SAMPLING METHOD DEVELOPMENT FOR MEASURING TILLAGE INDUCED CO_2 FLUX

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Abstract

The concentration of greenhouse gases in the atmosphere has increased steadily since about 1850. From the 280 ppm concentration in the 19th century, the industrial activity raised this value by 30-35% to 380-400 ppm till now. A substantial part of the total increase so far has been attributed to deforestation, conversion on farmland, and other agricultural activities. There are many methods used by researchers to measure CO_2 flux after different tillage tools and methods. Our research is made to measure the effect of different tillage methods on the CO_2 flux from soil and to evaluate the effect of conservation tillage tools on CO_2 emissions. Beside of these the research aim is to exactly determine the CO_2 emission savings of conservation tillage methods and intelligent tillage machines.

Our research has shown that the use of the environment-oriented, mulch -tillage methods can play a major role in reducing of greenhouse gas emissions by increasing the rate of organic matter oxidation.

One of our objectives were to develop a reliable and method to measure the short and long term effect of different tillage methods on the CO_2 flux after tillage.

Introduction

Carbon dioxide flux from soil is an important factor in the increasing of the concentration of greenhouse gases in the atmosphere. Any increase in soil carbon has important benefits for the sustainability and productivity of the agro ecosystem. CO_2 is one of the most important greenhouse gases, because increase in its concentration causes about 50% of the total radiative forcing (Rodhe, 1990).

Improved agricultural practices have great potential to increase carbon sequestration and decrease the net emission of carbon dioxide and other greenhouse gases, but available information has not been synthesized in a form that policy makers and land managers readily can use to mitigate CO_2 emissions in relation to the potential greenhouse effect.

There is many literature data about the

Intensive agricultural production systems that include intensive tillage result in soil degradation and erosion that impacts soil, water, and air quality. The effects of conservation tillage and residue interactions on greenhouse gas fluxes and soil carbon should be evaluated. Soil scientists have studied the dynamic nature of soil carbon from an agronomic perspective, but not from an environmental context. Thus, more information is needed to advance the current understanding of how agricultural production systems can be modified to enhance environmental quality.

We need direct measurements to quantify CO_2 flux as affected by agricultural management practices. Information is needed on both the short-term effect of agricultural management decisions and the long-term effects, as they may affect global climate change. (Jori, 2004)

Limited measurements are available on CO_2 evolution immediately after tillage in the field. Gas fluxes were measured using closed chamber system. The atmosphere immediately above the soil surface is enclosed by the chamber and the change in concentration of CO_2 or N_2O one hour after closure is measured. This change is a result of net emission from the soil and enables gas flux to be determined, using both manual and automated closed chambers. (Jori et al., 2004) The manual chambers (Clayton et al., 1994.) were cylinders of diameter 0,4 m, pushed into the soil to a depth of 50 mm and with the head space enclosed with an aluminium lid. Gas samples were taken in syringes or aluminium sampling tubes and subsequently analyzed in the laboratory by gas chromatography.

The CO_2 flux from the tilled soil surfaces was measured using a large portable chamber described by Reicosky, (1990), and Reicosky and Lindstrom (1993). Measurements for CO_2 flux were initiated within 5 min of the last tillage pass. Briefly, the chamber (volume of 3.25 m^3 covering a horizontal land area of 2.67 m^2) with mixing fans running was moved over the tilled surface until the chamber reference points aligned with plot reference stakes, lowered and data rapidly collected at 2-s intervals for a period of 80 s to determine the rate of CO_2 and water vapor increase. After the appropriate lag times, data for a 30-s period was used to convert the volume concentration of water vapor and CO_2 to a mass basis then linearly regressed as a function of time to reflect the rate of CO_2 and water vapor increase within the chamber expressed on a unit horizontal land area basis.

Our former study has shown that the examination of only the short term influence of tillage on soil CO_2 emission can lead to faulty implications because it did not give enough information about all consequences of tillage operation. Analyzing the long term (Figure 1.) emission of soil CO_2 has shown that short (e.g.3-5hours) measurement data can be extrapolated to calculate long term emission data considering soil temperature, moisture content and tillage intensity.

