EFFECT OF SOIL CONDITIONERS APPLICATION ON NUTRIENTS AND HUMIC SUBSTANCES CONTENT IN POT EXPERIMENTS

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Abstract: The aim of our work was to study the effect of selected soil conditioners on nutrients and humic substances content in pot experiments (Phytotron CLF PlantMaster, Wertingen, Germany). Object of our study was Haplic Cambisol reached from locality Vatín (Czech Republic). For pot experiments we used 835 g of soil and 50 g of each conditioners (biochar, digestate, lignite, compost), except lignohumate. Lignohumate was applied in dose 5 g and 835 g of soil, because of high content of soluble salts. As tested plant we chose lettuce (*Lactuca sativa*). Nutrients content was determined by Mehlich III. Humic substances fractionation was made by Kononova and Belchikova method. All studied conditioners mainly effected total carbon content in soil. Application of lignohumate had the highest effect on nutrients content and fractional composition of humus.

Key Words: nutrients, soil conditioners, humic substances

INTRODUCTION

Soil conditioners are supposed to improve soil quality, content of humic substances and plant nutrition regime. Lignohumate is a commercial product, rich in humic substances and micronutrients, with the growth stimulation effect. It can be applied for a wide range of plants. Digestate represents a residue after anaerobic fermentation process in biogas plant production. Its composition is mainly given by primary products and digestion processes. Usually high content of $N\text{-}NH_4^+$ is presented. According to the definition it is closer to the mineral fertilizers (C/N ratio is lower than 10:1), as quoted Richter and Kubát (2003), Cigánek et al. (2010). Biochar is coaled biomass, which is a product of thermal processes such a low temperature pyrolysis and carbonization. Primary material for biochar production is a waste biomass. Application of biochar is increasing the stable carbon forms in soil and sorption capacity for nutrients (e.g. nitrogen, phosphorus and potassium). Compost is an organic fertilizer made of all kind of organic residues, waste biomass, and a portion of soil. After the controlled composting processes, it is worthy organic material rich in nutrients and microelements (Kalina 2004, Zimolka et al. 2008). The natural cycle of nutrients is directly effecting soil chemical and biological soil properties so that soil quality/health. The aim of our work was to study the effect of selected soil conditioners on nutrients and humic substances content in pot experiments (Phytotron CLF PlantMaster, Wertingen, Germany).

MATERIAL AND METHODS

Object of our study was Haplic Cambisol reached from locality Vatín (Czech Republic). Soil was defined in terms of physical, chemical, and biological properties – see Table 1, 2 and 3. For pot experiments we used 835 g of soil and 50 g of each conditioners, except lignohumate. Lignohumate was applied in dose 5 g and 835 g of soil, because of high content of soluble salts. Detailed characteristic of selected conditioners is given in Pospisilova et al. (2015). As tested plant we chose lettuce (*Lactuca sativa*). During three month we followed the lettuce growing conditions – Figure 1, 2. Pot experiments were carried out in phytotron CLF PlantMaster (Wertingen, Germany). Regime is 20°C for day, 18°C for night, air moisture 65%, duration of sunshine is 12 hours, and intensity of lighting is 300 $\mu m \cdot m^{-1} \cdot s^{-1}$. After lettuce harvesting we determined the main soil chemical properties

– soil reaction, conductivity, nutrients content, total organic carbon content, and humic substances content. Soil reaction was determined by potentiometric method (Zbíral 1997). Soil conductivity was determined by measuring of soil conductivity (Zbíral 1997). Nutrients content was determined by Mehlich III. (Zbíral 1997). Total carbon content was determined according to Nelson and Sommers (1982). Humic substances fractionation was made by Kononova and Belchikova method (1963). One way ANOVA analysis was used for statistical data processing.

Table 1 Basic soil properties of Haplic Cambisol

Soil type	pH/H_2O	pH/KCl	CEC ($cmol \cdot kg^{-1}$)	Clay particles content (%)	Conductivity ($mS \cdot cm^{-1}$)	Carbonates (%)
1	2	3	4	5	6	7
Haplic Cambisol (Vatín)	5.1	4.7	14.2	22	0.2	-

(1) Soil type, (2) active soil reaction, (3) exchangeable soil reaction, (4) cation exchange capacity, (5) clay particles content, (6) condutivity, (7) carbonates

Table 2 Fractional composition of humic substances in Haplic Cambisol

Soil type	Total carbon content (%)	Sum of HS ($g \cdot kg^{-1}$)	Sum of HA ($g \cdot kg^{-1}$)	Sum of FA ($g \cdot kg^{-1}$)	Ratio HA/FA
1	2	3	4	5	6
Haplic Cambisol (Vatín)	1.43	4.60	1.30	3.30	0.41

