the growth of *Anadenanthera macrocarpa* seedlings produced in fertilized substrate, consisting of agro-industrial residues, and found means ranging from 4.27 to 29.19 cm.

For stem diameter, there was no difference between the substrates only until 60 days. However, in the other evaluation periods, the substrate Soil + Coconut Fiber promoted stem diameter higher than that obtained with Soil + Bovine Manure. The diameter of native seedlings is of great importance because it dictates the survival of plants in the definitive field. According to Carneiro (1995), seedlings should have a larger stem diameter aiming at a better balance of shoot growth.

For root length, the substrate composed of Soil + Coconut Fiber led to results that were higher and different from those obtained with Soil + Bovine Manure during all evaluation phases. Substrate porosity is very important for root development, and the substrate with coconut fiber was the one that most favored root length.

In addition, these materials increase organic matter content and water storage capacity, resulting in greater availability to plants (SOUTO et al., 2005), as well as substrate aeration, promoting the dynamic balance of the water-soil-plant-atmosphere system (CUNHA et al., 2012).

For DQI, the two substrates did not show significant differences at 30 and 60 days. After this period, the seedlings produced with the Soil + Coconut Fiber substrate showed higher means at 90 and 120 days.

Considering the criterion of Hunt (1990), DQI lower than 0.20 indicates that the seedlings are not with good final quality to be transplanted to the field, and the higher the DQI, the higher the quality of the seedling. In this case, seedlings produced with Soil + Coconut Fiber substrate can be considered of good quality.

CONCLUSIONS

A. colubrina seedlings fertigated with nutrient solution containing 50% sewage effluent and 50% public-supply water showed better results when produced in substrate composed of soil and coconut fiber. The substrate composed of soil and coconut fiber promotes greater growth of *A. colubrina* seedlings. The seedlings showed good quality; however, plants that were cultivated with 50% and 75% of wastewater showed higher quality at 120 days of cultivation.

REFERENCES

ABREU, A. H. M. et al. Produção de mudas e crescimento inicial em campo de Enterolobium contortisiliquum produzidas em diferentes recipientes. **Revista Floresta**, 45: 141-150, 2015.

ALVES, F. J. B.; FREIRE, A. L. O. Crescimento inicial e qualidade de mudas de ipê-roxo (*Handroanthus impetiginosus*) produzidas em diferentes substratos. **Revista Agropecuária Científica no Semi-Árido**, 13: 195-202. 2017.

ARTUR, A. G. et al. Esterco bovino e calagem para formação de mudas de guanandi. **Pesquisa Agropecuária Brasileira**, 42: 843-850, 2007.

BERNARDINO, D. C. S. et al. Crescimento e qualidade de mudas de *Anadenanthera macrocarpa* (Benth.) brenan em resposta à saturação por bases do substrato. **Revista Árvore**, 29, 863-870, 2005.

BEZERRA, L. J. D. et al. Analise de crescimento do algodão colorido sob os efeitos da aplicação de água residuária e biossólidos. **Revista Brasileira de Engenharia Agrícola e Ambiental**, Sup.: 333-338, 2005.

BRITO. R. F. et al. Uso de Águas Residuárias na Produção de Mudas de Caraíba. In: INOVAGRI INTERNATIONAL MEETING, 4., 2017, Fortaleza. **Anais...** Fortaleza: INOVAGRI, 2017. p. 1-16.

CARNEIRO, J. G. A. **Produção e controle de qualidade de mudas florestais**. Curitiba, PR: UFPR/FUPEF, 1995. 451 p.

CARVALHO, J. L. S. F. et al. de mudas de jatobá (*Hymenaeacourbaril L.*) em diferentes ambientes, recipientes e composições de substratos. **Cerne**, 9: 109-118. 2003.

CHAVES, L.; CARNEIRO, J. G. A.; BARROSO, D. G. Crescimento de mudas de *Anadenanthera macrocarpa* (Benth) Brenan (angico-vermelho) em substrato fertilizado e inoculado com rizóbio. **Revista Árvores**, 30: 911-919, 2006.

