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Effect of castor cake and elephant grass composting on edaphic fauna

Efeito da torta de mamona e do capim-elefante compostagem sobre a fauna edáfica

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ABSTRACT

*Elephant grass and castor cake when combined can make a promising organic fertilizer. However, castor cake contains potentially toxic chemicals, such as ricin and ricinine. To test potential effects of these chemicals, compost piles of elephant grass (**Pennisetum purpureum** Schum.) with castor cake were prepared with different C:N ratios (T1 = 40, T2 = 30, T3 = 20; T4 = 30 [control, elephant grass + crotalaria]) to evaluate colonization by edaphic fauna and any suppressive effects of castor cake. Soil organisms were collected with Berlese-Tullgren funnels. There were temporal differences between the treatments, and the epigeous fauna was mainly represented by members of the Acari and Entomobryomorpha. Elapsed time is the major factor in determining the composition of the epigeous fauna community associated with composting, indicating that castor cake has no suppressive effect.*

Key words: *organic compound, plant residues, soil fauna.*

RESUMO

O composto inteiramente vegetal, a partir da mistura de capim elefante e torta-de-mamona, apresenta-se promissor como adubo orgânico. No entanto, há preocupações quando se consideram os compostos químicos potencialmente tóxicos contidos na torta-de-mamona, como a ricina e ricinina. Assim, foram montadas pilhas de compostagem com diferentes relações C:N (T1 = 40; T2 = 30; T3 = 20; T4 = 30 (tratamento controle composto por Capim elefante + crotalária)) com o objetivo de avaliar, ao longo do tempo, a colonização da fauna edáfica e se a torta-de-mamona causa algum efeito supressor. A avaliação foi realizada com funis de Berlese-Tullgren. Houve diferenças pontuais entre os tratamentos, sendo a fauna epígea representada principalmente pelos grupos Acari e Entomobryomorpha. Verificou-se que o tempo é o principal fator na determinação da comunidade de fauna epígea associada à compostagem, indicando que o uso da torta-de-mamona não tem efeito supressor sobre a fauna edáfica ao longo do processo de compostagem.

Palavras-chave: *fauna do solo, composto orgânico, resíduos vegetais.*

INTRODUCTION

In organic systems, substrate and input demands can be satisfied with composted materials, which are readily available, inexpensive, and rich in nutrients (LEAL et al., 2007). Elephant grass and castor cake have these characteristics. Elephant grass (***Pennisetum purpureum*** Schum.) is a tropical forage plant that is rich in nutrients, with potential for biomass production (PEREIRA et al., 2000). The cake produced from castor (***Ricinus communis*** L.), which is widespread in Brazil, has a high nitrogen and protein content and undergoes rapid mineralization in the soil, it is therefore extensively used in agricultural as an organic fertilizer (FERNANDES et al., 2011; SANTOS et al., 2012).

Composting depends on the proliferation of several saprophagic invertebrates and microorganisms (SAMPERO & DOMINGUEZ, 2008), which fragment the plant material and increase the bioavailability of many elements (MENTA, 2012; MORAIS et al., 2013). The diversity and activity of these organisms are influenced by chemical and physical characteristics of the plant material, and they

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help to determine its decomposition rate (GATIBONI et al., 2009; JIANG et al., 2014).

However, a consistent concern regarding the use of different plant species as inputs is the possibility of negative effects on the organisms involved in decomposition. A study in Brazil has demonstrated that the ricin and ricinine in castor cake are efficient in controlling populations of phytonematodes (DINARDO-MIRANDA & FRACASSO, 2010). During the composting process, different inputs may interfere with the associated faunal community. Different combinations of inputs can enhance or reduce the community, and measurements of soil organism populations are therefore good indicators of the input quality (KUNDE et al., 2013). Thus, the objectives of this study were (a) to assess the edaphic fauna community in plant compost piles with different C:N ratios, and (b) to investigate whether castor cake had a suppressive effect on the colonization of this substrate.

