CHANGES ORGANIC CARBON CONTENT DEPENDING ON THE FERTILIZER MANAGEMENT

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Abstract: The current agricultural practices cannot do without external input. The ground biomass is removed from soil. For this reason, it cannot produce soil organic matter. It affects negatively many other soil properties (soil structure, cation exchange capacity, water retention, etc.) and yield. In recent years, biogas plants have been built increasingly. It exists the idea, we can apply by-products in soil. And it may represent an effective strategy to tackle the widespread loss of soil organic matter acknowledged in the last decades. This article describes the differences in content of organic carbon (Corg) between two terms sampling – the autumn 2014 and the spring 2015 by three fertilizer managements – manure, calcium ammonium nitrate and digestate. The samples were taken from two depths – 0.03–0.07 m and 0.13–0.17 m. In addition, the samples from spring sampling were evaluated statistically. Our results suggest that the most Corg content had a variant with manure application. There were differences of Corg content depending on the depth.

Key Words: Corg content, manure, calcium ammonium nitrate, digestate

INTRODUCTION

Soil organic matter (SOM) content is a very important chemical property of the soil. SOM is a soil quality indicator upon which agricultural production is dependent and agricultural practices. (Eleki et al. 2014) SOM improves, among the other, soil structure, cation exchange capacity and water retention. It is important for good physical, hydrological, chemical, biochemical and productive properties. (Reijneveld et al. 2010, Bertora 2009) It is important maintain site-specific SOM content. It is a prerequisite for a sustainable protection of soil function. (Šeremešić 2009)

The SOM is formed from the remains of plants, among others. But on ground biomass is often removed from soil. Many studies show that it is reasonable to assume that SOM will decrease if residues are removed from the soil and this cause degradation of soil resources in large scale (Dalzell et al. 2013, Eleki et al. 2014, Robinson et al. 1996). Moreover harvesting of crop residues will increase the risk of soil erosion (Dalzell et al. 2013).

The organic matter level of the soil will come into equilibrium with the cropping practices where cropping practices continue uninterrupted for a long period. Changes in cropping practice may cause changes in the SOM content. (Barber 1979)

It was indicated that land use change had a huge effect on SOM contents. Some studies suggest among other that mean SOM content decreases as a consequence of land and soil management practices. (Vellinga et al. 2004, Reijneveld 2010) A lot of studies proved that the appropriate managements have a significant impact on SOM content and may mitigate this effect. For example a reduced tillage, improved crop nutrition, organic amendments, cover crops and perennial vegetation. (Eleki et al. 2014, Šeremešić 2009) The long-term experiment of Fenton et al. showed that the crop rotation along with appropriate fertilization had an important impact on achievement of highest crop yields (Eleki et al. 2014, Varvel 2006).

Our modern lifestyle is reliant on the electric energy. Fossil fuels are running out and in addition, they cause many environmental problems. It is the reason why the interest in using renewable energy sources is constantly increasing (Galvez et al. 2012). Political situation, human knowledge, environmental problems, they resulted in the increase of the number of operating biogas plants.

But, it is likely that the intensification of overall bio-energy production will produce considerable amounts of by-products and will pose the problem of their disposal (Galvez et al. 2012). It exists the idea, we can apply by-products in soil. Van Camp et al. (2004) justifies it, that it may represent an effective strategy to tackle the widespread loss of soil organic matter acknowledged in the last decades.

In our investigation, a field trial was used to obtain the results the changes of organic carbon (Corg). The applied fertilizers were manure (M), calcium ammonium nitrate (CAN) and digestate (D). The described depths are 0.03–0.07 m and 0.13–0.17 m. The differences were observed under vegetation cover corn for each fertilizer management between sampling at the autumn 2014 and the spring 2015. Therefore, it was statistical evaluated the differences between all fertilizer management and the differences between the depths for all fertilizer management for sampling the spring 2015.

MATERIAL AND METHODS

Characterization of growing locality

The soil samples were taken from a field trial. The field trial was established on the area of Research grassland station Vatín – Faculty of Agronomy, Mendel University in Brno, Czech Republic in the spring of 2014. Vatín is located 49° 31´N and 15° 58´E, around 60 km NW of Brno, 5 km S of Žďár nad Sázavou. The elevation of the research station is 540 m above the sea level.

The soil type is Dystric Cambisol Loamic; parent material is gneiss (Bugnerová 2013, IUSS Working Group WRB 2014). Cambisol is the most widespread soil type in the Czech Republic (Tomášek 2007). These soils are developed in humid environments. Chemical and physical properties are varied. This is affected by soil organic matter content and soil texture. (Němeček et al. 2011)

Experimental design

It was applied three fertilizers on the vegetation cover corn (*Zea mays*). One plot has 10 m^2. The fertilizer managements were: manure (M), calcium ammonium nitrate (CAN) and digestate (D).

