Original Research Article

USE OF TANNERY SLUDGE AND URBAN COMPOST AS A SUBSTRATE FOR SWEET PEPPER SEEDLINGS

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ABSTRACT

There are many commercial substrates available in the market of vegetables nowadays. However, a growing pressure turned for sustainability in farming, promotes a line of utilization of waste with agricultural potential, such as the use of urban waste compost and tannery sludge, which, when available, can be used as sources of compost and alternative organic matter. The objective of this study was to evaluate the potential of tannery sludge associated with the urban waste compost in the substrate composition of sweet pepper seedlings, especially regarding emergence, development, and quality of seedlings. The experimental design was a randomized block design with six replications and eight treatments. The treatments consisted of mixtures of the residue of dehydrated tannery sludge and urban waste compost, varying in the proportions of 10%, 30%, 50%, 70%, 90% and 100% of each, as well as the use of a commercial substrate as a conventional treatment for the comparisons. Graphs were performed through linear regression analysis for the treatment of statistical data. The percentage of emergence, development, and quality of seedlings were evaluated 54 days after planting. The alternative substrates showed high potential in the production of seedlings, in which all the combinations used in the

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study were superior to the conventional treatment, except the germination, which did not present difference. The range for the use of tannery sludge in the preparation of substrates for sweet pepper seedlings is between 32.7 and 48.2% in a mixture with urban waste compost. The plants presented better quality with the use of 46.0% of tannery sludge and 54.0% of urban compost in the preparation of the substrate.

Keywords: *Capsicum annuum L.,* propagation, sustainability, waste

1. INTRODUCTION

Farming and industrial practices such as the overuse of agrochemicals, waste generation, and disposal, poor soil, and irrigation management may degrade soil and contaminate water resources and the atmosphere. In this context, there is a growing global concern associated with interrelated environmental issues such as soil degradation and erosion, desertification, urban waste management as well as the greenhouse effect and climate change [1,2].

Intensive farming and agroindustrial activities generate large amounts and different types of organic waste [3]. The production of these urban and industrial organic wastes is widespread. Therefore, strategies to recycle such composts in agriculture must be developed.

For the reuse of waste in agriculture, biological processes such as composting have been widely practiced, converting such waste into fertilizers rich in nutrients and soil amendments [4]. This composting process is the spontaneous biological decomposition of organic waste in an aerobic environment [5].

Other residues such as bovine tannery sludge is a potential agricultural fertilizer as it is rich in several essential nutrients for vegetables. Moreover, its benefit has been reported by several researchers [6-8]. Considering the high cost of agricultural inputs, this would be an attractive alternative in soil fertilization, therefore, promoting higher productivity and lower costs [9].

One of the destinations that have been explored for the use of such residues is in the preparation of substrates in the most diversified crops, as observed in studies carried out by Berilli et al. [10] and those used in conilon coffee seedlings by Sales et al. [11] and in *Schinus Terebinthifolius* Raddi and in the culture of *Thymus zygis* [12]. Such waste becomes very advantageous, thus economically contributing and reducing the environmental impact, especially in regions near industries that produce such waste [13].

Sweet pepper (*Capsicum annuum* L.) is a vegetable that belongs to the *Solanaceae* Family. It shows excellent economic relevance and is highly consumed in Brazil, with an estimated annual crop area of 13,000 hectares [14]. Although studies on the use of tannery sludge and urban compost in several crops have been found in the literature, there is still scarce information on the use of these sludge in such vegetable species as the sweet pepper.

Hence, the objective of this work was to evaluate the potential of tannery sludge associated to the urban waste compost in the substrate composition of sweet pepper seedlings, especially regarding emergence, development, and quality of seedlings.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

The experiment was carried out at the Federal Institute of Education, Science and Technology of Espírito Santo - Alegre Campus, located in the municipality of Alegre, state of Espírito Santo. The climate in the region is Cwa according to the classification of Köppen, that is, tropical hot humid, with cold and dry winter [15,16]. The experimental design used in

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the study was in randomized blocks, with six replications and eight treatments, each experimental plot had eight seedlings, in a total of 64 seedlings per replicate and 384 in the whole experiment.

