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MITIGATING GREENHOUSE GAS EMISSIONS FROM CULTIVATED ORGANIC SOILS CARROTS, PASTURES, BARLEY OR POTATOES? WHICH CROP TO CHOOSE?

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SUMMARY

In Sweden drained cultivated organic soils contribute to a substantial part of total emissions of greenhouse gases. The aim of this study was to investigate if it is possible for the farmer to reduce the greenhouse gas emissions by choosing a specific cropping system. In this study two different crops grown on the same field were compared regarding their emissions of CO_2 and CH_4. A range of different organic soils with various soil properties were used. The results show that the differences in greenhouse gas emissions are greater between sites than between crops. The conclusion in this study is that it is not possible to mitigate the greenhouse gas emission from drained organic soils by changing the cultivated crop.

KEY WORDS: organic soil, peat, greenhouse gas emission, cropping system, Myrklima

INTRODUCTION

About 9 % of the agricultural land in Sweden is organic soils, peat and gyttja soils. Agricultural peat soils have been estimated to contribute with 6-8 % of the total anthropogenic emission of greenhouse gases in Sweden (Berglund and Berglund, 2010). Managed grassland and pastures dominate the agricultural use of organic soils and annual crops only cover 25 % of the area (Berglund and Berglund, 2010).

Drained peatlands suffers from lowering of the soil surface, subsidence, caused by consolidation, shrinkage, compaction and oxidation of the organic material (Berglund, 1989). There are several factors affecting both subsidence and fluxes of CO_2 from agricultural soils. A rule of thumb for Swedish conditions estimates that permanent grassland has lower subsidence rate than cereals and row grown crops (Berglund, 1989). Since a part of the subsidence originates from degradation of the organic material row grown crops have been considered to emit more CO_2 than cereals and grassland. Different studies have shown results where permanent grassland has less, more or the same CO_2 emissions as barley (Maljanen et al., 2002, Lohila et al., 2004, Maljanen et al., 2010).

Drainage of peatlands also changes the fluxes of CH_4. From being producers of CH_4 in the pristine anaerobic environment draining decreases the emission and the peatland can even become net sink for CH_4 (Martikainen et al., 1995). For cultivated organic soils the CH_4 fluxes

are usually low but can differ depending mainly on changes in ground water level but also the crop can have an impact according to Kasimir Klemedtsson et al. (2009).
Investigations of the effect of different crops on greenhouse gas emissions from cultivated organic soil have given contradictory results. The reason for this might be that the studies are made on different locations with different soil properties. To achieve reliable results in comparing crops the study needs to be done with similar conditions in both crops i.e. the same soil properties, climate, drainage etc. In this study we measured CO_2 and CH_4 emissions from organic soil comparing crops in the same field. The study sites are located in the southern half of Sweden distributed to give a diverse set of soil properties. The aim of the study was to see whether it is possible for a farmer to mitigate the greenhouse gas emissions by changing the cultivated crop.

MATERIALS AND METHODS

Site description

Thirteen study sites were chosen for their difference in soil properties and spatial location. The study sites were situated on farms with fields differing in cultivation intensity. The study includes row crops which are very intensively cultivated, other annual crops that are less intensive and grassland and pastures which are quite extensively cultivated. The soil properties of these organic soils range from an organic matter content of 10% to 90%. All farms are located in the southern half of Sweden.

Experimental design and flux measurements

A comparison was made between two different crops grown on the same field divided by a field border or a ditch. The soil properties and drainage intensity were assumed to be the same for both crops. 10 study plots ($1m^2$) were placed in transect along the field border about 5-15 m into each crop. The study plots were divided into 5 plots with crop and 5 plots with bare soil. In the bare soil plots the crop was manually removed in beginning of season and thereafter kept clean by manual weeding once a month. Prior to gas sampling 0.25 m^2 of the plot with crop was cut for biomass measurement and to reduce photosynthesis. This area was then used for the gas flux measurement. At each sampling occasion a new square of the study plot was used. Also in plots with bare soil the sampling area rotated. At all study sites the set up was the same. The study plots were managed by the farmers in the same way as the rest of the field.

Gas flux sampling was performed once a month during the growing season, May to September, in 2010. All measurements were made during daytime. The gas flux measurement was performed with the closed dark chamber method. PVC collars were inserted 3 cm into soil before measurement. PVC chambers, 28 cm high, were placed over the collars during incubation, sealed with a rubber packing. Two chambers were used for CO_2 measurement, one on each crop. The CO_2 sampling was done at the same time on both crops, one collar at the time following the transect of collars. The air in the closed chamber was circulated during 5 minutes through a GMP343 CO_2 analyzer (Vaisala Ltd, Vantaa, Finland). For CH_4 emission measurements three chambers on each crop was sampled simultaneously. Sampling of the air in the closed chamber was conducted by circulating the air for 30 s between the chamber and a 22-ml vial sealed by a butyl rubber septum. Chamber air was sampled at 10, 20, 30 and 40 minutes after closure. The samples were analyzed by gas chromatography (Perkin Elmer clarus 500). The emission rate for the gases was calculated from the linear change of gas concentration in the chamber headspace.

RESULTS

Results from gas emission measurement at four fen peat sites are presented here (Figs. 1 and 2).

CO_2

Figure 1 shows results from CO_2 measurements on plots with crop and removed crop as average for the growing season at each site. There were statistical significant differences between crops at single sampling occasions but the pattern was not consistent over the whole season or between sites.

