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Improving the nutrient content of sheep bedding compost by adding cattle manure

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ABSTRACT

Sheep bedding has favorable characteristics for composting, such as providing readily assimilable carbon and facilitating aeration, which are essential for the growth of composting microorganisms. However, when composted alone, it may have disadvantages related to the time of composting and to the fertilizer value of the compost produced, due to its high lignocellulosic content. To investigate whether cattle manure could improve composting of sheep bedding as well as the agronomic quality of the compost produced, we mixed cattle manure with sheep bedding in varying proportions (0–100%) and evaluated several parameters of the composting process and of the final compost, such as changes in temperature, macronutrients, and carbon content before and after the composting process. The addition of ≥50% cattle manure to the mixture increased composting efficiency, resulting in a more stable compost with higher nutrient content. The high content of rice husk in sheep bedding limited the addition of higher proportions of this component to the composting mixture. We identified an efficient way to improve the quality of compost generated during waste management of sheep manure and bedding.

1. Introduction

Studies on sheep bedding have been conducted to evaluate the efficiency of the materials used in terms of production costs, development, animal well-being and behavior, as well as meat quality (Gonçalves et al., 2008; Wolf et al., 2010; Teixeira et al., 2012, 2013, 2014). Most results indicate that sheep bedding is advantageous for these variables.

However, after removing the material used as bedding in order to replace it, it must be stabilized in order to be reused as a source of nutrients for plants and organic matter for the soil. Therefore, the characteristics of the material chosen will directly affect the quality of the final organic fertilizer. Borhan et al. (2014) consider it a challenge to find suitable materials for bedding that have high moisture absorption, better cow comfort, high fertilizer value and that promote improvements in the facility's internal environment.

In most cases, the material used for bedding is chosen based on variables such as ease in obtaining (Avila et al., 2007; Wolf et al., 2010), water absorbency (Steef et al., 2009); emission of greenhouse gases (Garlipp et al., 2011), and water absorbency and emission of greenhouse gases (Borhan et al., 2014). The efficiency of the stabilization processes for this material and the agronomic value of the final product are most often overlooked.

Because it is a solid waste product, the sheep bedding can be stabilized through the composting process. The C:N ratio of this material, and especially the quality of C, can affect the performance of this process (Bernal et al., 2009). Rice husk is commonly used as bedding material, as it is a residue of the processing of cereal. However, its silica content makes it highly resistant to degradation. Leconte et al. (2009) observed that rice hulls were resistant to microbial attack, more than the sawdust itself. This was attributed to the large contact surface of the sawdust and to the water retention aided by the waterproof rice husk (due to the presence of silica).

Thus, the use of only sheep bedding (sheep rice husk + waste) in the compost can cause unfavorable results, such as a long

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stabilization period and low fertilizer value of the final compost. Given these problems, the concept of co-composting with other waste products may be introduced to benefit the system. Co-composting involves mixing one or more types of materials in order to improve the characteristics of the main residue and facilitate its stabilization. This strategy is being evaluated to improve the composting of waste that is difficult to degrade; one can add waste to decrease the C:N ratio (Zhang and He, 2006; Liu et al., 2011; Rashad et al., 2010) or straw to increase the C:N ratio of animal waste (Petric et al., 2009; Das et al., 2011; Qian et al., 2014). When composted without an easily degradable nitrogen source, rice husk presents lower values of organic matter decomposition, a low AH/AF ratio, and lower cellulase activity. When mixed mostly with composted animal waste, the decomposition becomes more efficient (Rashad et al., 2010).

In the case of sheep bedding, mixing with cattle manure can improve the composting process and the value of the final compost. Cattle manure presents good composting performance (including a high degradation rate of organic matter), as well as a high nutrient concentration in the system, characteristics that are both environmentally and economically favorable (Orrico Junior et al., 2012).

Given that several composting parameters are usually monitored (in order to evaluate the performance and the final product) and that such parameters are interrelated, it is important to analyze data using multivariate statistical techniques. These analyses consider the dependency relationships between variables, study the similarity between the sample elements, and allow simplifying the structure of data variability (Mingoti, 2005).

The aim of the current study was to combine sheep bedding + cattle manure while trying to establish an adequate ratio between the mixtures to maximize the efficiency of the procedure as well as the quality of the final compost.

