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Full Length Research Paper

Macrofauna of soil treated with swine wastewater combined with chemical fertilization

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This study aimed to evaluate the effects of the application of swine wastewater treated in anaerobic digester (0, 100, 200, and 300 m^3 ha^{-1}) combined with nitrogen fertilization (doses of 0 and 100% of the recommended culture of baby corn) on the edaphic macrofauna. Pitfall traps were used in the evaluation of the macrofauna and the collected organisms were classified at the taxonomic level by order. The diversity of the organisms was evaluated using the Shannon-Wiener, Pielou, and Group richness index. The results demonstrate that the use of swine wastewater increased the density of Hymenoptera significantly up to the dose of 200 m^3 ha^{-1}, with a significant reduction in the dose of 300 m^3 ha^{-1}. The combined use of swine wastewater and 100% of the recommended chemical fertilization dose for the culture up to the limit of 100 m^3 ha^{-1} resulted in a significant increase in the density of the Coleoptera order, being positively influenced by these two factors. The swine wastewater dose of 200 m^3 ha^{-1} resulted in greater edaphic fauna diversity and richness.

Key words: Edaphic fauna, swine waste, water reutilization.

INTRODUCTION

Swine production has increased year by year in the Brazilian and the international market. Brazil was responsible for 3.06% of the world production in 2008, a total of 2.01 million tons, of which 625 thousand tons were exported (USDA, 2008). Swine production has an important place in the Brazilian economy, as it is carried out in different degrees in all the states. However, 50% of the production is concentrated in the southern region (Abipecs, 2008). Another aspect of this activity is the large amount of waste it produces, which induces producers to use this waste as an organic fertilizer. However, not all producers have arable land large enough for the proper usage of waste as water and fertilizer without soil saturation and its negative effects. As a consequence, it is the buildup of nutrients (NO_3, Cu, Zn) and pathogens in soil, which can be carried, away by either runoff or leaching and contaminate the water sources (Baretta et al., 2003; Zhu et al., 2004). Therefore, the use of swine wastewater has been intensively studied all over the world (Suresh et al., 2009); on the other hand, the investigation of variations of edaphic fauna in response to the adoption of soil and culture management in Brazil is still incipient.

According to Baretta et al. (2003), the use of organic waste as fertilizer can affect the soil biota, mainly by providing nutrients to organisms and modifying the soil temperature and cover. Among the soil organisms, macrofauna and invertebrates play a key role in the ecosystem as they occupy several trophic levels in the soil food chain and affect the primary production both directly and indirectly, by changes in soil structure and

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Table 1. Initial chemical composition of the soil of the experimental area before the application of chemical fertilization and swine wastewater.

Parameter	Treatments					
	Chemical fertilization (100%)		Swine wastewater (m^3 ha^{-1})			
	0	100	0	100	200	300
Sodium (mg/dm^3)	2.91	2.50	2.66	2.50	3.00	2.66
Calcium ($Cmol_c/dm^3$)	5.85	5.81	5.86	6.24	5.36	5.87
Magnesium ($Cmol_c/dm^3$)	3.71	3.45	3.71	3.69	3.30	3.63
Potassium ($Cmol_c/dm^3$)	0.35	0.45	0.22	0.30	0.49	0.59
H+Al ($Cmol_c/dm^3$)	2.72	2.66	2.72	2.42	3.02	2.58
Total bases ($Cmol_c/dm^3$)	9.93	9.72	9.82	10.24	9.16	10.10
Cation exchange capacity ($Cmol_c/dm^3$)	12.66	12.39	12.55	12.66	12.22	12.68
Carbon (g/dm^3)	12.67	11.50	11.80	12.04	12.11	12.39
Organic matter (g/dm^3)	19.78	21.78	20.31	20.72	20.83	21.31
Base saturation (%)	72.06	77.88	77.32	80.64	74.36	67.56
Phosphorus (mg/dm^3)	8.68	13.77	8.87	11.63	14.21	8.87
Iron (mg/dm^3)	96.69	99.35	105.21	96.74	83.38	106.75
Manganese (mg/dm^3)	62.16	62.52	60.47	63.91	61.07	63.91
Copper (mg/dm^3)	10.72	10.49	10.39	10.31	10.80	10.93
Zinc (mg/dm^3)	2.21	2.96	2.02	2.87	3.60	3.85
pH	6.48	6.55	6.55	6.61	6.36	6.55
Dry mass (kg/h^{-1})	57.00	62.31	44.81	61.32	62.56	69.87