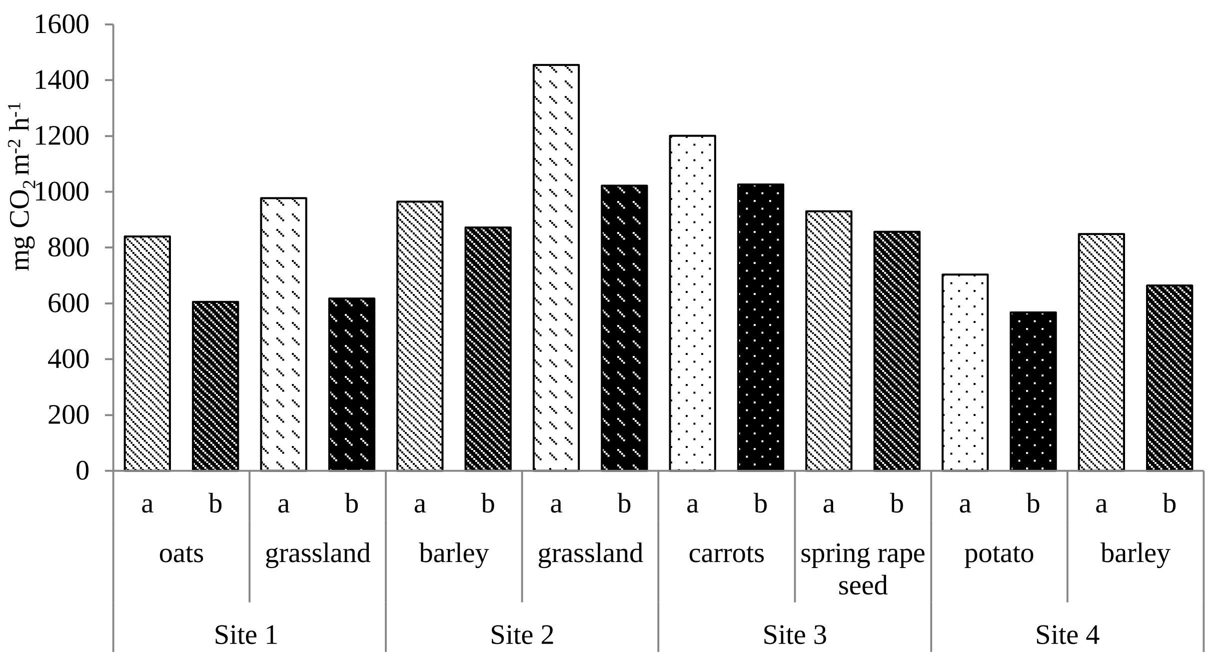

Fig. 1. Results from the comparison of CO_2 emissions from plots with different crops ((a) with crop and (b) removed crop) as average for the growing season. All sites are situated on fen peat soils.

CH_4

Figure 2 shows the results from the CH_4 measurements as average for the growing season at each site. There is no clear trend in the comparison of crops for the CH_4 fluxes. Usually the sites were sinks for CH_4 which is expected for well-drained soils.

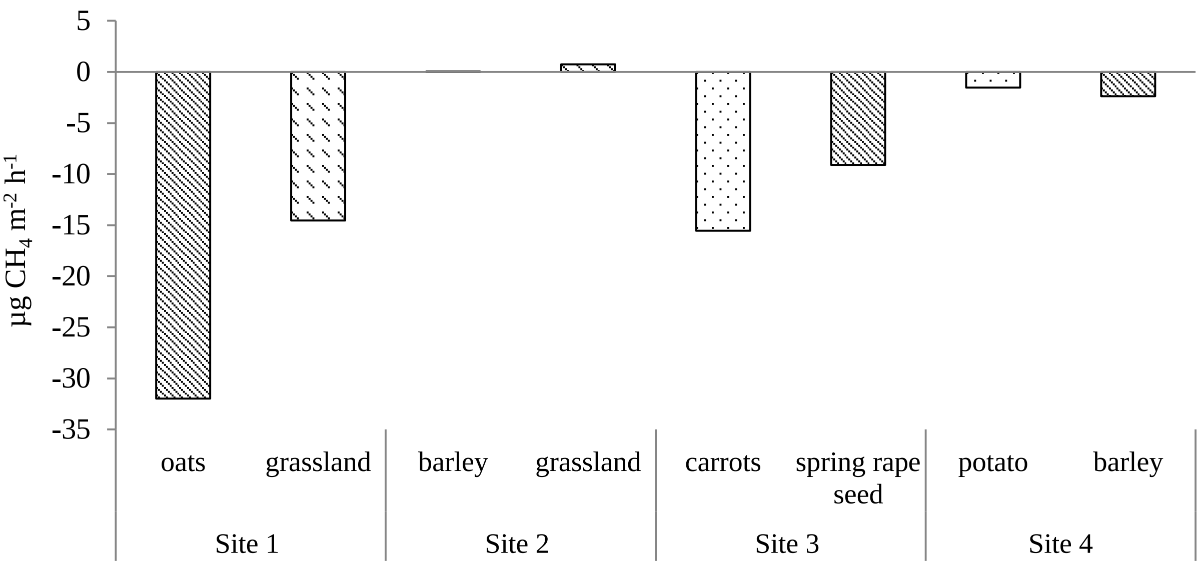

Fig. 2. Results from the comparison of CH_4 fluxes from plots with different crops as average for the growing season. All sites are situated on fen peat soils.

CONCLUSIONS

- The differences in CO_2 emission between the crops are small in comparison to the total CO_2 emissions from the soil.
- The differences in CO_2 emissions are greater between sites than between crops.
- The farmers cannot mitigate the CO_2 emissions from their organic soils by changing cropping system.
- The sites are generally a sink for CH_4 and the choice of crop does not affect the fluxes.

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