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Efficiency of biocompost potentiated with chemical fertilizer and facilitated aeration

Eficiência de biocompostos potenciados com adubo químico e aeração facilitada

Guilherme Junqueira Jerônimo[I], Ana Paula Milla dos Santos Senhuk[II], Mário Sérgio da Luz[III], Julio Cesar de Souza Inácio Gonçalves[IV], Deusmaque Carneiro Ferreira[V]

ABSTRACT

The aims were to reduce composting time, to evaluate the application of produced composts and to size two composting yards (conventional and potentiated). Eight compost heaps with 400 kg of food industry or urban organic waste were built: 1) control; 2) facilitated aeration; 3) potentiated with facilitated aeration and chemical fertilizer; and 4) chemical fertilizer. The analyzed parameters were pH, temperature, humidity and C/N ratio. Compost heap reached stabilization at 90 days without chemical fertilizer, at 60 days with chemical fertilizer and at 25 days when potentiated, regardless of the waste origin. Stabilized composts were applied to lettuce crop under natural conditions and compared with commercial compost. Composts with chemical fertilizer were the most effective in enabling lettuce seedling growth. For medium-sized cities, the conventional composting yard requires 6.58 ha, whereas the potentiated composting yard requires 1.69 ha, considering the recorded stabilization time of 90 and 25 days, respectively. The potentiated composting was the most efficient because its shorter stabilization time, did not require manual turning and produced compost with higher nutrient content. Besides that, requires an area 74.32% smaller than the conventional yard, fact that enables using this process to treat industrial and urban solid organic waste.

Keywords: Organic waste; Industrial waste; Urban waste; Solid Waste Treatment; Compost

RESUMO

Este estudo objetivou reduzir o tempo de compostagem, avaliar a aplicação dos compostos produzidos e dimensionar dois pátios de compostagem (convencional e potencializado). Oito pilhas de compostagem com 400 kg de resíduos orgânicos da indústria alimentícia ou urbanos foram construídos: 1) controle; 2) aeração facilitada; 3) potencializado com aeração facilitada e fertilizante químico; e 4) fertilizante químico. Os parâmetros analisados foram pH, temperatura, umidade e razão C/N. As pilhas de compostagem estabilizaram em 90 dias sem fertilizante e 25 dias quando potencializada. Compostos estabilizados foram aplicados à cultura da alface em condições naturais e comparados com composto comercial. Os compostos com fertilizantes foram os mais eficazes para o crescimento das mudas de alface. Para cidades de médio porte, o pátio de compostagem convencional

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[I] Mestrando no PPGCTA com atuação na Gestão e Gerenciamento dos Resíduos Sólidos. Universidade Federal do Triângulo Mineiro/ Mestrando do Programa de Pós-Graduação em Ciência e Tecnologia Ambiental (PPGCTA). guijunj@hotmail.com

[II] Programa de Pós-Graduação em Ciência e Tecnologia Ambiental (PPGCTA), Instituto de Ciências Exatas e Tecnológicas (ICTE) da Universidade Federal do Triângulo Mineiro (UFTM). ana.senhuk@uftm.edu.br

[III] Programa de Pós-Graduação em Ciência e Tecnologia Ambiental (PPGCTA), Instituto de Ciências Exatas e Tecnológicas (ICTE) da Universidade Federal do Triângulo Mineiro (UFTM). mario.luz@uftm.edu.br

[IV] Programa de Pós-Graduação em Ciência e Tecnologia Ambiental (PPGCTA), Instituto de Ciências Exatas e Tecnológicas (ICTE) da Universidade Federal do Triângulo Mineiro (UFTM). julio.goncalves@uftm.edu.br

[V] Programa de Pós-Graduação em Ciência e Tecnologia Ambiental (PPGCTA), Instituto de Ciências Exatas e Tecnológicas (ICTE) da Universidade Federal do Triângulo Mineiro (UFTM). deusmaque.ferreira@uftm.edu.br

requer 6,58 ha, enquanto o pátio de compostagem potencializada requer 1,69 ha, considerando o tempo de estabilização de 90 e 25 dias, respectivamente. A compostagem potencializada foi mais eficiente devido ao seu menor tempo de estabilização, por não exigir torneamento manual e produzir composto com maior teor de nutrientes. Ainda, requer uma área 74,32% menor que o pátio convencional, o que possibilita a utilização desse tratamento para resíduos sólidos orgânicos urbanos e industriais.

