

Wastewater from Fish Farms for Producing *Eucalyptus grandis* Seedlings

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ABSTRACT

This work aimed to evaluate the development and quality of *Eucalyptus grandis* seedlings produced with different dosages of wastewater from fish farming. The experiment was arranged in a completely randomized design with five treatments and four replicates. The treatments were fish wastewater (FW); daily nutritional solution (DNS), combinations of 50% DNS + 50% FW; 25% DNS + 75% FW and solution with weekly application (WNS). The best growth and development results of the eucalyptus seedlings were observed for the solutions applied daily and weekly. The 50% DNS + 50% FW combination did not differ from daily and weekly nutritional solutions for Dickson's quality index. Fertigation only with wastewater from fish farming resulted in lower growth and development of the seedlings, but the use of the combination of 50% FW + 50% DNS enabled the production of seedlings of similar quality to those fertigated with nutritional solutions.

Keywords: eucalyptus, forest nutrition, water reuse.

1. INTRODUCTION

Due to the growing concern with conservation and environmental sustainability, the usage of effluents in other activities has become an important option. Among effluents, we can mention the intensification of fish production which generates wastewater. When inappropriately designed, fish farming/production can lead to an increase in environmental impact in terms of waste production and water use (Mariscal-Lagarda et al., 2012). Faced with this environmental problem, studies on the reutilization of wastewater in agricultural activities, such as in the production of seedlings in commercial nurseries, represents a possibility of a source of nutrients and sustainable production.

The *Eucalyptus* genus is the most used in forest plantations in Brazil due to its high productivity and flexibility for soil and climate conditions (Gonçalves et al., 2008), being an important raw material for the paper, cellulose, charcoal and timber industry sectors. Due to this demand scenario of the timber sector, the production of quality seedlings is an important factor to increase the survival rate and initial growth (Gomes et al., 2002). The quality of seedlings can mainly be affected by the genetic components, substrates and water, and nutritional management (Silva et al., 2012).

Nutritional factors can be supplied with adequate fertilization, thus being an indispensable factor for producing quality seedlings (Assenheimer, 2009). However, for Silveira et al. (2003) there is a lack of information regarding the dose and the adequate nutrient ratio to be applied in fertilization at different stages of *Eucalyptus* seedling development. Most forest nurseries standardize the application of independent fertilizers for the different development stages of the seedlings. Thus, it is necessary to study doses, stages and application forms, as well as alternative sources of nutrients for use in the production of forest seedlings.

The issue of the environmental impact of nutrient-rich water discharges into rivers or the need to treat them and the high concentration of nutrients in fish-breeding water has led to new studies with effluents, which may reduce the normal concentration of nutrients applied to the substrate in producing seedlings in nurseries. Some studies indicate the possibility of using wastewater from fish farming in lettuce cultivation (*Lactuca sativa*)

(Cortez et al., 2009) or in the production of tomato seedlings (*Solanum lycopersicum*) (Rodrigues et al., 2010). However, there is a shortage of studies that seek to associate fish farming and forest seedling production.

Adequate nutritional management enabled the growth of horse whip (*açoita-cavalo*) (*Luehea divaricata* Mart.) seedlings in height, diameter and accumulation of biomass (Ceconi et al., 2006). In this context, several works have been developed seeking to improve quality and reduce production costs of seedlings (Simões & Silva, 2010), considering that the use of wastewater from fish farming in seedling production can reduce costs and minimize the negative impacts caused by their disposal.

The objective of this work was to evaluate the development and quality of *Eucalyptus grandis* W. Hill ex Maiden seedlings produced with different doses of wastewater from fish farming. Therefore, the hypotheses formed were: i) the wastewater benefits the growth and development of *E. grandis* seedlings; ii) the wastewater meets the nutritional demand of eucalyptus seedlings; iii) the wastewater can be an alternative for reuse in eucalyptus seedling production. It is hoped to determine new techniques of seedling production using tilapia wastewater as a source of nutrients, which reduces the environmental impact of the effluent from this production system.

2. MATERIALS AND METHODS

The experiment was carried out in the experimental area of the Universidade Tecnológica Federal do Paraná, Dois Vizinhos Campus in the Olericultura Sector (25°42'52"S and 53°03'94"W, altitude 530 m), in a protected environment of a high tunnel greenhouse, covered with 150 microns of plastic film. The experiment was conducted from January to May 2016.

