MICROBIOLOGICAL ACTIVITY UNDER STUBBLES IN DIFFERENT SOIL CULTIVATION SYSTEMS

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Abstract

There is close correlation between the degree and intensity of CO_2-emission from the soil and the structural state and organic matter content of the soil. Applying alternative soil cultivation methods based on reduced disturbance of the soil more favourable conditions can be created in order to increase the organic matter content of the soil and the availability of the nutrients for the crops. In order to quantify the increased CO_2-emission from soil due to soil preserving cultivation systems, in situ CO_2-emission of soil was measured by means of an ANAGAS 98 infrared gas analyser. In this paper the results gained from the measurement on stubbles are published, as we consider stubbles the most suitable state when the effects of different soil cultivation systems on the microbiological activity of the soil can be compared. Studying the effect of different soil utilisation/cultivation methods on the CO_2 emission from soil is indisputably actual and needs more efforts as it can contribute to develop a more environmental friendly agricultural production.

Key words: CO_2 / emission, organic matter content, soil cultivation system

INTRODUCTION

The carbon-dioxide gas emitted from the soil mainly originates from root respiration, microbiological activity and decomposition of organic matters. The volume and intensity of CO_2-emission is in close correlation to the structural state and organic content of the soil, hence it can be considered as a parameter of soil fertility. Measuring CO_2-emission, the most important (from agricultural point of view) characteristic of the soil can be directly quantified. As the practice of soil cultivation is changing in Hungary nowadays, consequently soil properties also change that result in the change of the microbiological activity, nutrient dynamics and organic matter profile of the soil. All these have a great influence on plant production.

The process of CO_2-circulation between the soil and the atmosphere is very changeable in time and space, getting more information on it could contribute to the correct assessment of the microbiological activity corresponding to the actual soil state. Measuring the CO_2-emission from the soil can provide several valuable information in the respect of soil utilisation as well. In 2002-2006 the CO_2-emission of the soil was measured with an ANAGAS CD 98 infrared gas analyser in the framework of a project on the pilot fields of Karcag Research Institute of University of Debrecen CAS

with the cooperation of the Department of Environmental Management. The main goal of the measurements was to determine the effect of soil cultivation technologies and certain agrotechnical elements on the CO_2-emission of the soil.

MATERIALS AND METHODS

The CO_2-emission measurements were carried out at the Karcag Research Institute of University of Debrecen, Centre for Agricultural Sciences (KRI). The Department of Soil Utilisation and Rural Development of the Institute has been dealing with a complex soil cultivation experiment on 15.8 hectares for ten years. The plots of this experiment provide good opportunity to measure the CO_2-emission from the soil. One fraction of this complex approach is measuring the CO_2-emission from soil. It is obvious if less fuel is consumed less load of greenhouse gases to the atmosphere, but at the same time it is said that soil conservation tillage techniques usually result in increased CO_2-emission from soil (GYURICZA, 2000). In order to quantify this, in situ CO_2-emission of soil was measured by means of an ANAGAS 98 infrared gas analyser (*Fig. 1.*) and 10 plastic (PVC) chambers of 950 cm^3 each.

Figure 1. The ANAGAS 98 infrared gas analyser

Later special, individually developed sets were used consisting of a metal frame and a plastic bowl each. In order to have perfect isolation, the metal frame is inserted into the soil (sharpened bottom edge) down to 5.5 cm and the trough around the frame is filled with water. The volume of the plastic bowls is approximately 18,000 cm^3, the diameter of the metal frames is 44 cm. This set was developed further by the authors in 2006, as it was

realised that a smaller set is more practical and suitable for CO_2-emission measurements on stubbles and can substitute the cylinder method that was used earlier (ZSEMBELI *et al*., 2005). As a result of the further development four smaller sets were constructed, each consists of a plastic bowl of 2,800 cm^3 in volume and a metal frame of 20 cm in diameter, while the height of the frame remained 8 cm (*Fig. 2*.). To determine the actual soil moisture contents and temperature TTN-M type probes were used.