nutrient availability via fragmentation and decomposition of organic matter. This alters the populations and the activities of microorganisms responsible for mineralization (Silva et al., 2006). This group also favors the fragmentation of the vegetable material, thus redistributing the organic matter and the mixture of the mineral and organic particles. Their fecal pellets also contribute to soil conditioning (Baretta et al., 2007). Thus, soil management and use are factors directly related to the macrofauna, and the use of animal wastes can have either positive or negative effects on the edaphic macrofauna, depending on the type and composition of the wastewater.

Studies performed in the western semi-arid part of Africa using cattle and sheep manureon corn straw, and *Andropogon* grass demonstrated that sheep manure and *Andropogon* straw are more beneficial to the macrofauna (Quédraogo et al., 2006). The addition of swine waste to the soil, associated with mineral fertilization, resulted in a greater diversity of organisms, suggesting the preference of the group for a more balanced fertilizer (Alves et al., 2008). Knowledge of the sensitive macrofauna groups, therefore, may provide information on soil alterations through the presence of one or more edaphic groups (Baretta et al., 2007). Given the importance and sensitivity of some of these organisms to environmental variations, this study aimed to evaluate the effect of the application of swine wastewater combined with chemical fertilizer on the density and diversity of the edaphic macrofauna of a typical dystroferric red latosol grown with babycorn in subtropical conditions.

MATERIALS AND METHODS

The experiment was performed in the municipality of Cascavel, Paraná State, Brazil (24° 48' S and 53° 26' W), and altitude of 760 m. The climate is humid subtropical (Cfa) with annual rainfall of 1800 mm, hot summer, rare frost, and a tendency of rain concentration during the summer, but without a defined season. The mean temperature is 20°C and the relative humidity of the air is 75% (Iapar, 1998). According to Embrapa (2006), the soil is classified as typical dystroferric red latosol with a very clayey texture. It has received nutrient input from the application of swine wastewater and chemical fertilization since 2006. In the beginning of this study in 2008, the following soil chemical composition was obtained (Table 1).

A randomized 2 × 4 factorial block experimental design was used to test treatments with two levels of chemical fertilization (0 and 100%) and four doses of swine wastewater (0, 100, 200, and 300 m^3 ha^{-1}), making up eight treatments with three repetitions in a total of 24 experimental plots with an area of 1.66 m^2. Swine wastewater was obtained from an integrated biosystem constituted of a biodigestor, a sedimentation tank, and a stabilization pond. It was chemically characterized by the APHA, AWWA and WEF method (1998). The results are given in Table 2.

Swine wastewater was applied in a single step, 7 days before sowing babycorn in soil on oat remains. Babycorn varietal BR 106 has a growing season of approximately 70 days. Sowing was manual in tillage in each of the lysimeters, the density of 12 seeds per linear meter spacing of 70 and 8 cm between rows and between plants, respectively, providing stand of 180,000 plants ha^{-1} on the remains oat. Considering the babycorn culture needs, which are based on the needs of corn, nitrogen fertilization was performed at a dose of 80 kg ha^{-1} nitrogen in the form of urea (Vasconcellos et al., 2001). Fertilization was performed in two steps, first by applying 30% of the recommended dose at sowing and the remaining during the culture cycle. The precipitation during the experimental period of 72 days was 72 mm dispersed in three precipitation events.

