

Original Research Article

Foliar Fertilization Using Liquid Tannery Sludge In Conilon Coffee Seedlings Production

ABSTRACT

Waste destination is a concern to industries and, one of the solutions are fertilizers. Therefore, the objective of this study was to evaluate the efficiency liquid tannery sludge as an alternative of foliar fertilization in Conilon coffee seedlings. The experiment was carried out in a randomized block design with six treatments and eight replications, for 228 days. The control treatment was pure water, and five doses of tannery sludge was applied monthly (6, 20, 8, 80, 11.47, 14.10, and 17.60 mL of sludge diluted in one liter of water). The biometric and gravimetric growth characteristics were evaluated. Also, the quality index of the seedlings was evaluated, and it was observed that the fertilization using tannery sludge diluted above 14.23 mL.L⁻¹ began to cause toxic effects on Conilon coffee seedlings. The doses usage between 8.80 and 14.23 mL.L⁻¹ showed potential use for the seedlings production.

Keywords: Coffea canephora, Sustainability, Propagatio, chrome

1. INTRODUCTION

Brazil has one of the largest cattle herds in the world and has been a leading global producer of leather, processing approximately 42 million leather skin a year and exporting to several countries, especially Italy, China and Hong Kong, which consumes half of the national production [1,2]. Although this activity generates significant profits, contributing to the economic and social development of the country, it has been a concern, mainly due to the large production of waste/effluents that are generated during the processing of bovine leather.

The leather tanning processes requires several mechanical and chemical treatment procedures that result in large amounts of residues with high concentrations of organic matter and various potentially toxic chemicals [1]. This problem is caused due to inappropriate disposal in landfills, sanitary landfills or industrial landfills.

Studies on the use of tannery sludge in agriculture are intensifying, since they have organic matter and a high nutrient content. However, certain restrictions must be considered, since this material also provides heavy metals, such as chromium and high concentrations of sodium [3,4,5]. Therefore, the study of tannery sludge and its application is important, since it can be an alternative of fertilization, and it can reduce production costs.

Positive results with the application of tannery sludge are found in the literature, for example, [6] in the corn crop, [7] in the sugar cane crop, [8] in wild passionflower seedlings and [9] in Conilon coffee seedlings. However, the amount used must be taken into account, since its toxic effects from chromium and sodium can alter the plant metabolism, reducing the plants development.

Throughout the world, coffee grows between 25 °N latitude and 25 °S, with specific climatic conditions necessary to achieve high yields and maintain its quality [10]. In Brazil, more specifically in the state of Espírito Santo, coffee crop is one of the main agricultural activities with the second largest planted area of the country and is considered the main source of income in family agriculture. Also, a large part of its coffee area (*Coffea canephora* Pierre ex A. Froehner) is being replaced by new crops with improved genetic materials [11,12]. Therefore, healthy and vigorous seedlings production is the first step towards a productive coffee crop, which may result in vigorous plants with greater the ability to express productive potential [9].

Thus, the use of potentially pollutant residues from an industrial process is an interesting alternative for the substrate and/or conventional fertilizer, so that tannery sludge in Espírito Santo is disposed in industrial landfills, with accumulated contamination potential [11]. The objective of this study was to evaluate the use of liquid tannery sludge as an alternative foliar fertilizer for the conilon coffee seedlings production.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

The experiment was carried out in a greenhouse of coffee seedlings propagation of the Federal Institute of Education, Science and Technology of Espírito Santo - Campus Itapina, located in the municipality of Colatina (19 ° 32 '22 "S 40 ° 37' 50" W). The experiment was a randomized block design with seven treatments and eight replications, with 21 plots for each treatment, totaling 147 plants per block and 1176 plants throughout the experiment. The treatments were composed of 5 concentrations of tannery sludge diluted in water (T-1; T-2; T-3; T-4; T-5) and a pure water solution (T-0) in Table 1.

Table 1. Description of the treatments used for foliar fertilization in Conilon coffee seedlings.