Palavras-chave: Resíduos orgânicos; Resíduos industriais. Lixo urbano; Tratamento de Resíduos Sólidos; Compostagem

1 INTRODUCTION

Large amounts of urban solid waste (USW) are produced in modern society on a daily basis; however, inadequate USW disposal can lead to severe environmental, social and economic issues (MENDEZ; MAHLER, 2018; FERRONATO; TORRETTA, 2019). According to the Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE, 2016), solid waste production in Brazil reaches 78.3 million tons per year, which is equivalent to 1.04 kg inhab^{-1} day^{-1}. In addition, 41.6% of this total amount is sent to controlled landfills or illegal dumps, whereas 9% of it is not collected and ends up discarded in vacant lots, water streams, rivers and other irregular destinations. USWs in Brazil have the following gravimetric composition: organic matter (51.4%), paper, cardboard and Tetra Pak packaging (13.1%), plastic (13.5%), glass (2.4%), metals (2.9%) and others (16.4%). Of the total waste, 31.9% is made of recyclable materials, whereas 51.4% (organic matter) of it can be used as organic compost in crops (ABRELPE, 2012).

The agrofood industry produces a great variety of organic wastes that potentially can be used as soil fertilizers and amendments due to their high contents of organic matter a plant nutrients (MARTÍNEZ-BLANCO et al., 2011).

The perspective of sustainable development, the need for efficient environmental management that ensures the environmentally sound final destination of solid waste is required. This means meeting the legal requirements set forth in the National Solid Waste Policy, as a means of preserving the environment and ensuring public health (DINIZ; ABREU, 2018).

Landfill systems remain the most appropriate destination for USWs, which should be associated with selective waste collection for organic waste recycling and treatment in order to extend their useful life and, consequently, to reduce environmental impacts and costs with landfill implementation, operation and completion (VAVERKOVÁ, 2019). Composting stands out among different organic waste treatment methods due to its low operation costs, as well as to its high social and environmental benefits (ARVANITOYANNIS; VARZAKAS, 2008;XIAO et al., 2017).

Composting is the spontaneous biological decomposition of organic matter deriving from waste, which is conducted in aerobic environments. Solid or semi-solid putrescible organic matter is transformed into CO_2, H_2O and complex metastable compounds (AWASTHI et al., 2014; XIAO et al., 2017).

According to Lundie and Peters (2005), composting is the appropriate solution to reduce costs with organic matter deposition in landfills, since it produces an organic corrector to be used in soils with low organic matter and nutrient contents; besides, it helps protecting the quality of the soil, groundwater and surface water, as well as human and animal health. Therefore, composting may act as an appropriate disposal option for biodegradable wastes (TORTOSA et al., 2012).

Despite several social, economic and environmental advantages, the application of large-scale composting processes remains challenging, mainly due to lack of segregation at the source and to compost maturation delay, a fact that makes the process more expensive and demands large areas to implement composting yards.

The aims of the current study were to enhance compost maturation in processes focused on composting the organic fraction of solid waste deriving from the food industry and from households, to apply the resulting biocompost in lettuce crop (*Lactuca sativa* L.) and to define the ideal size of composting yards to be implemented in medium-sized cities.

2 MATERIALS AND METHODS

2.1 Composting experiments

Experiments were developed based on the methodology adapted from Cordeiro (2010) and Silva (2016). The following composting enhancement techniques were adopted: facilitated aeration (reduces workforce), microorganism inoculation (decreases maturation time) and chemical fertilizer addition (decreases maturation time and increases nutrient content in the final compost).

Facilitated aeration was chosen over forced aeration because the last one leads to costs with equipment and electricity. The use of chemical fertilizers was implemented because this product is easy to be found in Brazil, as well as to accelerate the process and to add important nutrients to the final compost (organomineral). Microorganism inoculation (through the application of cattle manure) was used to populate the compost heaps with microorganisms and to accelerate the maturation process onset (LOUREIRO et al., 2007).

The experiments were carried out at the *Univerdecidade* Unit of Federal University of TriânguloMineiro, in compost heaps comprising 400 kg of the organic fraction of waste deriving from the food industry (*Tozzi Alimentos*) and 400 kg of urban (household) waste from Uberaba County-MG. The composting yard was sized based on specifications by Cerri et al. (2008), namely: soil waterproofing with concrete, 2% slope, collecting chute, containment box, cover and fencing.

In addition to the organic fraction of industrial and urban wastes, 50 kg of garden pruning waste (dry mass), 4 kg of mature cattle manure (microorganism inoculation) and 4 kg of chemical fertilizer (8% N; 28% P_2O_5 and 20% K_2O) were added to the compost heaps.