Figure 2. The two sets of the frame+bowl method

In this paper the results gained from the measurement on stubbles are published, as we consider stubbles the most suitable state when the effects of different soil cultivation systems on the microbiological activity of the soil can be compared. In stubble state, obviously after the harvest of the crop), root respiration is not characteristic, therefore the carbon-dioxide gas emitted from the soil is purely due to the microbiological activity, so more precise comparisons can be done.

RESULTS AND DISCUSSIONS

In 2003 we determined CO_2-emission on stubbles of early harvested crops (winter wheat, sorghum and chickling vetch) in July and September in 2003. *Fig. 3.* shows that higher emission was characteristic for the stubbles of crops with direct seeding. Usually microbiological activity in the soil is increasing by autumn as the decomposition of plant residues is taking place if enough moisture is available. In case of stubbles root respiration do not contribute to CO_2-emission, hence the microbiological activity increased by the higher soil moisture content must be the explanation of the higher emission values measured in September. Indeed, 18.8 mm precipitation fell just before the measurements. Similar experiences were reported in

scientific papers dealing with the correlation between soil moisture content and CO_2-emission (FRANZLUEBBERS et al., 2000; SOULIDES and ALLISON, 1961; FIERER and SCHIMEL, 2003).

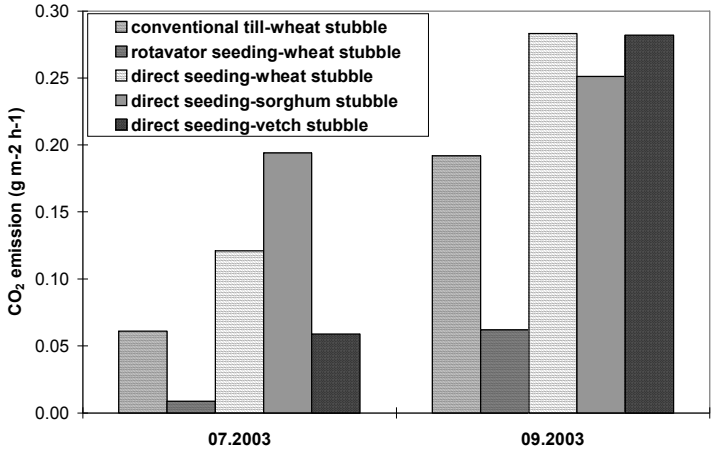

Figure 3. CO_2-emission values in the soil tillage experiment in 2003

In 2005 we had two opportunities to measure CO_2-emission in the soil tillage experiment. The results we gained are summarised in *Fig. 4*. We compared the values measured in the conventionally cultivated plots to direct seeding in two different crop vegetations (winter wheat and vetch). Higher emission values were detected in the cultivation system based on direct seeding in the case of both indicator crops at both dates, the difference was more developed for winter wheat. These differences can be explained with the higher rate of CO_2-emission due to the characteristically increased decomposition in autumn originating from the extra crop residues involved in minimum tillage like direct seeding.

