Impact of tillage on CO_2 and N_2O efflux in an agricultural crop

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Background

- **N_2O is produced by soil nitrifying and denitrifying microorganisms. In agricultural soils, the upper layer constitutes the main source of N_2O emission.**
  - ⇨ Oxygenation conditions in pores (WFPS) and soil temperature affect the activity of N_2O producing microorganisms. Determining variables also include soil properties like N and C availability, and soil pH.
- **Farming practices such as tillage can influence these soil properties and consequently affect GHG emissions.**
  - ⇨ However, there is no consensus concerning the effect of reduced and conventional tillage on GHG emissions by agricultural soils in temperate regions.

Material & Methods

Experimental set up and timing

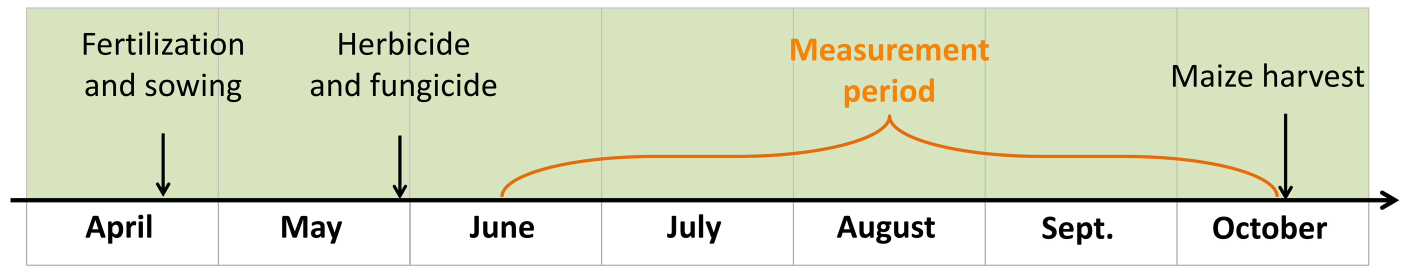

Fig. 1: Automated dynamic closed chambers: PVC collars + motorized lids + air circulation to gas analyzers (Gascard® NG OEM CO_2 analyzer and Thermo Scientific™ 46i N_2O analyzer:).
8 chambers per treatment were used to continuously measure CO_2 and N_2O fluxes at a 4.5-hour resolution.

- **Experimental site**: maize crop located in Gembloux, Belgium (silt loam under oceanic temperate climate).
- **Treatments compared**: reduced tillage (crop residues incorporation at 10-cm depth) and conventional tillage (crop residues incorporation at 10-cm depth + winter ploughing at 25-cm depth) since 2008.
- **CO_2 and N_2O flux measurements**: homemade automated dynamic closed chambers (Fig. 1).

Results

Impact of tillage on CO_2 and N_2O fluxes

- **CO_2 and N_2O emissions were significantly affected by tillage treatments (Fig. 2).**
  - ⇨ Reduced tillage distributes crop residues only in the uppermost layer, significantly influencing soil properties (Fig. 3e-f-g).
  - ⇨ We assume that it created more favorable conditions for microorganisms growth and for production of CO_2 and N_2O.

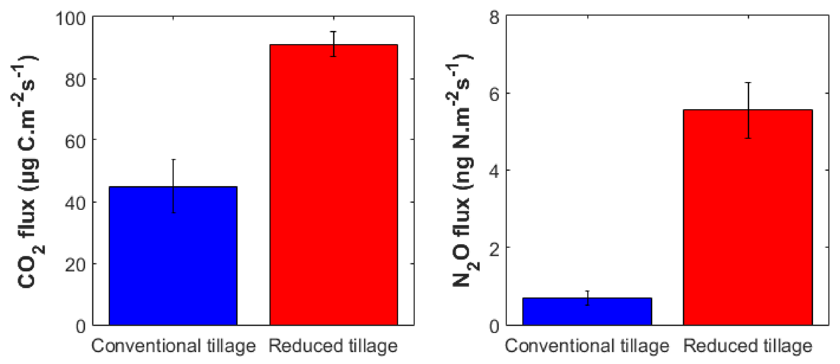

Fig. 2: Mean CO_2 (left) and N_2O (right) fluxes. The analysis of variance showed significant differences ($p < 0.001$) between treatments.

