Soil nitrous oxide fluxes following cover crops management under tillage and no tillage in South Brazil

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Abstract
Emissions of N_2O were measured following cover crops management (oat - O and vetch - V) under tillage (CT) and no tillage (NT) in a silt loam Acrisol in South Brazil. Effects of tillage systems and residue management on N_2O emissions were examined over 55 days in 2007 and 54 days in 2008. Larger emissions were measured in 2008 compared to 2007. N_2O emissions increased in the presence of crops residues and were further increased in NT V/M in 2007 (193±84 µg N/m^2/ha) and in CT V/M in 2008 (431±138 µg N/m^2/ha) and they are related to high water content and available soil nitrogen. Smallest fluxes of N_2O were measured from the NT O/M treatments, which 288±61 µg N/m^2/ha in 2007 and 274±19 µg N/m^2/ha in 2008.

Key Words
Global warming, soil nitrogen, residue quality, rainfall, denitrification.

Introduction
Emissions of N_2O are of concern because of the role of this gas in the greenhouse effect and the destruction of the ozone layer (IPCC 2007). Direct and indirect emissions from agricultural systems are now thought to contribute 6.2 Tg N_2O-N/y to a total global source strength of 17.7 Tg N_2O-N/y. In Brazil the inventories of greenhouse gases indicated that agriculture is a principal source of N_2O (MCT 2006). Emissions this gas from agriculture are related to soil processes in that N_2O emission is increased by application of inorganic fertilizer, incorporation of crop residues and animal waste. Residue composition and the quantity of biomass incorporated influence the N_2O emission at different levels for no tillage and conventional tillage (Baggs *et al*. 2003). Tillage systems, such as no till and conventional, directly determine the proximity of residues and the relative spatial concentrations of N, and hence interactions between residue application and cultivation are likely to determine soil N_2O.

Methods
Experimental area and treatments
The study was carried out in subtropical conditions of Southern Brazil. The experimental area is located at the 30° 50' 52'' S, 51° 38' 08'' W. The local climate is Cfa second Köpen classification, with an annual average temperature of 19.4 °C and precipitation of 1440 mm (Bergamaschi *et al*. 2003). Soil N_2O emissions and soil and meteorological variables were measured frequently after application ofcover crops residues in spring. In an Acrisol, we assessed the long-term effect (22 years) of soil tillage systems [no-tillage (NT) and conventional tillage (CT)] and cropping systems [oat/maize (O/M) and vetch/maize (V/M)] on N_2O emissions.

Air sampling and N2O emission
Air samples were collected in static chambers after cover crop management (O and V) in 2007 for 54 days and in 2008 for 55 days. Air samples were collected with syringes at 0, 15, 30 and 45 minutes after closing the chamber. The samples were analyzed for N_2O concentration by gas chromatography.

Soil and meteorological variables
Soil samples for determination of mineral N (nitrate and ammonium), soil moisture and dissolved organic carbon (DOC) were collected as composites of five replicate soil samples per plot, from a depth of 0–10 cm. A 10-g sub-sample of the soil was used to determine soil inorganic-N by extracting in 50 mL 1 M KCl. Concentrations of NH_4^+ and NO_3^- were determined by Kjeldhal. Soil moisture was gravimetrically determined by drying a sub-sample to 105 °C. Soil moisture was used to calculate water filled pore space (% WFPS) using bulk densities collected each week in conventional tillage and one time in no tillage. Dissolved organic carbon was extracted in water, filtrated in regenerate cellulose membrane (0,45 µm) and determined by C analyzer. The effects of soil and meteorological variables and N_2O fluxes were evaluated with multiple linear regressions.

Results

Larger fluxes occurred in 2008 more than in 2007 (Figure 1 and 2). In 2008 the maximum fluxes occurred between 20 to 30 days in all treatments. In both years conventional tillage increased N_2O emissions for O/M systems. Similar results were reported by Baggs *et al*. (2003; 2006). NT promotes the smallest fluxes in O/M systems. The accumulated N_2O emission after cover crop rolling averaged for the years for NT soil was three times greater for V/M system (mean:886.3 g N/ha) than for the O/M system (mean:280.8 g N/ha), which is explained by the high quality of vetch residue accelerating N release in soil (Millar and Baggs 2005). In CT soil, however, such emissions were similar in those two crops systems: mean of 742.0 g N/ha in O/M and 739.8 g N/ha in V/M because CT increased N_2O emissions in O/M systems. These results were contrary and higher than those in 2003 reported by Gomes (2006) in this same experiment. We believed that the high precipitation occurred after cover crops in 2007 and 2008 increased N_2O emission potential because this coincided with nitrogen release by crops. It probably reflects oxygen deficiency in soils favoring to denitrification (Farquharson and Baldock 2008). In 2007 this was confirmed as emissions for no and conventional tillage were controlled mainly by NO_3^- and dissolved organic C availability in soil and by water filled porosity (Eq. 1 and 2).

$$N_2O_{PC} = (\mu g\ N/m^2/ha) = -93{,}9 + 4{,}78NO_3 + 2{,}56WFPS + 0{,}26DOPC \quad (1)$$

($R^2 = 0{,}57$, n= 20, $p<0{,}001$)

$$N_2O_{PD} = (\mu g\ N/m^2/ha) = -79{,}9 + 2{,}05NO_3 + 1{,}33WFPS + 0{,}22DOC \quad (2)$$

($R^2 = 0{,}45$, n= 40, $p<0{,}001$)

