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Tannery sludge and urban waste compost in the production of *Solanum melongena* L. through regression and multivariate analysis

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ABSTRACT

In vegetable production, seedling propagation is one of the most important steps as it directly influences the final performance of the plants. In order for such condition, the propagation substrate must be in good condition. The objective of this work was to evaluate the effect of different combinations of tannery sludge and urban waste compost as substrates in comparison to the commercial substrate Maxfértil[®] on the growth and quality of eggplant seedlings. The experiment was conducted in a greenhouse using a randomized block design with eight treatments and six replications. The commercial substrate was Maxfértil[®], a crushed pine bark, with limestone, and seven treatments with increasing proportions of tannery sludge/decreasing urban waste compost (0/100; 10/90; 30/70; 50/50; 70/30; 90/10 and 100/0 v/v). Characteristics of emergence, growth, quality and leaf nitrogen (N) content were evaluated. No difference was found in the emergence of eggplant seedlings among the different treatments used; however, the growth characteristics, quality and N content featured significant effects when the seeds were propagated in alternative substrates. Regression adjustments pointed to an optimal range of 41–49% of tannery sludge associated with urban waste compost for the evaluated characteristics. The strong correlation between SPAD and N content shows its potentiality in detecting N deficiencies in seedlings. The use of tannery sludge residues associated with urban waste compost seems to be an appropriate and sustainable practice for recycling with high agromonic potential.

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eggplant; principal components; propagation; solid residues; sustainability

Introduction

In the vegetable production chain, seedling production is one of the most important steps as it directly influences the production and final quality of the plant. Thus, besides providing support to the plant, the substrate must have adequate conditions of moisture, macro and microporosity, nutrient and water availability (Sales et al. 2017). For the production of an appropriate substrate it is desirable to gather materials with different characteristics, in order to achieve better quality

seedlings and healthy roots as the formation of larger roots allows the seedlings to better exploit the substrate, allowing greater water and nutrient absorption (Souza et al. 2013; Costa et al. 2013).

Studies on the use of different residues have pointed to new sources of raw material for the production of seedlings of different species, such as vegetables and trees (Ünal 2015; Araújo et al. 2016; Quartezeni et al. 2018a; Guisolfi et al. 2018), making it necessary to study new substrates in order to evaluate the viability of such products. According to Berilli et al. (2016), the use of organic residues of industrial or urban origin in the production of seedlings may be an appropriate method to reduce their polluting effect, besides being a low-cost and highly efficient organic compound.

Among the various industrial activities developed in Brazil that generate waste, leather tanning is one of them. Leather goes through a process that requires the use of mechanical and chemical methods, generating large amounts of effluents with the possibility of an over production of chromium and sodium. However, it is a material that has high organic and mineral load with great potential for use in farming, especially in the production of substrates (Malafaia et al. 2014; Berilli et al. 2018a).

Another residue that has become a major social and environmental issue is urban solid waste. According to the Brazilian Association of Public Cleaning and Special Waste Companies (Abrelpe, 2018), in 2017, each Brazilian generated around 1035 kg/day of urban solid waste, which is equivalent to approximately 214,868 t/day of waste all over the Brazilian territory, so alternatives are necessary for its correct destination. However, this compost increases the phyto-availability of phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg), as well as the pH of CEC by reducing potential soil acidity, making the use of this compost a cost-effective option to replace or reduce the amount of chemical fertilizers, and production costs, as a consequence (Oliveira et al. 2002; Quartezeni et al. 2019).

Eggplant is an important vegetable in the Brazilian trade. This vegetable is commonly known for its nutritional values as well as its medicinal properties for the human diet. Therefore, it becomes a species of interest regarding tests of substrate alternatives for seedling production (Oliveira, Hernandez, and Assis Júnior 2009; Foo et al. 2018). Thus, the objective of this work was to evaluate the effect of different proportions of tannery sludge and urban waste composting on seedling emergence, development and quality, as well as to identify an ideal range of mixtures between tannery sludge and urban waste composting.

Material and methods

Study area location

The experiment was carried out at the Federal Institute of Education, Science and Technology of Espírito Santo – Alegre *campus*, in the municipality of Alegre, southernmost of Espírito Santo state, Brazil, located within the geographic coordinates: latitude 20°45'44" S, longitude 41°27'43" W, 134 m above sea level. Koppen's climate classification for the region is Cwa, with dry winter and rainy summer.

Experiment design and characterization of the residues

The experiment was conducted in a greenhouse using a randomized block design with eight treatments and six replications, each plot consisting of eight plants, totaling 64 plants per block and a total of 384 plants in the experiment. One treatment used commercial substrate brand Maxfertil® as a control (CS), which is made up of crushed pine bark, the other treatments, seven in total, used an increasing proportion of tannery sludge (TS) and decreasing proportion of urban waste

Table 1. Description of the treatments with different proportions (v/v) of farming waste in the substrate and commercial substrate.