The amount of fertilizer applied was derived from the N content. Each fertilizer supplied 150 kg ha^{-1} of N. The calcium ammonium nitrate and digestate were applied in two dates during year 2014 (spring – 60% of total delivered N and June – 40% of total delivered N) and manure was applied after vegetation season in one dose in November. The harvest residues were left in to the soil surface and they were incorporated into the soil during cultivation – disking to 0.16 m.

The soil samples were taken in October 2014 and in April 2015. It was from 2 depths – 0.03–0.07 m and 0.13–0.17 m. It is described the root zone.

Table 1 Content of organic C for applied fertilizer

Fertilizer	Organic C [%]
Digestate 1	2.18
Digestate 2	2.32
Manure	16.43

Legend: Digestate 1 – digestate applied in spring; Digestate 2 – digestate applied in July

Laboratory

The soil samples were processed standardized procedure on the fine earth (Zbíral et al. 2010). The Corg content was determined by wet method of Walkley-Black modified by Novák-Pelíšek (Jandák et al. 2013). The resulting solution was titrated with Mohr's salt and the content of organic carbon Corg (%) was obtained.

Statistical analysis

The data obtained were subjected to Shapiro-Wilkův W test for the identification of normal distribution of data. The differences Corg content for individually fertilizer management between two years was analyzed via a t-test and the difference between all fertilizer management for sampling the spring 2015 was analysed via one-way ANOVA. Post-hoc tests were carried out on all ANOVAs using Tukey HSD test at the level $p < 0.05$ using the Statistica 12 program (StatSoft, USA).

RESULTS AND DISCUSSION

The differences between sampling 2014 and 2015 for individually fertilizers and depths

The development of Corg content was affected, as had been anticipated, due to the application of manure in the autumn. This means, the Corg content in variant with M increased between autumn and spring sampling, and that in the both depths. Conversely, Corg content in variants with D and CAN between terms of sampling dropped. The differences at depth 0.03–0.07 m were in all cases statistically significant. But, the difference, in the only variant with CAN in the depth 0.13–0.17 m, was statistically significant only. The variants with M and D were not confirmed as the statistical significant. Although, it can observe from the box plots a development trend Corg content.

Surprisingly, there was no statistically significant difference in the variant with M the depth 0.13–0.17 m. The manure was applied on the surface and subsequently using postharvest incorporated into the soil. It would be expected that larger amounts of fertilizer in the soil to a given depth.

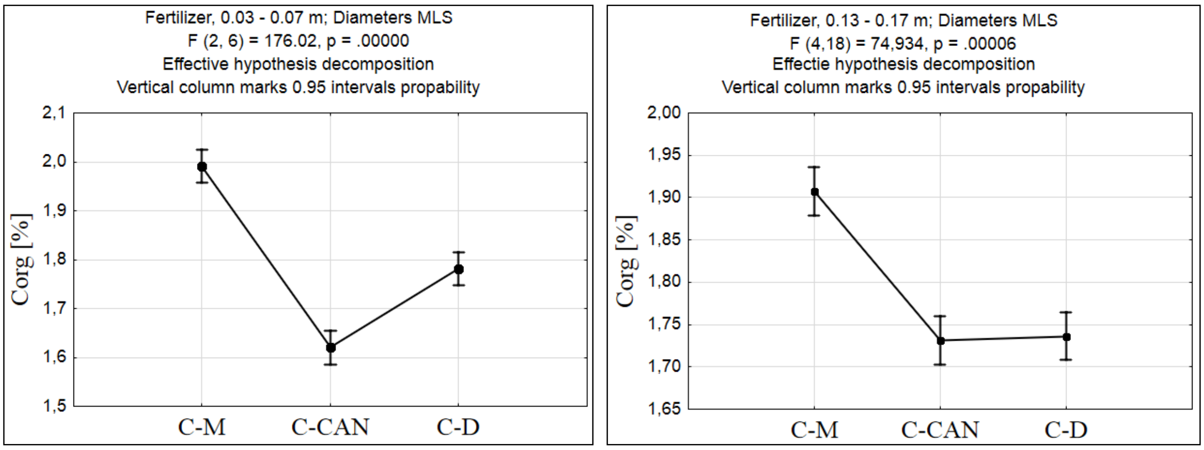
The comparison of Corg content of sampling 2015

The variant with M had statistically significant more Corg content at the both depth compared to the two remaining fertilizer management. You see at the Figure 1 and Figure 2.

