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INITIAL GROWTH OF *Citharexyllum myrianthum* plants UNDER PLANTING FERTILIZATION

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Resumo

Crescimento inicial de Citharexyllum myrianthum sob adubações de plantio. Objetivou-se avaliar o crescimento inicial de *Citharexyllum myrianthum* sob a influência de três fontes de adubos de plantio, em condições de vasos de 18 L. Os tratamentos utilizados foram: testemunha absoluta; 5 L de biossólido/vaso; 300 g de fosfato natural de rocha (FNR) e 200 gramas de NPK 06-29-06. As mudas foram cultivadas nos vasos a pleno sol, complementados com Latossolo Vermelho Amarelo distrófico. Aos 150 dias após transplantio, as plantas foram mensuradas, obtendo-se a altura da parte aérea e o diâmetro do coleto. Em seguida foi calculado o incremento dessas duas variáveis. Posteriormente, as folhas foram retiradas para determinação da área foliar (AF), separando-se a parte aérea do sistema radicular, sendo acondicionados em saco de papel e colocados em estufa a 65ºC, para secagem até atingir peso constante. Após pesagem deste material para obtenção da massa seca da parte aérea (MSPA) e radicular (MSR), as folhas foram moídas para a determinação dos teores foliares de N, P, K, Ca e Mg. Para avaliar o efeito dos tratamentos sobre o solo, retirou-se amostras dos vasos para a determinação dos teores de macronutrientes, matéria orgânica e CTC(t). Foi constatado que a AF e MSPA das plantas adubadas com NPK apresentaram valores significativamente superiores quando comparado as plantas cultivadas no tratamento testemunha. Indica-se adubar as plantas de *Citharexyllum myrianthum* com 200 gramas de N-P-K 06-29-06/cova ou com 5 L de biossolido/cova.
Palavras-chave: biossólido, espécie nativa, fertilização mineral, solubilidade de adubos, teor de nutrientes.

Abstract

The objective of this work was to evaluate the initial growth of *Citharexyllum myrianthum* under the influence of three sources of planting fertilizers, in conditions of 18 L pots. The treatments used were, as follows: absolute control; 5 L of biosolid/pot; 300 g of natural rock phosphate (NRP), and 200 grams of NPK 06-29-06. The seedlings were grown in pots in full sun, supplemented with Dystrophic Red Yellow Latosol. At 150 days after transplanting, the plants were measured, obtaining the height of the aerial part and the diameter of the stem. Then, the increment of these two variables was calculated. Subsequently, the leaves were removed to determine the leaf area (LA), separating the aerial part from the root system, and then packed in a paper bag and placed in an oven at 65ºC, for drying until reaching constant weight. After weighing this material to obtain the dry matter of the aerial part (APDM) and root (RDM). The leaves were ground to determine the foliar contents of N, P, K, Ca, and Mg. To evaluate the effect of treatments on the soil, samples were taken from the pots to determine the levels of macronutrients, organic matter, and CEC(t). It was found that the LA and APDM of plants fertilized with NPK showed significantly higher values when compared to plants cultivated in the control treatment. It is recommended to fertilize *Citharexyllum myrianthum* plants with 200 grams of N-P-K 06-29-06/hole or with 5 L of biosolid.
Keywords: biosolid, fertilizer solubility; mineral fertilization, native species, nutrient content.

INTRODUCTION

The Atlantic Forest is one of the most altered biomes in Brazil, particularly because of its historical and continuous exploitation, for agricultural and livestock activities and also because of the growth of the urban centers. Given this scenario, human intervention is necessary, with the adoption of practices aimed at re-establishing the functions of this system. Seeking to increase the forest coverage of this biome, efforts have been made to form forest stands, usually by planting seedlings of native tree species (BRANCALION *et al*., 2015).