Treatment	Description of the treatments
T-0 (dose 0)	Pure water (Control);
T-1 (dose 6.20)	6.20 mL of liquid sludge diluted in one liter of water;
T-2 (dose 8.80)	8.80 mL of liquid sludge diluted in one liter of water;
T-3 (dose 11.47)	11.47 mL of liquid sludge diluted in one liter of water;
T-4 (dose 14.10)	14.10 mL of liquid sludge diluted in one liter of water;
T-5 (dose 17.60)	17.60 mL of liquid sludge diluted in one liter of water;

The tannery sludge was supplied by Capixaba Couros LTDA, located in the municipality of Baixo Guandu - ES, containing the following composition: Organic Carbon 9.9%; Organic Matter Total 8.03 g/L; Nitrogen 2200 mg/L; Phosphorus 55 mg/L; Potassium 110 mg/L; Calcium 8930 mg/L; Magnesium 1370 mg/L; 1508 mg/L Sulfur; Boron 14 mg/L; Sodium 1700 mg/L; Chromium 3500 mg/L.

The seedlings were planted in 600 mL polyethylene bags previously filled with the substrate. The substrates used for the seedlings production of this experiment was a mixture considered traditional by the Conilon coffee seedlings producers, and for each 80 liters of red soil, 625g of P₂O₅ was added; 200g of calcium; 200g of KCl and 20 liters of cow manure. The chemical characteristics of the soil were described in Table 2 and the irrigation management during the whole experiment was done daily by microsprinkling, always maintaining the field capacity of the substrates.

78 **Table 2. Soil chemical characteristics.**

pH	P	K	P.REM	Ca	Mg	H+Al	CTC	t	SB	MO	V
	mg dm ⁻³		mg/ml	mmol _c dm ⁻³						g/dm ⁻³	
6.20	3.0	44.0	12.0	14.1	10.5	7.2	32.9	25.7	25.7	2.2	78.10

79 *Extraction and determination: pH in water (1:2.5); P. K: Mehlich 1; Ca. Mg. Al: KCl (1M); H +*
 80 *Al: calcium acetate (0.5M). CTC at pH 7.0.*

81
 82 To carry out the experiment, Conilon (*Coffea canephora* Pierre) seedlings of the
 83 clone cultivar Vitória Incaper 8142 (clone V8) were used. The seedlings were produced from
 84 cuttings obtained from the mature tissue of orthotropic branches which were removed from
 85 crops with adequate phytosanitary and nutritional aspect from Campus Itapina. After
 86 removing the branches of the mother plants, they were sent to the greenhouse and when
 87 they were ready to be planted, the main stem of the shoot about 3 cm below was cut 1 cm
 88 above the petiole. The secondary stems were cut 1 cm from the main stem, as well as 2/3 of
 89 the leaf area.

90 Application of the solutions corresponding to each treatment started after emergence
 91 of the first fully expanded pair of leaves and this procedure was repeated monthly until the
 92 seedling reached its commercial size, which occurred 228 days after staking. Applications
 93 were done at the end of the day and the plants remained with the solution without being
 94 irrigated until the next day. Then, the treatments were sprayed.

95 At the end of the experiment the following analyzes were done: plant height (cm)
 96 measured with a graduated ruler; stem diameter (mm) measured using a digital caliper;
 97 crown diameter (cm) measured with a graduated ruler; number of leaves done by counting;
 98 leaf area given by a Liquor 3100 licor brand leaf scanner (cm²); fresh and dry shoot mass
 99 fresh and dry root mass (g), and fresh and dry shoot mass (g). To obtain the dry mass, the
 100 seedling were placed forced circulation oven at 72 °C for 72 hours and then they were
 101 weighed on a precision analytical balance.

102 The Dickson quality index of seedlings [13], was calculated by the equation, $DQI =$
 103 $[(TDM) / (PH/CD + DSM/DRM)]$. Being TDM: the total dry mass; PH: plant height; DSM: dry
 104 shoot mass; CD: stem diameter; DRM: dry root mass. Statistical analyzes were performed
 105 by the [14], in which the quantitative data were submitted to the analysis of variance by the F
 106 test and when significant, they were adjusted regression models for the doses of tannery
 107 sludge.

