Soil Emission of Nitrous Oxide - Influence of Plants and Fertilisation

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Abstract
Micro-organisms produce nitrous oxide (N₂O) during the denitrification of nitrate (NO₃⁻) and nitrification of ammonium (NH₄⁺). Nitrogen fertilising increases the soil concentration of nitrate and/or ammonium and thus enhanced emissions may occur. Different emission rates have been reported in literature in dependence on the type of fertiliser, type of soil, type of cultivated plants, and climatic conditions, ranging from 0.001 % to 2.5 % for N₂O-N in relation to fertiliser-N. When the environmental impacts of agriculture are evaluated, this conversion factor plays an extraordinary role, especially in the climatic evaluation of the non-food sector, as it was the case in Germany (Environmental balance of biofuels, UBA 1993 and UBA 1999).

In the study reported here, soil emissions have been measured in an experimental field, where different short rotation crops were cultivated for use as biofuels. The aim of the soil emission measurements was the evaluation of environmental effects in connection with different fertilising levels (plots with 125 kg N ha⁻¹ a⁻¹ - plots A; plots with 75 kg N ha⁻¹ a⁻¹ - plots B and plots C; plots with no fertilisation - plots D). The experimental field was separated into 40 plots, each of 624 m². Gas samples of 100 ml were taken from 25 gas flux chambers at different plots (cover boxes with volume of 64 litres) four times per week and analysed by means of a gas chromatograph (GC). Two evacuated gas samplers were connected with each box. The first was opened, when the box was put on the water-sealed ring at the soil and the second one after two hours' collecting time. Then the boxes were removed and the samplers were connected with the GC-injection control system. In the course of the automatic GC-measurement the samplers were checked, the GC calibrated and the concentrations determined. In such a way, a higher accuracy than 5 ppb (5 10⁻⁹) could be achieved for nitrous oxide measurements at atmospheric mixing ratios.

The soil emission of nitrous oxide showed a considerable variability. One possibility to compare the effects of plants on the emission of N₂O is the accumulation of all emissions. The accumulated mean values of fertilised and non-fertilised plots resulted for rye and for orchard grass in an annual emission of 170 mg N₂O m⁻² (1.1 kg N₂O-N ha⁻¹). In the case of plots with triticale 155 mg N₂O m⁻² (1.0 kg N₂O-N ha⁻¹) were found. The lowest emissions were observed from plots cultivated with poplars (120 mg N₂O m⁻²; 0.8 kg N₂O-N ha⁻¹) and willows (90 mg N₂O m⁻²; 0.6 kg N₂O-N ha⁻¹). The difference between background emissions (plots with no fertilisation) and emissions from fertilised plots showed the same result for the emission factor, the relation between emitted nitrogen and applied nitrogen. As final result, it can be stated that an N₂O-N emission factor of 0.2 % is typical for the loamy sand soil (clay content 6.4 %, organic carbon content 0.91 % and pH value 6.0) of the experimental field under the local climatic conditions near Potsdam.