ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 07, Issue, 09, pp.15414-15418, September, 2017

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

VERMICOMPOST OF TANNERY SLUDGE AS SOIL CONDITIONING WITH GROWN TOMATO AND IRRIGATION WITH WASTEWATER

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ARTICLE INFO

Article History:
Received 04th June, 2017
Received in revised form
18th July, 2017
Accepted 09th August, 2017
Published online 30th September, 2017

Keywords:

Vermi composting,
Chemical attributes,
Reuse.

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ABSTRACT

With urban growth also increases without waste disposal that need to be reused as the tannery sludge and wastewater. Thus, the tanning humus sludge and wastewater are possible to be added to the soil. 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 x 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 (water supply and wastewater). 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. Three homogeneous samples were collected, with about 300 g of each vessel. 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. Thus it can be concluded that vermicompost used can be added to soil conditioners changing the soil chemical attributes positively.

Citation: Ananda Helena Nunes Cunha, Jonas Alves Vieira and Eliana Paula Fernandes Brasil, 2017. "Vermicompost of tannery sludge as soil conditioning with grown tomato and irrigation with wastewater", *International Journal of Development Research*, 7, (09), 15414-15418.

INTRODUCTION

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 (Cunha *et al.* 2015) and may result in vermicomposts with high nutritional content. Corroborating the proper disposal of waste that can be reused (such as wastewater), 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. The concept of conditioning involves applying to the soil material which favorably modify the physical and chemical properties thereof. These materials can be natural organic or inorganic and are able to retain large quantities of water, being necessary to test them in different cultures and soil and climate conditions to define the quantities and more appropriate forms of application (Bernardi *et al.*, 2005), especially in acidic soils. Acidic soils have pH <7, are deficient in exchangeable bases, have dominant cation flocculant (Al and, or, H), problems are chemical order and easy fix in the surface layer, the soils affected by salts generally have pH> 7, exchangeable bases in excess, have dispersant dominant cation (Na) and problems are chemical and physical nature, being unwieldy and correction. Thus, the lack of exchangeable bases in soil causes deficiency of nutrients for the plants, the base excess can cause nutritional imbalances or cause toxicity, as well as being a serious problem (Holanda *et al*. 1998), and to add a condition for reduce acidity and increase CEC (cation exchange capacity). The organic conditioners (as a source of nutrients) reduce soil acidity and increase cation exchange, being applied in various ways.

They may, however, present some inconvenience; biological source such salts in large quantities may contribute to the occurrence of nutritional imbalances (Ayers and Westcot 1999), which can be controlled if applied correctly and may also be assisted by irrigation water during use. Most fertilizers of organic origin (animal as beef and vegetable manure as rice husk and gray sugarcane sugar) contain various nutrients to plants (particularly nitrogen and phosphorus, as well as small quantities of potassium and elements rare). Although much lower than those of inorganic concentrations (Miranda *et al*. 2011), can contribute significantly to plant nutrition as in tomato cultivation as other benefits, observing the requirement of the plant, especially the availability of macro and micronutrients.

Table 1. Main characteristics of soil and vermicompost used in tomato cultivation Santa Cruz. Urutaí, GO, 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, 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
S (mg L^{-1})	48,86±12,48	2,00[1]
P (mg L^{-1})	17,69±41,39	0,22[1]
Na (mg L^{-1})	5,40±0,52	5,25[1]
Mg (mg L^{-1})	<LQ	2,43[1]
Ca (mg L^{-1})	<LQ	4,00[1]
P (mg L^{-1})	6,7±41,25	1,64[1]
B (mg L^{-1})	0,58±0,04	NR

Water 1: domestic sewage. Water 2: class 2 water. *Values for three replicates for each parameter analyzed. <LQ - Lower the quantification limit of the technique used (5mg $^{-1}$). NR: Not Done. [1]Source: Malafaia (2015).

Table 3. Experimental Units established for tomato cultivation Santa Cruz Kada irrigated with wastewater and treated with tannery sludge. Urutaí, GO. 2015

Treatments	Types of water	
	domestic sewage	class 2 water
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}; NPK: Concentration of urea(N): 300 kg ha^{-1}; Concentration of superphosphate(P): 300 kg ha^{-1}; Concentration of potassium chloride(K): 100 kg ha^{-1}.

The tomato is the vegetable most economically important crop in the Cerrado region, quite demanding in potassium and calcium (macronutrients) and boron (micronutrients) (Filgueira 2003). Goias stands out as a major producer of tomato, with 1,230,512 tonnes or 32.1% of the total, followed by São Paulo with 17.6%, Minas Gerais and Parana with 13.5% with 7.3% (IBGE 2013), and its production can be enhanced by the use of soil conditions such as wastewater and vermicomposting. 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 cultivated with tomato and irrigated with wastewater.