Waste	Proportion (%)							
	CS	UC	TS10	TS30	TS50	TS70	TS90	TS
C. substrate ^a	100	0	0	0	0	0	0	0
Tannery sludge	0	0	10	30	50	70	90	100
Urban w. compost ^b	0	100	90	70	50	30	10	0

^aCommercial substrate.^bUrban waste compost.**Table 2.** Chemical characteristics of the urban waste compost (UC), tannery sludge (TS) and commercial substrate (CS) used at different concentration in the evaluated treatments.

Mat	pH CaCl ₂	OM ¹ g kg ⁻¹	OM ²	C-org	N	P	K	Ca	Mg	S	Cr	Na	B	C/N
UC	7.30	505.2	415.4	230.0	24.9	12.9	18.1	40.7	5.1	5.2	0.036	6.3	0.039	9/1
TS	7.28	328.6	305.7	169.8	18.2	7.6	3.8	208.4	21.3	46.0	17.5	28.0	0.059	9/1
CS	5.78	533.3	509.4	283.0	10.8	6.9	5.3	9.0	3.6	2.2	0.047	0.2	0.010	26/1

Mat, material; pH, hydrogen potential; OM¹, total organic matter; OM², compostable organic matter; C-org, organic carbon; N, nitrogen; P, phosphorus; K, potassium; Ca, calcium; Mg, magnesium; S, sulfur; Cr, chromo; Na, sodium; B, boron; C/N, carbon/nitrogen rate.

compost (UC) (TS/UC – 0/100; 10/90; 30/70; 50/50 70/30; 90/10 and 100/0 v/v), as described in Table 1. The experiment was irrigated through an automated micro-sprinkler system, keeping the substrate always close to field capacity.

Residues used in the substrate were the commercial substrate (Maxfértil[®]), commonly used by farmers, bovine tannery sludge and urban waste compost used as an alternative source of substrate. The tannery sludge was obtained from the bovine leather process, provided by the company Capixaba Couros LTDA ME, located in Baixo Guandu, Espírito Santo state. The urban waste compost was obtained from the Urban Solid Waste Sorting and Composting Plant of the Secretariat of the Environment of the Municipality of Montanha, state of Espírito Santo. The materials were sent for chemical analysis at the private laboratory of Agronomic and Environmental Analysis – FULLIN, located in Linhares, state of Espírito Santo, and the results are shown in Table 2.

Evaluated characteristics

Planting was carried out using Berinjela Embú (*Solanum melongena* L.) cultivar seeds, produced by Tecnoseed[®], with a 95% emergence rate and emergence time between 7 and 10 days. Sowing was performed using three seeds per cell and thinning 20 days after sowing. Counting the total plants in each treatment was carried out to determine seed emergence rate, and then thinning, leaving only one plant per tray cell.

At 42 days after planting, emergency, plant height, stem diameter, canopy diameter, number of leaves, leaf area, dry mass of the aerial part, root dry mass and total dry mass, leaf nitrogen content and SPAD index were analyzed. Seedling evaluation was carried out using a graduated ruler, digital caliper, precision scale and green intensity meter – SPAD 502 Plus Chlorophyll Meter. Dry matter was determined by weighing the material dried in a forced circulation oven at 65 °C for 48 hr. Nitrogen (N) analysis followed the Kjeldahl methodology described by Bremner (1996) and leaf area measurement, the digital image vectoring methodology, obtained by the AutoCAD[®] 2016 computer software. After obtaining the data, seedling quality was evaluated by calculating the Dickson Quality Index, following Eq. (1)

$$DQI = \frac{TDM}{\left(\frac{PH}{SD}\right) + \left(\frac{DMAP}{RDM}\right)} \quad (1)$$

where DQI = Dickson Quality Index; TDM = total dry matter (g); PH = plant height (cm); SD = stem diameter (mm); DMAP = dry mass of the aerial part (g); RDM = root dry mass (g).

Data analysis

Prior to the analysis of variance, the assumption of normality of errors and homogeneity of variance was verified through Shapiro–Wilk and Bartlett tests, respectively. The data were submitted to analysis of variance and by Dunnett test $p < .05$ for the different treatments compared to the commercial substrate.

Subsequently, we unfolded the regressions comparing the proportions of tannery sludge and urban waste compost (TS/UC), in addition to performing simple correlation analyzes between the variables. Equations were selected based on the significance of the models, their biological significance and the coefficient of determination. In order to determine the influence of the proportions of the residues, multivariate analysis was also performed using the principal components. The entire statistical procedure was performed through the open source software R.

Results and discussion

Comparisons with the commercial substrate

The analysis of the experiment data allowed to observe differences in the development of *S. melongena* L. eggplant seedlings for all evaluated characteristics, except for emergence that did not present a significant result, when comparing the different treatments with the commercial substrate (Tables 3 and 4). The average emergence rate was 60.9%, which is less than 95% indicated by the manufacturer. According to Tillmann (2010) and Lins et al. (2015), this may be associated with the fact that commercial seeds are tested by manufacturers in laboratories, and when they are taken to greenhouses, it is common the occurrence of unevenness and lower percentage of seed emergence because they are not in a complete controlled environment like the one they were tested.