108 **3. RESULTS AND DISCUSSION**

109
 110 All values for the coefficient of determination (R^2) were significant in this
 111 experiment, indicating that the increased dosages affected the characteristics evaluated. An
 112 upward curve was adjusted for the number of leaves, due to the doses of liquid sludge
 113 applied to the aerial part of the plants (Figure 1 (a)), with coefficients of determination of
 114 $R^2=0.92$. The maximum emission of leaves estimated was 8.0 obtained with the dose of
 115 17.60 mL of liquid sludge diluted in one liter of water, corresponding to an increase of 2.0
 116 leaves in relation to the control dose (T-0).

117 The highest coefficient of determination was obtained by stem diameter, with a
 118 value of 0.99, indicating a near perfect fit of the equation, in which there was a 0.047 mm
 119 increase in the stem diameter for each application of 5 mL of liquid sludge. This may be
 120 related to the nutrients provided by tannery sludge, for example, or sulfur, calcium,
 121 potassium and phosphorus that are fundamental macronutrients in the early development of
 122 plants [15].

123 For the plant height, a quadratic polynomial model was obtained with coefficients
 124 of determination of $R^2 = 0.91$ (Figure 1 (d)). Through the adjusted model it was verified that
 125 the dose that maximized the plant height in 24.5 cm, was 17.60 mL of liquid sludge. This is

mainly due to the amount of nitrogen provided by the tannery sludge, which is a very important element, capable of directly interfering with the plant growth, in which low amounts can lead to lower plant development [16]. Other authors found positive responses with the tannery sludge concentration as observed by Almeida et al. [17] for the stem diameter of small green pepper seedlings up to 70% of sludge concentration to the substrate (v/v), Silva et al. [18] in the eucalyptus and white *Angico* forest species with a stem diameter up to 25% of tannery sludge (v/v). Besides several other studies in which the authors present significant gains with the use of this compound, as in Conilon coffee seedlings [9] in cowpea [19] lattice and ornamental pepper [20]. Therefore, these authors used the sludge in its solid form, since studies are scarce using the sludge as a foliar fertilization.