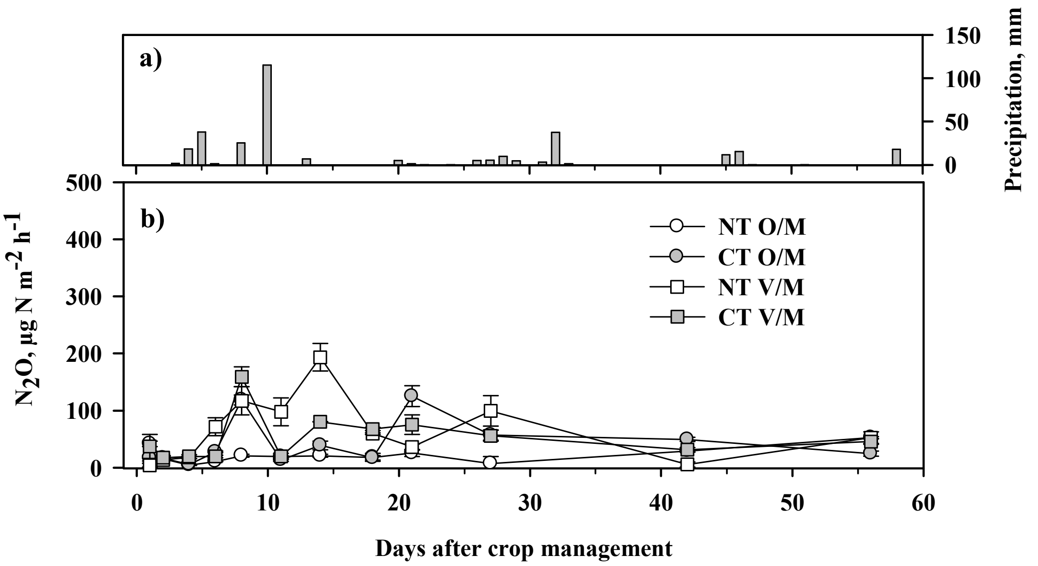

Figure 1. Precipitation (a) and soil nitrous oxide fluxes (b) during 55 days after oat (O) and vetch (V) management in tillage (CT) and no tillage (NT) in 2007. M=maize. Error bars represent standard deviation.

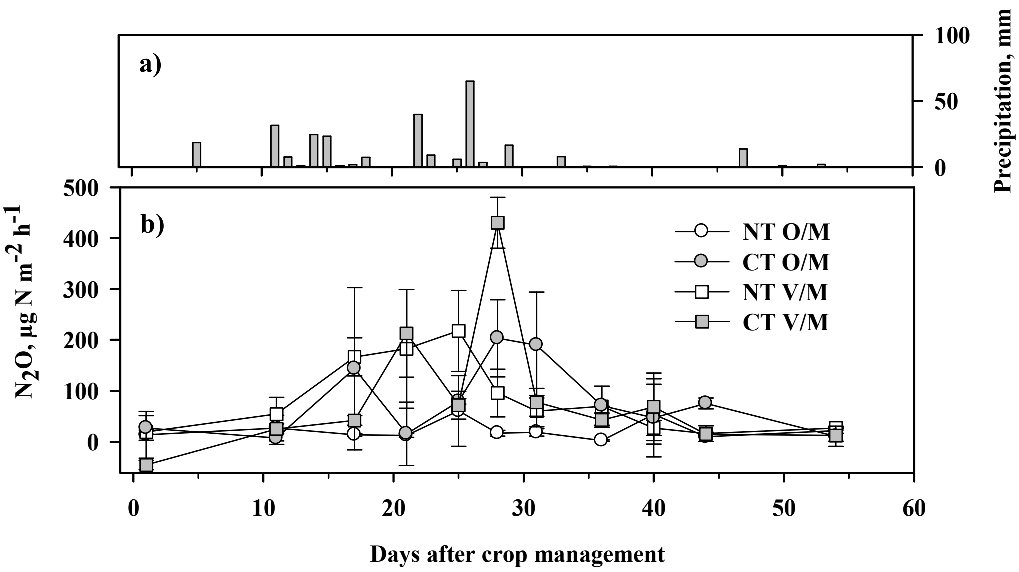

Figure 2. Precipitation (a) and soil nitrous oxide fluxes (b) during 54 days after oat (O) and vetch (V) management in tillage (CT) and no tillage (NT) in 2008. M= maize. Error bars represent standard deviation.

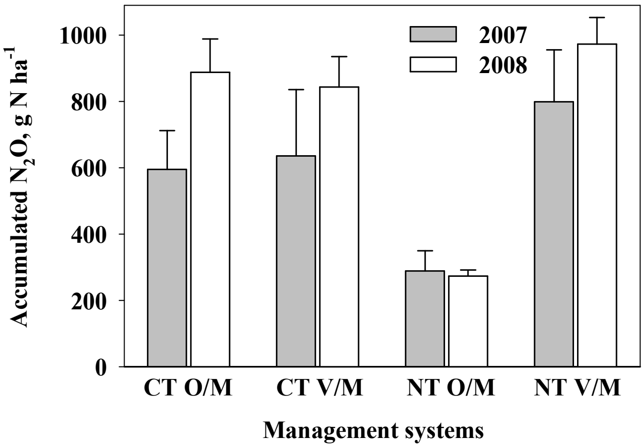

Figure 3. Accumulated N_2O emitted over 55 days in 2007 and 54 days in 2008 after oat (O) and vetch (V) management in tillage (CT) and no tillage (NT). M=maize. Error bars represent standard deviation.

Conclusion

The emission of N_2O was smaller in no tillage when this system was combined with oat/maize. However in vetch/maize managed as no tillage and conventional tillage there were no differences. The emission for V/M was higher than for O/M just for no tillage. The relation of nitrate, dissolved organic carbon and water ships filled porosity indicate that N_2O emission was predominantely derived by denitrification in the soil.

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