Materials used to build the compost heaps were previously comminuted in waste disposer (TR200 Trapp) to particle size smaller than 2 cm. The homogenized mass was divided into four equal parts in order to build four compost heaps for the organic fraction of industrial waste (maturation period from January 25 to April 18, 2018) and four compost heaps for the organic fraction of urban waste (maturation period from October 17 to December 19, 2018). The 1.80-diameter and 1.60-tall conical heaps were built on a branch-made support to enable base aeration.

The compost heaps built for the organic fraction of food industry and urban wastes presented the following composition:

- Compost heap 1 (control): 100 kg of organic waste, 12.5 kg of garden pruning waste and 1 kg of cattle manure - 113.5 kg, in total;

- Compost heap 2: Compost heap 1 with aeration facilitated by 100 mm PVC pipes;

- Compost heap 3: Compost heap 1 with aeration facilitated by 100 mm PVC pipes and added with 2 kg of chemical fertilizer.

- Compost heap 4: Compost heap 1 added with 2 kg of chemical fertilizer;

Composting heaps were monitored based on moisture, temperature, pH and C/N ratio analyses. Temperature was initially monitored during the first experimental days (to observe the thermophilic phase); subsequently, it was monitored once a week. Temperature measurements were performed with a mercury thermometer (0ºC to 150ºC), which was laterally inserted in the middle of the heap for 2 minutes.

On the other hand, pH measurements were carried out with benchtop pH meter (HMMPB-210). Humidity (W) was determined based on the oven drying method (TETCD model at 110V and 1500 W). C/N ratio was calculated based on total organic carbon (TOC) and on total nitrogen content, which were determined according to the Tinsley (TINSLEY, 1950) and Kjeldahl methods (ROCHA; ROSA; CARDOSO, 2009), respectively.

Oxygenation in compost heaps 1 and 4 was based on manual turning, which was conducted with the aid of a hoe, on a weekly basis. The compost heaps were irrigated with water, whenever necessary, in order to keep humidity at, or lower than, 40%. At the end of the composting process, the stabilized compost recorded C/N ratio equal to 10; the final mass of the compost heaps was weighed in LS500 electronic scale (Marte).

2.2 Compost application in lettuce crop

The agronomic efficiency of the compost heaps was evaluated through compost applications in lettuce (*Lactuca sativa* L.) crop under natural conditions. The adopted methodology was adapted from Gonçalves et al. (2014) and fromManual for Organic Vegetable and Fruit Fertilization (IAG, 2013).

Compost applications were carried out from March 12 to April 18, 2019; they were divided into 6 treatments (RT);

- TR1: Soil only (Control treatment);
- TR2: Commercial organic compost (soil:compost ratio 4:1 v/v);
- TR3: Organic compost deriving from industrial waste treated in compost heaps 1 and 2, without chemical fertilizer (soil:compost ratio 4:1 v/v);
- TR4: Organic compost deriving from industrial waste treated in compost heaps 3 and 4, with chemical fertilizer (soil:compost ratio 4:1 v/v);
- TR5: Organic compost deriving from urban waste treated in compost heaps 1 and 2, without chemical fertilizer (soil:compost ratio 4:1 v/v);
- TR6: Organic compost deriving from urban waste treated in compost heaps 3 and 4, with chemical fertilizer (soil:compost ratio 4:1 v/v).

Three (3) lettuce (*Lactuca sativa* L.) seeds were sown in 250-mL polyethylene container for each treatment. Plant growth analysis was carried out at the 17th, 24th, 31st and 38th experimental days, with 5 repetitions.

Table 1 shows fertility analyses applied to the soil and organic composts used in lettuce experiments.

Table 1- Soil fertility and organic compost parameters: commercial compost, compost heaps 1 and 2, and compost heaps 3 and 4

Parameters	**TR1**	**TR2**	**TR3**	**TR4**	**TR5**	**TR6**
Organic matter (g dm^{-3})	18.50	16.80	15.45	18.28	16.98	17.95
Ph	6.75	6.95	7.23	7.15	7.22	7.34
Phosphorus (mg dm^{-3})	0.30	2.65	2.25	4.98	2.11	5.16
Potassium (mmolc dm^{-3})	122	0.67	1.75	7.86	1.35	8.16
Calcium (mmolc dm^{-3})	3.50	2.90	2.71	3.03	2.75	2.99
Magnesium (mmolc dm^{-3})	1.60	1.81	1.60	1.92	1.13	1.87
Nitrogen	0.82	1.21	1.15	1.82	1.68	1.76
Zinc (mmolc dm^{-3})	10	45	41	43	39	44
Iron (mmolc dm^{-3})	1200	9989	250	265	242	255
Sum of bases (mmolc dm^{-3})	4.31	4.43	5.13	5.11	5.12	5.32
Cation exchange capacity (CEC) (mmolc dm^{-3})	8.31	280	245	315	230	335
% V (base saturation)	50	70	65	71	63	72

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The amount of water used for lettuce irrigation purposes was estimated based on the field capacity analysis of the soil used in the experiments, according to Albuquerque et al. (2010). Field capacity was approximately 0.4 cm^3 cm^{-3}; thus, 100 mL of water was required to irrigate the 250-mL vials.