MATERIALS AND METHODS

The experiment was conducted at Embrapa Agrobiologia, Seropédica, Rio de Janeiro. The raw materials used were 90-day-old aerial parts of crotalaria (***Crotalaria juncea*** L.), 120-day-old sprouted elephant grass, and castor cake (Azevedo® brand). All materials were shredded into 3-cm lengths with a mechanical chopper. The ratio of each raw material was calculated using Pearson's Square. Compost piles with different C:N ratios were assembled: T1 (C:N = 40, Elephant grass + 11.5 % castor cake); T2 (C:N = 30, Elephant grass + 18.4% castor cake); T3 (C:N = 20, Elephant grass + 32.9% castor cake); T4 (C:N = 30, Elephant grass + crotalaria [control]). Each pile was assembled on a plastic tarp in a pasture and measured 1.5m wide, 2.0m long, and 1.2m high. Piles were turned on days 14, 30, and 60. The average temperature of the piles decreased with time composting, from 48°C (30 days) to 30ºC (90 days).

Soil organisms were collected 30, 60, and 90 days after composting began and before turning, using a Berlese-Tullgren funnel. Following the method outlined by AQUINO et al. (2006), the composted material was placed into a 1.33-dm^{-3} metallic cylinder, with a 2-mm mesh across its base, and heated from above (15cm) by an incandescent bulb of 40W for 7 days. Organisms were moved away from the heat and fell down into the collector bottle, which contained 1% formaldehyde. Four replicates were randomly collected in each pile, from the surface to a depth of 10cm.

Invertebrates were counted and identified to major taxonomic group, according to the descriptions provided by DINDAL (1990). The following metrics were estimated: density (number of individuals·dm^{-3}), total richness (number of groups identified in each treatment), average richness (number of groups identified in each replication), and Pielou's evenness index (distribution of the number of individuals among the taxonomic groups), which is used to evaluate the biodiversity of a community (ODUM & BARRETT, 2011).

The homogeneity of error variances was evaluated with Cochran test, and normality was checked with the Lilliefors test, using Saeg 9.1 software. Data with non-parametric distributions were transformed (square root (x+1)). An analysis of variance (ANOVA) was conducted on parametric data with the Bonferroni correction (α = 0.05), using Sisvar 5.3 software. Non-parametric distributions were analyzed with the Kruskal-Wallis test (P = 0.05), using Saeg 9.1 software. A Principal Component Analysis, namely density or abundance of edaphic fauna, composting time, C:N ratio, and composting treatment were conducted with Canoco 4.5 software (LEPS & SMILAUER, 2003).

RESULTS AND DISCUSSION

The main groups of edaphic fauna in the compost piles, in decreasing order of density, were Acari, Entomobryomorpha, ***Coleoptera***, ***Diplura***, and ***Formicidae*** (Table 1). The high numbers of mesofauna in Acari and Entomobryomorpha may reflect their great importance in decomposition and the maintenance of soil fertility (ODUM & BARRETT, 2011). These fauna groups have ecological functional characteristics that are directly related to the conditions offered by the compost piles. Many springtail species interfere directly and indirectly with decomposition because they eat the available organic material and still associate themselves with microorganisms and fungi (ZEPPELINI FILHO & BELLINI, 2004). Mites are usually very abundant in the environment and are particularly associated with decomposing or already decomposed materials like fallen leaves, humus, rotting wood, and debris. Members of Coleoptera have a wide range of trophic functions, but most of them are phytophagous, fungivorous, or detritivorous. Formicidae have different habits, and they feed on other animals or on plant matter, including sap, nectar, and similar substances. Diplura are often found in humid places and under rotting wood (RUPPERT et al., 2005).

Temporal differences were found between treatments at 30 and 60 days after composting began. On day 30, the average richness in treatment T2 was

Table 1 - Main groups of edaphic fauna collected at day 30, 60, and 90 of composting with different treatments. [a]Different lowercase letters indicate a significant difference at $p = 0.05$ (Kruskal-Wallis test). [A]Different uppercase letters indicate a significant difference at $p = 0.05$ (ANOVA with Bonferroni correction). *ANOVA was calculated with transformed data. [1]Entomobryomorpha. T1 (C:N = 40, Elephant grass + 11.5% castor cake); T2 (C:N = 30, Elephant grass + 18.4% castor cake); T3 (C:N = 20, Elephant grass + 32.9% castor cake); T4 (C:N = 30, Elephant grass + crotalaria [control]).