MATERIAL 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, located on Highway Geraldo Silva Nascimento Km 2.5, approximate altitude of 812 m. According to Köppen, the municipality of 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 on Soil and Foliar analysis laboratory on School of Agronomy (EA/UFG) and laboratory Terra analysis of soil located in Goiania (Goias, Brazil). The data were interpreted and corrected as 5th approach (Soil Fertility Commission of Goias 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). Qualitative and quantitative analysis of domestic wastewater used was held at the Laboratory of Inorganic Chemistry of the State University of Goiás in Anápolis (Goias, Brazil). 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. The experimental design was completely randomized (DIC) in a factorial 6 x 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 - 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 topdressing 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

Table 4 shows values for parameter P that has suffered interference from the application of vermicompost, a fact that can see the value of this to the witnesses (T6 + A1 and T6 + A2), which were higher than the other treatments, demonstrating that the soil was fertilized and/or irrigated with wastewater properly managed to get nutritional response within the expected nutritionally. Phosphorus initial content was rated high (Soil Fertility Commission of Goias 1988), worth 17 dag kg^{-1} and kept the other treatments (above 14 ppm). Comparing the two water types (Table 4) revealed that only conventional fertilization showed lower value (T5 + A1) than the other treatments, with values or equal to (T2, T4 and T6) or larger (T1 and T3).

This fact highlights the vermicomposts in nutrient economy, and provide adequately the nutrients more easily to plants when compared to conventional fertilization, which confirms the organic fertilization highlighting the improvement of the physical and chemical properties of the soil (Sorrenti *et al*. 2008). At pH 5.5 phosphorus (P_2O_5) is typically already available, but has better absorption into the plants at pH 6 to 6.5, which influence the presentation of the soil, as the absorption of nutrients depends on the pH and the species plant (Primavesi 2002). Potassium (K_2O) is better used in soil pH greater than 5.5, observed in this study (Table 1) values were higher, increasing its absorption by plants. As can be seen in concentrations of potassium (Table 4) were higher in T4 (V4 = 50% LC + 50% sugarcane ash), since, as seen in Table 1 the value was higher this parameter for this vermicompost (1.6 kg dag^{-1}) when compared with other vermicomposts and the ground. It is also observed that the values for the witnesses were lower in both types of water, a fact explained in Table 4, which shows the concentration of this attribute in plant nutrition, ie other treatments failed properly absorb K, as this is presented in lower concentrations for not being supplied to the plant. The potassium value found in the soil was classified as high (greater than 50 ppm), according to the Soil Fertility Commission of Goiás (1988), a figure also found (126 mg kg^{-1}) by Sorrenti *et al.* (2008) when using red-yellow podzolic in tangerine cultivation with organic manure of cattle manure vermicompost in Pelotas, demonstrating that different locations can use vermicompost as fertilizer alternative for growing vegetables and fruits. Potassium is important for the tomato plant to strengthen the shoot against fungal and bacterial diseases, woody plant becomes more resistant to physical damage and retards senescence of leaves, prolonging the cycle. Experimental results suggest that application of K in poor soil (which is not the case of this experiment), favors the quality of the fruit (Filgueira 2003), noting that the potassium content in the soil remains high after the tomato crop is possible be effected another cycle. Fertilization made in tomato cultivation should be careful because this can remove soil large quantities by the plant and the fruit. Potassium can be removed by the air part of the plant in large quantities, as well as the fruit of the tomato, which absorbs 360 kg ha^{-1} and 56%, respectively (Fayad *et al.* 2002), the cultivation of Santa Clara in tutored culture getting 94,8t ha^{-1} ripe tomato. Already sulfur removes 49 kg ha^{-1} in the aerial part of the plant and 20% in the fruits, suggesting attention in providing these nutrients tomato plant resulting in satisfactory production. The sulfur values shown in Table 4 indicated stability for the different treatments (waste water) did not demonstrate statistical differences, unlike the treatments in the water supply, which showed differences between T2 (V2 = 25% LC + 75% rice husk) and T5 (conventional fertilization). Besides tomato remove considerable amounts ground calcium plant (202 kg calcium per hectare in the aerial part of the plant), as Fayad *et al.* (2002), this can still be used in new culture, ie beyond the vermicompost be used to assist in the physical and chemical attributes, it can be used for successive crops of tomatoes, providing high concentration of nutrients, mainly calcium. Calcium is closely linked to the quality of tomato fruits, since it is present in the middle lamella and cell walls. Through his connections, calcium plays structural function and gives firmness to the fruits (Vilas Boas 2014), an essential parameter for the post-harvest life, for the firmest fruit can have your extended shelf life without affecting the characteristics desired by consumers. The content of calcium and magnesium were classified as high (greater than 2.5 meq 100 ml^{-1} and greater than 0.6 meq 100 ml^{-1}, respectively), as soil fertility Commission Goiás (1988), which can be seen in Table 3 (3.30 dag kg^{-1} and 0.80 dag kg^{-1}), which explains the high concentration of these in the soil even after the tomato crop. The magnesium values (Table 4) highlights the T1 in different types of water, which may have been favored by most establishment of the vermicompost (V1 = 25% LC + 75% manure) confronting with the other, that even in same mixture have different proportions (V3 = 50% LC + 50% manure) and different substrates (V2 = 25% LC + 75% of rice husk and V4 = 50% LC + 50% cane gray). Thus, Gonçalves *et al.* (2000) reported that suitable substrates for the propagation of seedlings and root development can possibly be obtained from the mixture of 70 to 80% of an organic component (bovine manure, eucalyptus or pine bark, sugarcane bagasse sugar, urban waste, other waste and earthworm humus, as in V1 vermicompost), with 20 to 30% of a component used to raise the macroporosity (carbonized rice husk, biomass boiler ash, sugarcane bagasse carbonized), proportions contrary to these have been reported in this experiment, which used a lower percentage of tannery sludge and higher peel and sugarcane ash (V2 and V4). Boron concentrations (Table 4) show higher values at T1 and T5 + A1 + A2, the same observed when comparing different types of water (0.33 kg dag^{-1} and 0.28 dag kg^{-1}, respectively). The wastewater may be provided at a sufficient amount to increase this value, since the ideal quantity for tomato production is 0.2 mg.L^{-1} Boron second Catelhane and Araujo (1995). In the boron deficiency, new