First, 125 cm³ polypropylene tubes filled with Carolina Soil[®] commercial substrate were used, with the major components being decomposed pinus shell and expanded vermiculite. For sowing, in 2015, ten commercial grade with F1 improvement grade (LCFA004) cultivar seeds per *Eucalyptus grandis* W. Hill Ex Maiden tube were obtained from the Instituto de Pesquisas e Estudos Florestais (IPEF) of the clonal orchard seeds (PCS) in Piracicaba, São Paulo. Thinning was performed at 30 DAS, leaving only one plant per tube.

The fish species used was tilapia (*Oreochromis niloticus*). The fish were kept in a nursery dug with a capacity of 1,000 liters of water, which is renewed daily at a percentage of 50% of the volume, with a 1CV motor pump. In order to keep oxygen levels in the nursery water, submersible pumps were used to mix the water every 15 minutes. Oxygen concentration was monitored with a portable oximeter twice weekly at three points in the tank. The mean oxygen value were 26.6 mg L⁻¹.

The initial and final fish masses were 2.9 and 7.9 kg, respectively. The fish mass was quantified every 30 days and the amount of feed adjusted, considering a 3% supply of the live fish mass divided into two daily rations of commercial Anhambi®.

The experiment was arranged in a completely randomized design with five treatments and four replicates. Each experimental unit was composed of 96 seedlings. The treatments were fish wastewater (FW); daily nutrient solution (DNS) composed of the amount of 0.45 g L⁻¹ of calcium nitrate; 0.30 g L⁻¹ of ammonium nitrate; 0.25 g L⁻¹ of monoammonium phosphate; 0.30 g L⁻¹ of potassium nitrate; 0.25 g L⁻¹ of magnesium sulfate; 0.25 g L⁻¹ of ammonium sulfate; 0.50 g L⁻¹ of boric acid; combinations of 50% DNS + 50% FW; 25% DNS + 75% FW; and weekly nutrient solution (WNS), described by Gonçalves (2005) and constituting the base application (to fill the tubes): 715 g of ammonium sulphate and 577 g of monopotassium phosphate to 20,000 50 cm³ tubes and fertilization with 1,000 g of ammonium sulphate + 300 g of potassium chloride per 100 liters of water, used to fertigate 10,000 tubes weekly, intercalating the ammonium sulphate and potassium chloride applications. The dosages were all corrected for the number and volume of treatment tubes applied.

The treatment applications started at 45 DAS, using a watering can with daily frequency, and maintaining an irrigation volume of 1 mm day⁻¹. The rest of the water demand was treated using a sprinkler irrigation system, maintaining a total liquid volume of 6 mm dia⁻¹. For the treatment with weekly application, pure water was used in order to maintain the liquid irrigation volume.

The analyzed variables were shoot height, stem diameter, green mass, and shoot and root dry mass at 60, 75, 90, 105 and 120 days after sowing. Plant height was determined with a millimeter ruler from the stem base to the apex of the plant. The diameter measurement

was performed using a digital caliper at the stem height. A precision scale (0.0001 g) was used to determine the green and dry mass. The roots were washed in water to separate the substrate and the material (both roots and shoot) was placed in a forced air circulation oven at 55 °C ±3 until constant mass was reached. Ten plants per experimental unit were used to determine the variables described above.

Leaf area, length of the largest root and the Dickson quality index (DQI) were also evaluated at the end of the experiments (120 DAS). The length of the largest root was obtained with a millimetered ruler, measuring from the stem apex to the end of the longest root. The leaf area was determined with foliar area meter (CID Bio-Science, model CI-202, with photometric cell). The Dickson Quality Index was calculated based on the equation, $DQI = TDM / (HDR + SRDMR)$, where total dry mass (TDM), height-to-diameter ratio (HDR) and the shoot to root dry mass ratio (SRDMR) (Dickson et al., 1960).

The macronutrient and micronutrient content in the leaf tissue was determined, and only completely expanded leaves of the middle third of the plant were collected at 120 DAS, according to the methodology described by Malavolta et al. (1997). The meteorological data (temperature and relative air humidity) were obtained from dataloggers installed inside the high tunnel. The luminosity values were collected with a luximeter every 30 days during three consecutive days and at three times (9 a.m., 12 p.m. and 3 p.m.).

The obtained data were submitted to analysis of variance (F-Test) and the means were compared by the Scott Knott test ($p \leq 0.05$) using the GENES software program.

