Forms of carbon in the soil and their influence on soil quality

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Abstract: Labile and stabile carbon forms were determined in *Haplic Cambisol* (Malonty, arable soil) and *Haplic Cambisol* (Náměšť, arable soil). We assessed total carbon content, water extractable carbon content, humic substances content and microbial biomass content. Dozens of compost were as follows: Malonty – D1 = 30 t.ha-1 and D2 = 38.7 t.ha-1, Náměšť – D1 = 93 $t.ha^{-1}$ and D2 = 158 $t.ha^{-1}$. First year of experiment increasing priming effect was observed. Second year of experiment (locality Malonty) and fifth year of experiment increasing of humic substances, water extractable carbon and microbial biomass carbon was determined. UV-VIS absorbance of humic substances was higher after compost application. Correlation between microbial carbon content and water extractable carbon was found (r_{krit} = 0.159).

Key-Words: soil organic matter, carbon forms, humus fractionation, water extractable carbon, UV-VIS spectroscopy, microbial biomass

Introduction

Soil organic matter is the main component of soil which directly influence soil fertility. It is an important source of nutrients and take a part in many chemical, physical and biological soil processes. Humic substances (HS) are essential for the stabile aggregates formation, good chemical and biological properties. It directly influences soil water regime and aeration. Chemical composition of humic substances depends on plants residues, microbiological composition (1, 2). Further is chemical composition of HS influenced by anthropogenic factors (fertilizing, crop rotation, liming and others). Soil organic carbon is represented by ***stabile***, ***labile, and black carbon*** forms. Stable carbon forms are resistant against mineralization and biodegradation. They are represented by carbon of humic acids (HA) and fulvic acids (FA) - see (3, 4). Labile carbon is soluble and easily mineralized by soil microorganisms. It is determined as water extractable carbon –see 5. Quality of humic substances is given by HA/FA ratio and by spectral properties (UV-VIS absorbance) – see 6. Labile carbon is responsible for temporary stability of soil humus. It mainly consists from non-specific organic components and its decreasing caused loss of soil humus (7). Black carbon has not been studied very well. As it is known black carbon takes part in the global carbon cycle.

Aim of our study was to evaluate content and quality of humic substances after compost amendment. Object of our study were intensively cultivated *Cambisols*, the main soil type in the Czech Republic.

Material and Methods

Haplic Cambisol (locality Malonty) is situated 10 km south-east from Kaplice (region Český Krumlov). Average temperature is 6 °C, average precipitation 650 mm, and altitude 680 m. a. s. l. Long-term field experiments were established in spring 2012. Compost was made from grass, manure and slurry. Application dozens of compost were D1 = 30 t.ha-1and D2 = 38.7 t.ha-1. Soil type was classified according to Němeček et al. (2011) as *Haplic Cambisol* and soil profile was located at N: 48.68871°, E: 014.57433 ° (8, 9, 10).

Haplic Cambisol (locality Náměšť) is situated in the east part of Třebíč region (Czech-Moravian Highland). This region is warm and wet, with average precipitation 550 – 700 mm, average temperature 7 – 8 °C, and altitude 430 m. a. s. l. Long-term field experiments were established in spring 2008.

Compost was made from grass. Application dozens of compost were D1 = 93 t.ha-1and D2 = 158 t.ha-1 . Soil type was classified according to Němeček et al. (2011) as *Haplic Cambisol* and soil profile was located at N: 49°12,808´, E: 16° 09,757´ (8, 9, 10).

Basic soil properties are given in Tab. 1 – see (11). Basic soil properties were determined by standard methods. As it is evident *Cambisols* varied in soil reaction, conductivity, and clay percentage. Total organic carbon (C_{org}) content was determined by oxidimetric titration (12). Fractional composition of HS was made by short fractionation method (13). UV-VIS spectroscopy was performed by Varian Cary 50 probe spectrometer with optical fibre. Water extractable carbon content was determined by analyser Shimadzu TOC-VCSH with CO_2 detection in infrared spectral region. Carbon of soil microbial biomass was determined by fumigation-extraction method according to (14).

Table 1 Basic soil properties

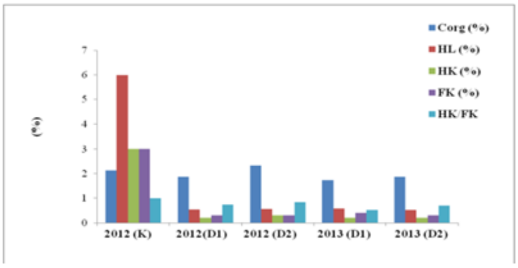
Soil type	Horizon (m)	pH/H_2O	pH/KCl	Conductivity (mS/cm)	Clay particles content (%)
1	2	3	4	5	6
KAm (Malonty)	0 – 0.2	6.26	5.06	0.06	24.04
KAm (Náměšť)	0 – 0.2	5.10	4.00	0.14	29.00