Table 4. Concentrations of phosphorous (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg) and boron (B) in soil analysis for different types of treatments and water. Urutaí, Go. 2015

Types of water	Treatments					
	T1	T2	T3	T4	T5	T6
				P (dag kg^{-1})		
A1	17,50Da	17,66Da	21,33Ba	16,83Da	19,66Cb	30,00Aa
A2	15,33Db	17,33Ca	18,33Cb	17,33Ca	21,66Ba	30,33Aa
				K (dag kg^{-1})		
A1	0,29Ca	0,32Ba	0,21Db	0,43Aa	0,17Eb	0,13Fa
A2	0,29Ba	0,25Db	0,27Ca	0,43Aa	0,21Ea	0,12Fa
				S (dag kg^{-1})		
A1	5,50Aa	5,50Ab	5,33Aa	5,33Ab	5,66Aa	5,66Aa
A2	5,16Ba	6,50Aa	5,16Ba	6,16ABa	5,00Ba	5,83ABa
				Ca (dag kg^{-1})		
A1	5,36Da	8,13Aa	7,00Bb	6,20Ca	4,75Ea	3,90Fa
A2	5,20Cb	7,80Ab	7,90Aa	6,00Bb	4,50Db	3,40Eb
				Mg (dag kg^{-1})		
A1	1,26Aa	0,70Db	0,85CDb	0,90BCa	0,83CDa	1,03Ba
A2	1,26Aa	0,93Ba	1,23Aa	0,66Cb	0,76BCa	0,86Bb
			B (dag kg^{-1})			
A1	0,33Aa	0,25ABa	0,23ABCa	0,11Da	0,13CDb	0,15BCDa
A2	0,10Bb	0,28Aa	0,18Aba	0,16Ba	0,28Aa	0,10Ba

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.

Thus, it is justified because the rice hull became heavily used as a substrate for growing plants, due to its high availability and characteristics favorable for plant development (Steffen *et al.* 2010), as this residue generated after rice processing, is usually burned in the mills for drying grain and abandoned in crops (Foletto *et al.* 2005), and can be reused in other activities like vermicomposting. Table 4 shows higher calcium values for T2 (V2 = 25% LC + 75% rice husk), both in wastewater and water supply. Witnesses showed lower values compared to the other treatments, as they received no fertilization noting that the conventional fertilization was overcome by adding humus to the soil, overcoming the situation to condition soil, resulting in vermicompost nutrient suppliers.

tomato leaves become tanned occurring, then the death of buds and leaves. The petiole becomes brittle and withered plant in the hottest hours of the day, because of damage to the root system (Silva *et al*. 2006), report not observed in this study. The correct supply of boron (condition observed in this experiment) favors the absorption and utilization of Ca by the plant, reducing the incidence of blossom-end rot (lack of Ca) as described by Filgueira (2003). Guerrini and Trigueiro (2004) point out that the formation of good quality seedlings involves the seed germination process, root initiation and formation of the root system and aerial part, which are directly related to characteristics that define the level of efficiency of substrates for development such as aeration, drainage, water retention and balanced nutrient availability, highlighting the vermicompost as soil conditioners.

Conclusions

Based on the results and under the experimental conditions we can conclude that:

- In general, the added and cultivated soils with tomato presented phosphorus, calcium and magnesium enhanced mainly in the addition of T2 = 25% LC + 75% of rice husk and T4 = 50% LC + 50% cane gray, which favors use thereof as soil conditioners;
- The addition of vermicompost added to domestic wastewater irrigation convert an important applicable soil conditioners technique.

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