3. RESULTS AND DISCUSSION

The average temperature during the experiment was 23.6 °C, and the average relative humidity was 74.9%. The temperature during the experiment was found to be within the appropriate ranges for cultivation, whereas the lower basal temperature is 10 °C (Martins et al., 2007) and the upper basal temperature is 36 °C (Dye et al., 2004). The average luminosity was 32,500 lux.

There were significant differences between the evaluated treatments regarding height (Table 1). Higher

growth of the seedlings was observed when fertigated with daily and weekly nutritional solutions with a height increase of 27.7 cm and 29 cm, respectively, at 120 DAS. Fertigation using the 50% FW + 50% DNS combination was the second best treatment with a height of 27.6 cm. The minimum height parameter of transplants to the field is 15 cm (Wendling & Dutra, 2010), and all treatments – except the fish wastewater one – met the conditions of adequate height for transplant. Height is an important parameter in the classification and selection of seedlings, as larger seedlings have a greater chance of survival and development in the field (Reis et al., 2008).

The superior height condition of the best treatments at 120 DAS enables evaluating the reduction in the seedling production period, taking into consideration a minimum height of 15 cm (Wendling & Dutra, 2010) as an indicator for the moment of transplant, so the seedlings of the best treatments could be transplanted at 105 DAS, reducing the nursery time by 15 days. This information can reduce the cost per seedlings produced, or even increase the rotation of seedlings in the nursery, resulting in a higher seedling production capacity.

In the same way as for height, the highest diameter values were obtained with the use of DNS (2.46 mm) differing from the WNS (2.30 mm) and the combination of 50% FW + 50% DNS (2.31 mm), which did not differ from the others (Table 1). The treatment with smaller diameter was with wastewater. Adequate diameter values were greater than 2 mm, which indicate adequate seedling formation (Wendling & Dutra, 2010). Only the wastewater treatment (0.91 mm) did not produce seedlings with adequate diameter, evidencing the need for complementation with other nutrient sources.

The length of the largest root at 120 DAS was observed in the 75% FW + 25% DNS (20.9 cm) treatment (Table 2). Regarding leaf area, the highest values were found with the use of WNS (159.4 cm²) and DNS (165.3 cm²), differing from the 50% FW + 50% DNS treatment (123.4 cm²). Leaf area has an important role in vegetal production, enabling greater photoassimilate production. However, when the seedling is transplanted, a larger leaf area can favor water loss by transpiration.

The increase in the leaf area of the plants irrigated with WNS and DNS may be related to the contribution

Table 1. Height and diameter of eucalyptus (*Eucalyptus grandis*) seedlings in response to the application of different fertigations with fish production wastewater evaluated at 60, 75, 90, 105 and 120 days after sowing. Dois Vizinhos, UTFPR, 2016.

Treatments	Height (cm)				
	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
WNS	4.2 a*	6.0 a	12.0 a	26.1 a	31.9 a
DNS	3.1 b	5.1 b	11.0 b	22.6 b	32.1 a
50% FW + 50% WNS	3.4 b	5.7 a	9.8 c	21.6 b	27.6 b
75% FW + 25% WNS	2.7 b	4.5 c	7.8 d	16.4 c	22.4 c
FW	2.6 b	4.4 c	4.7 e	5.1 d	7.0 d
Mean	3.2	5.1	9.1	18.3	24.2
CV (%)	18.9	5.4	2.2	7.2	6.7
Treatments	Diameter (mm)				
	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
WNS	0.48 a*	0.79 a	1.15 a	1.87 a	2.30 b
DNS	0.47 a	0.79 a	1.20 a	1.74 a	2.46 a
50% FW + 50% WNS	0.48 a	0.80 a	1.07 b	1.79 a	2.31 b
75% FW + 25% WNS	0.40 b	0.69 b	0.91 c	1.48 b	2.03 c
FW	0.40 b	0.66 b	0.72 d	0.76 c	0.91 d
Mean	0.45	0.74	1.00	1.51	2.00
CV (%)	4.0	4.1	4.5	6.3	4.9

WNS: weekly nutrient solution; DNS: daily nutrient solution; FW: fish wastewater; CV: coefficient of variance; *means followed by distinct letters in the column differ by the Scott Knott test at 5% probability.

of potassium, nitrogen and phosphorus from fertilizer nutrient sources, which are highly required in the initial stages of *Eucalyptus* seedling development (Pinto et al., 2011), which resulted in greater cell elongation and, consequently, greater leaf expansion.