From Figure 1 it can be to see, that the second position had the variant with D and third was the variant with CAN. The differences were at this depth for all variant of fertilizer management statistically significant.

The situation of Corg content was another at the depth 0.13–0.17 m. There was statistically significant Corg content only between M and the two remaining fertilizer managements. The Corg content at variant with CAN and D had comparable content (see Figure 1).

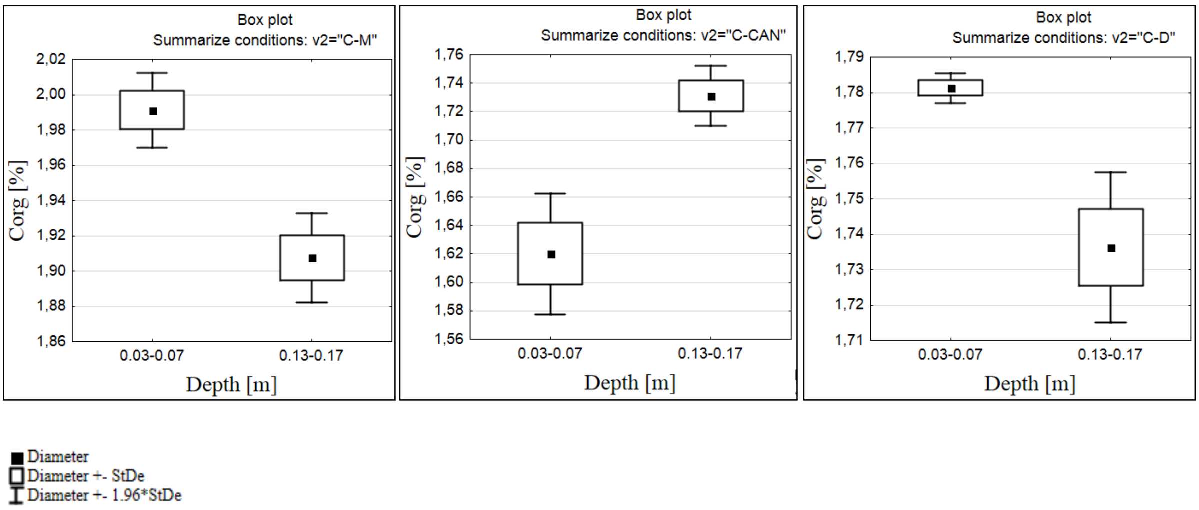
Figure 1 The Corg content of sampling 2015 – left for the depth 0.03–0.07 m, right for the depth 0.13–0.17 m



Legend: C – corn, M – manure, CAN – calcium ammonium nitrate, D – digestate

Although described depths are only 0.10 m each other, but between depths were statistically significant differences among the various depths. From Figure 2 it is showed, that the Corg content increased at the various with CAN. On the contrary, the Corg content at the various with M and D decreased.

Figure 2 The differences Corg content of sampling 2015 for individually fertilizer management – left variant with M, middle variant with CAN, right variant with D



Legend: C – corn, M – manure, CAN – calcium ammonium nitrate, D – digestate

Zhibin et al. (2014) also found in their long-term experiment positive effect of manure application. The application composted farmyard manure with combination with mineral fertilizer had the highest SOM content.

The positive effect of digestate application compare with mineral fertilizer application was found by Nabel et al. (2014). The dose-response experiment showed that digestate application built up a pool of SOM. But, the dose of digestate is very important. The digestate dose 40 t · ha^{-1} was optimal. The higher dose had lethal effect on crop and the lower dose showed no fertilization effect.

It is difficult to draw conclusions from one year field experiment. Because, it is the fact that SOM concentrations change slowly and can be difficult to detect over the course of typical field studies (Dalzell et al. 2013). For example, Zhibin et al. (2014) state that a period of about two decades is needed for establishing a new equilibrium following a change in management practices. Thereafter, SOM content remained stable because it had reached a steady state called saturation.

But, the digestate application is not so easy because every digestate type shows different features (Grigatti et al. 2015). So, long-term monitoring and in-depth analysis of the fertility of soils that are amended with digestated slurries are required (Bachmann et al. 2014).

CONCLUSION

It becomes common in agricultural practice that applies by-product of biogas plants in the soil as organic fertilizer. The fertilizer affects many soil properties. The Corg content is one of them.

Our results suggest that the most Corg content had the variant with manure application. There were differences of Corg content depending on the depth. The lowest Corg content had the variant with calcium ammonium nitrate.

ACKNOWLEDGEMENT

The research was financially supported by the IGA – Internal Agency Faculty of Agronomy MENDELU No. TP 7/2015.

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