One important factor in the formation of forest stands is fertilization at planting, as in general, forest implantations have occurred mainly in poor-fertility soils (SORREANO *et al*., 2012), as the areas with the best fertility are generally used for agricultural activities. One way to promote the growth of tree species is through the application of fertilizers. For fast-growing species, such as those of the *Eucalyptus genus*, medium and high solubility phosphate fertilizers are generally used as planting fertilizers, for example, conventional formulations with N-P-K.

For native tree species, plant responses to fertilization have been variable (FURTINI NETO, 2005), due to the soil, the fertilizer, and the species' growth behavior (SORREANO *et al*., 2012). It is expected that due to the relatively slow growth of native tree species, plants will respond better to low-solubility fertilizers or organic fertilizers. The use of low-cost alternative sources with high residual power may be interesting for cost reduction using conventional fertilizers, which are more and more expensive, with the advantage of making P Available more gradually over time in the soil, reducing the intensity of losses of this element through the unavailability of reactions. According to Martins *et al.* (2015), sources of natural rock phosphate (NRP) generally have slower solubility than conventional fertilizers, however, they provide macro and micronutrients in their composition, which are essential for the growth of the species over time.

As an organic fertilizer, with potential use in the implantation of stands for forest restoration, sewage sludge has been generated in treatment stations, which after adequate treatment, stabilization, and meeting the microbiological and chemical criteria established by CONAMA Resolution No. 498 /2020 (BRASIL, 2020), is now denominated biosolids. Generally, this material is deposited in sanitary landfills, which generates transport costs for sanitation companies, in addition to contributing to the reduction of the useful life of sanitary landfills. The use of biosolids can contribute to the reduction of economic expenses, which occurs with the use of chemical fertilizers, aimed at improving soil fertility.

According to Guedes *et al*. (2006) and Abreu *et al*. (2017), the sewage sludge biosolid is relatively rich in nutrients and organic matter in addition to a great potential for its use in farming and forestry activities. In the area of forest restoration, biosolids have been investigated and recommended for the production of seedlings (ABREU *et al*., 2017; ALONSO *et al*., 2018; CALDEIRA *et al*., 2018) and as a soil conditioner, in the recovery of degraded areas (GUERRINI *et al*., 2017). Also, as planting fertilizer for some tree species that occur in the Atlantic Forest (LIMA FILHO *et al*., 2021; LOPES and LELES, 2020; SILVA *et al*., 2020). The last three authors observed different responses among the evaluated tree species.

Among the species used in the implantation of stands aiming at forest restoration, *Citharexyllum myrianthum* Chamiáo is found. These species belong to the Verbenaceae family, from the Atlantic Forest, known as *pau viola* or *tarumã*. This species has a relatively rapid growth (FERNANDES *et al*., 2019), being indicated for reforestation. According to Carvalho (2003), it is classified as a pioneer to initial secondary, with fruit dispersion employing zoochory. It is a medium to tall tree, ranging from 8 to 20 meters in height.

The objective of this work was to evaluate the response of *Citharexyllum myrianthum* plants to planting fertilization with biosolid, with reactive natural phosphate, and also with N-P-K 06-29-06, to make a recommendation.

MATERIAL AND METHODS

The experiment was set in July and carried out until December 2019, in cylindrical vases, 30 cm in height and with a volumetric capacity of 18 L, in the municipality of Seropédica, state of Rio de Janeiro. The climate in the region, according to the Köppen classification, is Aw - with hot, rainy summers and cold, dry winters, where February is the rainiest month and July the least rainy, with an average temperature of 25.1°C (ALVARES *et al*., 2013).

The soil was used to fill and complete the vases for all treatments and the control was collected on a concave-shape hill, taken from the subsurface layer, in the lower third of a slope. It was classified as a typical Dystrophic Red-Yellow Latosol, with a sandy-clay-loam texture, argisolic dystrophic, composed of 49% sand, 35% clay, and 16% silt. The results of the soil chemical analysis are shown in Table 1.