Table 2. Chemical composition of the swine wastewater used in this study.

Parameter	Result
pH	7.9
Electric conductivity (dS m^{-1})	2.1
Turbidity (NTU)	278
Biochemical Oxygen Demand (BOD_5) (mg L^{-1})	550
Chemical Oxygen Demand (COD) (mg L^{-1})	1450
Total nitrogen (mg L^{-1})	338.8
Nitrate (mg L^{-1})	0.40
Nitride (mg L^{-1})	8.00
Total phosphorus (mg L^{-1})	211.9
Potassium (mg L^{-1})	440.0
Sodium (mg L^{-1})	17.0
Calcium (mg L^{-1})	2.25
Iron (mg L^{-1})	75.0
Magnesium (mg L^{-1})	0.95
Manganese (mg L^{-1})	16.5
Copper (mg L^{-1})	12.5
Zinc (mg L^{-1})	76.5
Total solids (mg L^{-1})	1481
Total fixed solids (mg L^{-1})	729.0
Total volatile solids (mg L^{-1})	671.0

The edaphic fauna was sampled with pitfall traps containing a preservative solution of 4% formaldehyde, one trap per plot. Sampling was performed in three phases of the experiment; 7 days after sowing (7 DAS), in the 15-leaf stage (41 DAS), and after ear sprouting (72 DAS). Each plot received a trap, which was installed in the center of the plot. The traps were left in the field for 7 days in each sampling and the content was identified in laboratory at taxonomic order level. Organism density, measured as the population size, was estimated by converting the number of individuals per trap/day. Only orders with occurrence higher than 1% were considered.

The data were submitted to variance analysis and normalized with transform $x^{0.5}$ + 0.5 as necessary using the free software SISVAR, version 4.2 (Ferreira, 2003) with F-test at 5%, followed by Scott-Knott test at 5%.

Macrofauna diversity was evaluated with the Shannon (H) index, uniformity with the Pielou (e) index, and species richness (Odum, 1983) using the free software DivEs - Diversidade de Espécies (Rodrigues, 2005). We point out that only the orders observed were considered in the analyses. The macrofauna diversity of the soil was evaluated by hierarchic grouping using the Euclidian metric by complete connection.

RESULTS AND DISCUSSION

Organism density

The analyses revealed six macrofauna organism classes for the tested treatments, Aranae, Hymenoptera, Hemiptera, Coleoptera, Orthoptera, and Diptera (Table 3). There was interaction of factors for the Coleoptera order at 41 and 72 DAS. The density of organisms of orders Aranae (Class Arachnida), Hemiptera, Orthoptera, and Diptera (Class Insecta) was relatively lesser than those of the other evaluated orders. In these groups, swine wastewater and chemical fertilization did not exert significant effects, although behavior tendencies were observed for all orders. The density of Hymenoptera organisms was influenced by the use of wastewater, being higher for the dose of 200 m^3 ha^{-1} at 41 and 72 DAS. This was the highest frequency observed for the studied organisms.

The Coleoptera order presented the highest density at 41 and 72 DAS, 10.85 and 2.90 organisms/trap/day, respectively for the dose of 100 m^3 ha^{-1} (Table 4). However, at 72 DAS, the densities for 100 and 200 m^3 ha^{-1} differed from the others at 5%. In general, the density of Coleoptera increased with chemical fertilization and the application of swine wastewater up to the dose of 200 m^3 ha^{-1}. At a dose of 300 m^3 ha^{-1}, there is a reduction in the density of the group in relation to the dose of 200 m^3 ha^{-1}.

Edaphic macrofauna diversity

Table 5 gives the diversity values for the edaphic macrofauna. The Shanon-Wiener (H) index and species richness did not differ significantly for the treatments applied in any of the evaluations, despite the larger H values observed for the dose of 300 m^3 ha^{-1} with 100% chemical fertilization. The greatest species richness was found for the dose of 200 m^3 ha^{-1}. However, there was a significant difference for the dose of 200 m^3 ha^{-1} at 41 and 72 DAS, with the lowest Pielou uniformity index (e) values.