Treatment	Acari	Coleoptera	Diplura	Entomo[1]	Formicidae	Total	Richness average	Pielou's index
	Number of individuals dm^{-3}							
Day 30								
T1	796.5^{A}	11.5^{a}	10.4^{A}	96.2^{A}	0.2^{a}	916.1^{A}	4.5^{B}	0.23
T2	635.7^{A}	8.7^{a}	21.1^{A}	$241,7^{A}$	2.8^{a}	$935,0^{A}$	8.0^{A}	0.34
T3	199.5^{A}	9.6^{a}	7.0^{A}	16.8^{A}	3.6^{a}	242.0^{A}	6.8^{AB}	0.32
T4	38.8^{A}	4.9^{a}	5.8^{A}	5.1^{A}	1.9^{a}	59.0^{A}	6.5^{AB}	0.55
Day 60								
T1	746.1^{a}	17.9^{A}	0.4^{a}	20.9^{B*}	2.4^{a}	801.4^{ab}	5.3^{a}	0.14
T2	22.4^{a}	3.6^{A}	1.5^{a}	11.5^{B*}	0.0^{a}	41.8^{b}	5.0^{a}	0.59
T3	172.9^{a}	5.7^{A}	1.5^{a}	84.2^{AB*}	6.8^{a}	276.1^{ab}	6.5^{a}	0.36
T4	402.9^{a}	5.1^{A}	2.1^{a}	340.9^{A*}	0.2^{a}	768.5^{a}	5.0^{a}	0.37
Day 90								
T1	1455.4^{A}	12.8^{A}	0.0^{a}	3.8^{A}	6.6^{A}	1488.2^{A}	6.0^{A}	0.06
T2	853.6^{A}	16.6^{A}	4.3^{a}	5.7^{A}	10.5^{A}	894.1^{A}	6.3^{A}	0.10
T3	430.4^{A}	16.2^{A}	0.6^{a}	39.2^{A}	9.6^{A}	511.6^{A}	7.8^{A}	0.25
T4	1247.8^{A}	6.8^{A}	1.3^{a}	15.8^{A}	5.1^{A}	1373.8^{A}	7.8^{A}	0.16

higher than in T1. Conversely, on day 60, the total organism density in the control (T4) was higher than in T2, and the ***Entomobryomorpha*** group in T4 was higher than in T1 and T2 (Table 2). These results indicated that the amount of castor cake used did not have an effect on the composition and diversity of

Table 2 - Relative proportion of other fauna groups (excluding Acari and Entomobryomorpha) collected in compost piles with different treatments on three collection dates. T1 (C:N = 40, Elephant grass + 11.5% castor cake); T2 (C:N = 30, Elephant grass + 18.4% castor cake); T3 (C:N = 20, Elephant grass + 32.9% castor cake); T4 (C:N = 30, Elephant grass + crotalaria [control]).

	30 days				60 days				90 days			
Taxon	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Araneae	-	0.3	0.7	-	-	-	1.0	-	0.6	3.8	1.8	0.2
Blattodea			3.6	2.5	-	-	-	-	-	-	-	-
Coleoptera	49.2	15.0	37.2	32.5	51.9	45.2	29.7	20.6	44.2	47.6	38.6	6.2
Dermaptera	-	-	-	-	0.5	-	-	-	0.6	0.5	-	0.3
Diplopoda	-	-	-	-	-	-	-	-	-	-	-	0.5
Diplura	44.4	36.6	27.0	38.8	1.1	19.0	7.9	8.4	-	12.4	1.3	1.2
Diptera	-	0.3	-	-	-	-	2.0	3.1	1.3	0.5	1.3	3.2
Formicidae	0.8	4.9	13.9	12.5	7.1	-	35.6	0.8	22.7	30.3	22.9	4.6
Heteroptera	4.0	4.2	16.1	5.0	0.5	-	2.0	0.8	-	0.5	0.4	0.3
Hymenoptera	-	-	-	-	1.1	2.4	-	-	-	-	-	-
Isopoda	-	0.3	-	-	0.5	-	-	-	-	-	-	-
Isoptera	0.8	-	-	-	-	-	1.0	-	0.6	1.6	0.4	0.9
Coleoptera (larvae)	-	0.7	0.7	-	30.6	16.7	4.0	4.6	4.5	1.6	6.3	3.2
Diptera (larvae)	-	1.6	-	1.3	4.9	4.8	2.0	19.1	22.1	1.1	24.7	76.9
Poduromorpha	-	35.6	-	-	1.6	9.5	11.9	42.7	-	-	0.4	0.5
Pseudoscorpionidae	-	-	-	7.5	-	-	1.0	-	2.6	-	-	-
Psocoptera	-	-	0.7	-	-	2.4	2.0	-	0.6	-	0.4	-
Sternorryncha	-	-	-	-	-	-	-	-	-	-	0.9	1.9
Thysanura	-	0.3	-	-	-	-	-	-	-	-	-	-
Thysanoptera	-	-	-	-	-	-	-	-	-	-	0.2	-

the associated fauna, because the treatment (T3) with the highest proportion of this material did not differ from the control. In addition, the lack of difference between parameters at 90 days indicates a small and temporary effect of the treatments on the soil fauna.