Table 1. Chemical characteristics of a typical Dystrophic Red-Yellow Latosol used in treatment formulations for the growth of *Citharexyllum myrianthum* in potted conditions.
Tabela 1. Características químicas de Latossolo Vermelho-Amarelo Distrófico típico utilizado nas formulações dos tratamentos para o crescimento de *Citharexyllum myrianthum* em condições de vasos.

pH	O.M.	P	K^+	Ca^{2+}	Mg^{2+}	Al^{3+}	H + Al	CEC(t)	V	m
-	dag kg^{-1}	----- mg dm^{-3} ------		------------ $cmol_c$ dm^{-3}--------------------					--------------% ----------------	
5.3	1.6	2.1	28.0	1.5	0.3	0.05	4.0	2.3	35.7	2.5

pH in water –1:2.5 ratio; OM = OCrg x 1.724; P and K: Mehlich extractor 1; Ca, Mg and Al: 1.0M KCl extractor; H+Al: calcium acetate; Org.C.: Walkley-Black. Where: H+Al = potential acidity; CEC(t) = Cation exchange capacity at pH 7.0; OM = organic matter; V = base saturation index and m = aluminum saturation index.

The treated biosolid used in the formulations was obtained from the sewage treatment plant in Ilha do Governador, city of Rio de Janeiro, whose chemical analysis results are shown in Table 2. The results indicated that the material was below the limit of heavy metal levels determined by the National Council for the Environment and following CONAMA Resolution 498/2020, which defines criteria and procedures for the production and application of biosolids in soils (BRASIL, 2020).

Table 2. Total levels of pH, macronutrients, organic matter (OM), C/N ratio, and total levels of micronutrients of biosolid used in one of the treatments for the growth of *Citharexyllum myrianthum,* in pot conditions.

Tabela 2. Teores totais de pH, macronutrientes, matéria orgânica (MO), relação C/N e teores totais de micronutrientes do biossólido utilizado em um dos tratamentos para o crescimento de *Citharexyllum myrianthum,* em condições de vasos.

pH	N	P	K	Ca	Mg	MO	C/N	Zn	Fe	Mn	Cu	B
-	-----------------g kg^{-1}------------------					--%--		---------------------ppm---------------------				
5.4	19.6	6.8	1.6	18.4	2.9	30.6	8.95	1009	25294	230	209	8,9

pH in water - 1:2.5 rate; Total contents quantified in the acid extract (nitric acid with nitric acid with perchloric acid); C – Walkley method - Black; OM = OCrg x 1.724; OM = organic matter.

The design used in the experiment was completely randomized, consisting of four treatments and six replications (totaling 24 plants), as follows: T1 – absolute control (soil with no fertilizer addition); T2 – 5 L of biosolid/pot; T3 – 300 g of natural rock phosphate (NRP)/pot, containing 20% P_2O_5 (10% soluble in citric acid) + 33% Ca; and T4 – 200 g of NPK 06-29-06 / pot, with 19% P_2O_5 soluble in citric acid + 14% Ca + 2% S + 0.2% B + 0.2% Cu + 0 .2% Zn. The amounts of nutrients applied in the treatments were calculated based on the total levels of nutrients present in the soil analysis, on the levels of nutrients contained in the biosolid, and also on the recommendation by Furtini Neto *et al*. (2005) and Silva *et al*. (2020).

Regarding the experiment set up, the plastic vases were painted with aluminized paint, to soften high temperatures. At the bottom of these, 1.5 cm of gravel was placed to help drain the irrigation water. The fertilizer formulations corresponding to the treatments were mixed with the soil and then the pots were filled with the resulting mixture. For absolute control, the pots were filled only with soil. After filling the pots, *Citharexyllum myrianthum* seedlings were planted, and produced in 280 cm³ tubes, using biosolids as substrate. Immediately after planting, the height (average value of 30 cm) and stem diameter (average value of 5 mm) of the seedlings were obtained.