Lettuce development parameters analyzed in the current study were based on Gonçalves et al. (2014), namely: number of leaves (simple counting of the number of lettuce leaves); mean plant height (measured from the plant neck to the end of the largest leaf); fresh mass (lettuce root and shoot mass); dry mass (lettuce root and shoot mass after 8 h of oven drying at 55°C).

Results recorded for these parameters were compared between treatments based on ANOVA and Tukey tests; comparisons were carried out in the Bioestat 5.3 software, at 5% significance level.

2.3 Potentiated composting sizing for medium-sized cities

After the experiments were finished, two types of composting yards were designed for medium-sized cities, based on data about waste generation in Uberaba County-MG. One composting yard was sized based on conventional composting parameters and techniques, whereas the other was sized based on parameters and techniques potentiated in the current study.

The methodologies adopted for the aforementioned sizing procedures were based on, and adapted from, *Manual para Implantação de Compostagem e de Coleta Seletiva no Âmbito de ConsórciosPúblicos* - Manual for the Implementation of Composting and Selective Collection Processes by State-owned Companies -(MMA, 2010).

Conventional composting method (such as the compost heap 1 used in the experiments) required twice the windrow size to enable manual turning. The total composting time reached 90 days and it was also necessary adding a value corresponding to 10% of safety, circulation, equipment and service areas.

On the other hand, potentiated composting method required calculating the total yard area in a different way, since it did not need twice the windrow size once it did not need manual turning (such as the compost heap 3 used in the experiments). Potentiated composting time was shorter than the conventional process. This method required 1-m spacing between windrows to enable the circulation of workers and equipment; it was also necessary adding a value corresponding to 10% of safety, equipment and service areas.