The species used for the experiment was *Capsicum annuum* L., in which was used Cascadura Ikeda variety seeds of Feltrin ® Company, presenting 80% emergency as informed by the company. Sowing was carried out on a 64-cell polypropylene tray, in which each tray represented a repetition. The substrate used was the mixtures of urban waste compost and tannery sludge. Maxfertil® commercial substrate was also used (Table 1).

Table 1. Description of the treatments used in this experiment (v/v).

Treatments	Component of the substrate
TC	100% Comercial substrate (Maxfertil)
TUC100	100% Urban compost
TSC0	10% tannery sludge + 90% urban compost
TSC30	30% tannery sludge + 70% urban compost
TSC50	50% tannery sludge + 50% urban compost
TSC70	70% tannery sludge + 30% urban compost
TSC90	90% tannery sludge + 10% urban compost
TSC100	100% tannery sludge

The tannery sludge was supplied by a tannery located in the municipality of Baixo Guandu, state of Espírito Santo. It is a residue from the effluent from bovine leather tanning after dehydration. The urban waste compost was supplied by an urban solid waste composting and sorting plant of the city of Montanha, state of Espírito Santo. The chemical properties of each substrate component are described in Table 2.

Table 2. Chemical characteristics of each substrate used for sweet pepper seedling growth.

Parameter	Unit	Urban compost	Tannery sludge	Commercial (Maxfertil)
pH in $CaCl_2$	-	7.30	7.28	5.78
TOMT	%	50.52	32.86	53.33
OMC	%	41.54	30.57	50.94
Organic Carbon[1]/	%	23.08	16.98	28.3
C/N ratio	-	9/1	9/1	26/1
Nitrogen (N)[2]/	g dm^{-3}	24.90	18.20	10.80
Phosphorus (P_2O_5)[3]/	g dm^{-3}	12.90	7.60	6.90
Potassium (K_2O)[3]/	g dm^{-3}	18.10	3.80	5.30
Calcium (Ca)[3]/	g dm^{-3}	40.70	208.40	9.00
Magnesium (Mg)[3]/	g dm^{-3}	5.10	21.30	3.60
Sulfur (S)[3]/	g dm^{-3}	5.20	4.60	2.20
Iron (Fe)[3]/	g dm^{-3}	8.70	1.40	8.30

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Zinc (Zn)3/	mg dm^{-3}	119.20	76.00	39.70
Copper (Cu)3/	mg dm^{-3}	32.50	9.50	26.50
Manganese (Mn)3/	mg dm^{-3}	160.00	71.80	326.60
Borum (B)4/	mg dm^{-3}	32.50	59.00	10.40
Sodium (Na)3/	mg dm^{-3}	6,300.00	20,800.00	200.00
Total Chrome (Cr)3/	mg dm^{-3}	0.03	17,500.00	0.04

OMC: Compostable Organic Matter; TOM: Total Organic Matter; Results in dry matter basis (mass/mass); 1/ potassium dichromate oxidation; 2/ Sulfur digestion; 3/ Nitro-perchloric digestion; 4/ Dry digestion.

Regarding the execution of the experiment, propagation trays with 128 cells each were used, so that three seeds per cell were added to the substrate, and the trays were kept in a greenhouse covered with translucent polypropylene material followed by shadow type screen with 50% light and a platform located at 70 cm from the ground. Micro-sprinkler irrigation was performed twice a day until the end of the experiment.

Thinning was performed 17 days after the emergency, leaving only one plant per cell. After the thinning, the number of leaves and height of the seedling were monitored. The evaluations were carried out 51 days after planting, in which the following variables were analyzed: Emergency (%); Plant height (PH); Number of fully expanded leaves (NL); Leaf area (LA) in cm²; Stem diameter (SD) in mm; canopy diameter (CPD) in cm; dry matter mass of the aerial part (APDM), root dry matter mass (RDM) and total dry matter mass (TDM) in grams. Dry matter was determined by the gravimetric method in a greenhouse with forced air circulation at 65 ºC for 72 hours, weighed with the aid of a precision analytical balance.

For determination of seedling quality, the Dickson quality index (DQI) [17] obtained by using the following equation:

$$DQI = [(TDM) / (PH/SD + APDM/ RDM)].$$

The indirect chlorophyll meter model SPAD-502 - Minolta brand was used in the leaves of the sweet pepper seedlings. The analytical measurement of total nitrogen in the samples was also carried out by the Kjedahl method, according to the methodology adapted by Galvani & Gaertner [18]. For measurements of the leaf area and perimeter of the seedlings, the leaves of each seedling were photographed, and with the aid of the AutoCAD® software, they were vectorized, and then each of the respective parameters was measured.