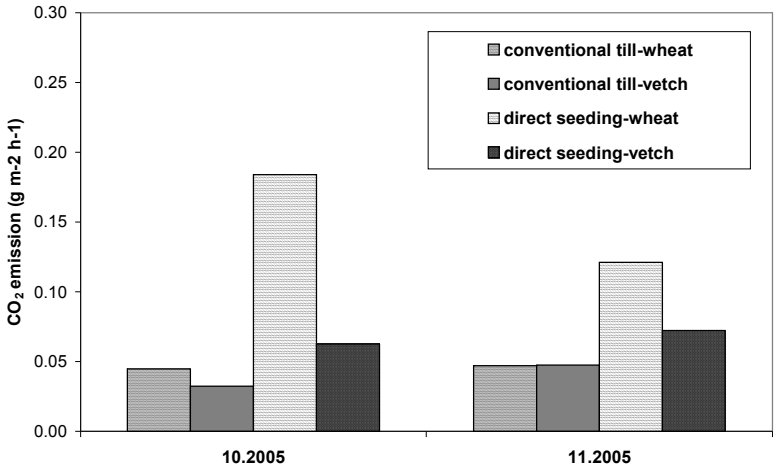

Figure 4. CO_2-emission values in the soil tillage experiment in 2005

Fig. 5. shows the CO_2-emission values determined for the treatments of the soil tillage experiment in 2006. Four measurement dates are indicated, the first measurement was done after the harvest and before the relevant tillage application, which was ploughing in the case of the conventional system and disc ripping in the reduced system. In July, which was very dry in 2006, higher emission was detected in the reduce tillage system in the case of both crops. In August the measurements were done after a rainy period of two weeks with 77.9 mm of rainfall, which is much higher than the average. Due to this amount of rainfall the differences disappeared, similar emission values were detected in all treatments, hence the effect of the tillage operations was suppressed by the effect of soil moisture content. This dominancy was experienced several times in the previous years as well. Nevertheless we consider the absolute values of emission quite low, as considerable increase was detected due to such an amount of water input in the previous years. In September rape was sawn in the winter wheat stubble, then thin manure was spread on those plots. Obviously this organic matter input stimulated the microbiological activity in the soil, hence 3-5 times higher emission of CO_2 was detected in the plots treated with thin manure compared to the plots without this treatment. In normal years a peak of the microbiological activity is characteristic in autumn as the decomposition of plant residues is taking place if enough moisture is available. Nevertheless the autumn and the early winter periods of 2006 were extremely dry in the region of Karcag, the amount of precipitation was only 9.1 mm in September, 23.8 mm in October, 20.9 mm in November and 1.9 mm in December. It is only 55.7 mm of rainfall in 4 month's time, which resulted

in the shortage of moisture in the soil. As a consequence of this low CO_2-emission values were determined in October.

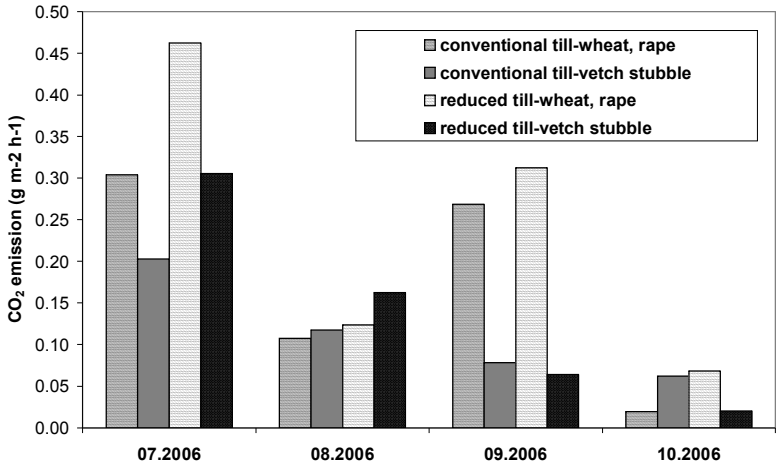

Figure 5. CO_2-emission values in the soil tillage experiment in 2006

CONCLUSIONS

There is close correlation between the degree and intensity of CO_2-emission from the soil and the structural state and organic matter content of the soil. Applying alternative soil cultivation methods based on reduced disturbance of the soil more favourable conditions can be created in order to increase the organic matter content of the soil and the availability of the nutrients for the crops. The tools we used for the in situ measurement could have been developed further, hence effective and handy sets are at our disposal to continue the project to gain more detailed information on the dynamics of CO_2-emission from the soil.

There are several methods to measure the CO_2-emission of the soil, but none of them is universal, and can be used in any circumstances. The most problematic part is the spatial delimitation of the measurement area as the surface of the soil can be very various and proper isolation is a must. We consider the *frame+bowl* method we developed suitable for measuring CO_2-emission of pastures and suggest it to researchers interested in this topic.

Studying the effect of different soil utilisation/cultivation methods on the CO_2 emission from soil is indisputably actual and needs more efforts as it can contribute to develop a more environmental friendly agricultural production.

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