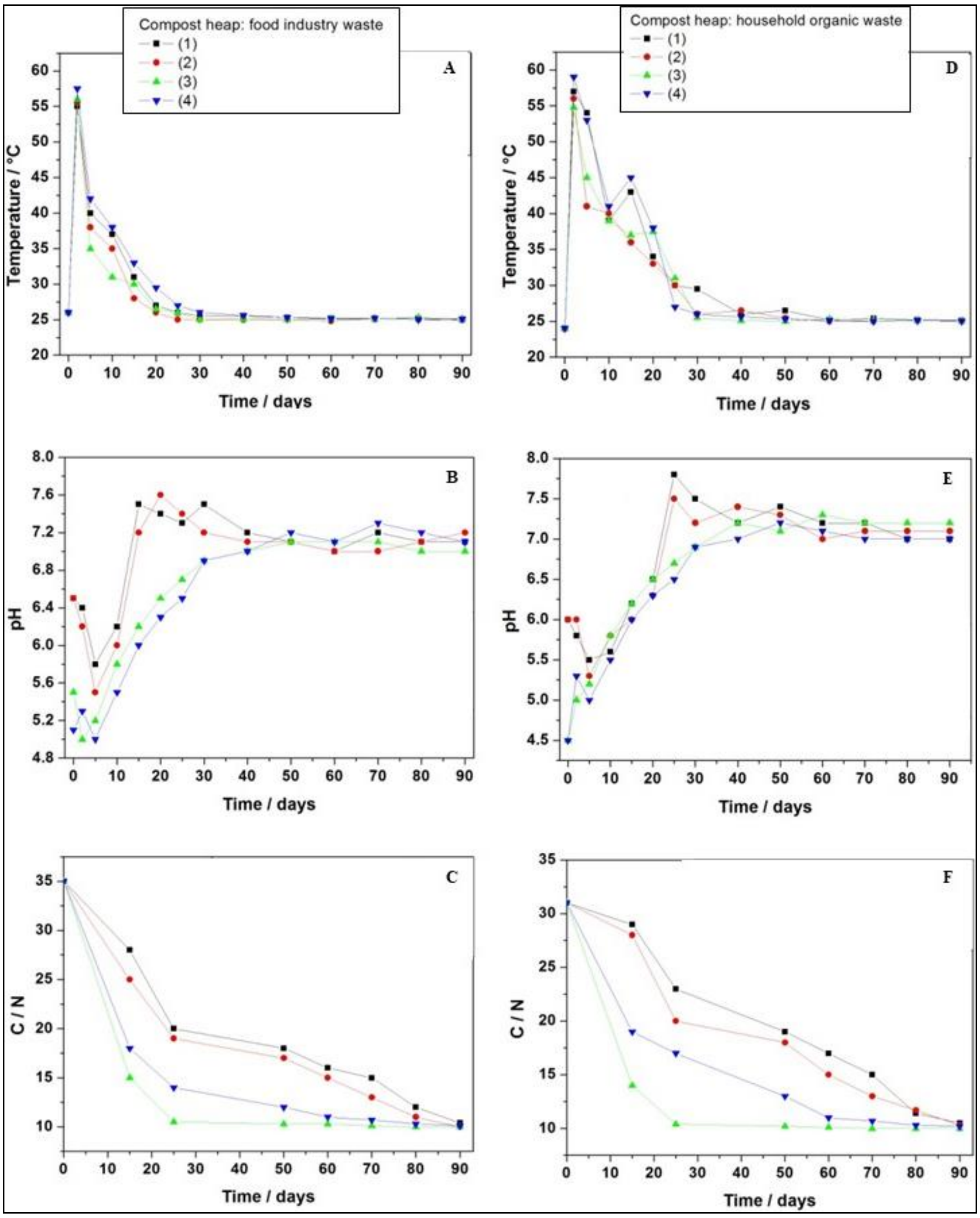
3 RESULTS AND DISCUSSION

3.1 Composting of the organic fraction of solid wastes

Temperature values in the compost heaps with organic waste deriving from the food industry and from households are shown in Figure 1 (A and B), which depicts the thermophilic (temperature higher than 55°C) and mesophilic composting phases. According to Heck et al. (2013), composting processes are characterized by three phases, namely: initial mesophilic phase - gradual temperature increase; thermophilic phase - temperature increase and consequent pathogen elimination; and final mesophilic phase - gradual temperature decrease until it reaches room temperature and stabilizes the compost.

The minimum temperature in all compost heaps was 55°C. According to the Canadian Compost Quality Standard by the Canadian Council of Ministers of the Environment (CCME, 2005), this temperature is essential to assure the elimination of pathogenic organisms and weeds. Temperatures higher than 80°C for long periods are detrimental to the process due to plant growth inhibition and even death of non-thermotolerant microorganisms.

Figure 1- Temperature, pH and C/N ratio values observed in the composting of industrial (A, B and C) and urban (D, E and F) waste



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The pH of compost heaps 3 and 4 was lower than that of compost heaps 1 and 2 (Figures 1C and 1D). This outcome can be explained by the presence of chemical fertilizer, since the nitrification process leads to medium acidification (release of H^+), mainly at the beginning of the process (FRANCISCO, 2008). The optimum pH range for microorganism development during the composting process can be seen at the beginning of the process (from 5.5 to 8.5) and at the end of it (from 7 to 8.5), based on Rodrigues et al. (2006).

The pH of the compost heaps has increased after 15 composting days due to ammonia nitrogen formation, which resulted from organic nitrogen hydrolysis. Subsequently, pH value tended towards neutrality. Such pH stabilization dues to maturation reactions and to the buffering power of the humus.

Composting processes are not efficient if the mixture pH is lower than 5, since it leads to significant decrease in microbiological activity and does not enable the thermophilic phase (MASSUKADO; SCHALCH, 2010). The pH values observed throughout the composting process of solid wastes deriving from the food industry and from households were in compliance with data available in the literature (MASSUKADO; SCHALCH, 2010). Similar results were reported by Cordeiro (2010) and Silva (2016), according to whom the pH of the compost heaps ranged from 4.8 to 5.8 at the beginning of the composting process; then, it increased to 6.5 (ammonia nitrogen) and reached neutrality (pH 7.0) at biocompost stabilization.

Humidity contents in all four compost heaps were kept from 40 to 60%. This humidity range is ideal to enable microbiological activity and, therefore, to trigger organic matter decomposition (MERCKEL,1981).

Compost heaps with industrial (Figure 1E) and household (Figure 1F) organic wastes started the composting process at C/N ratio within the compatibility range - 35:1 and 31:1, respectively. Compost heap 3 reached C/N ratio 10:1 near the 25th experimental day; whereas compost heap 4 reached this ratio at 60 days and compost heaps 1 and 2, at 90 days.

According to Massukado and Schalch (2010), the C/N ratio compatibility range at the beginning of the composting process was 20:1 to 40:1. According to Kiehl (1998), the C/N ratio reached approximately 10:1 when the compost reached maturity, i.e., when it became a humidified product.

