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Vermicompost of tannery sludge and sewage as conditioners soil with grown tomato#

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The objective was to evaluate the effect of tannery sludge vermicompost in the chemical properties of soil cultivated with tomato and irrigated with wastewater. The experimental design was completely randomized in a factorial 6 × 2, totaling twelve treatments with three replications. The treatments were: four tannery sludge vermicompost (25% Sludge tannery(LC) + manure - T1, 25% Sludge tannery(LC) + rice husk - T2; 50% Sludge tannery(LC) + manure - T3 and 50% Sludge tannery(LC) + cane gray - T4), conventional fertilization (T5) and control (without fertilization - T6) and two types of irrigation water (domestic sewage and class 2 water). The physico-chemical characteristics and chemical soil and vermicompost (fertilizers) were determined before the culture of the installation vessels and after ninety days of driving the tomato crop. The data were submitted to analysis of variance by F test and comparisons between treatment means were performed by 5% Tukey test. In general, concentrations of chemical parameters in the soil after addition of vermicompost have increased, particularly in the addition of T2 = 25% LC + 75% of rice husk and T4 = 50% LC + 50% cane gray. The treated soil demonstrated pH, CEC, organic matter and saturation enhanced base increased, sodium and potential acidity decreased. Thus it can be concluded that vermicompost used can be added to soil conditioners changing the soil chemical attributes positively.

Key words: vermicomposting, chemical attributes, reuse.

INTRODUCTION

The soil conditioners may also cause changes in the pH of the soil, converting the metals in forms not readily available to plants and microorganisms (Hamon et al., 2002). Studies related to the use of conditioners in contaminated soils by heavy metals were mostly developed for temperate soils. In tropical soils, which

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mostly exhibit pH values ≤ 5 and low levels of organic matter and nutrients, especially P, and high content of iron oxides, soil conditioners response with regard to mobility and availability of heavy metals can be distinguished. In Latosols, for example, oxides and Fe hydroxides influence the characteristics of adsorptive soils and consequently the retention of metals (Silveira et al., 2002).The soil salinity levels should be checked, given that sodium is one of the parameters that most interfere in the soil salt content and so it is interesting to ascertain the content of this and other nutrients in the irrigation water as well as on the ground. Under moderate salinity reduction in the yield of tomatoes due to the reduction in the average fruit weight (Cuartero and Munoz, 1999), where as in conditions of high salinity reduction in productivity is a result of the lower number of fruits per plant; the number of bunches per plant decreases only when the irrigation water has a high salt concentration and under long exposure periods. The use of waste (as tannery sludge) by monitoring and management, aims to reduce the environmental impacts, which proposed an agro industrial system and treatment of final waste, as vermicomposting, they may be suggested. The correct management of waste generated can turn waste from one activity to another input, such as tannery sludge to be used in this study. Therefore, it is important to reuse waste for growing vegetables in general such as tomatoes, enabling responsible for production, quality and committed to the concept of sustainable development (Factor et al., 2008), given the importance of adding substances to soil improving growing conditions.

When the final destination is the exposure to soil, this must be done carefully so that there is contamination of the environment. Thus, as arises vermicomposting disposed biotechnology and may result in vermicomposts with high nutritional content. Corroborating the proper disposal of waste that can be reused (such as waste-water), the provision of water in the soil for agronomic purposes, it is a technique that has been used in different countries (Metcalf and Eddy, 1991). This technique has some advantages such as conservation of water, with its wide availability and its ability to enable the intake and nutrient cycling (thus reducing the need for commercial fertilizers), and contribute to the environmental preservation (Hespanhol, 2002), which together with the use of vermicomposts can assist soil conditioners as providing nutrients. It is known that vermicomposting stands out as biotechnology and/or process of bioremediation interesting for the reuse of solid and liquid wastes able to generate material with high agricultural potential, with high potential for reuse is possible. Above all, their use in the processing of tannery waste is still little known, needing therefore assessments that leverages the processing of such waste more noble products from the agricultural point of view as well as a soil conditioner. As the disposal of waste a viable environmental issue that needs more attention, the vermicomposting process combined with the reuse of wastewaters emerge as biotechnology that may have high potential for use and nutritional value for tomato cultivation in Goiás. In this sense, the objective of the experiment was to evaluate the effect of tannery sludge vermicompost in the chemical properties of soil irrigated with waster water and cultivated with tomato.