The data obtained in the study were submitted to analysis of variance using the Dunnett test at 5% probability. When significant, regressions with the proportions of sludge mixed with urban waste compost were unfolded. The complete statistical procedure was performed with the help of the open source software R.

3. RESULTS AND DISCUSSION

By observing the data of this experiment, it can be found that out of all the evaluated characteristics, only the emergence of the plants did not present statistical any difference. The other characteristics were affected by the treatments (Tables 3 and 4). As a result, it was observed that the residues used in the study did not affect the emergence of the pepper plants since no difference was when compared to the commercial Maxfertil substrate (Table 3). According to Almeida et al. [19], high emergency values result in lower production costs, as fewer losses caused by the inputs are found.

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The characteristics stem diameter, canopy diameter and number of leaves showed the same response pattern (Table 3), in which all treatments differed from the conventional treatment, with values higher than it. This lower result of the conventional treatment may be related to the more considerable amount of nitrogen from the tannery sludge and urban compost. In addition, a higher C/N ratio is found in the conventional Maxfertil treatment (Table 2), which may have resulted in lower N release for plants. Residues with a higher concentration of C in relation to the nitrogen results in a greater N efficiency as its mineralization is usually slow because the microorganisms absorb most of the available N, which is made available only after decomposition of the material [20,21].

Plant height and leaf area (Table 3) displayed differences when compared to the conventional treatment, except for TSC100, in which the substrate was made using 100% dehydrated tannery sludge. The largest leaf area was obtained with the TSC30 treatment, 17.85 cm², which is higher than the TC in more than 1000%. The use of organic residues in substrates can promote relative gains in the leaf area of the plants, as observed by Silva et al. [22], using doses of bovine manure in the cultivation of pepper (*Capsicum frutescens* L.).

Table 3. Means of stem diameter (SD), plant height (PH), canopy diameter (CPD), leaf area (LA) and number of leaves (NL) of sweet pepper seedlings grown in the commercial substrate with different concentrations of tannery sludge and urban residue compost.

Treatment	Emergence (%)	SD	PH	CPD	LA	NL
		mm	----------cm----------		cm²	
TC	81.21	1.07	2.29	16.43	1.48	2.00
TUC100	83.33$^{n/s}$	1.70*	4.57*	50.44*	13.52*	4.16*
TSC10	80.55$^{n/s}$	1.65*	4.64*	50.21*	14.71*	4.51*
TSC30	89.58$^{n/s}$	1.73*	5.34*	60.26*	17.85*	5.37*
TSC50	85.42$^{n/s}$	1.78*	5.03*	62.58*	16.12*	5.08*
TSC70	84.20$^{n/s}$	1.63*	4.72*	58.80*	16.16*	5.05*
TSC90	72.22$^{n/s}$	1.41*	3.09*	39.63*	9.94*	3.95*
TSC100	79.57$^{n/s}$	1.32*	2.54$^{n/s}$	33.35*	5.03$^{n/s}$	3.77*
Mean	82.01	1.54	4.03	46.46	11.85	4.24
CV(%)	9.52	5.91	10.19	11.64	33.28	6.97

*Means followed by * in the column are statistically different from each other by the test of Dunnett at 5% (p<0.05) level.*

The use of the urban compost and the dehydrated tannery sludge as a substrate component significantly improved the dry matter mass of the aerial part, root system and total dry matter mass of the plants as observed in Table 4. The same pattern of response is observed with the Dickson quality index, in which all the treatments used in the study were different and superior to the conventional treatment. The quality index of Dickson has been used by several authors to evaluate the quality of seedlings of vegetables and other crops [23,24].

The SPAD index and the content of N accumulated in the leaves showed a similar pattern of response, with values different and superior to the conventional treatment. Consequently, it can be noticed that the urban compost and tannery sludge increased the

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nitrogen content in the plants since these compost are rich in nutrients, especially for nitrogen (Table 2).

Table 4. Dickson quality index (IQD), mass of the aerial part dry matter (APDM), root dry mass (RDM) and total dry mass (TDM), SPAD index and N content in sweet pepper seedlings grown in the commercial substrate and different concentrations of dehydrated tannery sludge and urban residue compost.