Throughout the experiment and on days without rain, the pots were irrigated to keep soil moisture close to 70 – 80% of the field capacity. As cultural treatments, the spontaneous plants found in the vases were removed. This operation was carried out at two and four months, to avoid competition for water, light, and nutrients of the plants of interest with possible weeds.

At 150 days after transplanting, the height (H) and stem diameter (SD) of *Citharexyllum myrianthum* plants were measured. Using data on the height and diameter of the stem measured at time 0 and at 150 days, the increment of these variables was calculated, that is, how much the plants grew in height and diameter, during the experiment conduction. Then, to evaluate the effect of the fertilizers on the soil, five months after the application of the treatments, two samples of soil were taken from each pot, on opposite sides of the plant, at a depth of 20 cm, using an auger-type probe. The soil removed was dried in the shade, crushed, sieved, and sent for analysis at the Fertility Laboratory of the Federal University of Viçosa, to determine the levels of P, K, Ca, Mg, Al, and organic matter, in addition to evaluating the cation exchange capacity– CEC(t).

The next day, the leaves of the plants were removed to determine the leaf area using the area meter (Model LICOR LI-3000). The plant material was collected and then the aerial part and the root system were detached. The root system was washed in running water, with the aid of a hose, removing the substrate excess. These materials were packed in paper bags, and dried in an oven with air circulation at 65ºC, until reaching a constant dry mass. After weighing the material from the aerial part and root system, thus obtaining the dry masses, the leaves were removed from the packaging, ground in a WLS-3004 model mill, and sent to the laboratory to determine the leaf contents of N, P, K, Ca, and Mg.

The data obtained were submitted to analysis of the normality of the errors by the Shapiro-Wilk test, and then, the analysis of variance (ANOVA) was used, and when a significant difference was detected, the comparison of means was performed using the t-test of independent samples, at a 5% error probability level, using the Sisvar 5.6 program (FERREIRA, 2019). For the content of foliar nutrients, the data obtained were compared with the average values obtained from the upper and lower leaves of *Citharexyllum myrianthum* plants, indicated by Sorreano *et al*., 2012.

For a better description of the influence of treatments on the growth of the species, nutrient content in the soil and leaf content, principal component analysis (PCA) was carried out, to identify the grouping of treatments and the correlations among the variables referring to the attributes of the soil and plants. The PCA was performed with the aid of the R 3.6.0 program. (R CORE TEAM, 2019).

RESULTS

At 150 days after transplanting the seedlings in vase conditions and statistical analyses, it was observed that only leaf area (LA) and dry matter mass of the aerial part (DMAP) of plants fertilized with N-P-K 06-29-06 showed significantly higher values when compared to the control. The other treatments did not differ statically from the control by the t-test, at a 5% error probability (Table 3).

Table 3. Mean values of biometric parameters of *Citharexyllum myrianthum* plants at 150 days after transplant.
Tabela 3. Valores médios dos parâmetros biométricos das plantas de *Citharexyllum myrianthum* aos 150 dias após transplantio.

Comparisons	IncH	IncDC	LA	DMAP	RDM
	cm	mm	cm²	g	g
Bio x Test	38.1 and 35.2^{ns}	12.4 and 10.2^{ns}	2315 and 1459^{ns}	39.2 and 30.3^{ns}	37.3 and 40.3^{ns}
NRP x Test	39.9 and 35.2^{ns}	11.6 and 10.2^{ns}	2284 and 1459^{ns}	33.4 and 30.3^{ns}	36.5 and 40.3^{ns}
NPK x Test	38.5 and 35.2^{ns}	12.2 and 10.2^{ns}	3586 and 1459*	50.9 and 30.3*	32.5 and 40.3^{ns}

Where: Bio = biosolid; Test = control; NRP = natural reactive phosphorus; IncH = increment in height; IncDC = increment in collar diameter; LA = leaf area; DMAP = dry matter mass of the aerial part; RDM = root dry matter mass. ns = not significant and * = significant, using the t-test at 5% error probability.