MATERIALS AND METHODS

The study was conducted between April and July 2015, in a protected environment, experimental area belonging to the Federal Institute Goiano - Campus Urutaí, altitude of 812 m. According to Köppen, Urutaí (GO) is Aw climate with warm climatic conditions, humid to semi-arid, and tropical climate with average annual rainfall of 1402 mm and an average temperature of 23.4°C. The soil used in the experiment was collected in IF-Goiano Urutaí. This is considered in accordance with the classification of EMBRAPA (2006), as Hapludox clay soils. The physico-chemical characteristics and chemical soil and vermicompost (fertilizers) were determined (Tedesco et al., 1995) before the culture of the installation vessels through chemical analysis. The data were interpreted and corrected as 5th approach (Comissão de Fertilidade de Solos de Goiás, 1988). In addition, the data were compared with the technical criteria for organic fertilizer compound, to define the four best vermicomposts (V1, V2, V3 and V4). The initial chemical characterization of the soil and the vermicompost used in the experiment are shown in Table 1.The vermicomposts employed in this study were obtained from the tannery sludge mixture (primary sludge - LC) with the following substrates: V1 = 25% + LC 75% manure; V2 = 25% LC + 75% rice husk; V3 = 50% LC + 50% manure; and V4 = 50% LC + 50% cane gray. The vermicomposting process lasted for a period of 75 days after inoculation of adult individuals of the species *Eisenia foetida*, as described in Cunha et al. (2015).

The water from sewage was obtained from stabilization pond located at the Federal Institute Goiano Campus Urutaí from domestic sewage treatment. The water supply was obtained from water treatment own campus, also located on the premises of the institution. The qualitative analyzes of water were performed at the Laboratory of Inorganic chemistry of the state university of Goiás, Campus Anapolis. The methods of analysis followed the recommendations of the American Public Health Association (2012) and described in Borges et al. (2015). The samples were taken three times during the growing season of the tomato and the results are shown in Table 2. Some of the supply water analysis was used as the results described in Malafaia, (2015).The irrigation scheduling was performed in accordance with Salomão (2012), from mini tank Class A circular in shape, inner diameter 52 cm and height (internal) of 24 cm mounted on a wooden pallet and installed inside the room protected where it was developed this experiment. Irrigated volume daily to keep the water retention capacity of the soil by 70% (243 ml kg^{-1}) during the experiment was based on the vessel area to be irrigated (0.03 m^2) and crop evapotranspiration (ETc), as described in Malafaia (2015). It is noteworthy that the restored water volume was measured in a graduated cylinder. The experimental design was completely randomized (DIC) in a factorial 6 × 2, resulting twelve treatments, with three replicates, totaling thirty-six installments. Each plot consisted of a vase of eight liters and useful volume of six liters, with each pot plant. The soil was placed in the pots and the treatments were added as described in Table 3. The treatments consisted of six substrates (the top four vermicomposts classified according to the fertility parameters V1, V2, V3 and V4, conventional fertilizer - NPK and without fertilization

Table 1. Main characteristics of soil and vermicompost used in grown *Lycopersicum sculentum* (cv. Santa Cruz Kada). Urutaí, GO. Brazil. 2015.

Atributtes	Soil	V1	V2	V3	V4
pH (H_2O)	5.40	8.70	7.17	8.40	8.45
P (dag kg^{-1})	17.00	1.25	0.44	1.31	1.28
K (dag kg^{-1})	0.31	1.40	0.42	1.09	1.60
Ca (dag kg^{-1})	3.30	5.40	4.22	9.26	8.30
Mg (dag kg^{-1})	0.80	0.50	0.15	0.36	0.48
S (dag kg^{-1})	6.00	0.02	0.27	0.42	0.37
B (dag kg^{-1})	0.60	3.50	3.50	39.00	48.50
Cu (dag kg^{-1})	1.40	84.00	18.00	61.00	63.00
Fe (mg kg^{-1})	34.00	112.50	7921.67	124.60	300.00
Mn (mg kg^{-1})	32.00	318.67	492.00	287.33	779.00
Zn (mg kg^{-1})	5.20	124.90	55.63	105.30	35.00
Organic matter (%)	1.60	15.10	29.23	17.60	11.27
Clay (%)	34	-	-	-	-
Silt (%)	19	-	-	-	-
Sand (%)	47	-	-	-	-
V (%)	68.00	-	-	-	-
Na (dag kg^{-1})	50.00	-	-	-	-
H+Al (dag kg^{-1})	2.10	-	-	-	-
CEC (dag kg^{-1})	6.50	-	-	-	-

