

Nitrous oxide emissions from a clay soil depend on timing of autumn mouldboard ploughing

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Abstract

Soil tillage under wet conditions can have negative consequences on the soil structure, especially on clay soils. This may result in decreases in crop growth and thereby nitrogen (N) uptake causing increased levels of soil mineral N during periods with no crop N uptake. A more dense soil structure as well as increase amounts of nitrate could give increased losses of N by leaching or by gaseous emissions. Declining grain yields during almost ten years of mouldboard ploughing in late autumn (November) under wet conditions compared with ploughing in September when the soil still is dry raised the question if deteriorated soil structure increases nitrous oxide (N₂O) emissions. Data on N₂O emissions measured by manual chambers from a Swedish long-term field experiment with early and late mouldboard ploughing compared with tine cultivation as primary tillage will be presented as well as data from micrometeorological measurements.

Key Words

Clay soil, N₂O emissions, mouldboard ploughing, timing.

Introduction

Agriculture is the largest anthropogenic source of nitrous oxide (N₂O), accounting for 65% to 80% (Crutzen *et al.* 2008, IPCC 2006). Nitrous oxide is 298 times more potent as green house gas compared to carbon dioxide (on a 100 year basis) and has a long half time in the atmosphere (114 years). Thus, there is a need for measurement of fluxes and identifying the driving variables causing the emission. By identifying critical occasions in the crop rotation, changed management options may be developed from the results. Knowledge is needed on emission of N₂O from Swedish clay soils, and on possible ways to mitigate these emissions by altered farming practice. It is well known today that the risk for nitrogen (N) leaching from sandy soils in Sweden is high during the winter season if the soil is ploughed early in autumn compared to delayed tillage operations (Stenberg *et al.* 1999; Aronsson 2000; Aronsson *et al.* 2003). The N leaching from clay soils have been reported to be lower (Torstensson 2003; Ulén *et al.* 2005; Lundström 2004). However, Wetterlind *et al.* (2005) found differences in mineral N accumulation in the soil profile 0-90 cm during autumn in wet years compared with dry years with higher accumulations dry years. Wet years, there was little accumulation of mineral N. This could indicate gaseous N losses from the soil wet years rather than leaching losses. Stenberg *et al.* (2005) found that grain yields during an eight-year period declined in the late ploughed treatments compared with the early ploughed. This indicates a deteriorated soil structure, negatively affecting yields, due to ploughing during wet conditions in late autumn. Here, early autumn ploughing was compared with late ploughing as well as tine cultivation in respect of emissions of N₂O, soil mineral N dynamics and grain yields.

Methods

Lanna experimental farm is situated in south-west Sweden (lat. 58 21'N, long. 13 08'E) on a large agricultural plain. The soil was classified as an Udic Haploboroll (USDA) with two diagnostic horizons, a Mollic epipedon and a Cambic horizon (Bergström *et al.* 1994). The clay content increases with depth, 45.1% in 0-30 cm, 57.2% in 60-90 cm and 58.4% in the 60-90 cm layer. Top soil pH (H₂O) is 6.8 and sub-soil pH 7.0-7.2. Organic carbon content is 3.4% in the top-soil and 0.6% and 0.0% in the sub-soil layers. The soil structure has been described as strong coarse subangular blocky in the top-soil and strong fine to medium angular blocky and strong coarse angular blocky in the sub-soil layers. The 1961-1990 average annual precipitation was 560 mm and annual temperature 6.1°C (Alexandersson and Eggertsson Karlström 2001). Normally the soil is frozen during parts of the winter. The drains normally flow from November to April and for longer in some years (Larsson and Jarvis, 1999). The soil is normally unsaturated to a depth of 2.2 m and this zone is characterized by numerous cracks and biotic macropores. Cereal crops as winter

wheat, spring barley and spring oats, and oil seed rape (winter or spring) are common crops in the area. Lanna research station is representative for several areas of Swedish clay soils.

Micrometeorological measurements (MT) are conducted over six plots of 1 ha size (Figures 1 and 2). The MT emission is calculated from the difference in the N₂O concentrations at 0.5 and 1m height measured with a Tunable Laser system, at the same time as the air movement between the different intakes is measured. Chamber measurements of N₂O emission is carried out in a long-term soil tillage field experiment (Figures 1 and 2 and Table 1) where early ploughing (A) is compared with late ploughing (C) and tine cultivation (J) described by Stenberg *et al.* (2005).