Clustering analysis of the edaphic macrofauna

The dendogram (Figure 1) shows the formation of three distinct homogeneous groups: one formed by the Hymenoptera order, and followed by the Coleoptera order, which had the greatest density of macrofauna organisms (Table 3). The third group was formed by the other orders, which had lower relative frequency (Hemiptera, Diptera, Orthoptera, and Aranae).

Although the density of Araneae organisms was low, this group deserves special attention as it is an indicator of the good quality of the soil (Paoletti and Bressan, 1996) and reflects well the use of inadequate cultivation practices and management, especially the contamination by heavy metals (Marc et al., 1999). In a study by Alves et al. (2008), using swine waste stored in a manure tank for 40 days, the Araneae order had a higher occurrence in soil not treated with swine wastewater or treated with less than 200 m^3, which demonstrates the sensitivity of this group to this environmental condition, in contrast to the results of the present study. Although the differences

Table 3. Density of edaphic macrofauna groups (organisms/trap) sampled on the soil as a function of the treatments used at 7, 41 and 72 DAS.

Order	Treatments					
	Chemical fertilization (%)		Swine wastewater (m^3 ha^{-1})			
	0	100	0	100	200	300
First sampling - 7 DAS						
Araneae	0.09^A	0.13^A	0.09^A	0.09^A	0.16^A	0.09^A
Hymenoptera	3.54^A	4.13^A	4.16^A	3.21^A	5.26^A	2.97^A
Hemiptera	0.16^A	0.10^A	0.07^A	0.18^A	0.11^A	0.16^A
Coleoptera	0.83^A	1.10^A	0.66^A	1.11^A	1.40^A	0.66^A
Orthoptera	0.13^A	0.16^A	0.07^A	0.14^A	0.28^A	0.07^A
Diptera	0.16^A	0.04^A	0.02^A	0.04^A	0.16^A	0.19^A
Second sampling -41 DAS						
Araneae	0.20^A	0.20^A	0.14^A	0.26^A	0.26 ^{A}	0.16^A
Hymenoptera	3.86^A	3.19^A	2.54^A	2.80^A	6.14 ^{B}	2.61^A
Hemiptera	0.47^A	0.52^A	0.35^A	0.69^A	0.49 ^{A}	0.45^A
Orthoptera	0.10^A	0.17^A	0.09^A	0.16^A	0.19 ^{A}	0.16^A
Diptera	0.67^A	0.42^A	0.40^A	0.66^A	0.30 ^{A}	0.83^A
Third sampling - 72 DAS						
Araneae	0.07^A	0.05^A	0.06^A	0.02^A	0.06^A	0.06^A
Hymenoptera	3.22^A	2.26^A	1.69^A	2.57^A	4.35^B	2.35^A
Hemiptera	0.41^A	0.30^A	0.26^A	0.47^A	0.40^A	0.30^A
Orthoptera	0.04^A	0.08^A	0.03^A	0.07^A	0.07^A	0.07^A
Diptera	0.03^A	0.05^A	0.06^A	0.04^A	0.04^A	0.02^A

Values followed by equal capital letters in the same line do not differ according to the Scott-Knott test at 5% significance. DAS, Days after sowing.

Table 4. Density of Coleoptera order (organism/trap/day) as a function of the treatments applied with significant interaction at 41 and 72 DAS.

Wastewater (m^3 ha^{-1})	Nitrogen fertilization (%)	
	0	100
Second sampling - 41 DAS		
0	4.54^{Aa}	1.90^{Aa}
100	2.42^{Aa}	10.85^{Bb}
200	2.04^{Aa}	4.04^{Aa}
300	6.85^{Aa}	1.95^{Aa}
Third sampling - 72 DAS		
0	0.14^{Aa}	0.76^{Aa}
100	0.14^{Aa}	2.90^{Bb}
200	0.85^{Aa}	2.23^{Bb}
300	0.95^{Aa}	0.90^{Aa}

Values followed by equal capital letters in the same column and lowercase letter in the same row equals do not differ according to the Scott-Knott test at 5% significance.

were not significant, there was an increase in the total density of organisms with the treatments. Therefore, it can be proposed that the different characteristics of swine wastewater used in the two studies led to the difference in the results.