Legend: (-): parameter not evaluated. The available macro and micronutrient concentrations were evaluated. CEC: cation exchange capacity; Base saturation (V%). V1 = 25% de LC+75% manure; V2 = 25% de LC+75% rice husk; V3 = 50% de LC+50% manure; e V4 = 50% de LC+50% cane gray.

Table 2. Values of qualitative analysis, quantitative and standard deviation domestic sewage and class 2 water, used in the experiment. (Urutaí, GO. Brazil. 2015).

Parameter analyzed	Medium values of water 1/ standard deviation*	Medium values of water 2/ standard deviation*
pH	6.89±0.07	6.74±0.33
Cu (mg L^{-1})	2.49±0.50	1.00[1]
Fe (mg L^{-1})	0.91±0.27	0.68[1]
Na (mg L^{-1})	5.40±0.52	5.25[1]
Mn (mg L^{-1})	1.14±0.31	1.20[1]

Water 1: domestic sewage. Water 2: water class 2. *Values for three replicates for each parameter analyzed. 1Fonte: Malafaia (2015).

- control) and two waters (A1 = wastewater and A2 = class 2 irrigation water). They were randomly distributed and constituted by the combination of the substrate with water, as described in Table 3.

The dose of NPK used in treatments "soil + NPK" (Table 3) was calculated based on the nutritional needs of the crop, the nutrient concentrations in the soil and yield expectation of culture 200 t ha^{-1} as Filgueira (2003). NPK sources were urea, superphosphate and potassium chloride, respectively. The vermicompost doses added to the cultivation soil were calculated based on the concentration of K present in them highly demanded by the tomato crop element being supplied as a single dose 100 kg ha^{-1}. Thus, the following doses of vermicompost were established: Dose A: 18 Mg ha^{-1}; Dose B: 46 Mg ha^{-1}; C Dose: 21 mg h^{-1}; Dose D: 23 Mg ha-1. It is noteworthy that this work top dressing was performed (200 kg ha-1 N split in doses of 50 kg ha-1 at 20, 40, 60 and 80 days after transplanting).

The tomato cultivation was conducted for ninety days and after this period were collected homogeneous three samples with about 300 g of each vessel for subsequent analysis of chemical properties. The data were submitted to analysis of variance by F test and comparisons between treatment means were performed by 5% Tukey test. All statistical analyzes were performed with the aid of SISVAR software (Ferreira, 2011).

RESULTS AND DISCUSSION

The pH levels observed in Table 4 demonstrate increase of this parameter after addition of humates soil (Table 1),

Table 3. Experimental Units established for grown *Lycopersicum sculentum* (cv. Santa Cruz Kada) irrigated with wastewater and treated with tannery sludge. Urutaí, GO. Brazil. 2015.

Tratamentos	Tipos de água	
	Residuária	Abastecimento
Soil + V1 (dose A) = T1	x	
Soil + V2 (dose B) = T2	x	
Soil + V3 (dose C) = T3	x	
Soil + V4 (dose D) = T4	x	
Soil + NPK = T5	x	
Soil (control) = T6	x	
Soil + V1 (dose A) = T1		x
Soil + V2 (dose B) = T2		x
Soil + V3 (dose C) = T3		x
Soil + V4 (dose D) = T4		x
Soil + NPK = T5		x
Soil (control)= T6		x

Legend: Dose A: 18 Mg ha^{-1}; Dose B: 46 Mg ha^{-1}; Dose C: 21 Mg ha^{-1}; Dose D: 23 Mg ha^{-1}; Concentration of urea: 300 kg ha^{-1}; Concentration of superphosphate: 300 kg ha^{-1}; Concentration of potassium chloride: 100 kg ha^{-1}.

Table 4. Concentrations of pH, CTC, potencial acidity (H+Al), sodium (Na), organic matter (M.O.) e base saturation (V) soil analyses for diferente treatments and types of water. Urutaí, GO. Brazil. 2015.