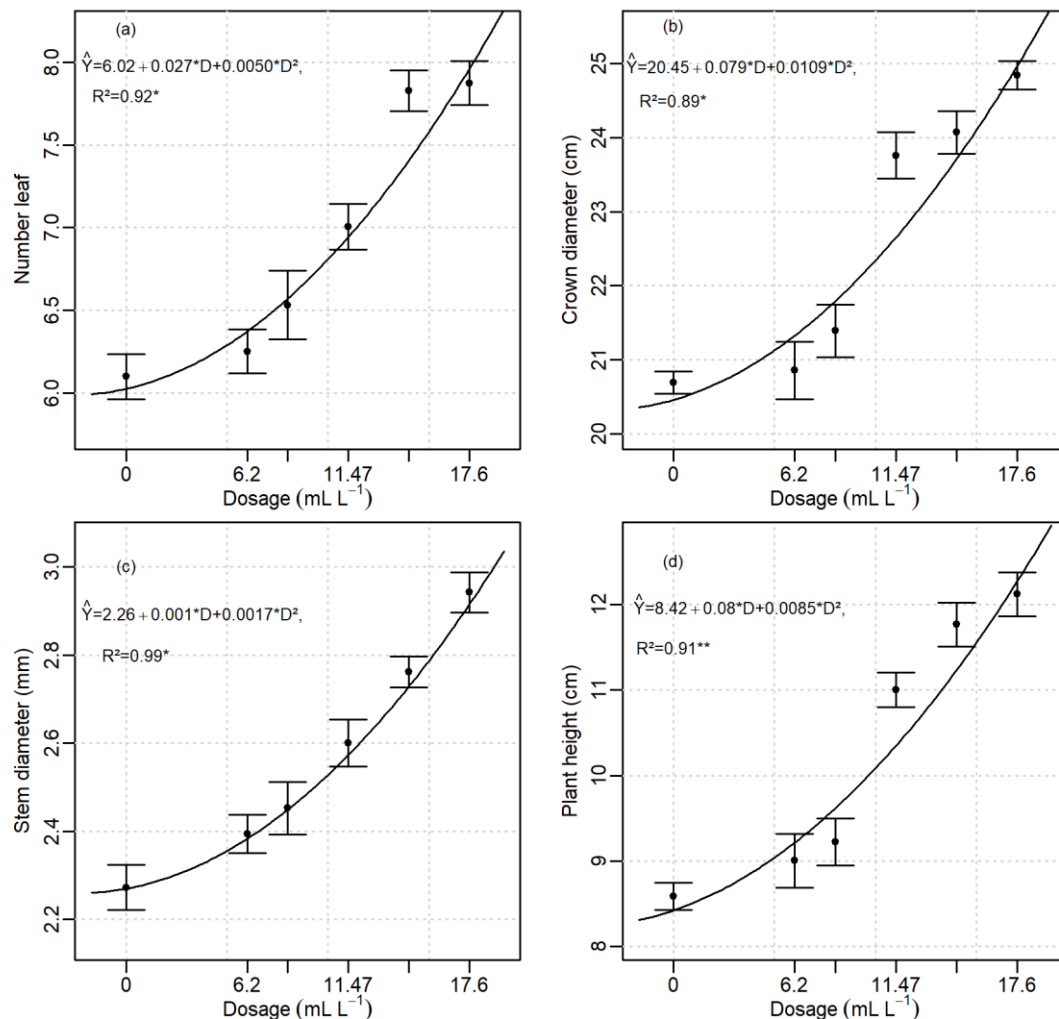


Figure 1. Quadratic polynomial regression analysis for number of leaves (a) crown diameter (b) stem diameter (c) and plant height (d) of Conilon coffee seedlings, due to different doses of foliar fertilization with tannery sludge.

For the leaf area in (Figure 2 (a)) due to the doses of applied tannery sludge, a quadratic polynomial model was obtained with coefficients of determination of $R^2 = 0.98$. When estimating the optimal dose of the equation $\hat{Y} = 172.58 + 14.817 * D - 0.5204 * D^2$, the value of 14.23 mL of tannery sludge was found, in which for this dosage the obtained value of leaf area was 278.05 cm². Despite the growth curve obtained for the number of leaves (Figure 1 (a)), it presented an increasing pattern, and the size of these leaves was lower in doses higher than 15.77 mL of tannery sludge, since from this dose there was decrease in the leaf area.

One of the possible causes for the decrease in the leaf area may be associated with salt stress caused by high sodium content with increasing doses, damaging the normal seedlings development and the leaf area is an important adaptive mechanism of plants that are under excessive salt and water stress, and consequently decreases its photosynthetic area [21,22]. Furthermore, there is a toxic effect caused by chromium, which may have contributed to intensify this decrease in the leaf area.

While studying the use of tannery sludge in the solid phase in Conilon coffee seedlings, the authors Berilli et al. [23] found a linear increase of chromium accumulation in the foliar tissues due to the increase of the proportion of tannery sludge in the substrate. Possibly, adding tannery sludge at levels below 14.23 mL.L⁻¹, had insufficient nutrient availability and adding the sludge at concentration levels from this dose can cause toxicity to the Conilon coffee seedlings.