Besides the important role that the Diptera order plays in the decomposition of organic matter, it is an indicator of soil quality, mainly in relation to the management intensity and environmental resistance. The effects of management and the intense use of pesticides and fertilizers can be observed in its population reactions. Some groups can be positively influenced by the use of organic fertilizers (Büchs, 2003), which is true in the present study, considering that although there were not significant differences between the evaluated doses, the effective density was greater for the dose of 300 m^3 ha^{-1}.

According to Brown (1997) and Fauvel (1999), representatives of the Hemiptera order can respond to the increase in invading plants, inhibition of decomposition, and pollution, which makes them indicators of disturbances in cultures. In the present study, the tendency observed for this group, which had a better distribution for the dose of 100 m^3 ha^{-1}, corroborates this interpretation and suggests that the use of other doses and different levels of treatment may provide a more accurate indication of the use of swine wastewater.

Ants, Hymenoptera order, are the dominant group in

Table 5. Mean Shannon diversity index (H), Pielou uniformity (e) and order richness of the macrofauna as a function of the applied treatments at 7, 41 and 72 DAS.

Index	Treatments					
	Chemical fertilization (%)		Swine wastewater (m^3 ha^{-1})			
	0	100	0	100	200	300
First sampling - 7 DAS						
Shanon-Wiener	0.43[A]	0.45[A]	0.40[A]	0.42[A]	0.45[A]	0.49[A]
Pielou	0.55[A]	0.54[A]	0.53[A]	0.53[A]	0.52[A]	0.56[A]
Richness	6.41[A]	6.91[A]	5.66[A]	6.83[A]	7.66[A]	6.50[A]
Second sampling - 41 DAS						
Shanon-Wiener	0.53[A]	0.61[A]	0.58[A]	0.59[A]	0.48[A]	0.64[A]
Pielou	0.64[A]	0.67[A]	0.70[A]	0.65[A]	0.53[B]	0.74[A]
Richness	7.08[A]	8.08[A]	7.00[A]	8.00[A]	8.00[A]	7.33[A]
Third sampling - 72 DAS						
Shanon-Wiener	0.43[A]	0.54[A]	0.46[A]	0.49[A]	0.43[A]	0.55[A]
Pielou	0.64[A]	0.73[A]	0.71[A]	0.71[A]	0.56[B]	0.77[A]
Richness	6.83[A]	5.66[A]	4.50[A]	5.16[A]	6.00[A]	5.33[A]

Values followed by equal capital letters in the same line do not differ according to the Scott-Knott test at 5% significance. DAS, Days after sowing.

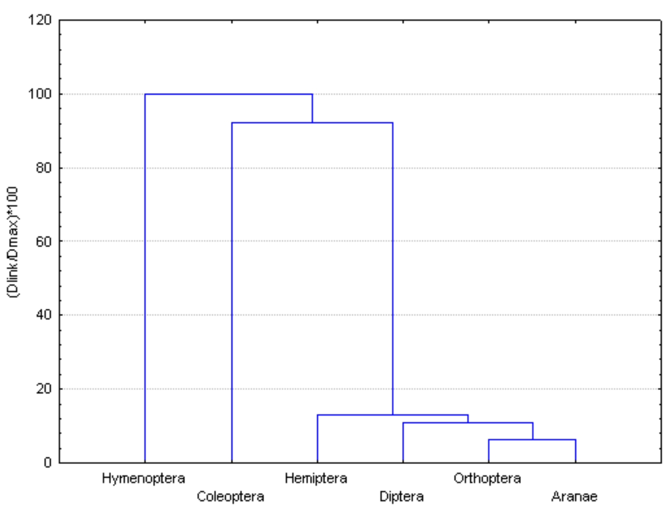

Figure 1. Dendogram of the edaphic macrofauna clustering as a function of the applied treatments for the entire experimental period.