Types of water	Treatments					
	T1	T2	T3	T4	T5	T6
pH						
A1	5.60^{Cb}	6.06^{Bb}	6.30^{Aa}	6.46^{Aa}	6.00^{Bb}	6.06^{Bb}
A2	6.26^{Ba}	6.33^{ABa}	6.43^{ABa}	6.53^{Aa}	6.43^{ABa}	6.23^{Ba}
CTC (dag kg^{-1})						
A1	8.45^{Ca}	10.10^{Aa}	9.20^{Bb}	7.92^{Da}	6.86^{Ea}	6.11^{Fa}
A2	7.43^{Cb}	9.47^{Bb}	9.66^{Aa}	7.52^{Cb}	6.43^{Db}	5.31^{Eb}
H+Al (dag kg^{-1})						
A1	1.53^{Aa}	0.90^{Ca}	1.05^{BCa}	0.46^{Da}	1.06^{Ba}	1.13^{Ba}
A2	0.56^{Bb}	0.43^{BCb}	0.41^{BCb}	0.40^{Ca}	0.86^{Ab}	0.90^{Ab}
Na (dag kg-1)						
A1	4.50^{ABa}	6.00^{Aa}	4.00^{Ba}	4.66^{ABa}	4.66^{ABa}	4.00^{Ba}
A2	4.00^{Ba}	4.16^{ABb}	4.33^{ABa}	5.66^{Aa}	4.66^{ABa}	5.00^{Aba}
M.O. (%)						
A1	2.23^{Ca}	2.96^{Ab}	2.13^{Cb}	2.63^{Cb}	2.03^{Cb}	1.56^{Da}
A2	2.10^{Ca}	3.56^{Aa}	3.53^{Aa}	2.63^{Ba}	2.33^{Ca}	1.60^{Da}
V (%)						
A1	80.33^{Db}	90.66^{Bb}	88.33^{Cb}	93.66^{Ab}	80.66^{Db}	80.66^{Db}
A2	91.33^{Ba}	94.33^{Aa}	95.66^{Aa}	95.00^{Aa}	85.66^{Ca}	84.33^{Ca}

Means followed by the different upper case letter in line and lower case in column differ to each other at 5% probability by Tukey test. T1: 25% Sludge Tannery (LC) + 75% manure; T2: 25% LC + 75% rice husk; T3: 50% LC + 50% manure; T4: 50% LC + 50% cane gray; T5: NPK; T6: control; A1: domestic sewage; A2: class 2 water.

which was classified as moderately acid (less than 5,50) as Comissão de Fertilidade de Solos de Goiás, (1988) and after the tomato crop could still be reused for new cultivation of tomatoes because, as highlighted by Primavesi (2002), the pH range interferes with the absorption of nutrients. Thus, the problem is not the correct pH, but the balanced supply of nutrients. The availability of nutrients is influenced by soil pH, which in this experiment showed a value of 5,40 (solo). Nitrogen (N) is better used by the plant in soil with a pH above 5,50 (achieved in the other treatments, Table 1). The maximum availability occurs at soil pH between 6,00 and 6,50 and then decrease. The tomato crop requires an optimum range of soil pH is between 5,50 and 6,80 (Primavesi, 2002).The supply of wastewater may have influenced the drop in pH values, because all values were (except T2 and T5) lower for this type of water when compared to the A2. Even with the decrease in pH (Table 4) after the beginning of cultivation of tomato (Table 1), the range is acceptable for a new culture cycle. Any pH as the base saturation and exchange capacity are influenced by soil use and can be modified by managements correct as adding soil conditioners, which involves the application of material which favorably modify the chemical properties (Bernardi et al., 2005), reducing the soil acidity and increasing the CTC.As noted the CTC values increased after the addition of vermicompost to the soil, so that the witnesses had the lowest values compared to other treatments (for different types of water). In general the A1 treatments were favored by irrigation of wastewaters that with the large amount of dissolved salts, mainly of urban origin (Metcalf and Eddy, 1991), may have promoted the exchange of cations. CTC evidence the soil's ability to retain and exchange positively charged ions in the colloid surface, perhaps one of the most important physical and chemical properties of the system. His determination can be made saturating the soil with a cation index, which is then translocated and determined, or adding to the exchangeable bases with the potential acidity (Camargo et al., 2009). This property presents the release of chemical elements as N, P, K, Ca and Mg, which leave the organic medium, said immobilized, to pass through the medium of nutrients for the plants (Camargo et al., 2009), which facilitates exchangeable forms.