The characteristics plant height, canopy diameter, stem diameter, leaf area, number of leaves and N content showed the same response pattern, which was different and superior to the commercial substrate treatment. This may be mainly due to the higher values of N, Ca, Mg and S contained in tannery and urban waste compost and the higher C/N ratio in the commercial substrate treatment (Table 2). Waste with higher carbon concentration compared to N induces a higher N deficiency as its mineralization is generally slow because microorganisms absorb much of the available N, being available only after the mineralization of the material (Cunha, Mendes, and Giondo 2015; Berilli et al. 2017).

Similar results were observed by Berilli et al. (2019), in *Capsicum annuum* L. seedlings, using the commercial substrate Maxfétil[®] compared to a mixture at different proportions (v/v) of tannery sludge and urban waste compost. The authors used increasing proportions of tannery sludge/decreasing urban waste compost (0/100; 10/90; 30/70; 50/50 70/30; 90/10 and 100/0 v/v), and observed that the number of leaves, stem and canopy diameters, root dry matter and dry matter of the aerial part were higher in the alternative residues mix and their individual use than in commercial treatment. The authors, Castoldi et al. (2014), also worked with vegetable seedlings production with alternative substrates comparing the commercial Plantmax HA, in which alternative substrates produced larger and shorter “mimosa” cv. Faloêz Roxane lettuce seedling than commercial substrate. A similar result was observed by Huang et al. (2019), in which they evaluated alternative substrates based on biochar, chicken manure and vermicomposting for tomato and basil seedlings in a greenhouse, with the objective of replacing the commercial peat-based

Table 3. Average values of emergence (EMG), plant height (PH), stem diameter (SD), canopy diameter (CPD), leaf area (LA) and number of leaves (NL) in eggplant seedlings in different substrates.

Treatments ^a	EMG (%)	PH	CPD	SD (mm)	LA (cm ²)	NL
		cm				
CS	54.9	2.1	2.1	0.76	1.2	2.1
UC	67.4 ^{ns}	4.8*	4.1*	1.27*	11.5*	3.9*
TS10	63.9 ^{ns}	5.1*	3.7*	1.33*	10.6*	3.9*
TS30	70.7 ^{ns}	5.7*	4.5*	1.37*	15.2*	4.1*
TS50	63.0 ^{ns}	5.8*	4.9*	1.45*	17.6*	4.3*
TS70	56.2 ^{ns}	5.4*	4.6*	1.38*	18.6*	4.2*
TS90	54.6 ^{ns}	4.3*	3.3*	1.16*	11.4*	3.5*
TS	56.2 ^{ns}	3.4*	3.1*	1.05*	6.6*	3.1*
Mean	60.9	4.6	3.8	1.2	11.6	3.6
Dms	22.0	0.69	0.93	0,15	5,0	0,34
CV (%)	22.3	9.6	15.5	8.1	27.3	5.9

ns, not significant.

^aThe nomenclature from treatments are found in Table 1.

*Mean differ from the commercial substrate (CS) at 5% level ($p < .05$) probability by the test of Dunnett.

Table 4. Average values of nitrogen (N), SPAD, dry matter of the aerial part (APDM), root dry matter (RDM), total dry matter (TDM), Dickson quality index (DQI) of eggplant seedling in different substrates.

Treatments ^a	N	SPAD	APDM	RDM	TDM	DQI * 10 ⁻³
	(g kg ⁻¹)		g			
CS	3.44	17.7	7.7	2.9	10.6	1.95
UC	6.01*	21.3	36.1*	11.8*	47.9*	6.98*
TS10	6.16*	21.1	35.3*	13.2*	48.5*	7.47*
TS30	7.49*	20.5	48.3*	14.6*	62.9*	8.37*
TS50	7.90*	22.0*	58.6*	17.6*	76.1*	10.36*
TS70	8.69*	22.5*	54.5*	17.9*	72.4*	10.42*
TS90	10.25*	30.3*	28.3*	11.0*	39.3*	6.34*
TS	11.01*	31.4*	17.3 ^{ns}	8.0*	25.3 ^{ns}	4.67 ^{ns}
Mean	7.6	23.3	35.8	12.1	47.88	7.1
Dms	1.7	3.9	13.6	5.1	18.23	2.7
CV (%)	11.0	10.8	23.97	26.4	24.0	24.3

ns, not significant.

^aThe nomenclature from treatments are found in Table 1.

*Means differ from the commercial substrate (CS) at 5% ($p < .05$) probability level through the test of Dunnett.

Berger BM7 substrate. Thus, we can see that the substrate mixture favors these development characteristics, therefore contributing to a better seedling production.

N content in plants was higher than commercial substrate and different in all combinations of organic waste (Table 4). This proves that N was less absorbed in commercial substrate treatment, which may be associated with a slow release due to the higher C/N ratio mentioned above, as well as the smaller amount found in the organic waste.

However, in relation to SPAD index (Table 4), there was no difference between the TCRU, TS10 and TS30 treatments when compared to the commercial substrate. As SPAD presents a non-destructive indirect measurement of chlorophyll, it can be said that the higher N content in the TCRU, TS10 and TS30 treatments was not converted to chlorophyll, but to other nitrogenous compounds or even stored as nitrate in the vacuoles. According to Krapp (2015), N is an essential element found in most macromolecules and in many signaling and secondary compounds, including nucleic acids, proteins, cell wall components, hormones and vitamins.