Treatment	DQI	APDM	RDM	TDM	SPAD	N
		-------------------g-------------------				g kg^{-1}
TCM	0.003	0.008	0.004	0.012	10.40	0.95
TUC100	0.011*	0.041*	0.017*	0.058*	21.14*	1.47*
TSC10	0.010*	0.043*	0.015*	0.058*	22.96*	1.72*
TSC30	0.015*	0.061*	0.024*	0.085*	23.61*	1.90*
TSC50	0.016*	0.061*	0.024*	0.085*	28.45*	2.21*
TSC70	0.015*	0.060*	0.022*	0.082*	33.20*	2.23*
TSC90	0.010*	0.030*	0.014*	0.044*	34.40*	2.32*
TSC100	0.009*	0.023*	0.011*	0.034*	32.65*	2.26*
Mean	0.011	0.041	0.016	0.057	25.85	1.89
CV(%)	13.74	13.02	14.33	11.30	14.66	12.2

*Means followed by * in the column are statistically different from each other by the test of Dunnett at 5% ($p<0.05$) level.*

At evaluating the stem diameter, plant height, canopy diameter, leaf area and a number of leaves as a function of the different combinations of tannery sludge and urban compost, a quadratic adjustment can be found in all characteristics (Figure 1). In all the evaluated characteristics, it is clear that the conventional substrate presented values below the different combinations between tannery sludge and urban compost, as well as by using 100% of sludge and 100% of urban compost.

The best adjustments are observed in the plant height (Figure 1b) and leaf area (Figure 1d), with values of coefficient of determination of 0.97 and 0.96 respectively. By observing its estimation equation, it can be seen that the proportion that maximized the plant height gain was 36.0% tannery sludge and 64.0% urban compost, showing a maximum height gain of 5.3 cm. However, when the leaf area was estimated, it was observed a value close to that obtained for plant height, in which the proportion that maximized the gain in 17.9 cm^2 of leaf area was through the use of the mixture of 39% tannery sludge and 61% urban compost.

Hence, it was observed that the use of 40% or more of tannery sludge in the substrate provided a reduction in the leaf area, in which this pattern of response can be attributed to the possible toxicities caused by chromium and sodium in this residue (Table 2). As observed in an experiment conducted by Berilli et al. [25], the addition of tannery sludge into the substrate raises the levels of chromium in plant tissues. Moreover, the accumulation of this element in the leaves may impair the normal growth of the plants and reduce the number of parenchyma cells that make up the leaf mesophyll [26].

For the stem and canopy diameters (Figures 1 a, c), the proportions of tannery sludge that maximized the gain for these characteristics were 32.7% and 41.6% respectively. However, when leaf emission (Figures 1 e) was evaluated, this proportion

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showed a slight increase, reaching a maximum emission of 5.3 at the proportion of 48.2% tannery sludge + 51.8% urban compost residue.

Therefore, although the proportion of 48.2% of tannery sludge had presented higher leaf emission, these leaves were smaller than those obtained at tanning sludge doses of 39% as a greater gain in the leaf area was observed in this proportion. The authors Sales et al. [27] found a linear increase in the number of leaves with the application of tannery sludge via leaves in conilon coffee plants, nevertheless, they observed a reduction in the leaf area from the dose that maximized the gain (15.77 mL L^{-1}) which was caused by the reduced leaf size.

