Effects of soil tillage systems and fertilization on the CO_2 emission of chernozem soil

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Abstract: The correlation between carbon dioxide emission and agriculture has been a crucial issue for humanity for decades. As a result of global climate change, this correlation deserves special attention mainly in terms of how greenhouse gas emission can be reduced. For this reason, this subject becomes increasingly important. CO_2 is a very important compound and it is one of the greenhouse gases which not only offsets the cooling of the Earth, but too high CO_2 emission leads to global warming. By saving the carbon in the soil, it is possible to protect the organic materials in the soil and improve soil fertility. The performed measurements enabled us to study the relationships between the different types of cultivation and carbon dioxide emission.

Keywords: carbon dioxide, emission, greenhouse effect, cultivation, fertilizer

Introduction

Global climate change has been one of the main subjects and challenges for humanity for a long time. 20% of greenhouse gases - which significantly contribute to climate change - result from agricultural activities. More specifically, 50-75% of anthropogenic methane emissions and 5% of carbon dioxide are related to agriculture. Indirectly, 14% GHG emission is caused by deforestation and the burning of biomass (Gyuricza et al., 2002). Carbon dioxide emission derives from the decrease of organic matter, but emission is influenced by soil moisture, temperature, soil quality and cultivation (Fogarassy et al., 2008).

By performing environmental friendly agriculture, the carbon dioxide emission deriving from the soil can be reduced; therefore, it is very important to reduce soil disturbance as much as possible in order to preserve its organic matter. The migration (source cycle) of soil organic matter contributes substantially to global climate change, since it is significantly influenced by the intensity of soil respiration. The volume of carbon dioxide emission through soil respiration is ten times as high as that of fossil-fuel combustion (Mielnick-Dugas, 2000). Consequently, it can be observed how important it is to provide satisfactory amount of plant nutrients. In particular, agriculture, including deforestation, burning of the biomass and crop cultivation systems are responsible for 5% of carbon dioxide emission (Láng, 2003). Emission can be reduced by fixing carbon in the soil. Bacteria, fungi and worms, which form a more complex organic matter called humus, contribute to this process substantially, by fixing carbon in the soil. Using direct methods of "re-filling" carbon back into the soil – organic fertilisers (plant- or animal-derived matter) – the fixation of carbon is feasible, resulting in 2-20 million tonnes/year carbon remaining in the soil, which is not only important from the point of view of global climate change mitigation measures, but also promotes soil recovery.

In the framework of environment friendly agriculture, it is necessary to achieve reduced energy consumption and reduced volume of mechanical works in order to affect the carbon and carbon dioxide emission from the soil. In the opinion of Hagymássy et al., (2015), precision is an important part of environmental friendly agriculture. If organic matter remains in the soil, it will positively influence the structure of the soil, its stability, buffer

capacity, water storage capacity, biological activity and the nutrient balance (Holland, 2004). Conventional tillage systems have certain consequences which lead to soil and environmental deterioration, resulting in soil compaction soil structure degradation, decreased level of organic matter, worsening bearing capacity and increasing carbon dioxide emission. The benefits of these soil tillage systems are minor in comparison to their disadvantages (Birkás, 2002). Taking all these aspects into consideration, it is important to replace conventional tillage systems with conservation tillage systems.

Soil tillage is the basis of agricultural land use which contributes to the increase of carbon dioxide emission, thereby causing global climate change. As a matter of course, this is not as intensive as industrial pollution, but comparing with the Earth's surface, in particular with the surface used for agricultural purposes, this emission is significant. When performing tillage, as a result of ploughing, carbon dioxide emission suddenly increases, but it is later restored, mainly due to drier climate and conservation tillage systems (Rochette et al., 1997; Ellert and Janzen, 1999). Accordingly, at the beginning, the intensity of emission mainly depends on the depth of soil tillage (Reicosky and Lindstrom, 1993). In the course of the saturation of soil, carbon dioxide is displaced. In parallel with the drying of the soil, the volume of gases increases (Stefanovits et al., 1999).

Materials and methods

In our experiment, we conducted measurements in order to define the influences which soil tillage systems and fertilizers have on the emission of carbon dioxide. In order to achieve the research objective, we examined the tillage and fertilization effects in a polyfactorial long-term field experiment at the trial site of the University of Debrecen (Hajdúság loess plato, 47° 30' N, 21° 36' E, 121 m elevation) on 20 October 2015 and 8 July 2016.

The experiment had a split-split-plot design, with the main plots having three tillage treatments. The investigated tillage treatments were mouldboard ploughing (MP) to a depth of 30 cm, strip tillage (ST) to a depth of 28 cm and chisel ploughing (CP) to a depth of 35 cm, non-fertilized (control). Two nitrogen fertilization levels (80 kg N ha^{-1} and 160 kg N ha^{-1}) were applied in a randomized way on the secondary sub-plots in four replications.