Another significant factor in vegetable production is the dry matter production. In this study, almost all treatments had higher mean values than the commercial substrate, except for the TS, which was equal to the commercial substrate for the dry matter characteristics of the aerial part and total of the plant. Thus, the same response pattern was observed for the DQI, in which the

TS was the same as the commercial substrate, since the calculation of the IQD takes into account the total dry matter and aerial part dry matter.

According to Panda and Choudhury (2005), one aspect that reduces the gain in dry matter in tannery sludge substrates is the high concentration of chromium in this material. According to the authors, this element has the potential to biochemically modify normal plant cells, causing oxidative stress and disturbances in chloroplast ultrastructure, therefore compromising the plant photosynthesis rate. Thus, the TS treatment was equal to the commercial substrate one possibly due to the toxicity of this element, jointly with sodium, found in larger quantities in the tannery sludge (Table 2).

Experiments performed by Quartezeni et al. (2018b) and Sales et al. (2018a) showed that substrates containing tannery sludge show higher flavonoid yields, being a secondary plant defense compound capable of acting as antioxidants, inactivating free radicals. Another limiting reason associated with lower mass gain is the osmotic potential of the soil and root cells, since the sludge has a high sodium concentration (Table 1), which may alter the osmotic regulation of the plant and make it difficult to transport water and solutes to the aerial part, impairing seedling development (Sena, Zaidan, and Castro 2006; Almeida et al. 2017).

Estimates of the best residue combination

Significance was observed in the unfolding of the regressions for all characteristics analyzed, regarding the variations of the proportions of tannery sludge and urban waste compost (Figures 1–3). The regression analyses performed for the characteristics PH, CPD, NL and SD (Figure 1) reveal similar curves between the graphs and show quadratic functions, with coefficients of determination greater than 0.90, except for the CPD which presented 0.81.

For the PH and CPD characteristics (Figure 1A, B), the proportions of tannery sludge that maximized the gain for these characteristics were 41% and 42%, respectively. When NL and SD were evaluated, the proportions that maximized the gain were very close to those previously found, with 42% and 43%, respectively. Thus, the proportions greater than 43% of tannery sludge reduced the characteristics PH, CPD, NL and SD. The rise in the doses of tannery sludge in the substrate may increase the chromium levels in the seedling tissues, causing mesophyll disorganization and chloroplast changes (Berilli et al. 2016, 2018b). Thus, this reduction in growth may be strongly linked to these changes.

For the characteristics of the aerial part and root system dry matter (Figure 2A, B), it was observed that the proportions that maximized the gain were 46% and 47%, respectively, while for the total dry matter of the plant (Figure 2C) the rate that maximized the gain was 44% presenting 71.8 mg. The same response pattern was observed for DQI, and the use of 44% tannery sludge and 56% urban waste compost mixture maximized seedling quality gain.

Thus, it can be seen a reduction in gain of the dry matter of the aerial part greater than 47% of tannery sludge in the substrate, due to a possible toxicity caused by chromium and sodium elements. However, when evaluating total dry matter and seedling quality, the maximum value that can be used without reducing carbon gain and quality is 44%. According to Silva et al. (2015), the increase in tannery sludge doses causes changes in the contents of potentially toxic elements and may be one of the causes that hindered the development of seedlings at the higher doses of tannery sludge.

The leaf area and SPAD characteristics were quadratically adjusted, while the N content was adjusted by first degree linear regression (Figure 3). It can be observed through the estimation equation, that the proportion that maximized the gain in leaf area was 49% and tanning sludge mixed with 51% of urban waste compost in which it obtained a value of 18.1 cm². For the N content, it is observed that the tanning sludge increment always resulted in higher values.