The potential acidity (Table 4) was identified only for the contents H^+ for the results to aluminum saturation was zero. T1 demonstrated as higher value, that is, which may have been favored by the ratio of the manure (75%), which differs from T3, which has a smaller percentage thereof in the humus (50%), which can be checked dag the values 1,53 dag kg^{-1} and 1,05 dag kg^{-1}, respectively. In general, the potential acidity was decreased in all treatments, since the initial value (Table 1) was 2,10 dag kg^{-1}. This fact is justified in studies on the use of vermicompost (Landgraf et al., 2005; Steffen et al., 2010) on decreasing the acidity of the soil. The potential acidity, preferred term to others as titratable acidity, hydrolytic etc., is measured by the amount of strong base required to raise the pH to a particular value, often to 7,00 in our midst. This introduce the total acid present between the starting level (soil pH) and final (7,00) pH (Camargo et al., 2009).The sodium values (Table 4) for T2 in the wastewater was higher than the control, different from T4 in the class 2 water. The values between different types of water did not show statistical differences, except for T2 in the A2, which showed a lower value in the wastewater. Sodium is one of the parameters that most affects the salt content of the soil and so it is interesting to check the content thereof in irrigation water as well as in soil. Under moderate salinity reduction in the yield of tomatoes due to the reduction in the average fruit weight (Cuartero and Munoz, 1999), whereas in conditions of high salinity reduction in productivity is a result of the lower number of fruits per plant; the number of bunches per plant decreases only when the irrigation water has a high salt concentration and under long exposure periods. Opposed results were observed in this study, since the electrical conductivity was considered low usage restriction (Ayers and Westcost, 1999) and in addition, the salinity increases the incidence of blossom-end rot (Martinez et al., 1987; Filgueira, 2003) making the fruit unusable both for consumption and for the industry, which was not observed in this study.

The amounts of organic matter were increased (Table 4) as compared to the initial value of this parameter the soil (1.60%) to be added to the soil, which highlights the importance of humus and soil conditioning. In wastewater the T2 showed higher and A2 the T2 and T3 showed higher values. The figures presented by the control approached the initial values of the soil, which shows that treatments consisting of vermicomposts contrasting to the conventional treatment (T5 + A1 and T5 + A2). According to Santos et al. (2010), the use of organic wastes produced by activity animal as a source of plant nutrients and soil conditioner has become a viable alternative in terms of environmental protection, significantly reducing the use of chemical fertilizers and minimizing o environmental contamination. Furthermore, the supply of raw material into a long-term and low cost is guaranteed mainly by providing this in the surface layer of the soil. Thus, as found by Pina et al. (2015), the use of organic waste increased content of nutrients and organic matter in the soil, promoting greater root growth when assessing the influence of different organic waste associated with chemical fertilizers on sugarcane, sugar-rooting and yield in soil classified as Typic Quartzarênicos in Campo Grande, MS, Brazil. The initial base saturation value (68%) has been ranked as high (Comissão de Fertilidade de Solos de Goiás, 1988) and remained in this classification with values between 80 and 95% (Table 4), which shows that increased after the addition of vermicompost, and the lowest values were identified in the controls (80.66 and 84.33%).

The wastewater not favored treatments for base saturation when compared to treatments with A2, although the treatments were highlighted by vermicomposts increase, which were higher than conventional treatment, a fact verified by alternative studies application unconventional sources in the cultivation of vegetables (Cunha et al., 2014), aiming at savings of fertilizers and irrigation water front to environmental preservation.

Conclusion

Based on the results and according to the experimental conditions can be concluded that:

1). The added and cultivated soils with tomato had pH, CTC, organic matter and base saturation levels were incremented based mainly on the addition of T2 = 25% LC + 75% of rice husk and T4 = 50% LC + 50% cane gray, which favors use thereof as soil conditioners;
2). The levels of sodium and potential acidity were decreased after the addition of vermicompost and tomato crops, beneficial result for the use of this by changing the chemical characteristics of the soil;
3). The addition of vermicompost added to domestic wastewater irrigation convert an important technique applicable soil conditioners.

Conflict of Interests

The authors have not declared any conflict of interests.

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