It can be seen in Figure 1, which represents the average plants of each treatment, that the plant fertilized with the NPK formulation developed more leaf area, leading to significantly higher values of dry matter mass, when compared to the control plants. For plants fertilized with the other fertilizers, it was not possible to observe differences in vegetative growth.

Figure 1. Medium *Citharexyllum myrianthum* plants subjected to control and sources of planting fertilizers at 150 days after planting in 18 L pots.
Figura 1. Plantas médias de *Citharexyllum myrianthum* submetidas a testemunha e fontes de adubos de plantio aos 150 dias após plantio em vasos de 18 L.

In the evaluation of foliar macronutrient contents of *Citharexyllum myrianthum* plants (Table 4), based on data from Sorreano *et al*. (2012), *Citharexyllum myrianthum* growing in a complete nutrient solution and in the omission of N, P, K, Ca, and Mg, that only plants grown in 5 L of biosolids per pot and in 200 grams of N-P-K 06-29-06 as fertilization at planting, presented values of N content ≥ than plants without deficiencies. For the other macronutrients, all average values of contents were lower than the plants cultivated by Sorreano *et al*. (2012), with no deficiency symptoms.

Table 4. Mean values of leaf macronutrient content (g kg^{-1}) of *Citharexyllum myrianthum* plants at 150 days after transplanting and references of deficiency symptoms, based on Sorreano *et al*. (2012).
Tabela 4. Valores médios dos teores foliares de macronutrientes (g kg^{-1}) das plantas de *Citharexyllum myrianthum*, aos 150 dias após transplantio e referências de sintomas de deficiência, com base em Sorreano *et al*. (2012).

Treatments/symptoms	N	P	K	Ca	Mg
Control (no fertilization)	18.8	1.3	15.0	12.5	1.7
5 L biosolid	33.4	3.0	16.6	16.0	3.1
300 g de reactive natural phosphate	18.4	2.0	14.0	18.1	2.4
200 g NPK 06-29-06	35.0	2.4	17.4	15.2	1.9
No deficiency symptoms *	21.0	10.2	22.0	27.0	9.3
With deficiency symptoms **	12.0	1.0	7.0	6.0	3.6

N - Kjeldahl method; P and K - Mehlich extractor 1; Ca and Mg - 1.0M KCl extractor. * nutrient content of *Citharexyllum myrianthum* plants grown in a complete solution, and ** nutrient content of *Citharexyllum myrianthum* plants grown in solution with omission, respectively, of N, P, K, Ca, and Mg. Source: *Sorreano et al*. (2012).

Regarding the nutrient content in the soil of the vases, at the end of the cultivation of the plants, a difference was found between the evaluated parameters (Table 5). Phosphorus was the nutrient with the highest discrepancy in values among the soils of the treatments, and, on average, a significantly higher content occurred in the soil that was applied with 300 grams of reactive natural phosphate and lower values in the control. The organic matter content, cation exchange capacity, and Ca were significantly higher in the 5-L biosolid mixed with soil treatment when compared to the control.

Table 5. Average values of nutrient content in the soil at 150 days after cultivation of *Citharexyllum myrianthum* in an 18-L vase.
Tabela 5. Valores médios dos teores de nutrientes e matéria orgânica no solo, aos 150 dias após cultivo de *Citharexyllum myrianthum*, em vasos de 18 L.