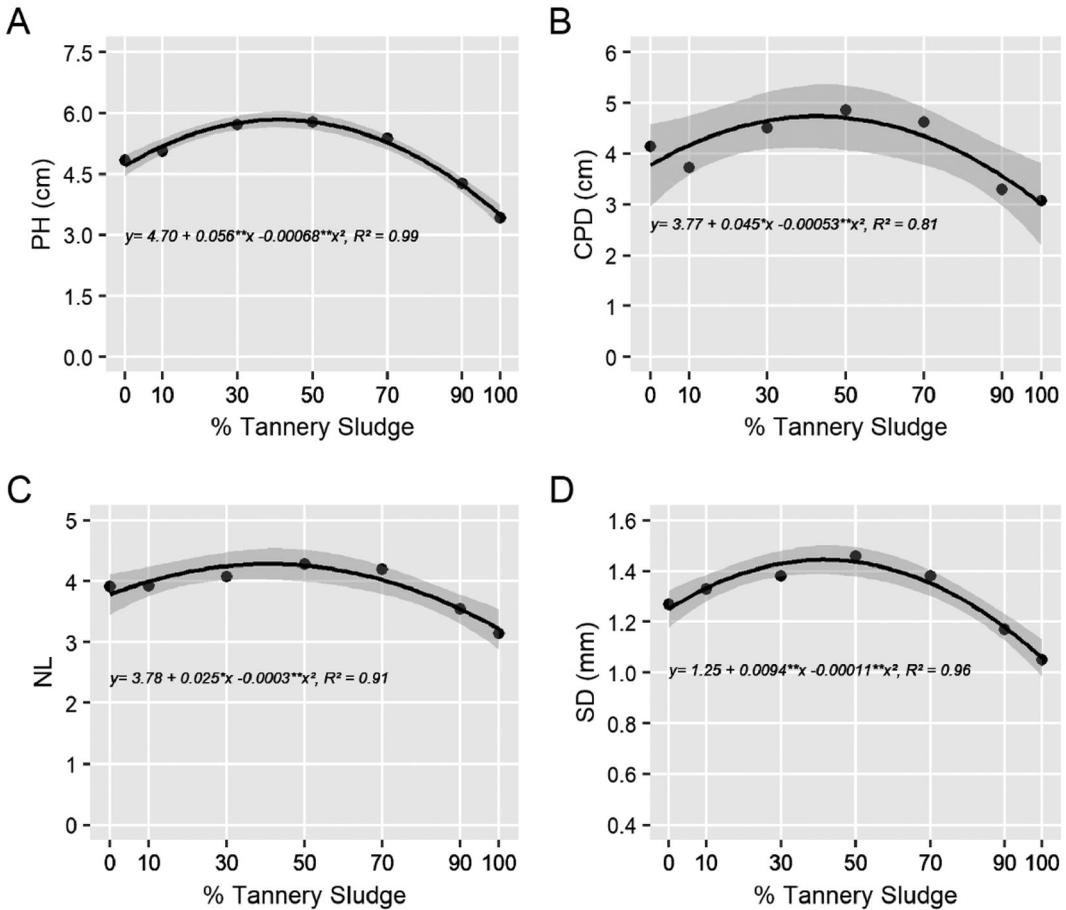


Figure 1. Regression for the characteristics plant height (PH, A), canopy diameter (CPD, B), number of leaves (NL, C) and stem diameter (SD, D) according to the different proportions of tannery sludge and urban waste compost. Shadow line is the 95% confidence interval around regression line. Significant at * $p < .05$; ** $p < .01$.

This residue contains high N content, which confers high potential in farming. However, the use of alternative waste mixtures with tannery sludge is very important as it assists in stabilizing organic matter as some plants cannot withstand the high loads of dissociated elements or the salinization caused by this residue (Berilli et al. 2018c). Thus, even if the combination of other organic residues with the tannery sludge is able to reduce the N content in the sample, the benefits to plants from this combination are increased, as seen in this paper, where for all growth and yield characteristics, the best adjustments were quadratic, so the ideal proportion of the mixture could have been estimated.

Based on the evaluated characteristics, a scheme was set up to identify the proportions that maximized the gains (Figure 4). Thus, it can be seen that the proportions that maximized the gain for these characteristics ranged from 41% to 49% of tannery sludge, complemented by the urban waste compost, which is considered the interval of interest for eggplant seedling production.

Through this scheme, it can be stated that tannery sludge values less than 41% in the production of eggplant seedlings may reduce the gain in growth characteristics due to lack of nutrients, while values greater than 47% can attribute a reduction in growth characteristics due to over values of chromium and sodium present in the tannery residue. Thus, by considering the high cost