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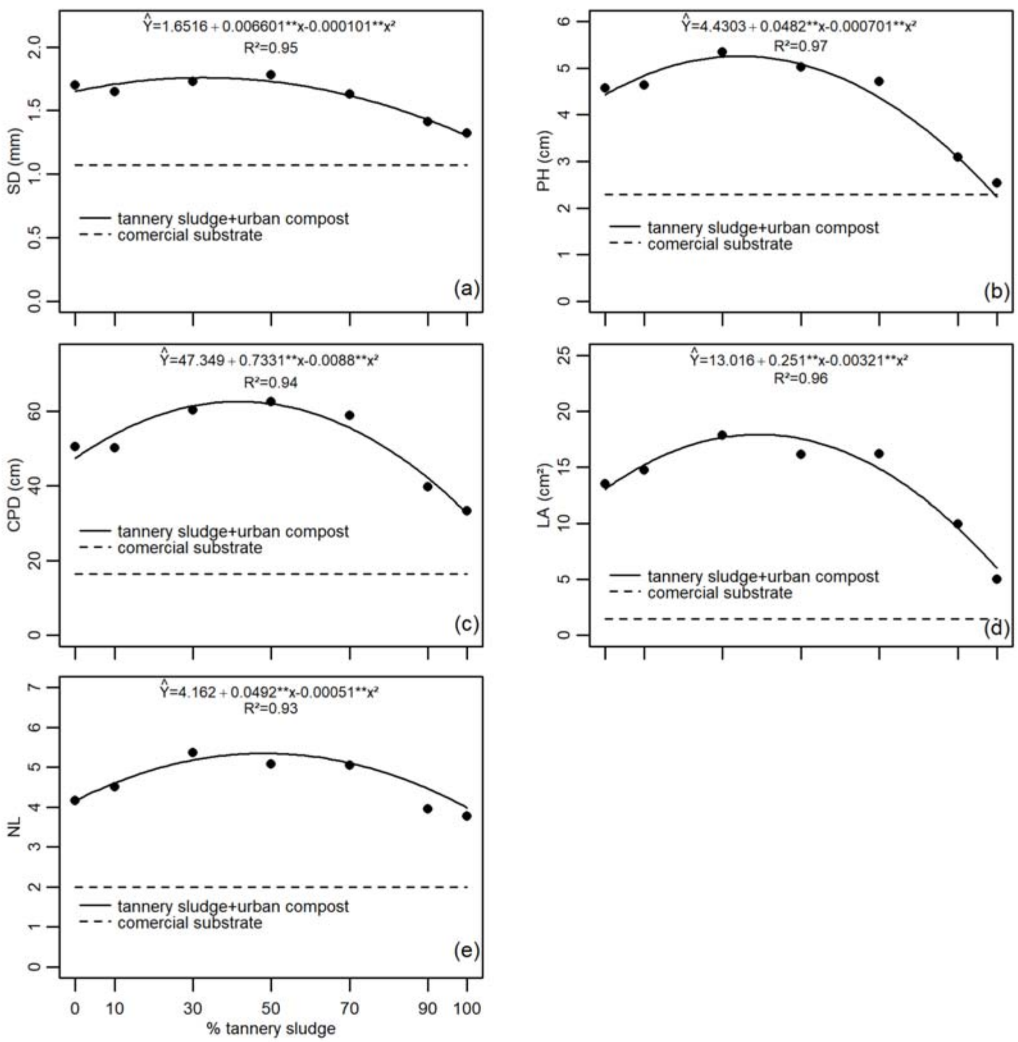

Figure 1. Regression for characteristics of stem diameter (a), plant height (b), canopy diameter (c), leaf area (d) and number of leaves (e) as a function of the different proportions of tannery sludge and urban compost.
*Significant at * p <0.05; ** p <0.01*

In relation to dry matter of the aerial part and the root system (Figure 2 a, b), it was observed that the proportions that maximized the gain were 46.2 and 45.3% respectively, while for the total dry matter of the plant (Figure 2c), the proportion of 44.6% showing 0.087 grams maximized the gain. The same response pattern was observed for the DQI in the which the use of 46.0% tannery sludge + 54.0% urban compost was the proportion that maximized the gain for this characteristic.

As observed by Berilli et al. [10], the use of mixtures of residues with tannery sludge is very important as it helps to stabilize the organic matter since some plants do not withstand the high loads of dissociated elements or the salinization caused by this residue.

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According to the authors, the tannery sludge was stabilized with the use of 30% humus mixed with 30% tannery sludge and 40% soil, showing better quality of coffee plants, with no deleterious effects of chromium and sodium.

