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Carbon storage in soil size-density fractions after 20 years of compost fertilization

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Fractionation by particle size provides a rough differentiation between young active, and older intermediate and passive soil organic matter. Soil samples from three treatments of a 20 years` fertilization experiment, C2 which had been fertilized with 10 t ha^{-1} (wet wt.) compost per year on average, N2 with mineral N fertilizer at 32 kg N ha^{-1} $year^{-1}$, and the unfertilized control (O) were subjected to particle size fractionation and to density fractionation. After low-energy sonication the samples were separated into the size fractions coarse sand (200-200 µm), fine sand (200-63 µm) silt (63-2 µm) and clay (2-0.1 µm). Density fractionation using Na-polytungstate with 1.8 g cm^{-3} density was applied to separate particulate organic matter (POM) from the sand-sized fraction. Compost fertilization resulted in an increase in C_{org} in all size and density fractions. In total, the C_{org} content was 10 % higher with compost fertilization than in the unfertilized control. Approximately 40 % of the additional soil carbon was located in the POM, 56 % in the silt-sized fraction and 3 % in the clay-sized fraction. With mineral N fertilization the sum of C_{org} contents of all fractions was about the same as without fertilization, with an increase of POM-C_{org} and a decrease of C_{org} in the silt and clay-sized fraction.

Keywords: fractionation, particulate organic matter, POM, soil organic matter

1 Introduction

Particle size fractionation allows to distinguish young active from older intermediate and passive soil organic matter. The organic matter in the sand-sized fraction consists mostly of plant residues, while the silt and clay fractions represent a sink for the products of the decomposition process, for material of microbial origin and for humified organic matter, which turns over more slowly (Magid et al., 1995). The active soil organic matter pool with turnover rates < 10 years is best represented by the light fraction (< 1.6-2 g cm^{-3}) obtained by density fractionation and by the soil microbial biomass (von Lützow et al., 2007). Therefore, the aim of this study was to find out in which fractions the C_{org} imported by compost fertilization accumulates.

2 Material and Methods

The field experiment with compost fertilization STIKO was set up in 1992 near Vienna, Austria, with a total of 12 treatments in 6 replications. In March 2012 topsoil samples (0-30 cm depth) were taken from three of the treatments. Treatment C2 had been fertilized with 10 t ha^{-1} (wet wt.) compost per year on average, N2 with mineral N fertilizer at 32 kg N ha^{-1} $year^{-1}$, and O was the unfertilized control. The biowaste compost used had been produced by the composting plant of the City of Vienna from source-separated organic household wastes and yard trimmings. The soil of the experimental field is a Molli-gleyic Fluvisol. Average annual temperature was 10.5 °C, average annual rainfall 552 mm. Details on cultivation, crops and yields were reported by Erhart et al. (2005).

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Particle size fractions of the soil samples were obtained after low-energy sonication following Stemmer et al. (1998). Dried soil samples (35 g dry wt.) were dispersed in 100 ml of distilled water using a probe-type ultrasonic disaggregator (Vibra Cell). The device was set to 50 J s^{-1} output energy for 120 s, and the tip was plunged 15 mm into the suspension. Coarse sand (2000-200 µm) and fine sand (200-63 µm) were then separated by manual wet sieving with distilled water. Supernatant water was siphoned off carefully retaining particulate organic matter. To separate silt-sized particles (63-2 µm) from clay (< 2 µm) the remaining suspension was centrifuged at approximately 150 g for 2 min. The pellets were resuspended in water and centrifuged again. This process was repeated three times. To obtain the clay-sized fraction, all supernatants were collected and centrifuged at 4080 g for 30 min. Resuspended pellets were recentrifuged under the same conditions. The light fraction POM (density < 1.8 g cm^{-3}) was separated from an aliquot of the sand fraction (coarse+fine) using Na-polytungstate as a heavy liquid. After drying and weighing, soil total N was analyzed in all five fractions following the Dumas method with an automated instrument. Total carbon was determined by dry combustion. For organic carbon, the amount of carbonate, analyzed by the modified Van Slyke Manometric method was subtracted from the total carbon. In the remaining soluble fraction DOC and N (N_{org}, NO_x-N and NH_4-N) were analyzed colorimetrically by flow analysis.