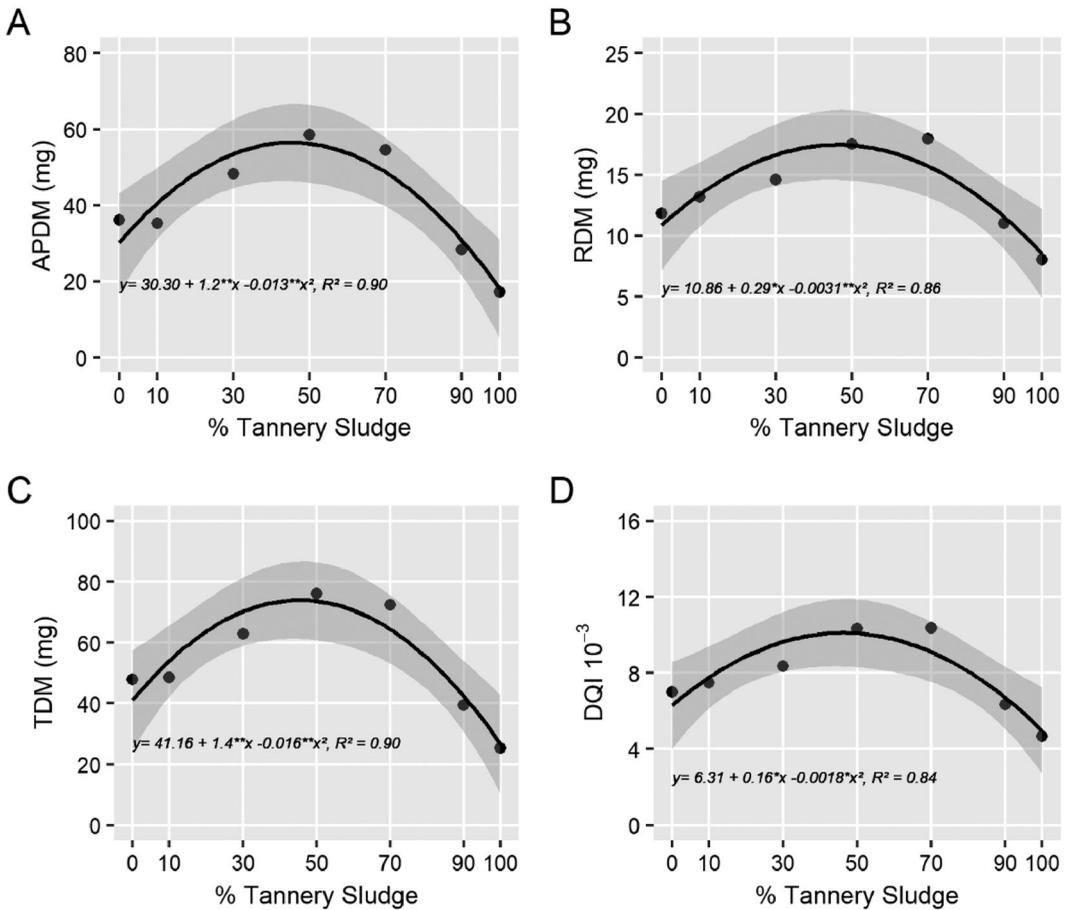


Figure 2. Regression for characteristics of the aerial part dry matter (APDM, A), root dry matter (RDM, B), total dry matter (TDM, C), Dickson quality index (DQI, D) as a function of different proportions of sludge tannery and urban waste compost. Shaded line represents the 95% confidence interval around the regression line. Significant at * $p < .05$; ** $p < .01$.

of farming inputs, the study of tannery sludge and its application is important, as it can be an attractive alternative for fertilization, increasing productivity and reducing production costs (Malafaia et al. 2016; Sales et al. 2018b).

Correlation matrix and principal components

When the data were correlated (Pearson correlation) to verify the existence of association between the variables, interesting results were observed (Figure 5). A significant correlation ($p < .05$ and $p < .01$) between all the evaluated growth variables in which they were positive, except when compared with SPAD and N content, where these variables were significant only in some cases.

The SPAD showed a high and positive correlation ($r = 0.75$) only with leaf N content, since N is part of chlorophyll pigments. In summary, the SPAD device measures the leaf greenness index, which correlates with chlorophyll content. The high correlation between N and chlorophyll (SPAD) content in the leaves of eggplant seedlings shows the possibility of using the non-destructive practice of chlorophyll indirect measurement by portable chlorophyll meter to estimate the leaf N content of the seedlings. Eggplant chlorophyll readings may therefore be useful in detecting N deficiencies.