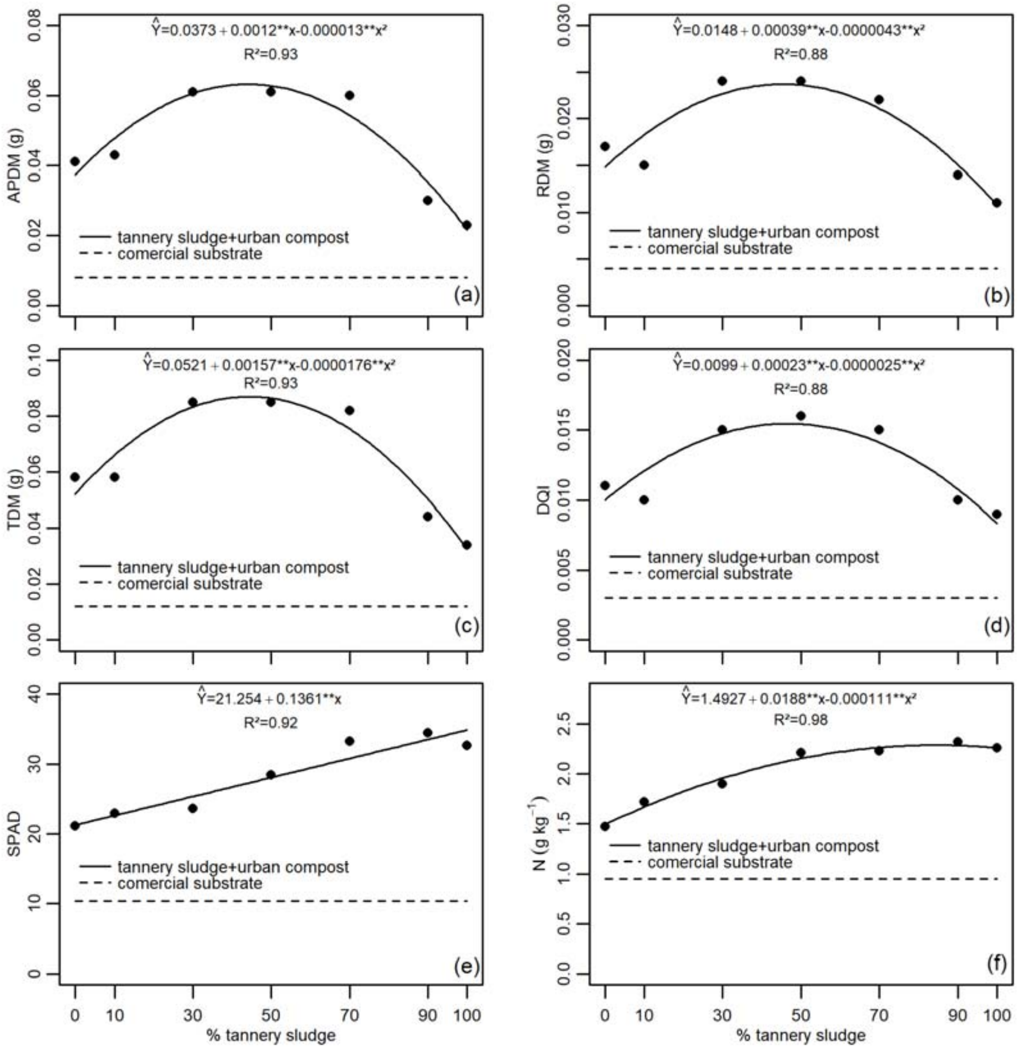

Figure 2. Regression for characteristics of dry matter of the aerial part (a), root dry matter (b), total dry matter (c), Dickson quality index (d), SPAD index (e) and N content (f) as a function of different proportions of urban compost and tannery sludge.
*Significant at * p <0.05; ** p <0.01*

The SPAD index showed a linear gain (Figure 2 e) as the proportion of tannery sludge increased. However, when evaluating N accumulation in the leaves (Figure 2 f), it was found increases up to the proportion of 85% tannery sludge + 15% urban compost. In general, the use of these residues promoted considerable gains in the growth of sweet pepper seedlings when compared to the use of conventional Maxfertil treatment. Also, the growth characteristics evaluated in the study showed a maximum gain within the range from 32.7 to 48.2% tannery sludge mixed with urban waste compost in the preparation of the substrate.

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4. CONCLUSION

The data allowed to conclude that the urban compost residue is an adequate amendment to be used combined with tannery sludge in the substrate for the production of sweet pepper seedlings.

The use of tannery sludge and urban compost residues combined with the substrate did not affect the emergence of sweet pepper seeds and improved the development of the plants when compared to the conventional substrate.

The range for the use of tannery sludge in the preparation of substrates for pepper seedlings is between 32.7 and 48.2% in mixture with urban waste compound, for the preparation of the substrate for pepper plants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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