

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 **has** 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 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, Propagation, 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 **produced** during the bovine leather **process**.

The leather tanning process 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 **increasing**, 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, **Malafaia et al. [6]** in the corn crop, **Chand et al. [7]** in *Ocimum basilicum* L., **Sales et al. [8]** in wild passionflower seedlings and **Berilli et al. [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 it 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 a greater productive potential [30].

Thus, the use of potential pollutant waste from an industrial process is an interesting alternative for conventional substrate and/or fertilizer, when properly used. It has todiluted and in a specific manner, since the tannery sludge in Espírito Santo is deposited 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 with coffee seedlings propagation located in the Federal Institute of Education, Science and Technology of Espírito Santo - Campus Itapina, in Colatina (19 ° 32 '22 "S 40 ° 37' 50" W) in the year 2015. 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) in order to reduce the large amount of chromium and sodium present in they tannery sludge 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⁻¹; Nitrogen 2200 mg.L⁻¹; Phosphorus 55 mg.L⁻¹; Potassium 110 mg.L⁻¹; Calcium 8930 mg.L⁻¹; Magnesium 1370 mg.L⁻¹; Sulfur 1508 mg.L⁻¹; Boron 14 mg.L⁻¹; Sodium 1700 mg.L⁻¹; Chromium 3500 mg.L⁻¹.

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 farmers, 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.

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

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

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

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

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

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

3. RESULTS AND DISCUSSION

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

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

For the plant height, a quadratic polynomial model was obtained with coefficients of determination of $R^2 = 0.91$ (Figure 1 (d)). Through the adjusted model it was verified that 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 results 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 beans [19] in tomato crop [20]. Therefore, these authors used the sludge in its solid form, since studies are scarce using the sludge as a foliar fertilization.