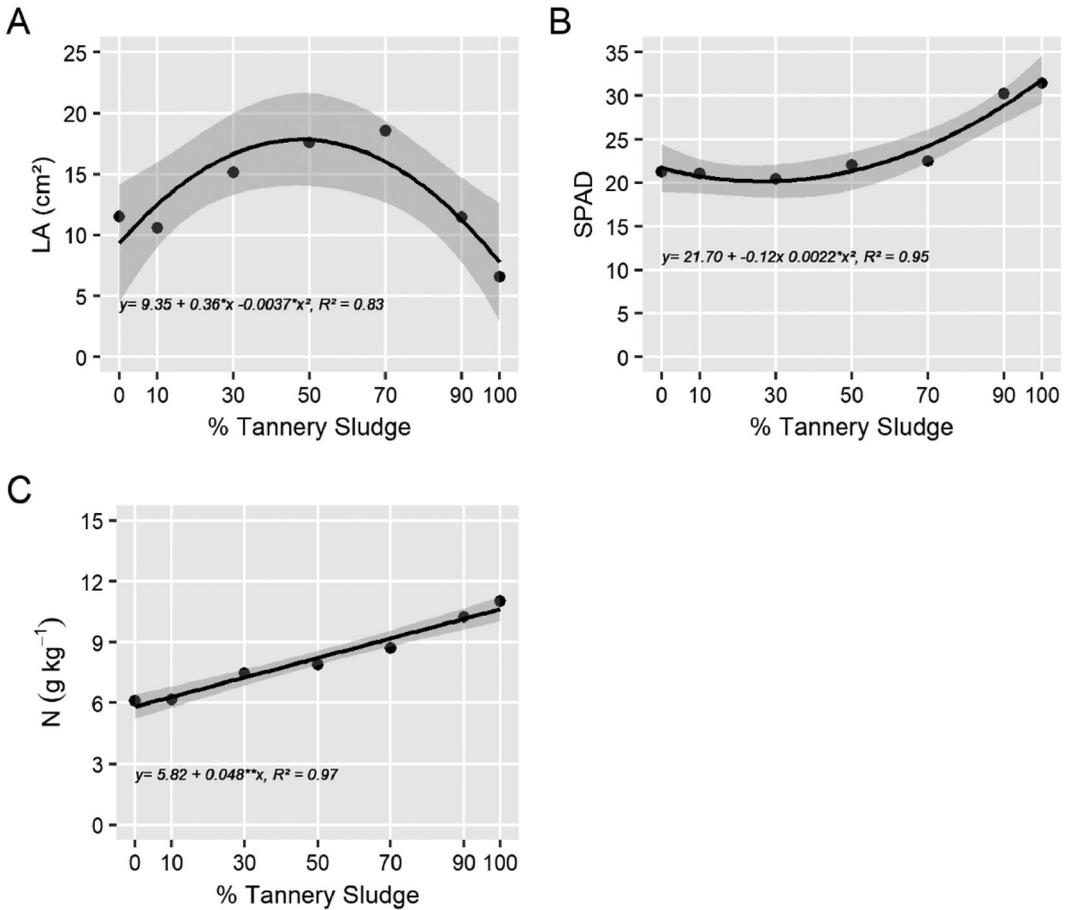


Figure 3. Regression for leaf area (LA, A), SPAD (SPAD, B) and N (N, C) content as a function of the different proportions of tannery sludge and urban waste compost. Shaded line is the 95% confidence interval around the regression line. Significant at * $p < .05$; ** $p < .01$.

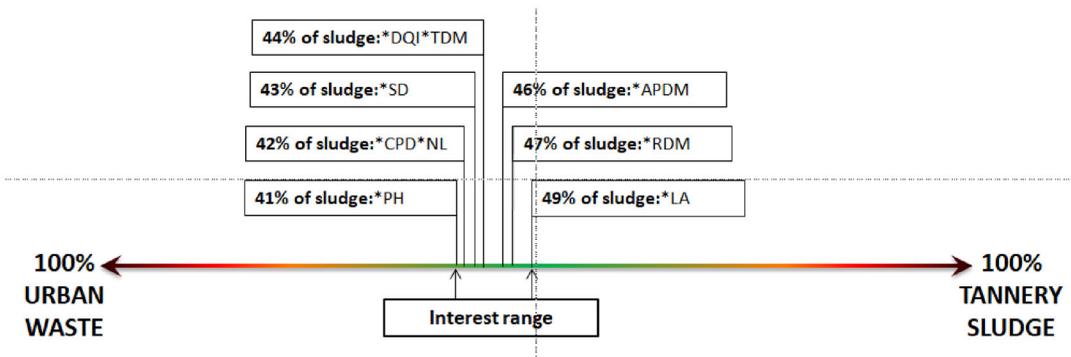


Figure 4. Scheme showing the interval of the estimated maximum points.

According to Reis et al. (2006), chloroplasts can present up to 70% of N of mesophilic cells. Values close to those found in this experiment were observed by Dantas et al. (2012) in *Theobroma cacao* crop, with significant and positive correlation ($r = 0.74$) between SPAD index and leaf N content.

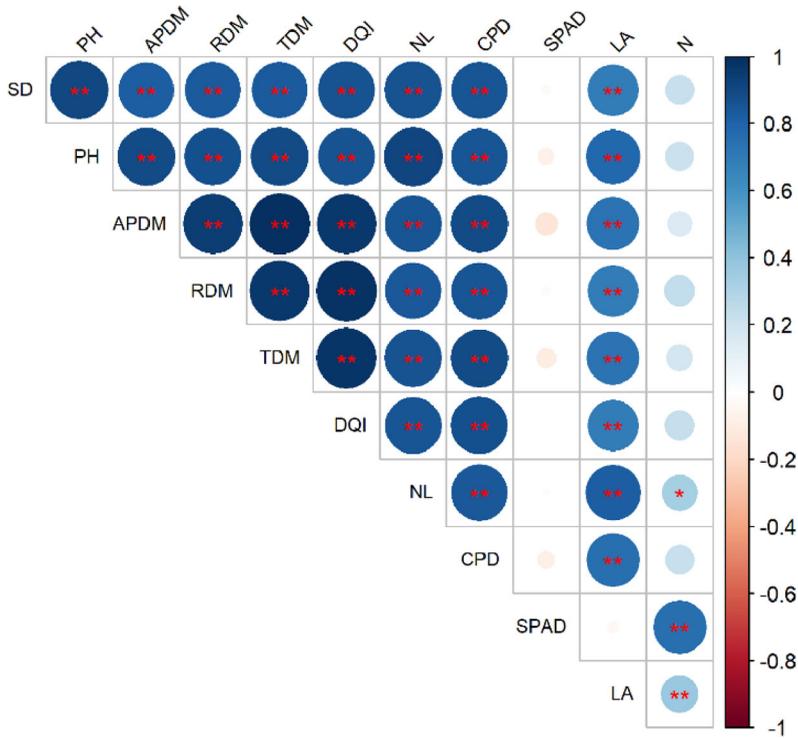


Figure 5. Association (Pearson correlation) between all evaluated variables. Significant at * $p < .05$; ** $p < .01$.