The most efficient maturation rates were the ones observed for compost heap 3 (facilitated aeration and synthetic fertilizer addition), which comprised composts deriving from food industry and household wastes. This compost heap required less time to stabilize the organomineral compost and it was followed by compost heap 4 (synthetic fertilizer addition and no facilitated aeration). Compost heaps 1 (control) and 2 (facilitated aeration) have shown slower compost stabilization than compost heaps added with synthetic fertilizer.

Facilitated aeration use reduced compost maturation time by providing oxygen to enhance microbial activity; besides, it reduced the use of workforce during the process, since it did not require manual turning (CORDEIRO, 2010).

According to Jiang et al. (2011), the aeration rate was the most important factor significantly affecting NH_3, CH_4 and N_2O emissions. Their study has also shown that higher aeration rates reduced CH_4 emissions, a fact that corroborated the greenhouse effect reduction.

Synthetic fertilizer addition to the organic waste during the composting process reduced biocompost maturation time, since it potentiated bacterial bio-decomposer increase in a short period of time; besides, it synthesized organomineral compost with high soluble phosphorus content. The efficiency of the phosphorus deriving from organomineral fertilizers was similar to that of soluble fertilizers (PEREIRA; FIALHO, 2013).

The mass of the stabilized composts in each compost heap with food industry and household waste was determined at the end of the composting process. The mean mass reduction in the compost heaps reached 60.6% (industrial waste) and 68.25% (urban waste); this outcome corroborates the key role played by this process in treating the organic fraction of solid wastes.

This result is in compliance with the one observed by Massukado and Schalch (2010), according to whom composting processes can enable mean reduction by up to 65% the total compost heap volume. In addition, the material is converted into stable organic matter throughout the degradation process; besides, it releases CO_2 and H_2O, among other compounds in smaller amounts.

3.2 Agronomic valuation of industrial and urban organic wastes subjected to potentiated composting

Table 2 shows results of experiments conducted with industrial and urban composts under natural conditions.

All parameters (number of leaves, plant height, fresh mass and dry mass) analyzed during the development of lettuce seedlings recorded higher values in treatments 2 to 6 than in the control (soil, only), except for dry mass, which was analyzed at the 17th developmental day and did not show significant difference between treatments (Table 2).

Table 2- Parameters evaluated during lettuce development (number of leaves, plant height, fresh mass and dry mass) based on different treatments (TR)

Parameter /develop. days	**Treatments/ mean ± standard deviation**					
	TR1	**TR2**	**TR3**	**TR4**	**TR5**	**TR6**
N. of leaves						
17	2.00 ± 0 ^{a}	3.20 ± 0.45 ^{b}	3.20 ± 0.45 ^{b}	3.40 ± 0.55 ^{b}	3.40 ± 0.55 ^{b}	3.80 ± 0.45 ^{b}
24	3.20 ± 0.45 ^{a}	4.20 ± 0.84^{ab}	4.20 ± 0.84^{ab}	4.60 ± 0.55 ^{b}	4.00 ± 0.71^{ab}	4.80 ± 0.45 ^{b}
31	3.40 ± 0.55 ^{a}	5.20 ± 0.45 ^{b}	5.60 ± 0.89^{bc}	6.40 ± 0.55 ^{c}	5.80 ± 0.45^{bc}	6.60 ± 0.55 ^{c}
38	4.20 ± 0.45 ^{a}	6.00 ± 1.00 ^{b}	6.20 ± 0.45 ^{b}	7.00 ± 0.71 ^{b}	6.60 ± 0.55 ^{b}	7.20 ± 0.84 ^{b}
Plant height (cm)						
17	1.42 ± 0.08 ^{a}	3.48 ± 0.19 ^{b}	3.42 ± 0.43 ^{b}	5.58 ± 1.28 ^{c}	3.32 ± 0.51 ^{b}	5.66 ± 1.36 ^{c}
24	1.64 ± 0.23 ^{a}	5.40 ± 0.57 ^{b}	5.66 ± 0.34 ^{b}	7.28 ± 0.56 ^{c}	5.40 ± 0.46 ^{b}	7.74 ± 0.67 ^{c}
31	2.76 ± 0.52 ^{a}	7.52 ± 0.28 ^{b}	7.70 ± 0.39 ^{b}	9.68 ± 0.30 ^{c}	7.88 ± 0.50 ^{b}	10.02 ± 0.36 ^{c}
38	3.00 ± 0.32 ^{a}	9.52 ± 0.37 ^{b}	9.70 ± 0.45 ^{b}	11.64 ± 0.80 ^{c}	9.96 ± 0.56 ^{b}	12.04 ± 0.72 ^{c}
Fresh mass (mg)						
17	2.72 ± 0.16 ^{a}	6.03 ± 2.58 ^{a}	5.31 ± 0.93 ^{a}	11.73 ± 5.11 ^{b}	5.44 ± 1.43 ^{a}	11.67 ± 3.19 ^{b}
24	3.65 ± 0.91 ^{a}	16.79 ± 3.53 ^{b}	16.63 ± 3.61 ^{b}	30.50 ± 6.28 ^{c}	21.18 ± 4.39 ^{b}	32.32 ± 7.17 ^{c}
31	3.61 ± 0.64	37.78 ± 2.97	37.17 ± 1.84 ^{b}	51.78 ± 4.24	37.94 ± 5.82	52.83 ± 2.95