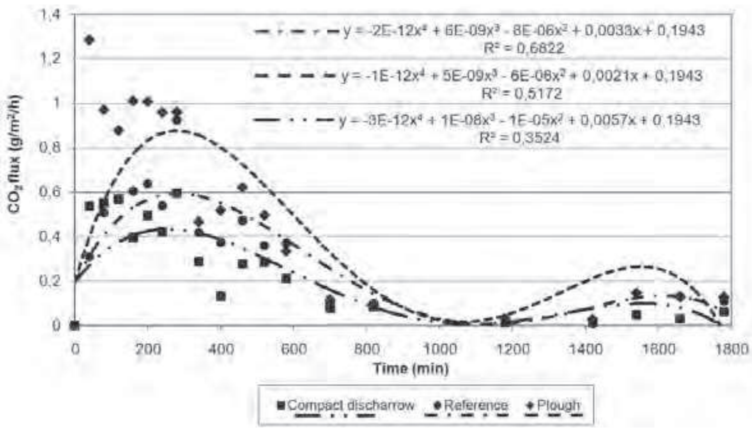

Figure 1. Long term (30 hour) emission of CO_2 after tillage

Studies in the past years were pointed on the importance of correct measurement techniques. The cumulative method, where the emitted CO_2 is collected for hours or longer in the same chamber covering the same area of soil surface, according to our measurements can change the natural environment of soil under the sampling chamber. (Rádics, Jóri 2006) Therefore to get correct result of the investigation the method with ventilated sampling chambers have to be used, where the chambers were emptied after each measurement and the sampling was followed on a new place on the test plot where the emission was unaffected before the measurement.

Earlier measurements have also shown that the measurements were more reliable by using chambers with larger basic area and higher volume-area coefficient. Therefore new sampling chamber have to be developed, to get an easy sampling method with more accurate result.

Materials and methods

The studies were made in county Somogy near Mesztegnyő (Table 1.). The first study was conducted on sandy sandy clay soil on wheat stubble in August 2011. The second study was initiated on clay soil on sunflower stubble in September 2011.

The measurement term was 4 hours, the sampling period was 15 minutes and started after the tillage operation immediately. Tillage treatments were done with middle-deep loosener and field cultivator.

The air CO_2 concentration and temperature was measured and registered before every cycle, to determine the exact value for soil CO_2 flux characteristics.

The influence of tillage on soil CO_2 evolution was assessed by recording two series of successive measurements. Each series included a pre-tillage measurement to assess „reference” flux uniformity, followed by two different past-tillage measurement to compare fluxes along tilled and undisturbed plots. The sampling was made on the plot by random settlement.

Soil CO_2 flux was measured in situ using the calibrated TESTO 535 CO_2 tester. We used 8 litre polyethylene sampling chamber (chamber ID:C02) as by the initial studies in early years (Figure 2.). The result of the earlier studies have shown that the measurements are more reliable using chambers with larger basic area and higher volume-area coefficient, therefore a new chamber (chamber ID:C03) was developed (volume:27 litre) (Figure 3.). Due to the larger volume and height of the sampling chamber, homogenization of the gas content was required. Therefore integrated ventilators with low air flow were applied. To isolate the examined area the frame of the sampling chamber was 5cm deep inserted into the soil.

To validate earlier years experiences the former cumulated method was also used, to compare the results of the new chamber with the earlier results. The validation of the new chamber was made also by the ventilated method where the chambers were emptied after each measurement.

Table 1. Site and treatment specification

No.	Operation/ Date	Weather condition	Machine	Working depth, cm
1.	Primary tillage on wheat stubble 08.09.2011	Dry, sunny, 28-31°C	Middle-deep loosener	38-42
2.	Stubble mulching on sunflower stubble 09.17.2011	Dry, sunny, 25-28°C	Field cultivator	14-16

Figure.2 TESTO 535 CO_2 tester and “C02” portable chamber

Figure3 The “C03” ventilated portable chamber

Fig.4 Middle-deep loosener

Fig.5 Field cultivator

Result and discussion

Evaluation of the trends of measured data has shown that the results are identical with the former research. The emitted CO_2 in the first study was higher than in the second one, because the research was made in summer with high temperature (28-31°C) on loosened field (Figure 4.) and at lower temperature (25-28 °C) on cultivated field (Figure 5.), which is a less intensive treatment.

The deviation of the average of data getting from C02 and C03 chambers (Figure 6-7.) is smaller than the deviation of data getting from C02 chambers. Furthermore the average of the deviation of data getting from C03 is more smaller than the getting one of C02.