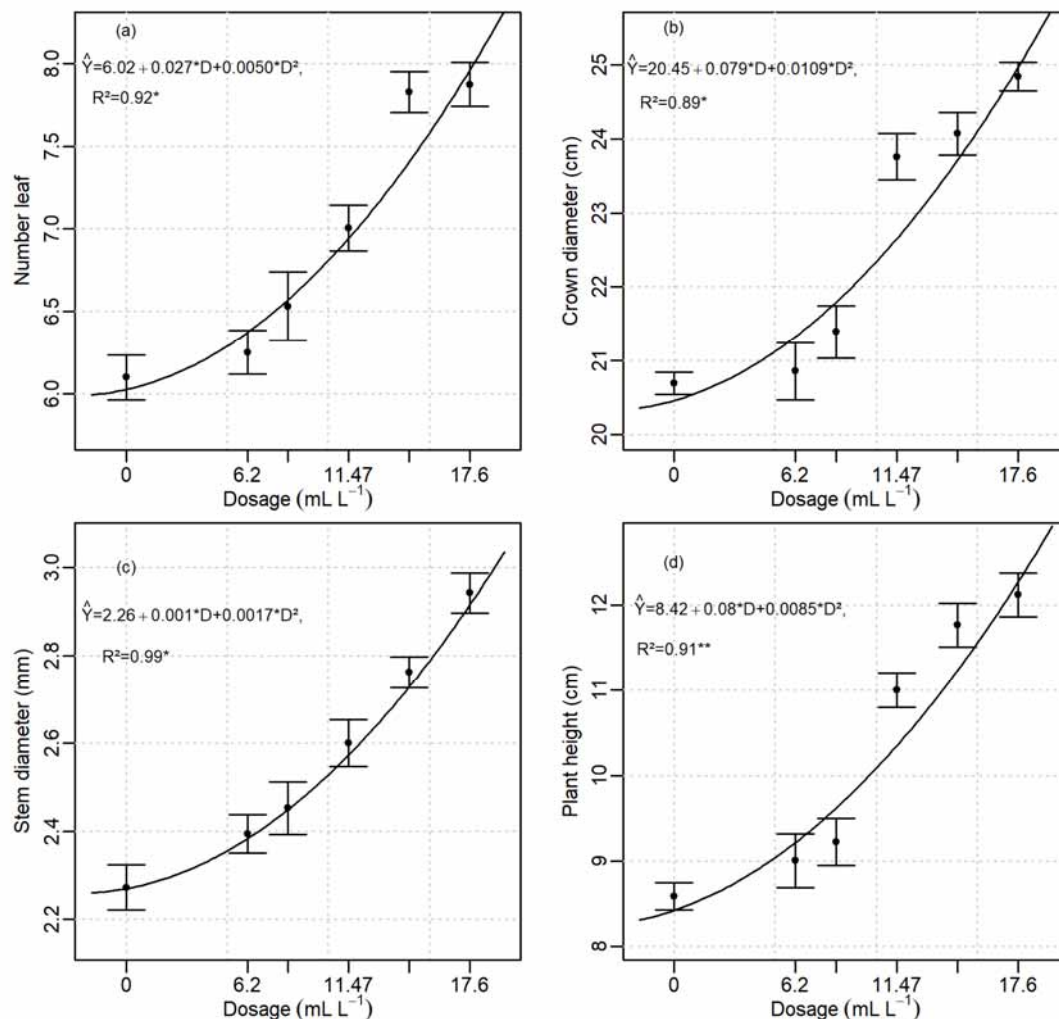


Figure 1. Quadratic polynomial regression analysis for number of leaves (a) crown diameter (b) stem diameter (c) and plant height (d) of Conilon coffee seedlings, due to different doses of foliar fertilization with tannery sludge.

144 Significant at * $P < 0.05$; ** $P < 0.001$

145

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

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

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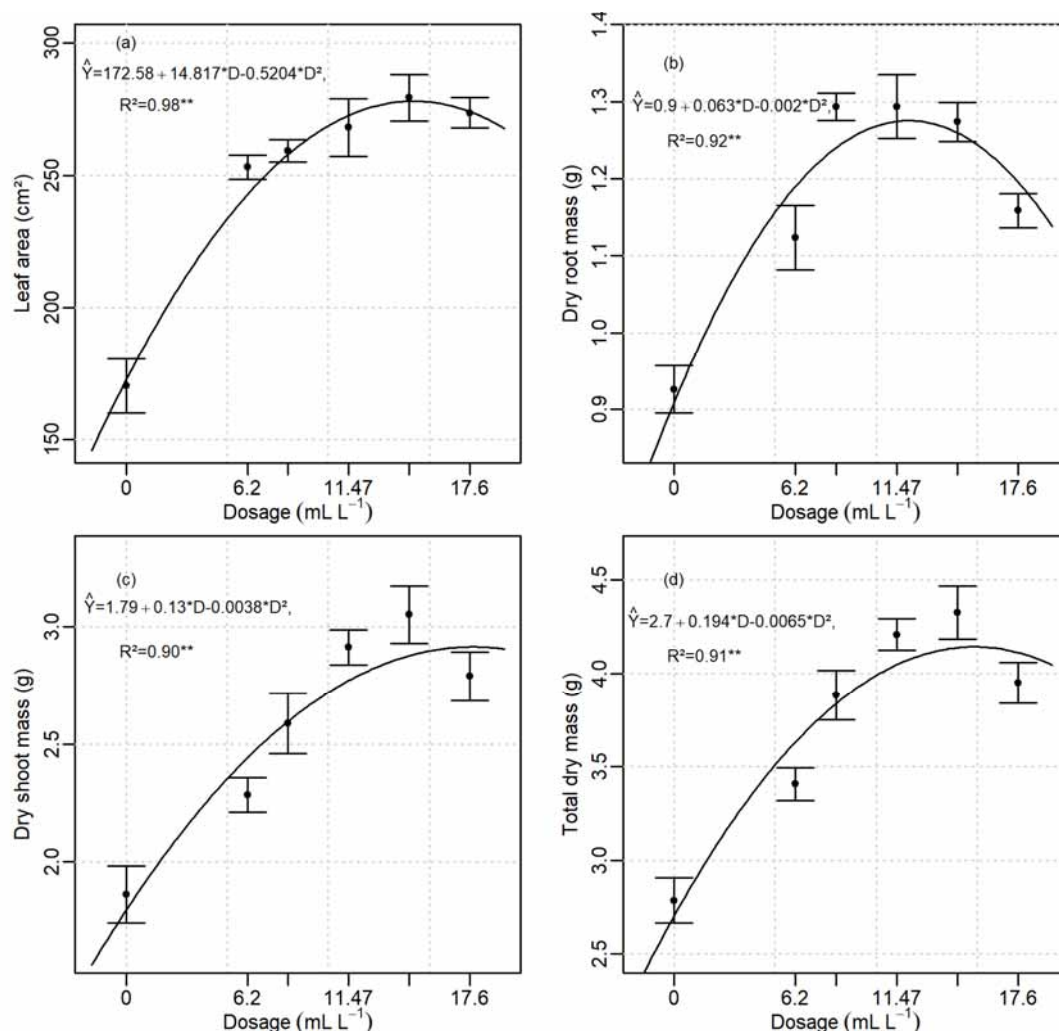


Figure 2. Polynomial regression analysis for leaf area parameters (a), dry root mass (b), dry shoot mass (c) and total dry mass (d) of Conilon coffee seedlings due to different doses of foliar fertilization with tannery sludge.