	^{a}	^{b}		^{c}	^{b}	^{c}
38	5.27 ± 1.00 ^{a}	43.20 ± 3.26 ^{b}	43.70 ± 4.41 ^{b}	62.44 ± 3.88 ^{c}	44.34 ± 3.53 ^{b}	66.38 ± 8.48 ^{c}
Dry mass (mg)						
17	0.15 ± 0.02 ^{a}	0.55 ± 0.19 ^{a}	0.42 ± 0.10 ^{a}	0.87 ± 0.92 ^{a}	0.34 ± 0.04 ^{a}	0.81 ± 0.89 ^{a}
24	0.23 ± 0.07 ^{a}	2.07 ± 0.75 ^{b}	2.85 ± 0.81 ^{b}	2.92 ± 0.86 ^{b}	2.90 ± 0.82 ^{b}	2.84 ± 0.39 ^{b}
31	0.29 ± 0.09 ^{a}	3.11 ± 0.57 ^{b}	3.68 ± 0.77 ^{b}	4.18 ± 1.06 ^{b}	3.65 ± 0.23 ^{b}	3.91 ± 0.22 ^{b}
38	0.34 ± 0.04 ^{a}	4.19 ± 0.46 ^{b}	4.59 ± 0.68 ^{b}	5.15 ± 0.63 ^{b}	4.57 ± 0.43 ^{b}	4.94 ± 0.45 ^{b}

TR1: control (soil); TR2: commercial organic compost; TR3: industrial organic compost without fertilizer; TR4: industrial organic compost with fertilizer; TR5: urban organic compost without fertilizer; TR6: urban organic compost with fertilizer.
Different letters on the same line indicate statistical difference between treatments based on ANOVA and Tukey tests ($p < 0.05$).
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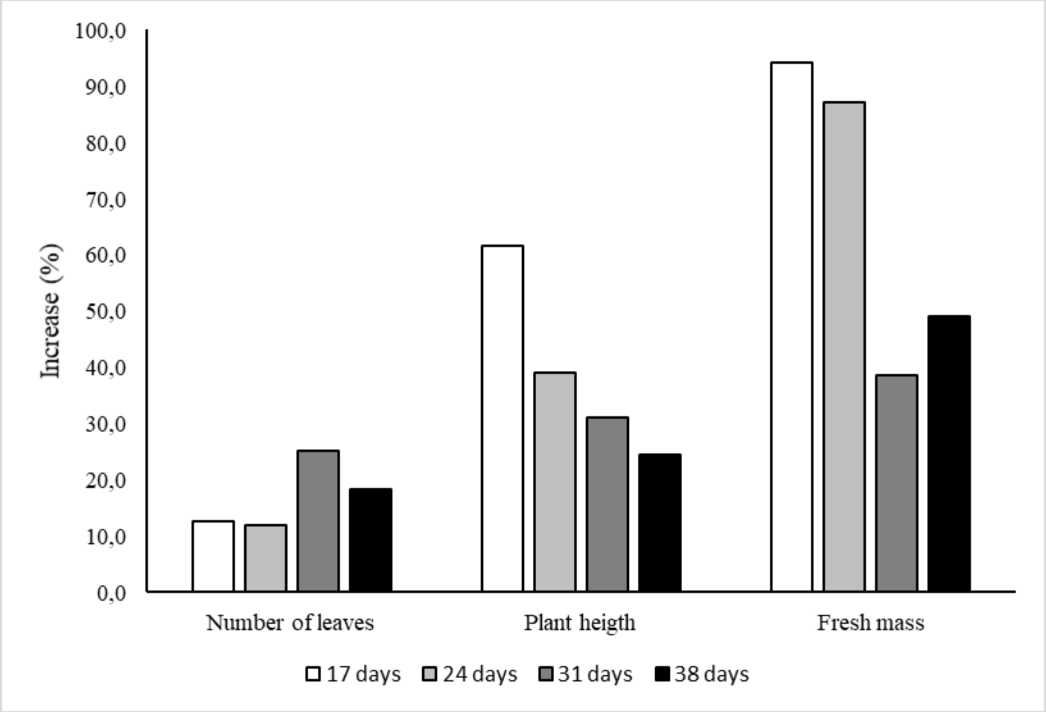
Lettuce seedlings subjected to treatments 4 and 6 have shown better development than seedlings subjected to other treatments (Table 2). It happened due to higher agronomic valuation of the organomineral compost, which presented higher macro- and micronutrient levels (Table 1), since treatments 4 and 6 comprised (industrial or urban) organic composts added with fertilizer. Except for the first analysis, which was conducted at the 17th seedling development day, treatments 4 and 6 were the ones recording the highest values for parameter 'number of leaves', which ranged from 4.7 to 7.2, on average, from the 24th to the 38th seedling development day; whereas values recorded for treatment 2 (commercial organic compost) at the same period ranged from 4.2 to 6 (Table 2).

