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N2O emissions in boreal cereal production: effect of fertilization rate and autumn versus spring ploughing

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Mineralization of nutrients from crop residues is an important source of N2O emission during the off season and in early spring when plant uptake is small. Crop residues incorporated in autumn may be mineralized if snowpack prevents soil from freezing, leading to nutrient losses from crop production system by leaching and run off during snow melt. Spring ploughing has been recommended in many countries to prevent nutrient loss and to abate erosion during snow melt. Depending on winter climate, timing of tillage can affect the nutrient cycling and N losses in crop production. We therefore monitored nitrous oxide (N2O) emissions throughout two vegetation periods by static chamber technique in a long-term cereal trail in south eastern Norway, comparing different ploughing times (spring and autumn) at three fertilisation rates (0, 60 and 120 kg N ha-1). The soil was loamy clay and the crop rotation included wheat, barley and oat. Autumn ploughing plots were ploughed in October and left fallow during winter while spring ploughing plots were ploughed in April right before the sowing. In both years, higher annual N2O emissions were observed in autumn ploughed plots (0.9 – 1.4 kg N2O-N ha-1 yr-1) as compared to spring plough (0.82 – 1.2 kg N2O-N ha-1 yr-1) at low (0 and 60 kg N ha-1) fertilisation rate whereas N2O emission at 120 kg N ha-1 was higher in the spring plough treatment (1.86 kg N2O-N ha-1 yr-1) than in autumn plough treatment (1.6 kg N2O-N ha-1 yr-1). Directly after spring thaw, higher N2O emission rates (35-79 μg N2O-N m-2 h-1) were observed in spring ploughed plots as compared with autumn ploughed plots (18-26 μg N2O-N m-2 h-1) throughout a short period of two weeks. This was probably related to higher soil moisture and more fresh carbon available from the stubble in non-ploughed during this period. There was no direct effect of spring ploughing on N2O emissions. Initially high NH4- and NO3-contents after snow melt decreased rapidly with crop emergence, irrespective of tillage time. N2O emissions showed a strong seasonality in both ploughing regimes with highest emissions during summer. Together with the low mineral N contents during summer, this implies that microbial N2O production in high latitude crop production is strongly controlled by competition for mineral nitrogen with plants. N leaching during wet springs may be another factor restraining N2O emissions early in the vegetation period. Interestingly, N2O emissions dropped in autumn, despite increasing mineral N contents and soil moisture, indicating a strong effect of soil temperature on N2O emission in high latitude crop production. On an annual basis, differences in N2O emissions in the two ploughing regimes were small, giving similar emission factors of 0.4 and 0.7 % of applied nitrogen lost as N2O in 2009 and 2010, respectively.