N2O emissions from cropping systems with integrated weed management. The nitrogen challenge: building a blue print for nitrogen use efficiency and food security

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N2O EMISSIONS FROM CROPPING SYSTEMS WITH INTEGRATED WEED MANAGEMENT

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Integrated weed management (IWM) in cropping systems aims to lower the reliance on herbicides of the crops, by introducing new combinations of agricultural practices in the system development (Munier-Jolain et al, 2009). These combinations may greatly change from a system to another and include a large variety of practices, such as false seed beds, late sowing, mechanical weeding, reduced tillage, specific crop rotations that alternate spring and winter crops, the choice of crop varieties and the use of pesticides with low ecotoxic impacts. Several implemented agricultural practices are likely to alter soil biogeochemical cycles and different components of the greenhouse gas budget (balance between the carbon sequestration and the greenhouse gas emission) of the system: e.g. crop rotation, dates and level of nitrogen fertilization and tillage. The main objectives of our study were to evaluate i) the N2O fluxes emitted from soil during one year for 4 cropping systems (i.e. 3 IWM systems and a local reference of conventional system), and ii) to investigate the relationship between the measured fluxes and soil parameters and the agricultural practices of each system.

Materials and methods

One reference cropping system (S1) and 3 IWM cropping systems (S2, S3 and S5) were studied (Table 1). Nitrous oxide (N2O) emissions were measured continuously using the automated chamber method (Vermue et al., 2013) from March 2012 to March 2013. Soil temperature and moisture were continuously recorded for the different systems and soil bulk density and inorganic N periodically measured.

Results and discussion

The intensity of the N2O emissions was highly variable, both over time and between systems. N2O emissions and water filled pore space (WFPS) were significantly correlated for all systems but no significant correlation could be established between N2O emissions and soil inorganic N dynamics. Over the year of experimentation, the IWM system S2 emitted significantly more N2O (5226 ± 670 g N-N2O ha-1) than the IWM system S5 (777 ± 177 g N-N2O ha-1), which also emitted significantly more N2O than the IWM system S3 (177 ± 172 g N-N2O ha-1) and the reference system S1 (326 ± 168 g N-N2O ha-1). In no-till system S2, WFPS values were significantly higher, and may have greatly enhanced the denitrification activity and the N2O fluxes emissions. The different crop rotations between systems may also have impacted N2O emissions, particularly the introduction of alfalfa, in the crop rotation of S5 system which may have enhanced N2O emissions.

Conclusion

Over the year, the continuous monitoring of the four cropping systems allowed to identify N2O fluxes as mostly resulting from short periods of favorable soil conditions for N2O production by denitrification in soils i.e. high WFPS and temperature. Overall the intensity of N2O fluxes significantly differed between systems, suggesting a strong impact of agricultural practices on N2O emissions. Some very high emissions, exceeding 5 kg N-N2O over the measurement period was observed on the S2 system characterized by the absence of tillage. Despite some limit of the experimental device, the results strongly suggest that a no-tilled integrated weed management system can promote N2O emissions in comparison to tilled systems either conventional or integrated. As an equivalent emission of 0.7 t C-CO2 ha-1 was observed to be emitted by the S2 plot, the probable carbon sequestration in this system has probably been canceled during the very rainy year of measurement. However, efficiency of no-till systems for mitigating global warming are known to increase with years, this study need to continue since the literature suggests that the observed effect of IWM on N2O emission could change overtime.

Table 1: Main characteristics of the 4 studied cropping systems (from Chikowo et al., 2009).

Crop system	Acronym	Description
Reference system	S1	Designed to maximize financial returns. Use of chemical herbicides to control weeds. Moldboard plowing each year. Choice of herbicides according to recommendations of extension services. Crop rotation: winter wheat/winter barley/oilseed rape.
IWM	S2	Minimum tillage between 2000 and 2007. No tillage since 2008. Time-consuming operations such as plowing, harrowing and mechanical weeding excluded. Treatment frequency index[1] reduced by 25 %. Diversified crop rotation[2].
IWM	S3	Plowing and other tillage operations allowed when necessary for weed seedbed management but mechanical weeding is excluded. Treatment frequency index reduced by 50 %. Diversified crop rotation[2] + leguminous.
IWM	S5	Use of any herbicides excluded. Physical and cultural means are allowed to contain weed infestation. Diversified crop rotation[2].

[1] amount of pesticides spread per ha expressed in % of the standard approved dosages of pesticides per ha.
[2] oilseed rape/winter cereal/spring crop/winter cereal/summer crop/winter cereal.

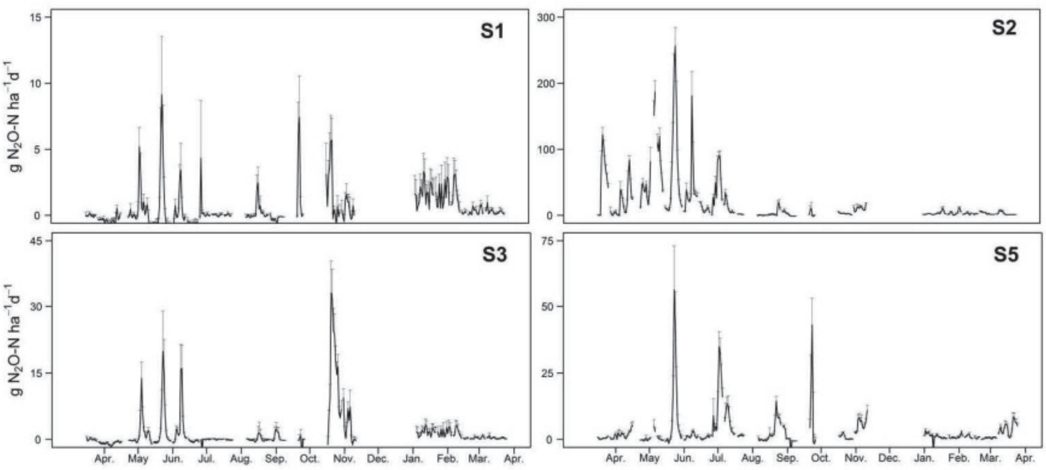

Figure 1: N_2O emissions for the 4 studied cropping systems.

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