With regard to the DQI, the DNS (0.122), WNS (0.113) and the combination of 50% FW + 50% DNS (0.121) did not differ (Table 2). Although it was observed that the combination of 50% FW + 50% WNS did not present the best results for height, diameter or shoot and root dry mass, it did enable forming a balanced seedling in height and biomass accumulation. Gomes & Paiva (2004) suggest that the minimum DQI value should be greater than 0.20. Thus, none of the treatments reached this value.

It was observed that the treatments with greater accumulation of fresh and dry shoot mass were for WNS (4.7 g plant⁻¹) and DNS (4.5 g plant⁻¹) (Table 3). The treatment with less biomass accumulation was the wastewater. This condition can be associated with the low nitrogen availability provided by the solution and quantified by leaf tissue analysis (Table 5), where the concentrations were below adequate for eucalyptus.

It can also be affirmed that plants with higher leaf area values provide higher photosynthetic rates and consequently higher dry matter accumulation (Rocha et al., 2014). It was observed that treatments with greater leaf area resulted in greater biomass accumulation. According to Carmo et al. (2016), shoot dry mass is related to the development of the stem and amount of leaves. This growth parameter is very important, since the leaves are responsible for the accomplishment of photosynthesis.

In works by Rocha et al. (2014), the authors evaluated the growth and leaf nutrition of *Eucalyptus sp.* submitted to wastewater from fish farming, public supply and sewage effluent, in which it was reported that the sewage effluent presented greater seedling growth in size and vigor. The authors attributed the gain in growth to the higher nutrient content, mainly nitrogen, present in the sewage effluent in relation to the other types of water. Cerqueira et al. (2017) evaluated the use of effluent from a clonal mini garden as fertilization for clonal eucalyptus seedlings, verifying that the use of this effluent in fertilizing eucalyptus seedlings presented promising results, while it also resulted in seedlings with a higher quality standard which enabled the reuse of the effluent generated in the clonal mini garden.

Significant differences between treatments were found for fresh root mass at 120 DAS, where the best results (2.45 g plant⁻¹) were found in the 50% FW + 50% DNS solution (Table 4). It can be observed that the fertilization with 50% FW + 50% DNS favored development of vigorous roots without folding.

According to Kozłowski et al. (1991), the initial growth of the plants in the field depends on photosynthates stored by the seedlings. The largest accumulation of photosynthesis occurs in the seedling shoot. In contrast, when some nutrients such as nitrogen and phosphorus limit plant growth, the roots become a strong drain of carbohydrates, thus causing greater limitation to shoot growth than root growth (Araújo & Machado, 2006). It was verified that the nitrogen and phosphorus contents in the evaluated treatments did not limit the growth of the eucalyptus seedlings.

Table 2. The highest root length (H.R.L.), leaf area (L.A.) and Dickson Quality Index (D.Q.I.) of *Eucalyptus grandis* seedlings were evaluated in response to the application of different treatments with wastewater from fish farms evaluated at 60, 75, 90, 105 and 120 days after sowing. Dois Vizinhos, UTFPR, 2016.

Treatments	H.R.L. (cm)	L.A. (cm ²)	D.Q.I.
WNS	17.8 c*	165.3 a	0.113 a
DNS	18.5 c	159.4 a	0.122 a
50% FW + 50% WNS	19.9 b	123.4 b	0.121 a
75% FW + 25% WNS	20.9 a	84.0 c	0.097 b
FW	17.5 c	12.5 d	0.056 c
Mean	18.9	108.9	0.10
CV (%)	3.5	10.8	9.9

WNS: weekly nutrient solution; DNS: daily nutrient solution; FW: fish wastewater; CV: coefficient of variance; *means followed by distinct letters in the column differ by the Scott Knott test at 5% probability.

Table 3. Shoot fresh mass (S.F.M.) and shoot dry mass (S.D.M.) of *Eucalyptus grandis* seedlings in response to the application of different treatments with wastewater from fish farming evaluated at 60, 75, 90, 105 and 120 days after sowing. Dois Vizinhos, UTFPR, 2016.