most ecosystems. It is present in the most diverse habitats, which justifies its dominance in relation to the other observed groups. According to Marinho et al. (2002) and Andersen et al. (2002), ants are good indicators of areas that suffered antropic action by soil management and industrial pollution, and of the successful recovery of degraded areas, due to their strong relation with the conditions of the soil and the vegetation and its decomposition. Some peculiar characteristics of this group are high abundance and species richness, easy sampling, morphospecies separation, and specialized taxa sensitive to environmental alterations. This present results demonstrate that initially there were no differences between the responses to the different doses of swine wastewater used, probably due to the great mobility of the group and the similar quality of food in the areas analyzed without developed vegetation. The more complex the vegetation, the greater the diversity of the group (Cordeiro et al., 2004). However, from the second sampling on, the preference of the group for the 200 m^3 ha^{-1} was visible. The density of ants gradually increased with the increase in the dose of swine wastewater up to 200 m^3 ha^{-1}, after which there was a sharp fall to levels very close to those of the 0 m^3 ha^{-1} doses. This demonstrates that the use of wastewater with the studied characteristics resulted in the improvement of the soil conditions within certain limits for this group; however, it is a limiting factor at high doses. Furthermore, such behavior may result from the greater soil cover of the 300 m^3 ha^{-1} dose and the greater availability of substrate for other groups of the macrofauna, which results in a smaller dominance of ants over the other orders (Warren and Zou, 2002; Parr et al., 2007). Alves et al. (2008) reported maximum occurrence of this group for the use of 50 m^3 ha^{-1} of primary waste of swine wastewater and a reduction for higher doses. Although in both cases, the study areas had a history of swine wastewater use, it is important to point out that the waste characteristics in the mentioned study were quite different from those of the present study, which may have been a determining factor in the difference in behavior. The response observed in the present study is important, as the structure of the ant community is fundamental in the investigation of the environmental impact of soil management practices, as they keep and maintain the soil quality and contribute to the redistribution of particles, nutrients, organic matter, and improve the soil water infiltration and aeration by the increase in soil porosity.

Concerning chemical fertilization, a greater tendency to distribution of ants in the non-treated plots at 41 and 72 DAS was observed. This result to the low quality and quantity of food in the soil, which ends up favoring the order, as other more sensitive and less mobile groups do not compete for the area, in contrast to plots treated with chemical fertilization, in which the more developed vegetation and the larger amount of organic matter afforded more favorable conditions for the development of the other edaphic groups (Alves et al., 2008).

The results demonstrate that after 41 DAS, the density of these organisms increased, which suggests that the systematic use of swine wastewater with similar characteristics may result in the depletion of the group, corroborating observations by Alves et al. (2008), for doses of 50 m^3 ha^{-1}. These results are more pronounced for the 200 m^3 ha^{-1} dose. Another factor which may have contributed to this behavior is the long dry period (30 days), which coincided with the period of 72 DAS.

During the three evaluated periods, the Orthoptera order had low density without significant difference between the treatments. However, the tendency observed during the study was that the 200 m^3 ha^{-1} dose and 100% chemical fertilization favor a greater occurrence of this group; however, higher doses of wastewater are detrimental to the group. Another important fact is that even under the same and more favorable conditions of 200 m^3 ha^{-1} doses and 100% nitrogen fertilization, this group was also reduced due to either the time effect or the dry season. However, this group of organisms does not seem to be a good indicator of possible environmental disturbances resulting from the use of swine wastewater. Baretta et al. (2003) reported that they are non-selective and rather migratory, moving with great ease in search of food. They are commonly found in areas with minimal survival conditions and which have not been suddenly disturbed by great environmental alterations.