(1) Soil type, (2) total carbon content, (3) sum of humic substances, (4) sum of humic acid, (5) sum of fulvo acid, (6) ratio HA/FA

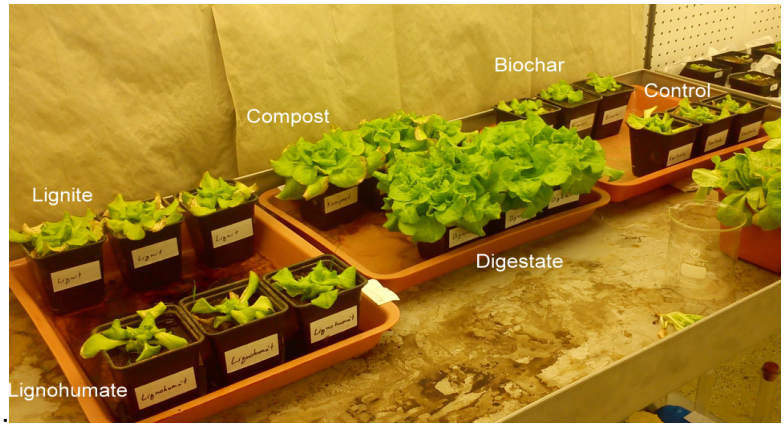
Table 3 Nutrients content in studied Haplic Cambisol

Soil type	Ca ($mg \cdot kg^{-1}$)	Mg ($mg \cdot kg^{-1}$)	K ($mg \cdot kg^{-1}$)	P ($mg \cdot kg^{-1}$)
1	2	3	4	5
Haplic Cambisol (Vatín)	868	208.6	321.4	55.5

(1) Soil type, (2) calcium, (3) magnesium, (4) potassium, (5) phosphorus

Figure 1 The beginning of the pot experiment

Figure 2 The end of pot experiment



RESULTS AND DISCUSSION

Haplic Cambisol (Vatín) was sandy loam textured, with acid active soil reaction (5.1) and acid exchangeable soil reaction (4.7). Total carbon content reaching values 1.43%, which means low humus content. Sum of humic substances was middle (e.g. HS = 4.6 g · kg^{-1}, HA = 1.30 g · kg^{-1}, and FA = 3.30 g · kg^{-1}). Content of phosphorus (55.5 mg · kg^{-1}) and potassium (321.4 mg · kg^{-1}) was satisfactory. Content of calcium was low and reached 868 mg · kg^{-1}. Magnesium content was good and reached 208.6 mg · kg^{-1}. Nutrients content after conditioners application is listed in Figure 3. As it is evident, phosphorus content increased after compost (125.5 mg · kg^{-1}) and biochar (73.1 mg · kg^{-1}) application. Decreasing of phosphorus was found after digestate (49.6 mg · kg^{-1}) application. This could be explain by very low content of phosphorus in digestate (C = 2.18%, N = 0.44%, Ca = 0.13%, K = 0.50%, Mg = 0.09% and P = 0.08%). Potassium content was high or extremely high in all studied samples. Especially lignohumates were rich in potassium (5507 mg · kg^{-1}), as quoted the producer declaration. This was the result of decreasing lignohumate concentration in pots experiments to avoid soil salinity. After lignohumate application potassium content decrease five times (1675 mg · kg^{-1}). High variability was found for calcium content in all studied samples. Low content of calcium was found after lignohumate application (787 mg · kg^{-1}). Average values of calcium (after others conditioners application) varied from 1101–2000 mg · kg^{-1}. Content of magnesium was the highest after lignite application (339.8 mg · kg^{-1}). Average values of magnesium after conditioners application varied from 208–339 mg · kg^{-1} – see Figure 3. Further we evaluated fractional composition of humic substances after conditioners application – see Figure 4. Three times higher content of humic acids was found after lignohumate application (from 4.6 g · kg^{-1} to 13.6 g · kg^{-1}). Quality of humic substances was the highest after lignohumate application (HA/FA ratio was 1.79).