The goal of our experiment was to evaluate the influence of soil tillage and nitrogen fertilizer on the volume of carbon dioxide emission from the soil surface. During our experiment, we compared the differences between mouldboard ploughing, strip tillage and chisel ploughing. Mouldboard ploughing is a conventional method of soil tillage, which strongly modifies the structure of the soil. Strip tillage does not cause dramatic changes to the soil structure, with the attempt to maximise the erosion prevention benefits of keeping organic matter and plant residues on the soil surface. Our measurements were carried out five times on each treatment. Carbon dioxide measurements were conducted by using the device CI-340, which is a light portable device to be used both in the field and in the laboratory for measuring the carbon dioxide emission of the soil. A 630 m^3 sampling device (reservoir) was used and the changes of carbon dioxide concentration were measured in five minutes. Carbon dioxide emission from the soil was converted into $g/m^2/h$ measurement units.

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Results and discussion

It can be concluded that utilising fertilizer carbon dioxide emission significantly increases. The highest amount of carbon dioxide emission was measured in the case of conventional tillage and mouldboard ploughing. The carbon dioxide emission we measured in the case of 80 kg N/ha mouldboard ploughing treatment amounted to 0.1259 g/m^2/h. In the case of the 160 kg N/ha chisel ploughing the obtained result was almost the same: 0.1223 g/m^2/h. The results of strip tillage in all fertilization treatments were significantly lower than those of the mouldboard ploughing or chisel ploughing.

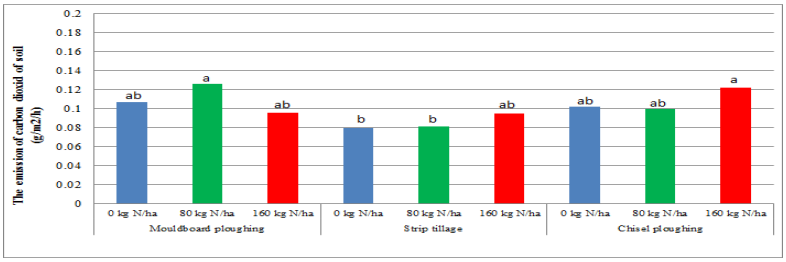

Figure 1. *Effects of soil tillage systems and fertilization on the CO_2 emission of chernozem soil. (Debrecen-Látókép, 2015. 10. 30.)*

The results of the second measurements in 2016 have yielded different results in comparison with those of the experiment in 2015. In general, the results of all three tillage methods and nitrogen fertilizer treatments were higher. It was the most remarkable result that the highest emission was measured in the case of all three tillage systems on the plots with 80 kg N/ha. The highest volume was measured on the 80 kg N/ha plots being cultivated by means of chisel ploughing: 1.2828 g/m^2/h. The lowest results was measured in the case of strip tillage which was lower on the less disturbed soil. The highest results were obtained in the case of chisel ploughing.

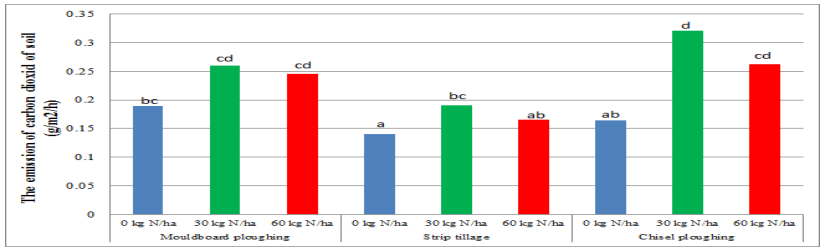

Figure 2. *Effects of soil tillage systems and fertilization on the CO_2 emission of chernozem soil. (Debrecen-Látókép, 2016. 07. 08.)*

Conclusions

The soil, as one of the main sources of carbon dioxide emission, significantly contributes to global climate change, which makes it extremely important to focuse on agricultural land use. By conducting our measurements, we analysed the influence of utilising fertilizers in different doses and performing different types of soil tillage. Our experiment shows that the increasingly widespread conservation tillage systems have a positive influence on carbon dioxide emission.

In our experiment, in the case of all three different nitrogen fertilizer doses, the carbon dioxide emission results of strip tillage were lower than those in the case of mouldboard ploughing and chisel ploughing treatments.

The performed measurement proved our hypothesis, i.e. the level of carbon dioxide emission of less disturbed soil is lower due to the fact that it has a better ability to store organic matter. We consider it to be necessary and appropriate to conduct follow-up research and measurements in the future.

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