2. Material and methods

2.1. Origin of residues: sheep bedding and cattle manure

The sheep bedding used in this study comes from a feedlot where the animals remain on the bed (rice husk) throughout the fattening cycle. The cattle manure come from a confinement system where the animal feed is composed of 60% forage from the whole corn plant silage, and 40% concentrate, containing grain bran and mineral supplement. The characteristics of the sheep bedding and the cattle manure used in this study are shown in Table 1.

Table 1
Characteristics of the sheep bedding and the cattle manure used as composting substrates.

Parameter	Substrate	
	Sheep bedding	Cattle manure
pH	8.96	9.10
EC (dS m^{-1})	12.76	10.23
Carbon (%)	41.84	43.88
TKN (%)	1.50	2.79
Phosphorus (g kg^{-1})	5.67	7.89
Potassium (g kg^{-1})	13.27	38.45
Ash (%)	24.68	21.02
Cellulose (%)	26.20	18.00
Hemicellulose (%)	20.77	22.88
HA/FA	0.84	1.23
C/N	28	16

EC: Electrical conductivity; TKN: Total Kjedahl nitrogen; HA/FA: Humic acid/fulvic acid; C/N: Carbon/nitrogen.

2.2. Experimental set-up and procedures

The experiment was conducted at the Experimental Center of Agricultural Engineering (NEEA) of the Western Paraná State University (UNIOESTE), Cascavel campus, Brazil, from April to July 2012. Windrows were formed on a covered, concrete floor-composting pad, to protect compost from the weather. Ten windrows were formed, two from each experimental condition, based on the following sheep bedding and cattle manure ratios: 0:100, 25:75, 50:50, 75:25, 100:0, representing experimental conditions T_{100}, T_{75}, T_{50}, T_{25}, and T_0, respectively. Each windrow had an initial weight of 200 kg dry matter (DM) basis. Three days after windrows had been formed (which was considered composting day 1), an initial sample was collected from each windrow. Sub-samples were collected at six different points within the swath. After being homogenized, the sub-samples formed a single composite sample. After windrows were formed, manual turning was performed twice a week in the first month and weekly afterward to aerate and moisten the material. Moisture content was recorded at each turning by drying a small amount of windrow material. The amount of water added to keep moisture content around 60% was calculated individually for each windrow and depended on windrow weight at each turning. Composting was monitored until windrow temperature was similar to the ambient temperature, when the material was considered stable.

2.3. Analytical methods

Windrow temperature was monitored daily at six points using a mercury thermometer graduated to 250 °C, inserted to 0.2 m depth into each windrow. Homogenized samples from each windrow were analyzed at the beginning and end of composting. The samples were pre-dried at 50 °C in a forced air oven up to constant mass to avoid losses, especially of nitrogen. After drying, the samples were ground in a grinder with a 20 mesh sieve, and then used for all determinations (contents of nitrogen, phosphorus, potassium, ash and carbon and organic matter fractionation), which were analyzed in a moist sample. In all analyses, results were corrected to dry basis (105 °C).

Electrical conductivity (EC) and pH were determined in the same solution, consisting of a suspension of sample in distilled water (1:10 m/v). pH readings were done using a TECNAL TEC-3MP bench potentiometer and electrical conductivity was determined using an MS Tecnopon Special Equipment mCA 150 bench conductometer. Ash content was determined according to the American Public Health Association (APHA et al., 2012).

Carbon (C) content was determined by ignition in a muffle furnace at 550 °C for 12 h, according to Cunha-Queda et al. (2003). Organic matter content obtained after burning was divided by 1.8 to determine carbon content. Organic matter fractionation and the quantification of carbon in humic acid (HA) and fulvic acid (FA) fractions used to calculate the HA/FA ratio were performed according to Benites et al. (2003).

Total Kjedahl nitrogen (TKN) was estimated using a Kjedahl distiller, according to Malavolta et al. (1997). The C/N ratio was calculated from C and TKN estimates. Cellulose and hemicellulose contents were obtained by determining neutral detergent fiber (NDF) and acid detergent fiber (ADF) in a Marconi MA-444/CI digestion fiber apparatus using the sequential method described by Campos et al. (2004). Phosphorus (P) and potassium (K) contents were determined using the dry extraction procedure described in Alcarde (2009). The method involves heating the sample in a muffle furnace at 550 °C, thus allowing the destruction of organic matter. After firing, the residue is dissolved in HCl and transferred to a volumetric flask before analysis. Phosphorus readings were