Analysis showed statistically significant differences in total organic carbon content after soil conditioners application. Most were statistically significant after application lignite and lignohumate 50 g – see Figure 5. It was also a statistically significant difference between the application lignohumate and compost. The application of lignite as additives in soil maintenance is efficient, presumably less expensive in comparison with contemporary commercial fertilizers and environmentally preferable as they are natural products. Mechanisms lignite based humic substances in the processes of cell proliferation is different compared to the humic substances found in the soil. It seems that future research should focus on finding appropriate and effective combination of humic substances/agents pretreatment effectively simulate molecular re-aggregation of parental lignite. (Vlčková et al. 2009). Soil conditioners have a positive influence on physical, chemical and biological properties. As also reported (Salaš et al. 2012) application of lignite had the positive effect on soil organic matter content in sandy soils. Similar results were published by Havelcová et al. (2009). The soil condition mainly effected humic substances quality. It was also found out that there is a tendency of increasing humus content after lignite application (Jandák et al. 2014).

Figure 3 Average nutrients content after conditioners application

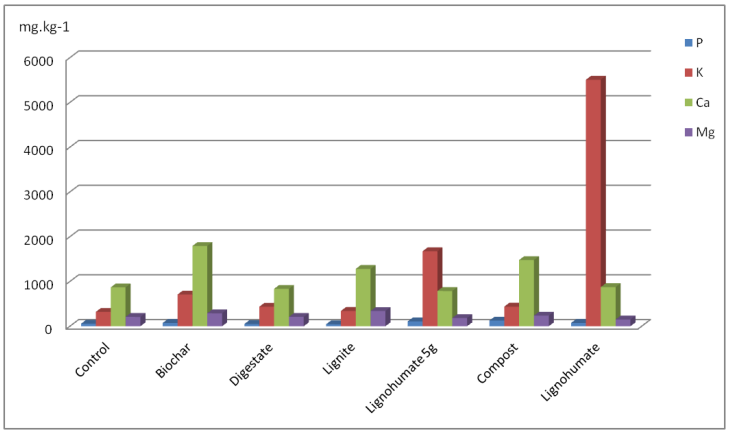


Figure 4 Total carbon content and humus fractional composition after conditioners application

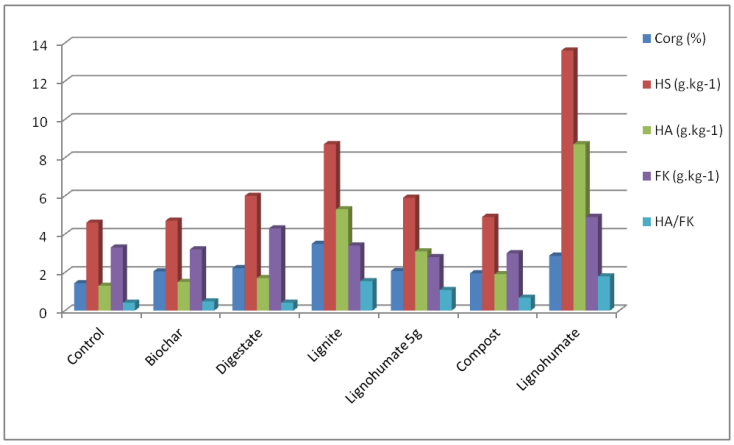
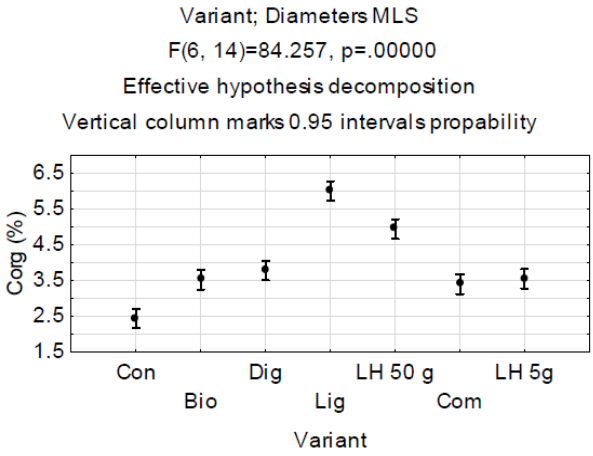


Figure 5 Differences between variants in total organic carbon content



Con (control), Bio (biochar), Dig (digestate), Lig (lignite), LH 50 g (lignohumate), Com (compost) LH 5 g (lignohumate)

CONCLUSION

All studied conditioners mainly effected total carbon content in soil. Application of lignohumate had the highest effect on nutrients content and fractional composition of humus. On the other hand high concentration of lignohumate caused soil salinity and bad lettuce growing condition. Inspite of statistically significant results in pot experiments the field application of studied conditioners is quite expensive (e.g. lignite cca 11. 000 Kč · ha^{-1}). There fore the effect of their application should be studied to cover all expenditure.

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