Parameters 'plant height' and 'fresh mass' recorded significant difference between treatments since the first analysis - the highest values were also observed for TR4 and TR6. The comparison between these treatments and TR2 (commercial organic compost) has shown greater increase in plant height and fresh mass in the first two analyses (at the 17th and 24th seedling development days); these two parameters were up to 61% and 94% higher, respectively (Figure 2).

Parameter ‘dry mass’ did not show significant difference between treatments (2 to 6); lettuce plants recorded 4.7 mg of dry mass, on average, at the end of the experiment. There was significant difference only between these treatments and the control, in which lettuce seedlings recorded 0.3 mg of dry mass, on average, at the end of the experiment.

Studies conducted by Gonçalves et al. (2014) and Medeiros et al. (2008) have also shown that organic compost produced from wastes recorded more statistically significant values for lettuce parameters such as plant height and fresh mass.

Figure 2 - Increase in the number of leaves, plant height and fresh mass of lettuce seedlings subjected to treatments with organic compost and fertilizer (TR4 and TR6) in comparison to the treatment with commercial organic compost (TR2)



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3.3 Potentiated composting application in medium-sized cities

In the current study, the investigated medium-sized city solid waste production reaches 297 t day^{-1}, on average, whereas its annual production reaches 108,405 tons (SENE; SOUZA; MARINO, 2015). If one takes into consideration the mass gravimetric composition rates of the investigated city (58% organic waste, according to the aforementioned study), it is possible stating that the amount of organic matter produced in the city reaches 62,874.9 t. year^{-1} or 172.26 t day^{-1}.

The density of the waste to be composted has specific weight equal to 550 kg m^{-3} (MMA, 2010). In addition to this parameter, value equal to 25 should be adopted for the C/N ratio in this dimensioning process, as well as windrow height equal to 1.8 m and base dimension equal to 3.5 m (NUCASE, 2007).

The waste volume to be composted is equal to 313.2 m^3. The length of the windrow to be placed in the yard on a daily basis is approximately 99.43 m. According to Cerri et al. (2008), total compost stabilization time ranges from 90 to 120 days; therefore, the number of windrows in the composting yard should meet the number of days required for total compost stabilization – the current study adopted 90 days. In addition, it is necessary increasing the total operation area by 10% to enable circulation, safety, equipment and service areas; thus, the area of the conventional composting yard should be equal to 6.58 ha.

Similar amount of organic waste was used in the potentiated composting yard. Thus, windrow length to be adopted is also 99.43 m; however, the number of days necessary for compost stabilization in this yard is different; based on results of the experiments, the time to be adopted is 25 days. Thus, the area of the potentiated composting yard should be equal to 1.69 ha.

Therefore, based on the potentiated composting methods adopted in the current study, the area of the composting yard for a medium-sized city should cover 1.69 ha, which is 74.32% smaller than the area necessary to implement the conventional composting method. This outcome highlights the applicability of the potentiated method in saving time, workforce, financial resources and facility areas, besides producing composts with higher nutrient content at the end of the process.

6 CONCLUSION

The compost stabilized in the compost heap comprising facilitated aeration and chemical fertilizer addition presented better agronomic valuation, shorter maturation time, no need of manual turning and reduced cost with composting process. The area of the potentiated composting yard was approximately 74 times smaller than that of the conventional composting yard for a medium-sized city.

Potentiated composting is an effective treatment to be applied to the organic fraction of solid wastes, since it produces an organomineral fertilizer that has direct application in agriculture; besides, it reduces the amount of organic waste sent to landfills and contributes to the sustainable development of different cities.

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