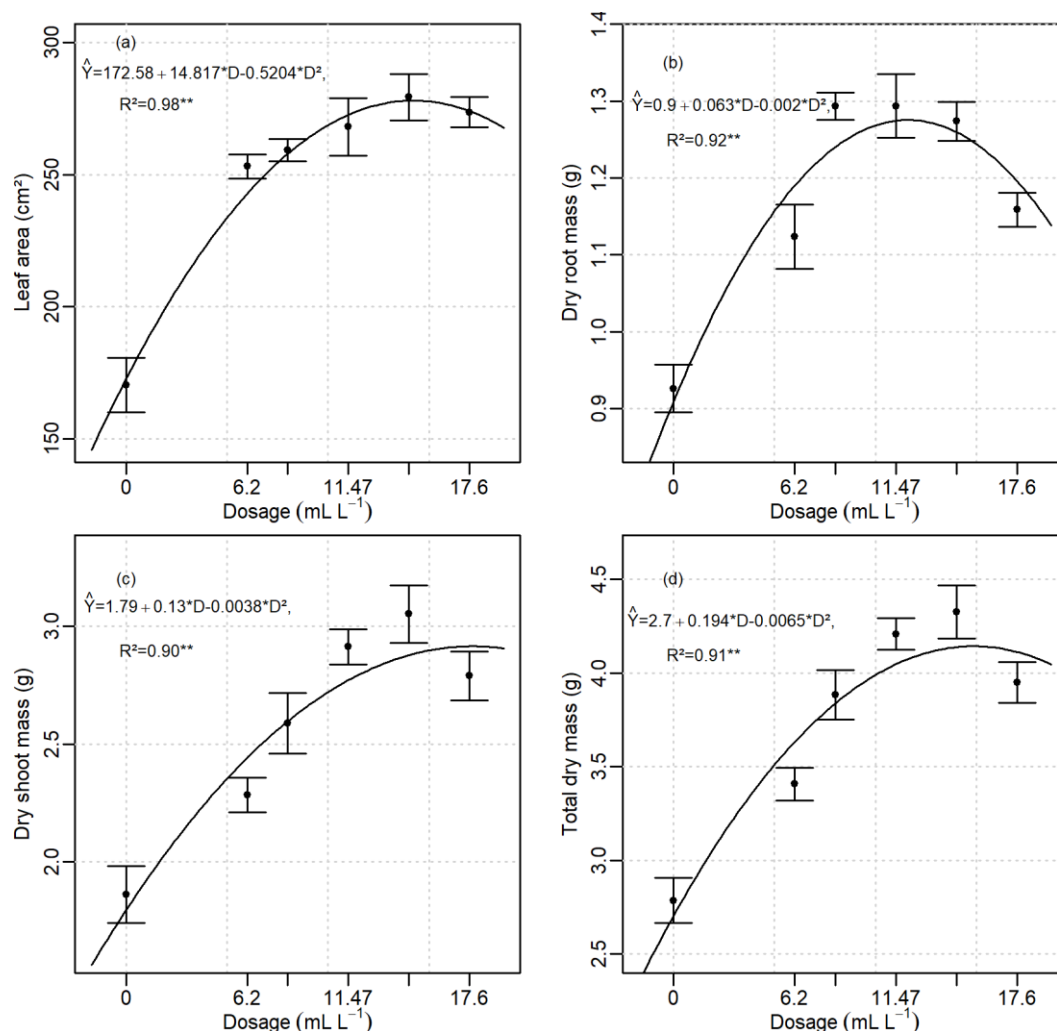


Figure 2. Polynomial regression analysis for leaf area parameters (a), dry root mass (b), dry shoot mass (c) and total dry mass (d) of Conilon coffee seedlings due to different doses of foliar fertilization with tannery sludge.

For the dry root mass system (Figure 2 (b)), the highest weight found was 1.39 g, obtained using the dosage of 15.75 mL of tannery sludge applied to the aerial part of the coffee seedlings. It is observed that as the dose of tannery sludge increases, the dry root mass increases to the ideal dosage (15.75 mL.L⁻¹), which higher doses result in a proportional decrease in dry root mass.

Analyzing the variations in the dry shoot mass (Figure 2 (c)) due to the gradual increase of the doses of tannery sludge applied via foliar, it is clear that the equation obtained explains 90% of the response of the dry shoot mass in the applications of the tannery sludge via foliar in the Conilon coffee seedlings. From the obtained equation it was verified that the dose that maximized the dry shoot mass, in 2.90 g was at the dose of 17.21 mL.L⁻¹ of tannery sludge. These results are related to the influence of chromium and sodium present in the tannery sludge, since this metal has the ability to alter the biochemistry of cells compromising the photosynthetic process by oxidative stress or chloroplast disorders, consequently reducing the aerial part of these plants [24,25,26].