Comparisons	P	K	Ca	Mg	CEC(t)	OM
	------- mg dm^{-3} --------		----------------- $cmol_c$ dm^{-3}-----------------			dag kg^{-1}
Bio x Test	135.6 and 2.1*	26 and 29^{ns}	6.3 and 1.6*	0.5 and 0.3*	6.2 and 2.0*	3.2 and 1.6*
RNP x Test	338.4 and 2.1*	32 and 29^{ns}	2.5 and 1.6^{ns}	0.5 and 0.3*	3.2 and 2.0^{ns}	1.6 and 1.6^{ns}
NPK x Test	226.7 and 2.1*	222 and 29*	2.5 and 1.6^{ns}	0.3 and 0.3^{ns}	3.6 and 2.0^{ns}	1.6 and 1.6^{ns}

Total contents, determined in the acid extract (nitric acid with perchloric acid); RNP = reactive natural phosphate OM = COrg x 1.724; CEC(t)= Effective cation exchange capacity; OM = organic matter. ns= not significant and * = significant, using the t-test at a 5% probability of error.

For potassium, a higher average value was observed in the soil that received 200 g of N-P-K 06-29-06. In the evaluation of the Mg content, on average, significantly higher levels were found in the soil of the treatments fertilized with biosolid and reactive natural phosphate, when compared with the control.

Figure 2 shows the dispersion of the eigenvalues of the soil attributes, the plant, and the treatments concerning the first two components of the principal component analysis (PCA). It could have been observed that the levels of nutrients in the soil and in the plants presented a positive correlation with the treatments with the application of biosolid and N-P-K 06-29-06, except for the variables pH and root dry mass (RDM), which presented the opposite pattern, showing a higher positive correlation with treatment that received reactive natural phosphate.

The pattern observed concerning the treatment with 200 grams of N-P-K (06-29-06) per vase, indicates that this was what most positively influenced the growth in LA and consequent higher APDM of the plants. Fertilization with NPK and biosolids mainly influenced the rise in macronutrient levels in the leaves and in the soil. On the other hand, the application of 300 g of reactive natural phosphate (T3) increased the levels of pH and root dry matter. Control, as expected, did not influence soil and plant attributes.