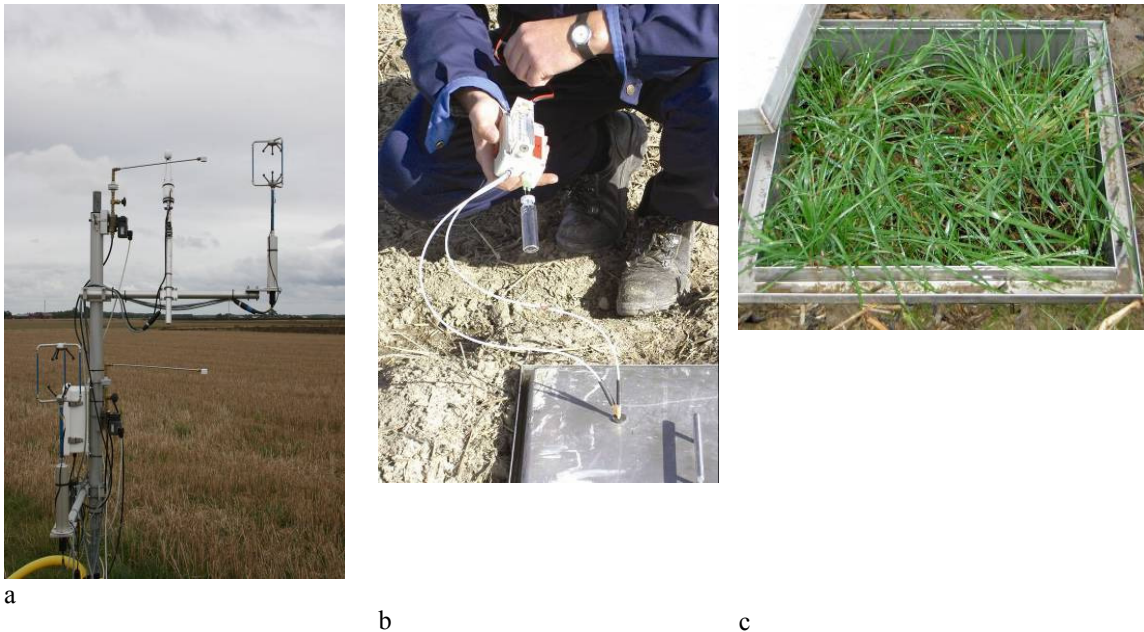


Figure 1. Micrometeorological equipment at Lanna (a), and chambers (b and c) used for gas sampling in the long-term experiment.

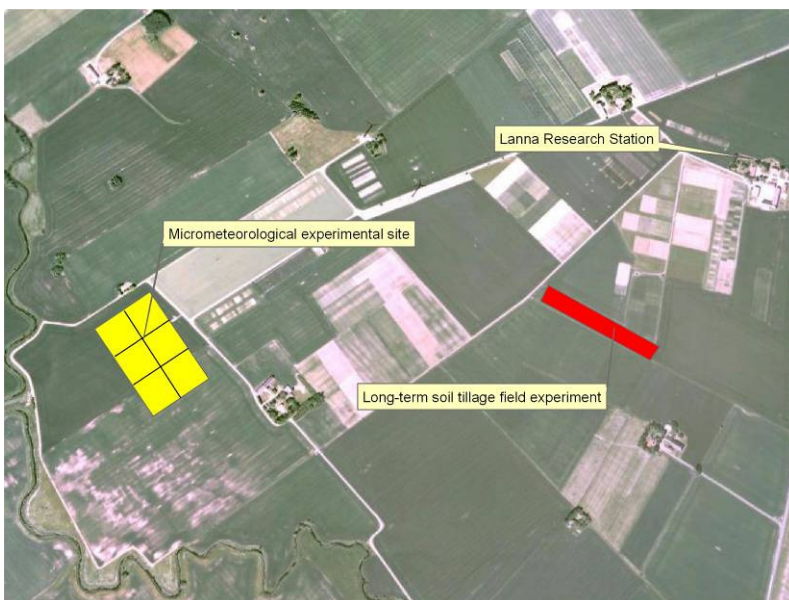


Figure 2. The experimental sites on a clay soil at Lanna research station in south-west Sweden.

Table 1. Treatments in the long-term field experiment at Lanna research station.

A	Early mouldboard ploughing/Straw incorporation/No catch crop
B	Early mouldboard ploughing//Straw removal/No catch crop
C	Late mouldboard ploughing/Straw incorporation/No catch crop
D	Late mouldboard ploughing//Straw removal/No catch crop
E	Carrier-cultivation to 5 cm early spring/No catch crop
F	Carrier-cultivation to 5 cm early spring with perennial ryegrass as a catch crop
G	Stubble cultivation 10 cm 1 Sept., straw incorporation/No catch crop
H	Stubble cultivation 10 cm 20-25 Oct., straw incorporation/No catch crop
I	Carrier-cultivation to 5 cm 1 och 25 sept, straw incorporation/No catch crop
J	Early and late stubble cultivation/Straw incorporation/No catch crop

Results

Measurements of N₂O emissions in the long-term field experiment started in September 2009. Emission data from early and late autumn ploughing will be presented at the conference, as well as grain yields and soil mineral nitrogen concentrations from the measurement period.

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