CUNHA, E. Q. et al. Atributos físicos, químicos e biológicos de solo sob produção orgânica impactados por sistemas de cultivo. **Revista Brasileira de Engenharia Agrícola e Ambiental**, 16: 56-63, 2012.

DICKSON, A.; LEAF, A. L.; HOSNER, J. F. Quality appraisal of while spruce and white pine seedling stock in nurseries. **Forestry Chronicle**, 36: 11-13, 1960.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, 35:1039-1042, 2011.

FONSECA, E. P. et al. Padrão de qualidade de mudas de *Trema micrantha* (L.) Blume, produzidas sob diferentes períodos de sombreamento. **Revista Árvore**, 26: 515-523, 2002.

GASPAR, G.; BEZERRA, F. M., MOTA, F. S. Citronella (*cymbopogon winterianus*) development irrigated with treated domestic wastewater and supply water. **Brazilian Journal of Environmental Sciences**, 55: 145-157, 2020.

GUIMARÃES, A. S. et al. Fontes e doses crescentes de adubos orgânicos e mineral no crescimento inicial de pinhão manso. **Mens Agitat**, 4: 17-22, 2009.

HUNT, G. A. Effect of styroblock design and cooper treatment on morphology of conifer seedlings: In: COMBINED MEETING OF THE WESTERN FOREST NURSERY ASSOCIATIONS, 1990, Roseburg. **Proceedings...** Fort Collins: United States Department of

Agriculture, 1990. p. 218-222.

JOSÉ, A. C; DAVIDE, A. C.; OLIVEIRA, S. L. Produção de mudas de aroeira (*Schinus terebynthifolius*) para recuperação de áreas degradadas pela mineração de bauxita. **Cerne**, 11: 187-196, 2005.

KRATKA, P. C.; CORREIA, C. R. M. A. Crescimento inicial de aroeira do sertão (Myracrodruon urundeuva Allemão) em diferentes substratos. **Revista Árvore**, 39: 551-559, 2015.

LORENZI, H. **Árvores Brasileiras: Manual de identificação e cultivo de plantas arbóreas nativas do Brasil**. 2. ed. Nova Odessa, SP: Plantarum, 1998. 384 p.

OLIVEIRA, E. L. **Manual de utilização de águas residuárias em irrigação**. 1. ed. Botucatu, SP: FEPAF, 2012. 192 p.

PEREIRA, M. O. et al. Qualidade de sementes e mudas de *Cedrela fissilis* Vell. em função da biometria de frutos e sementes em diferentes procedências. **Revista de Ciências Agroveterinárias**, 16: 376-385, 2017.

PILON, N. L.; DURIGAN, G. Critérios para indicação de espécies prioritárias para restauração da vegetação de cerrado. **Scientia Forestalis**, 41: 389-399, 2013.

REBOUÇAS, J. R. L. et al. Qualidade de mudas de sabiá irrigadas com efluente doméstico. **Floresta**, 48: 173-182, 2018.

SCHORN, L. A.; FORMENTO, S. **Silvicultura II: Produção de mudas florestas**. 1. ed. Blumenau, SC: Universidade Regional de Blumenau, 2003. 58 p.

SILVA, A. L. et al. Influência de diferentes substratos no crescimento inicial de *Ormosia arborea* (Vell.) Harms (Fabaceae). **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, 8: 22-27, 2013.

SOUZA, P. B. et al. Floristic and diversity of tree species and shrub under a stand of *Anadenanthera peregrina* (L.) Speg. **Cerne**, 18: 413-421, 2012.

SOUTO, P. C. et al. Decomposição de estercos dispostos em diferentes profundidades em área degradada no semi-árido da paraíba. **Revista Brasileira de Ciência do Solo**, 29: 125-130, 2005.

TORRES, D. M. et al. Tratamento de efluentes e produção de água de reúso para fins agrícolas. **Holos**, 8: 1-15, 2019.

VIEIRA, C. R.; WEBER, O. L. S. Avaliação de substratos na produção de mudas de mogno (*Swietenia macrophylla* King). **Revista Uniara**, 8: 153-166, 2015.