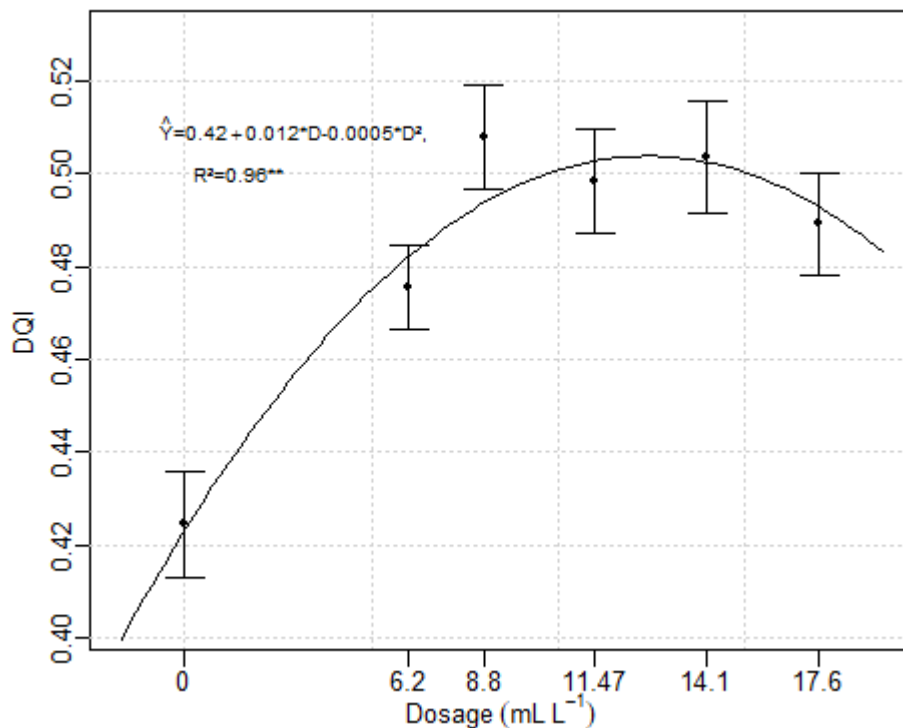
Significant at * $P < 0.05$; ** $P < 0.001$

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 results 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

185 compromising the photosynthetic process by oxidative stress or chloroplast disorders,
 186 consequently reducing the aerial part of these plants [24,25,26].

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



194
 195 **Figure 3. Polynomial regression analysis for the Dickson quality index of Conilon**
 196 **coffee seedlings as a function of different doses of foliar fertilization with tannery**
 197 **sludge.**

198 **Significant at * $P < 0.05$; ** $P < 0.001$**

199
 200 The use of tannery sludge as a source of alternative fertilization in coffee seedlings
 201 is potentially feasible, since this industrial waste presents a relative availability of nutrients
 202 such as sulfur, magnesium, calcium, nitrogen, phosphor, potassium, as well as of organic
 203 matter as also observed by Berilli et al. [26] However, there is a need for more research
 204 related to the disturbances in plant tissues, since the toxic elements present in this material
 205 can cause oxidative damage to the plants.
 206

207 **4. CONCLUSION**

208
 209 There was a significant response to all the variables evaluated in this study in
 210 relation to the application of liquid sludge doses in Conilon coffee seedlings growth.

211 Doses above 14.23 mL of tannery sludge promoted a decrease in the leaf area
212 due to chromium and sodium elements.

213 The tannery sludge applied in the aerial part shows to be an alternative source of
214 nutrients in the Conilon coffee seedlings growth. It is recommended to be applied between
215 8.8 and 14.23 mL of tannery sludge for coffee seedlings, since doses above began to
216 damage the photosynthetic system of the plants.

217

218 **COMPETING INTERESTS**

219

220 Authors have declared that no competing interests exist.

221

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