3 Results and Discussion

The particle-size fractionation of the Fluvisol yielded 1.7 % coarse sand, 17.9 % fine sand, 74.6 % silt and 5.8 % clay on average. In all treatments, the largest part (75-80 %) of soil C_{org} was found in the silt-sized fraction, followed by 11-12 % in the clay-sized fraction and 5-7 % in the fine sand-sized fraction (Table 1). For N, the proportions were similar (Table 2). 89-92 % of C_{org} and 91-92 % of N_t were located in the particle size fractions smaller than 63 µm.

Table 1 C_{org} in size-density fractions

Treatment	Size / density fraction					
	Particulate organic matter (POM)	Coarse sand (2000-200 µm)	Fine sand (200 – 63 µm)	Silt (63-2 µm)	Clay (2-0.1 µm)	<0.1 µm and soluble
	g kg^{-1}					
O	1.05	0.54	0.77	12.72	1.88	0.22
C2	1.75	0.83	1.19	13.69	1.94	0.21
N2	1.47	0.58	1.10	12.61	1.80	0.22

Table 2 N_t in size-density fractions

Treatment	Size / density fraction					
	Particulate organic matter (POM)	Coarse sand (2000-200 µm)	Fine sand (200 – 63 µm)	Silt (63-2 µm)	Clay (2-0.1 µm)	<0.1 µm and soluble
	g kg^{-1}					
O	0.09	0.04	0.13	1.44	0.26	0.06
C2	0.12	0.06	0.13	1.55	0.25	0.09
N2	0.10	0.04	0.12	1.47	0.23	0.08

The C/N ratio decreased with diminishing particle size from 14-15 in the coarse sand-sized fraction to 7-8 in the clay-sized fraction. While the largest part of the organic matter in the sand-sized fraction is particulate organic matter, mostly derived from plant residues, the organic matter in the finer fractions is dominated by microbially derived metabolites (von Lützow et al., 2007). The control treatment O, which had not been fertilized for 20 years, showed the lowest C_{org} concentration in most of the particle-size fractions and in the POM. In the control, also the yields, and correspondingly the C and N inputs by straw, roots and exudates, had been lower than in the other treatments. The compost treatment C2 had the highest C_{org} concentrations in all size-fractions, while the mineral fertilizer treatment N2 was between the other two in most fractions. The differences in C_{org} concentrations between treatments were largest in the POM, where C_{org} concentrations were two thirds higher in the compost treatment C2 than in the control. In the silt-sized fraction the C_{org} concentration in treatment C2 was 7 % higher than in the unfertilized control. However, due to the relatively large variation, the differences between treatments lack statistical significance. For soil N, the proportions were similar.

The results indicate that compost fertilization increased soil organic matter across all size fractions and particularly in the POM fraction, while low inputs had depleted soil organic matter in the unfertilized control. In total, the C_{org} content was 10 % higher with compost fertilization than in the unfertilized control. Approximately 40 % of the additional soil carbon was located in the POM, 56 % in the silt-size fraction and 3 % in the clay-size fraction. With mineral N fertilization the sum of C_{org} contents of all fractions was about the same as without fertilization, with an increase of the POM-C_{org} and a decrease of C_{org} in the silt and clay-sized fraction.

4 Conclusions

After 20 years of compost fertilization, soil organic C and N were increased across all size-density fractions as compared to the unfertilized control. Both the light fraction, which responds much faster to changes in carbon input than smaller size fractions, and the silt- and clay-sized fractions which act as medium- and long-term sinks for added C_{org}, were increased. 59 % of the increase in C_{org} was already found in medium- to long-term stable form.

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References

ERHART, E., HARTL., W. and PUTZ, B. (2005) Biowaste compost affects yield, nitrogen supply during the vegetation period and crop quality of agricultural crops. In *Europ. J. Agron*. vol. 23, pp. 305-314.

MAGID, J., GORISSEN, A. and GILLER, K.E. (1995) In search of the elusive „active" fraction of soil organic matter: three size-density fractionation methods for tracing the fate of homogeneously 14C-labelled plant materials. *Soil Biol. Biochem*. vol. 28, pp. 89-99

STEMMER, M., GERZABEK, M., and KANDELER, E. (1998) Organic matter and enzyme activity in particle-size fractions of soils obtained after low-energy sonication. *Soil Biol. Biochem*. vol. 30, pp. 9-17.

LÜTZOW Von, M. et al. (2007) SOM fractionation methods: Relevance to functional pools and to stabilization mechanisms. Review. *Soil Biol. Biochem*. vol. 39, pp. 2183-2207.