Overall, treatment T1 (with the lowest castor cake content) exhibited the lowest Pielou's index value (Table 1). This index, which ranges from 0 to 1, was used to compare taxonomic diversity between treatments and can indicate whether a particular group is dominant (ODUM & BARRETT, 2011). For this treatment, the dominant group was Acari, which represented over 85% of the density at each collection time (Figure 1). There was no

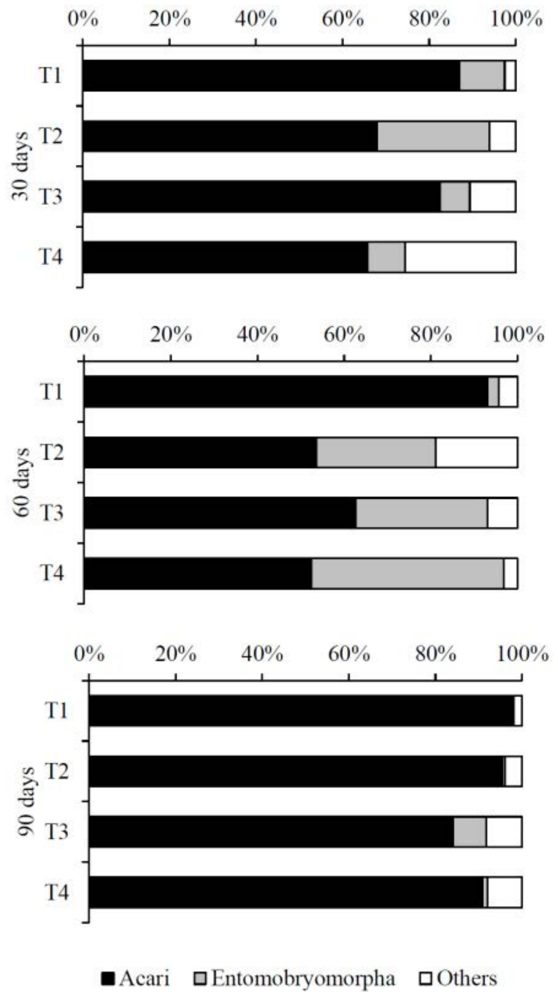

Figure 1 - Proportion of Acari and Entomobryomorpha groups collected on three different dates from compost piles with different treatments. T1 (C:N = 40, Elephant grass + 11.5% castor cake); T2 (C:N = 30, Elephant grass + 18.4% castor cake); T3 (C:N = 20, Elephant grass + 32.9% castor cake); T4 (C:N = 30, Elephant grass + crotalaria [control]).

observable relationship between the amount of castor cake used (and its possible toxic effects) and colonization by Acari.

The Acari represented over 50% of individuals in all other treatments at every sampling time. Compost piles supply resources that are ephemeral, unevenly distributed, and rich in energy; they sustain communities of detritivore micro-arthropods like mites, where many species experience frequent population peaks in response to fresh inputs (TAYLOR et al., 2010). Springtails, which are also detritivores, have a similarly rapid response with population peak (GATIBONI et al., 2009).

The relative compositions of the less-abundant taxa (Figure 1) are shown in 2. Members of Blattodea and Thysanura were only found in the first collection, while Diplopoda, Sternorrhyncha, and Thysanoptera appeared only in the last collection. Coleoptera and Diptera, including their larvae, generally increased over time, as did predatory taxa in Araneae, Dermaptera, Formicidae, and Isotera. Diplura, Heteroptera, and Poduromorpha showed a relative decrease over time. These results clearly demonstrated the coexistence and autogenic succession of groups and functions as the physical environment changed and reflected competitive interactions produced within the community itself (ODUM & BARRETT, 2011).

Among these groups, according to BRUSSAARD (1998) and MENTA (2012), mites, springtails, isopods, and millipedes, in addition to a diversity of insect larvae, are considered the most important transformers of plant and animal materials, directly or indirectly facilitating microbial decomposition. Additional groups (Hymenoptera, Isopoda, Pseudoscorpionida, and Psocoptera) were present sporadically and may not be associated with the composting process; their presence might reflect their relationships with other organisms and/or preferred temperature and moisture conditions within the compost piles.