Treatments	S.F.M. (g planta ⁻¹)				
	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
WNS	0.14 c*	0.29 ^{ns}	1.39 a	4.1 a	4.7 a
DNS	0.17 b	0.29	1.34 a	3.36 b	4.5 a
50% FW + 50% WNS	0.20 a	0.32	1.24 a	3.35 b	4.0 b
75% FW + 25% WNS	0.13 c	0.21	0.84 b	2.12 c	2.6 c
FW	0.11 c	0.21	0.39 c	0.39 d	0.5 d
Mean	0.15	0.27	1.04	2.66	3.3
CV (%)	12.9	24.5	11.6	7.5	9.6

Treatments	S.D.M. (g planta ⁻¹)				
	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
WNS	0.03 b*	0.06 ^{ns}	0.31 a	0.91 a	1.66 a
DNS	0.04 a	0.07	0.30 a	0.74 b	1.63 a
50% FW + 50% WNS	0.05 a	0.08	0.25 b	0.68 b	1.29 b
75% FW + 25% WNS	0.03 b	0.05	0.18 c	0.48 c	0.89 c
FW	0.04 a	0.07	0.07 d	0.08 d	0.28 d
Mean	0.03	0.07	0.22	0.58	1.15
CV (%)	20.0	22.0	9.0	15.2	6.9

WNS: weekly nutrient solution; DNS: daily nutrient solution; FW: fish wastewater; ns: no significant; CV: coefficient of variance; * means followed by distinct letters in the column differ by the Scott Knott test at 5% probability.

With regards to root dry mass at 120 DAS, it was observed that the treatment with the highest mass was the combination of 50% FW + 50% DNS (0.480 g plant⁻¹) (Table 4). The lower accumulation of root dry biomass was due to using the wastewater from fish farming, possibly because of lower availability of nutrients, especially nitrogen (Table 5). According to a study conducted by Salvador et al. (2012) with different concentrations of starch wastewater in the production of eucalyptus seedlings (*E. grandis*), the authors verified that in the root dry mass production they highlighted concentrations of 25 and 12.5% of the starch wastewater in addition to using the commercial fertilizer (Yogen5®); as concentrations above these provided the worst conditions for root dry mass production, possibly because this residue did not meet the nutritional demand of the seedlings. The authors also report that the chemical composition of starch wastewater supports the potential of the compound as biofertilizer, as a function of the presence of potassium, nitrogen, magnesium, phosphorus, calcium, sulfur, iron and other micronutrients.

For the macronutrients, nitrogen was the mineral element extracted in greater quantity by eucalyptus seedlings, followed by potassium, calcium, magnesium, phosphorus and sulfur (Table 5). Micronutrients in descending order of extraction were iron, manganese, boron, zinc, copper and sulfur. The nutrient content bands in the dry matter of eucalyptus leaves considered adequate in g kg⁻¹ for N, P, K, Ca, Mg and S, respectively, are: 13.5-18; 0.9-1.3; 9-13; 6-10; 3.5-5 and 1.5-2; for Mn, Zn, B, Cu and Fe in mg kg⁻¹ are: 400-600, 35-50, 30-50, 7-10 and 150-200 (Gonçalves, 2005).

Considering the adequate ranges previously described, the macronutrient contents found in the leaf tissue for the studied solutions presented values below the recommended values in T2 and T5 for N; T1 and T3 for Ca; T2; T3; T4 and T5 for S (Table 5). All treatments were within the appropriate range for K, with higher K content in WNS treatment. In addition, all treatments presented values above the recommended range for P and Mg. Regarding the micronutrients, Mn and Zn were below the recommended levels in all treatments. They also presented concentration below recommended

Table 4. Fresh root mass (F.R.M.) and dry root mass (D.R.M.) of *Eucalyptus grandis* seedlings in response to the application of different treatments with fish farming wastewater evaluated at 60, 75, 90, 105 and 120 days after sowing. Dois Vizinhos, UTFPR, 2016.

Treatments	F.R.M. (g planta ⁻¹)				
	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
WNS	0.02 c*	0.05 b	0.41 c	1.13 c	1.66 c
DNS	0.05 b	0.08 b	0.59 b	1.51 b	1.74 c
50% FW + 50% WNS	0.09 a	0.16 a	0.79 a	1.91 a	2.45 a
75% FW + 25% WNS	0.07 a	0.12 a	0.44 c	1.81 a	2.12 b
FW	0.06 b	0.10 b	0.22 d	0.38 d	0.50 d
Mean	0.06	0.10	0.49	1.34	1.69
CV (%)	32.0	30.6	25.0	15.6	10.5