For the Dickson quality index variable (DQI) shown in Figure 3, a high coefficient of determination ($R^2 = 0.96$) adjustment is observed by the equation. The trend curve points to estimated optimum values for a concentration of about 12.00 mL.L^{-1} of liquid tannery sludge. However, all values found in this experiment for the Dickson quality index are close to the data obtained by the authors Dardengo et al [27] and Pereira et al. [28] for Conilon coffee seedlings, besides being above 0.20. This value was established by [29] as the minimum to guarantee the coffee seedlings quality.

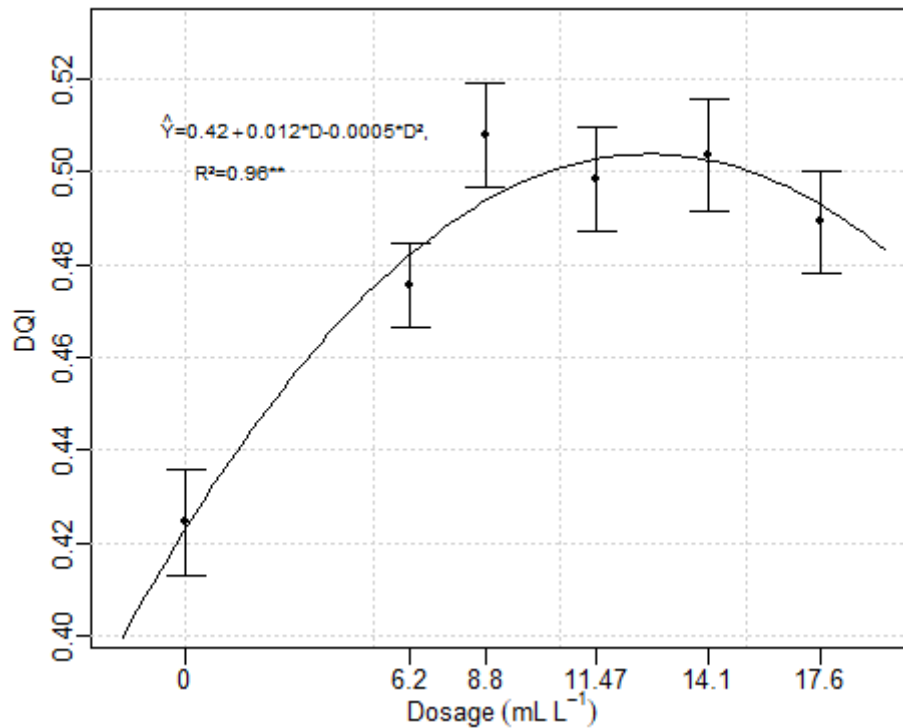


Figure 3. Polynomial regression analysis for the Dickson quality index of Conilon coffee seedlings as a function of different doses of foliar fertilization with tannery sludge.

The use of tannery sludge as a source of alternative fertilization of leaf fertilization in coffee seedlings is potentially feasible, since this industrial waste presents a relative availability of nutrients such as sulfur, magnesium, calcium, nitrogen, phosphor, potassium, as well as of organic matter as also observed by Berilli et al. [26] However, there is a need for more research related to disturbances in plant tissues, since the toxic elements present in this material can cause oxidative damage to the plants.

4. CONCLUSION

There was a significant response to all the variables evaluated in this study in relation to the application of liquid sludge doses in the formation of Conilon coffee seedlings.

Doses above 14.23 mL of tannery sludge promoted a decrease in the leaf area by disturbances caused by chromium and sodium elements.

The tannery sludge applied in the aerial part shows to be an alternative source of nutrients for the formation of Conilon coffee seedlings. It is recommended to be applied

between 8.8 and 14.23 mL of tannery sludge for coffee seedlings, since doses above began to damage the photosynthetic system of plants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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