Composting time was the main component that influenced the composition of the associated fauna, as shown in figure 2. Other authors had already noted the association of time with colonization patterns of epigeous fauna. According to TAYLOR et al. (2010) and FUJII & TAKEDA (2012), the biomass and abundance of different groups of soil fauna can drastically change both temporally and spatially.

Figure 2 also shows weaker relationships between groups and treatments. Psocoptera, Pseudoscorpionidae, and Blattodea were most associated with treatment T3, while other groups,

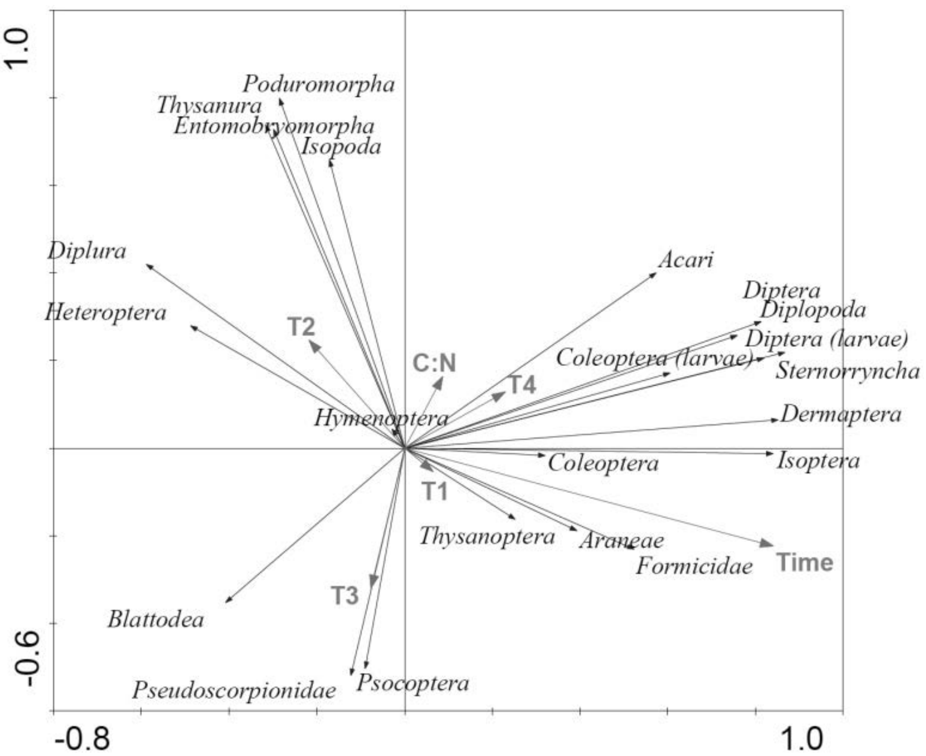

Figure 2 - Ordination diagram of major components, using the abundance of edaphic fauna groups, type of treatment (T1, T2, T3, and T4 [control]), carbon to nitrogen ratio (C:N), and composting time (time). T1 (C:N = 40, Elephant grass + 11.5% castor cake); T2 (C:N = 30, Elephant grass + 18.4% castor cake); T3 (C:N = 20, Elephant grass + 32.9% castor cake); T4 (C:N = 30, Elephant grass + crotalaria [control]).

including Diplura and Entomobryomorpha, were associated with treatment T2. In fact, it is possible that group richness and individual abundance are related to the quality of the plant material being decomposed (RESENDE et al., 2013; JIANG et al., 2014). However, input quantity may not determine the abundance, biomass, taxonomic richness, or composition of the associated fauna community (ASHFORD et al. 2013).

CONCLUSION

Compost piles of elephant grass and castor cake were primarily colonized by Acari, Entomobryomorpha, Coleoptera, Diplura, and Formicidae, which act as pioneers in soil communities and have a high capacity for colonization and reproduction. Different amounts of castor cake, which modified the C:N ratio, did not appear to influence fauna community composition. Composting duration was the most important factor in determining community composition and diversity, allowing succession and competition. Castor cake, when used as a raw material in association with other energy sources for the production of organic fertilizer, did not suppress the activity of the organisms that promote composting.

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