Treatments	D.R.M. (g planta ⁻¹)				
	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS
WNS	0.004 b	0.007 b	0.049 a	0.14 a	0.39 b
DNS	0.005 b	0.008 b	0.050 a	0.13 a	0.43 b
50% FW + 50% WNS	0.004 b	0.007 b	0.053 a	0.13 a	0.48 a
75% FW + 25% WNS	0.003 b	0.005 b	0.030 b	0.12 a	0.40 b
FW	0.012 a	0.019 a	0.022 b	0.04 b	0.22 c
Mean	0.005	0.009	0.04	0.11	0.38
CV (%)	30.3	34.4	24.5	35.5	10.16

WNS: weekly nutrient solution; DNS: daily nutrient solution; FW: fish wastewater; CV: coefficient of variance; *means followed by distinct letters in the column differ by the Scott Knott test at 5% probability.

in T1 and T2 treatment for Cu. Lastly, elements B and Fe were within or above the appropriate range.

It can be observed that the wastewater concentration had adequate nutrient contents for seedling growth, except for N, Mn and Z, and that the use of this waste can represent an important possibility in the intensive production of fish associated to seedling production in nurseries as a way of using waste (fish excrement and

food leftovers), aiming to make the seedling production more sustainable and integrating the production of two activities, which results in greater diversity of products or non-exploited resources.

Similar results were observed by Nogueira Filho et al. (2003) when they investigated the development of lettuce grown in a NFT hydroponic system with fish pond water in a superintensive closed system with tilapia,

Table 5. Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn) levels of eucalyptus leaves as a function of different treatments with wastewater from fish farming. Dois Vizinhos, UTFPR, 2016.

Treat.	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	g kg ⁻¹						mg kg ⁻¹				
T1	20.56 a*	1.35 b	12.83 a	5.21 b	3.93 b	2.30 a	30.06 d	4.61 b	195.0 c	202.13 c	21.68 b
T2	12.71 c	1.32 b	9.62 c	8.56 a	6.46 a	1.07 c	48.47 e	5.57 b	535.0 b	322.02 a	34.28 a
T3	17.90 b	1.96 a	10.36 c	5.52 b	4.01 b	1.36 b	141.02 a	7.44 b	210.4 c	122.51 e	17.75 c
T4	16.49 b	1.74 a	11.37 b	8.68 a	5.65 a	1.22 b	91.96 b	9.51 a	1319.0 a	167.88 d	22.82 b
T5	13.05 c	1.65 b	11.40 b	8.06 a	5.72 a	1.04 c	76.41 a	13.34 a	1485.5 a	229.95 b	23.08 b
Mean	16.14	1.60	10.91	7.21	5.16	1.40	76.54	8.09	849.14	208.90	23.92
C.V. (%)	3.86	9.21	3.32	3.17	5.58	4.32	1.16	23.21	25.66	2.58	2.20

T1: weekly nutrient solution; T2: daily nutrient solution; T3: 50% FW + 50% WNS; T4: 75% FW + 25% WNS; T5: fish wastewater; CV: coefficient of variance; *means followed by distinct letters in the column differ by the Scott Knott test at 5% probability.

and found that plants cultivated with wastewater only resulted in lower fresh mass production and nutrient concentration in the leaves, except for Ca, Mg, B and Fe, while cultivars with wastewater + 25% of Castellane & Araújo (1994) nutrient solution presented a fresh mass equivalent to 100% of the Castellane & Araújo (1994) nutrient solution.

In evaluations of the chemical characteristics of wastewater from an intensive fish farming system aiming at its possible use in the cultivation of three lettuce cultivars in hydroponics, Cortez et al. (2009) verified that the *matrinxã* breeding system was not able to generate (using fish excrements and food leftovers) dissolved residues with adequate potassium and magnesium levels for hydroponic lettuce cultivation, making mineral supplementation opportune in order to enable good development of the plants.

4. CONCLUSIONS

The best growth and development results of *Eucalyptus grandis* seedlings were found in the treatments which used chemical fertilization.

The use of the combination 50% FW + 50% DNS presented significant results in terms of eucalyptus seedling quality, similar to those fertigated with nutrient solution only. Fertigation with only wastewater from fish farming resulted in lower growth and development of seedlings.

Fish wastewater can be used in combination with nutrient solutions, which may represent an alternative to reuse in the production of *Eucalyptus grandis* seedlings, reducing the environmental impact of effluent from this type of animal production.

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