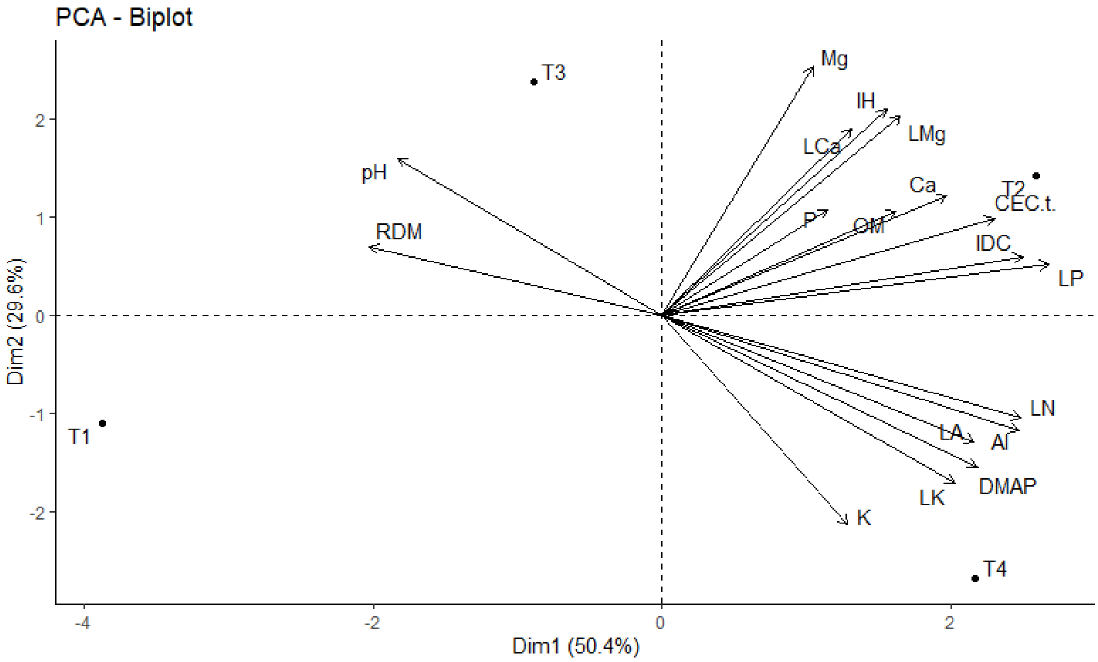

Figure 2. Principal component analysis using growth variables (IH = height increment, IDC = stem diameter increment. LA = leaf area; DMAP = dry matter of the aerial part and RDM = root system dry matter), nutrient content leaf (LN, LP, LK, LCa, and LMg) and nutrient content in the soil (P, K, Ca, Mg, and Al), in addition to pH and soil organic matter (OM).

Figura 2. Análise de componentes principais usando variáveis crescimento (IH = incremento em altura, IDC = incremento em diâmetro do coleto. AF = área foliar; MSPA = matéria seca da parte aérea e MSR = matéria seca do sistema radicular), teor de nutrientes foliar (NF, PF, KF, CaF e MgF) e teor nutrientes no solo (P, K, Ca, Mg e Al), além de pH e matéria orgânica do solo (MO).

DISCUSSION

A significantly higher difference in leaf area and dry matter mass of *Citharexyllum myrianthum* plants, in the treatment with the application of 200 g of N-P-K (06-29-06) + 14% Ca, was probably caused by the greater solubility of the phosphate in this formulation (NOVAIS *et al.*, 2007), which helped in the faster absorption of the available nutrients by the plants, in the period in which the experiment was carried out. Another point that may have influenced the vegetative growth of this species is the nitrogen in the N-P-K (06-29-06) formulation, as, according to Cantarella (2007), this element has a great influence on plant growth, thus leading to obtaining a larger area leaf and aerial part dry matter mass.

The leaf area and dry matter mass of the aerial part are two important parameters in the formation of stands aimed at forest restoration, because the rapid forest cover offered by the species of interest hinders the growth of spontaneous vegetation (SANTANA *et al.*, 2020), which consequently, reduces the need for cultural treatments for longer periods, and the costs of forming the stand, in addition to helping to protect the soil (KEYS *et al.*, 2018). In this work, *Citharexyllum myrianthum* plants fertilized with N-P-K (06-29-06) had greater competitive potential with spontaneous herbaceous vegetation, which can become harmful. The leaf area of the control treatment plants was significantly lower when compared to the other fertilized plants. This indicates that when the plants were fertilized with NPK, the nutrients contained in the soil solution positively influenced the growth in the leaf area of this species. The small responses of the other growth variables to fertilization may be related to the relatively short time of the experiment, since in the biosolid, the nutrients are in the organic form (ABREU *et al.*, 2017) and in the reactive natural phosphates, the phosphorus is solubilized more slowly (NOVAIS and SMYTH, 1999; NOVAIS *et al.*, 2007).

The response to biosolid fertilization varies between species. Despite the species *Citharexyllum myrianthum* having fast growth, in this work, considering the conditions of the experiment, it was not possible to observe the statistical difference in increment in height of the aerial part and in the diameter of the collar, concerning the applied treatments. In the planting of *Schinus terebinthifolius*, *Lafoensia glyptocarpa*, *Inga laurina*, *Senna multijuga*, *Peltophorum dubium*, and *Enterolobium contortisiliquum*, species that occur in the Atlantic Forest, Silva *et al*. (2020) found that the doses of biosolids used as fertilizer increased the growth rate of

Schinus terebinthifolius and *Peltophorum dubium*. However, the highest dose (8 L) reduced the growth of *S. multijuga* by up to 50%, while *I. laurina*, *G. americana*, and *E. contortisiliquum* had no change in their growth. Similar observations were observed by Lopes and Leles (2020), who reported the distinct behavior between three tree species that received biosolid and N-P-K, as planting fertilizer, in Red Yellow Latosol, under field conditions.