Among the orders that are indicators of environmental quality, Coleoptera demonstrated establishing a simultaneous relationship between the two studied factors (Table 4). According to Thomanzini and Thomanzini (2002) and Hunter (2002), the increase in the density of these organisms in relation to the first sample may be related to their feeding characteristics, since they feed on the feces of other organisms. Therefore, in the initial analysis, the similarity of the treatment results may be associated with the short time between the applications of swine wastewater and sampling, not being sufficient for the establishment of this group. Another possible determining factor of the dynamics of this group after 41 DAS was the vegetable cover, which was more developed in relation to the initial analysis and provided more favorable edaphoclimatic conditions.

The interaction of the studied factors demonstrates that at 41 and 72 DAS, the group responded directly to chemical fertilization, which did not occur for swine wastewater. Alves et al. (2008) reported that the combination of organic residues and mineral fertilization favors the occurrence of this group, sometimes even more than the isolated treatments, demonstrating that combined fertilization may produce positive responses. According to Wardle et al. (1995), this group is usually associated with a larger amount of organic matter in the soil and with organic residues on the soil surface. Due to the history of the area, larger amounts of both parameters are found in the plots treated with 100% chemical fertilization (Table 2). These organisms also are sensitive to the application of high doses of swine wastewater, having presented a reduction for doses of 200 and 300 m^3 ha^{-1}. The reduction observed at 72 DAS may have been determined by a lower availability of organic matter, since the low organic matter content of the swine wastewater treated by anaerobic biodigestion was easily consumed in the normal soil decomposition processes of organic matter in the very initial phase of the present study, which corroborates with the work of Antoniolli et al. (2006). Another important factor may have been the dry season in the period, which affected all the studied populations.

The results edaphic macrofauna diversity found demonstrate that only the Pielou index for the dose of 200 m^3 ha^{-1} was significant from the second sampling on, probably because of the high density of the organism of the Hymenoptera order, which was responsible for the high percentage of total organisms, corroborating the work of Alves et al. (2008). Nevertheless, although there were not significant differences in organism richness, it was more pronounced for the doses of 200 m^3 ha^{-1}, indicating that despite the predominance of the ant group in the Hymenoptera order, other edaphic groups succeeded in settling, even though with a small population.

On the other hand, although the Shannon index was not significant for the analyzed periods, it demonstrates a positive tendency for a greater diversity with the use of swine wastewater. According to Silva et al. (2006), this result is related to the plant density, which is more developed in plots submitted to the swine wastewater treatment and the greater availability of food in these plots (Table 3).

In the clustering analysis (Figure 1), the median distance between the number of sampled organisms of each group or taxon demonstrates the similarity of the treatments in relation to the edaphic macrofauna diversity. The Hymenoptera order stood out from the others, followed by the Coleoptera order, and the other groups were similar to each other. This distinction between the groups demonstrates the existence of homogeneity within each group, but that they are heterogeneous in relation to each other. The isolation of the mentioned orders is quite probably associated with the capacity of response of these edaphic groups to the applied treatments, particularly of the Hymenoptera order (Rovedder et al., 2004). These authors also observed the same behavior for these organisms, which they attributed to the relative frequency of the order, which is normally much higher than those of other organisms as a result of their inherent characteristics.

Conclusion

The application of chemical fertilization and swine wastewater did not affect the density and the diversity of orders Hemiptera, Diptera, Orthoptera, and Aranae. The diversity of Hymenoptera was significantly and positively affected by the application of swine wastewater up to the dose of 200 $m^3 ha^{-1}$.

The diversity of the Coleoptera order was significantly and positively affected by the application of swine wastewater combined with chemical fertilization up to the doses of 100 $m^3 ha^{-1}$ and 100%, respectively. The diversity and richness of the macrofauna was positively affected by the application of swine wastewater up to the dose of 200 $m^3 ha^{-1}$.

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