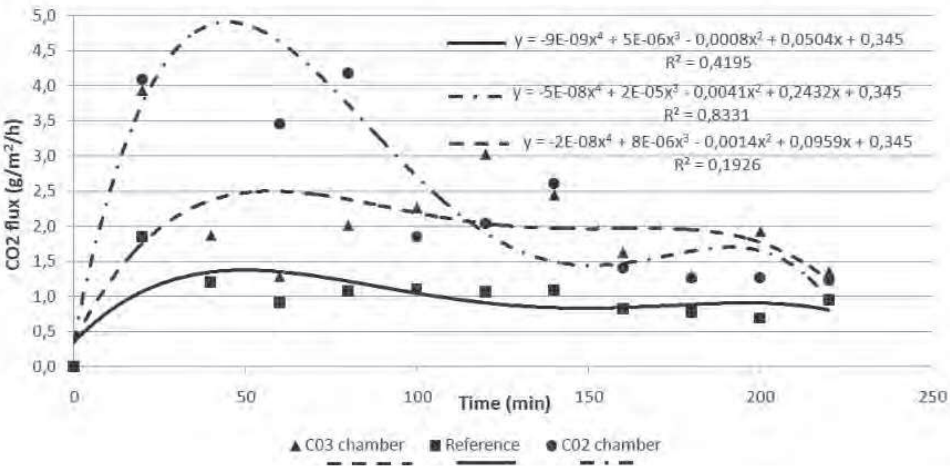

Figure 6. Results of the first study (loosener)

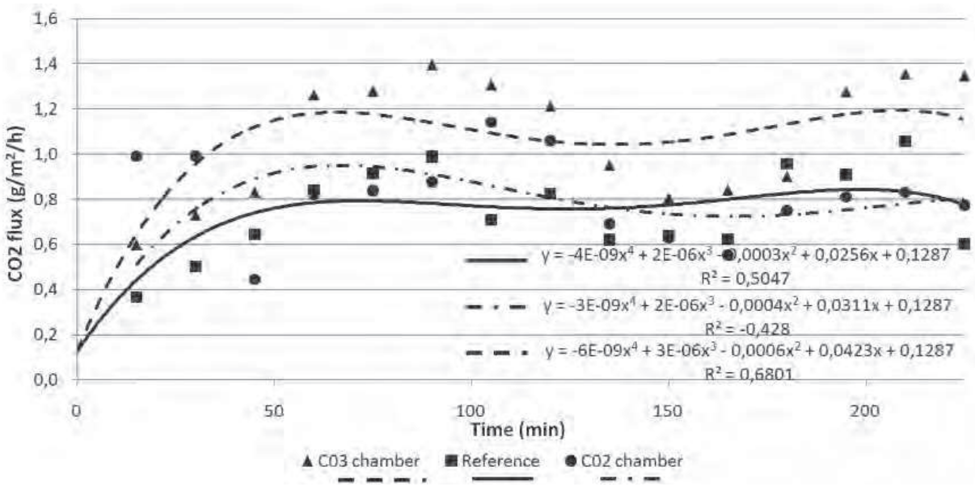

Figure 7. Results of the second study (cultivator)

In order to compare the result of early research to the new one we have done measurement also with the C03 chamber using the cumulative method. Based on the result of former study it can be stated, that the cumulative method is usable to compare the effect of the different tillage operation only.

There is an advantage of cumulative method, that not necessary to empty and resettle of chambers in the case of comparison of different tillage operations. Using this method the time consumption can decrease significantly and the number of measurement can increase as well.

The getting result has shown, that the reliable measurement time of C03 chamber can be longer with 50% using the cumulative method than the C02 one As a result of new system the comparison of different operations can be done more accurate.

Conclusions

There is a great need to determine exactly the amount of tillage induced CO_2 loss of different tillage practices. Investigated the results, the study has shown that the new developed sampling chamber is suitable to determine adequate soil CO_2 emission of different soil types and treatments.

The evaluation of data has shown that the C03 chamber provides more reliable result, because this chamber with the cumulative method can be used for a longer time.

Further studies should be done with the C03 chamber to have enough information to determine correctly the CO_2 savings of conservation tillage methods.

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References

1. Clayton,H. et al. (1994): Journal of Geophysical Research.1994.99:16599-16607.

2. Jóri, J.I.-Rádics, J.-Pazsiczky, I.-Szabó, I.-Gyuricza, Cs. (2004): Tillage induced CO_2 loss. AgEng 2004 conference. Leuven, Book of abstracts, 48-49p.

3. Jóri J. István (2004): Tillage Intensity and Tillage-Induced CO_2 Loss. Progress In Agricultural Engineering Sciences. Akadémiai Kiadó. Budapest. 2004 Sample Issue. 35-45.p.

4. Rádics J, Jóri J I (2006): Long term effect of tillage on CO_2 emission. Proceedings of World Congress (CIGR) Agricultural Engineering for a Better World. Bonn, Németország, 2006. Bonn: pp. 1-8. Kötet megjegyzések: Abstract 150-152, +CD

5. Reicosky, D.C.-Lindstrom, M.J. (1993): Fall tillage method: Effect on short-term carbon dioxide flux from soil. Agronomy Journal. Vol.85.(1993) No.6. p.1237-1243.

6. Reicosky,D.C. (1990): Remote sensing reviews.1990.5(1):163-177.

7. Rodhe,H. (1990): a comparison of the contributionof various gases to the greenhouse effect.Science.1990.248:1217-1219.