Lima Filho *et al*. (2019) observed positive and quadratic responses (4 L dose) in the growth of *Ceiba speciosa* plants in 18-L vases, six months after planting. In the field, the positive responses observed were with a maximum dose of 3 L of biosolids per furrow, at planting. Lopez and Leles. (2020) did not observe responses of *Schinus terebenthifolius* plants, in 18-L vases, in planting fertilization with sewage sludge biosolid, using soil similar to that of this work. These differences in growth responses of tree species to biosolids are possibly caused by the ecological aspects, climate, and soil of the species' natural occurrence.

Regarding the leaf analyses carried out in this work to investigate nutritional aspects of the leaves of *Citharexyllum myrianthum* plants at the end of the experiment, according to Dechen and Nachtigall (2006) and Sorreano *et al*. (2012), plants with higher nutrient content are usually more competitive in the local environment and have greater growth potential, given the adversities found in the field. According to Sorreano *et al*. (2012), in all treatments, *Citharexyllum myrianthum* plants had some deficiency of P, K, Ca, and mainly Mg, in which the values were lower than those of plants with symptoms of deficiency. This, theoretically, nutritional deficiency, in all treatments, can help to explain the small response of plant growth in height and diameter, of the fertilization treatments of planting in the vase condition, in relation to the control. This phenomenon highlights the need for planting fertilization for *Citharexyllum myrianthum*, when grown in Red Yellow Oxisols, at fertility levels similar to that used in this work.

As for the higher K value observed in plants treated with N-P-K, it was probably due to the high solubility of N-P-K (06-29-06), which promoted greater absorption of N and K in leaf tissues. Silva *et al.* (2020) observed that the application of biosolid resulted in an increase in leaf contents of P and Ca in *Lafoensia glyptocarpa* and Mg in *Senna multijuga*, but reduced P contents in *Genipa americana*. The authors found that the species *Schinus terebinthifolius*, *Lafoensia glyptocarpa*, *Peltophoprum dubium*, *Inga laurina*, and *Senna multijuga*, when they received 4 L of biosolid per plant, showed greater accumulation of leaf macronutrients, corroborating data from this work.

Analysis of the macronutrient and organic matter content in the soil and the cation exchange capacity (CEC) may indicate the ability of the growth potential of *Citharexyllum myrianthum* plants as soils with a higher content of available nutrients have the potential to provide better growth to plants of interest. In this work, the treatment that was mixed with 5-L of biosolid resulted in N levels above those indicated by Sorreano *et al*. (2012), in addition to high CEC and organic matter, when compared to the control, as also observed by Silva *et al*. (2020) and Lopes and Leles (2020). According to Silva *et al*. (2020), the biosolid contains high levels of macronutrients (N, P, Ca, and Mg) and organic matter that contributes to improving soil characteristics, therefore contributes to plant growth (GUEDES *et al*., 2006; ABREU *et al*., 2017), indicating the potential for the use of this compound as an organic fertilizer, in the implantation of stands aimed at forest restoration.

As for the high value of phosphorus in the soil fertilized with reactive natural phosphate, its high presence in the soil and low in the plant shows that this nutrient was not efficient as a fertilizer, where the plant was unable to absorb and assimilate it in a short period. According to Novais and Smyth, (1999), natural phosphates are fertilizers that generally present low P availability for plants in a short period, corroborating the data reported in this work.

Regarding the principal component analysis (PCA), this allowed for identifying patterns in the data set obtained for the treatments, in which the biosolid was the most indicated for the improvement of the soil attributes and the evaluated characteristics of *Citharexyllum myrianthum*, followed by the treatment with N-P-K 06-29-06.

CONCLUSION

For soils similar to the one in this work, it is recommended to fertilize *Citharexyllum myrianthum* plants with 200 grams of N-P-K 06-29-06/pit or with 5 L of biosolid/pit.

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