High correlations indicate direct effect between the analyzed variables, indicating cause and effect. However, the correlations between growth variables and SPAD were not significant, indicating no effect between them. The same occurred with the N content, which correlated only with the SPAD, NL and LA. However, the correlations between growth variables and SPAD were not significant, indicating no effect between them. The same occurred with the N content, which correlated only with the content of N, NL and LA.

The relationships between growth and quality of the seedling and the different proportions of tannery sludge and commercial substrate treatment can be visualized from the principal component analysis (PCA). Figure 5 reports ordering biplotation of PCA output modeling. Data variability was explained in 72.2% in axis 1 and 16.0% in axis 2, totaling 88.2% of total data variability (Figure 6). In the first principal component, the variables that most influenced the growth and quality of eggplant seedlings were TDM, APDM and DQI ($r = 0.970$, 0.963 and 0.962 , respectively). For the second principal component, strong correlations were observed in the principal component scores for the SPAD with 0.943 and for the N content with 0.906 .

The analysis of axis 1, referring to the first principal component shows a clear separation between the groups. Treatments CS, TS and TS90 are found on the left side of the vertical line passing through zero. However, this group is still divided on axis 2, where it can be seen that the commercial substrate (CS) did not correlate with any variable corroborating the univariate statistics results. The other variables are axis 2 in the first principal component.

Treatments containing 90% and 100% tannery sludge were closely associated with SPAD and N. This is mainly related to the amount of N in the tannery sludge (Table 2), where it was responsible for increasing leaf N contents and SPAD. Nevertheless, these higher doses were not beneficial in the other growth variables analyzed, which is in line with the regression estimates of tannery sludge doses, in which the range for optimum gain of characteristics ranged from 41% to 47% of tannery sludge, supplemented by urban waste compost residue. As observed by Caldeira

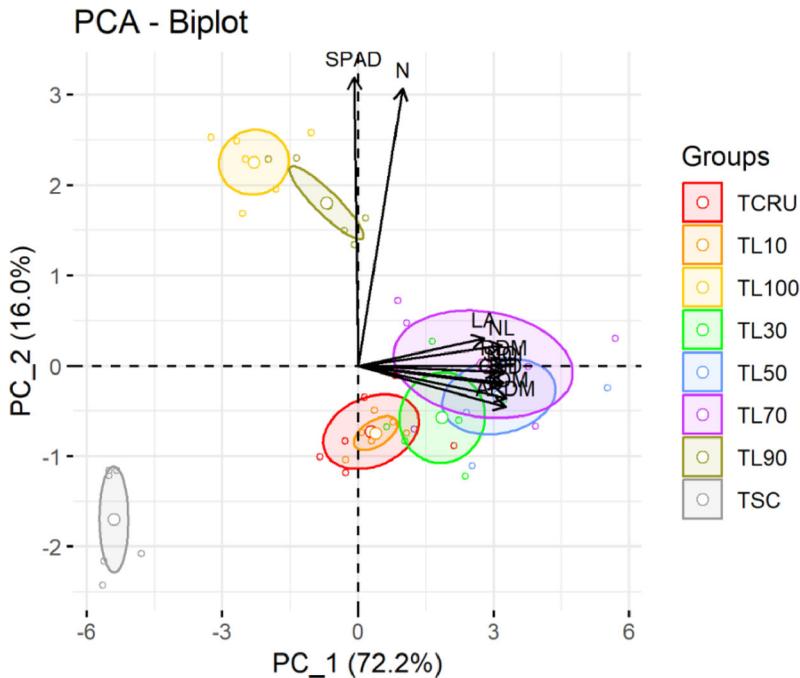


Figure 6. Principal component analysis of variables associated with the growth and quality of eggplant seedlings grown on different substrates. Plant height (PH), canopy diameter (CPD), number of leaves (NL), stem diameter (SD), N content (N), leaf area (LA), Dickson quality index (DQI), aerial part dry matter (APDM), root dry mass (RDM) and total dry matter (TDM).

et al. (2018), the joint analysis of the effects of substrates on morphological characteristics is important because it allows to group the treatments according to their growth performance.

Conclusion

The data supported the conclusion that the urban waste compost residue is a suitable conditioner to be used together with tannery sludge in the substrate for the production of eggplant seedlings. The growth and quality of eggplant plants evaluated on alternative tannery sludge and urban waste compost substrates were superior to commercial Maxféertil[®], except that emergence was the same, becoming a viable alternative in seedling production. The use of principal components was efficient in grouping the treatments according to their growth response, showing a strong association of treatments with 90% and 100% tannery sludge with leaf N content and SPAD index, and no association of commercial Maxféertil[®] with the evaluated characteristics. The interval for the use of tannery sludge in preparing eggplant seedling substrates is between 41% and 49% associated with urban waste compost.

Authors' contributions

Authors 2, 3, 5 and 6 made the field collections. Authors 2 and 4 performed the statistics and wrote the manuscript. Authors 1, 7 and 10 performed the writing and supply of the materials used to develop the research. Authors 8 and 9 performed the preparation of substrates. All authors read and approved the final manuscript.

Conflict of interest

No conflict of interest was reported by the authors.

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