(1) Soil type, (2) horizon, (3) active soil reaction, (4) exchangable soil reaction, (5) conductivity, (6) clay particles content

Results and discussion

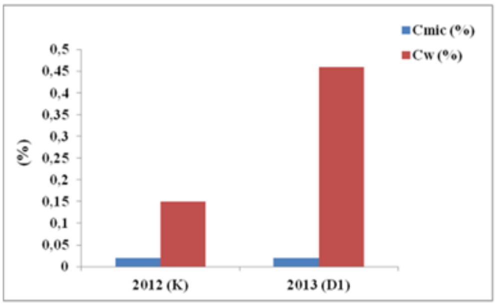
Haplic Cambisol (Malonty) –maximum of total C_{org} was determined second year after compost application (variant D1 = 30 t.ha-1), and reached 2.33% (2013). Average values of total C_{org} in 2012 was 1.88% – see Fig. 1.

Fig. 1 Total organic carbon content and fractional composition of HS in *Haplic Cambisol* (Malonty)



Content of water extractable carbon was 4.9% from C_{org} content. Microbial biomass represented 2% from total $C_{org.}$ Results showed, that compost was used for both stabile and labile carbon formation. Only small part was used for microbial biomass formation and respiration. Increasing of HS was also confirmed by absorbance of HS in UV-VIS spectral range. HS absorbance was higher after compost application (variant D1 = 30 t.ha^{-1}) to compare with control. Higher dozen of compost (D2 = 38.7 t.ha^{-1}) caused also maximum C_{org} increasing in 2013 (2.33%). Average value in 2012 was 2.13%. Content of water extractable carbon was 4.62% from total C_{org} content – see Fig. 2. Amount of water extractable carbon was higher to compare with variant D1. We can conclude that high dozens of compost were not very effective, because they were mainly used for labile carbon formation, microbial biomass, and respiration. Absorbance of HS in UV-VIS spectral range was comparable with variant D1. This could be explain by the similar HS content on both variants – see Fig. 1. Linear correlation between microbial biomass and amount of dissolved organic carbon was found ($r = 0.21552$, $n = 27$, $\alpha = 0.05$, $r_{krit} = 0.159$).

Fig. 2 Microbial carbon and water extractable carbon content in *Haplic Cambisol* (Malonty)



Haplic Cambisol (Náměšť) – maximum of total C_{org} was determined five years after compost application (variant D1 = 93 t.ha-1). In 2008 was average C_{org} content 1.32%. In 2012 was average C_{org} content 2.4% – see Fig. 3. Content of water extractable carbon was 4.5% from total C_{org}. Microbial biomass represented 2% from total C_{org} – see Fig. 4. Results showed, that compost was used for both stabile and labile carbon formation. This was also confirmed by absorbance of HS in UV-VIS spectral range. Absorbance was higher after compost application to compare with control. Very high dozens of compost (D2 = 158 t.ha-1) caused increasing of water extractable carbon and microbial biomass. Maximum of total C_{org} (2.6%) was five years after compost application (2012) – see Fig. 3. Content of water extractable carbon was 5.4% from total C_{org}. Amount of water extractable carbon was higher to compare with variant D1 – see Fig. 4. We can conclude that high dozens of compost were not used effectively, because of increasing the labile carbon forms and respiration. Absorbance of HS in UV-VIS spectral range (variant D2 = 158 t.ha-1) was comparable with variant D1 = 93 t.ha-1.

Fig. 3 Total organic carbon content and fractional composition of HS in *Haplic Cambisol* (Náměšť)

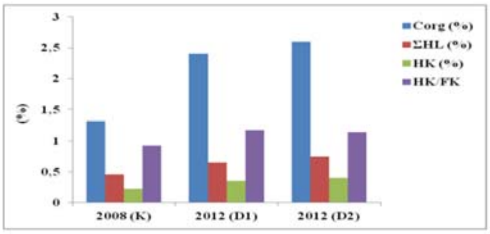
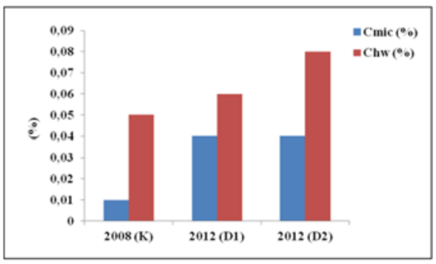


Fig. 4 Microbial carbon and water extractable carbon content in *Haplic Cambisol* (Náměšť)



Conclusion

High dozens of compost (D2 = 158 t.ha-1) were not used effectively. Increasing of water extractable carbon and microbial biomass was determined.

Formation of stabile humic substances (HA, FA) was lower. Our results showed that the carbon sequestration is directly influenced by intensive cultivation.

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