Temporal variability of N_2O emissions

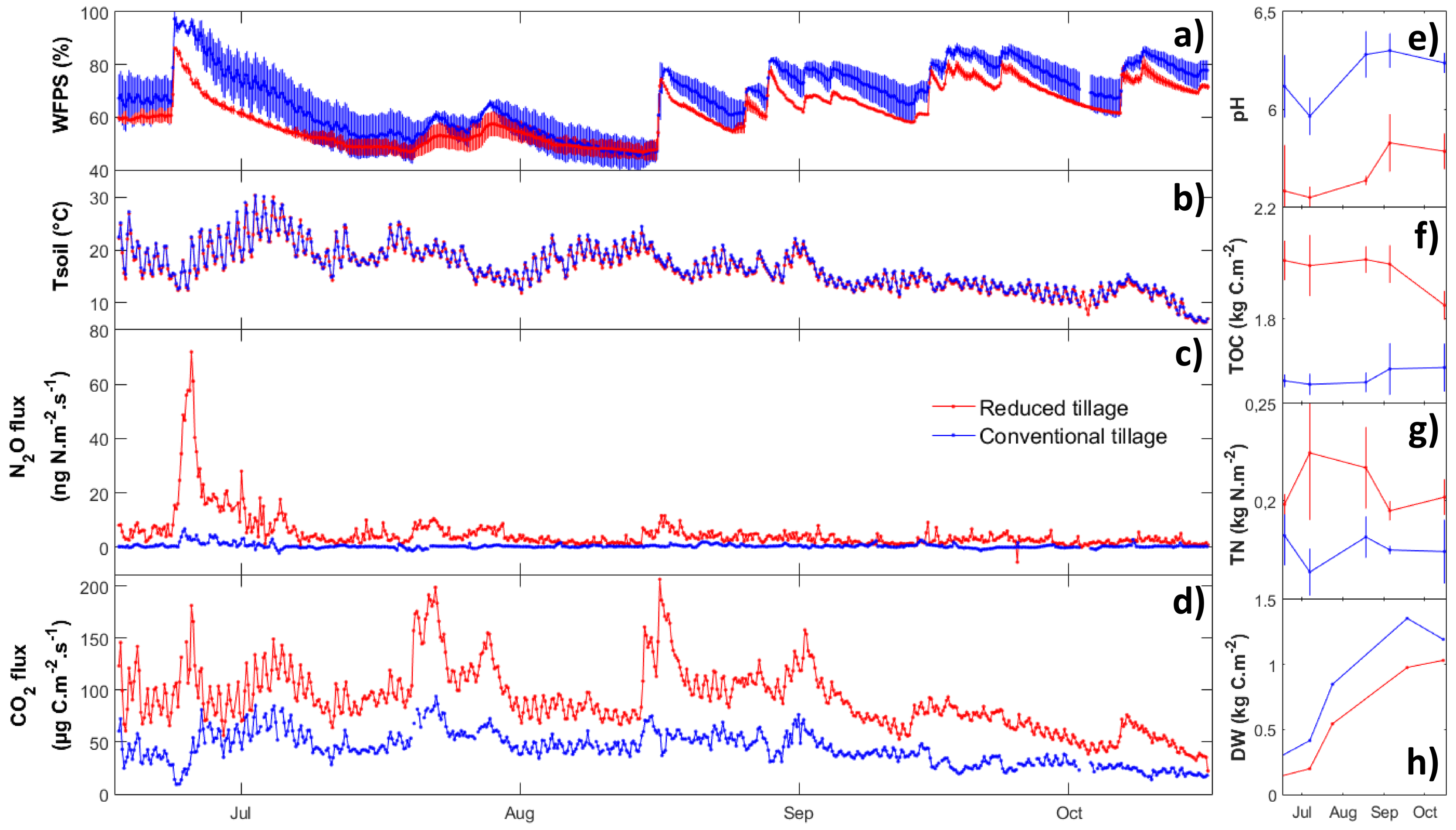

Fig. 3: *a)* Water-Filled Pore Space (WFPS) at 10-cm depth. *b)* Soil temperature (Tsoil) at 10-cm depth. *c)* Nitrous oxide fluxes. *d)* Carbon dioxide fluxes. Time series from *a* to *d* are given at a 4.5h resolution. *e)* Soil pH (0-10cm). *f)* Soil total organic carbon (TOC). *g)* Soil total nitrogen (TN). Soil properties (*e* to *g*) significantly differ between treatments except for TN in the first sample. *h)* Maize dry weight (DW).

- **N_2O emission peak in both treatments in mid-June, and background fluxes afterwards (Fig. 3c)**
  - ⇨ N_2O production was triggered by an increase of WFPS (Fig. 3a) following heavy precipitations, leading to an emission peak less than 24h after the rainfall in both treatments.
  - ⇨ Later on, the absence of important peak after rainfall could be due to an increased competition for soil N between microorganisms and growing maize (Fig. 3h).

Drivers of N_2O background fluxes

- **In reduced tillage, soil temperature explained ~10% of N_2O background flux variability (Fig. 4).**
  - ⇨ Increased soil temperature stimulates of microbial activity (agreement of N_2O and CO_2 fluxes, Fig 3c-d). WFPS added in the linear regression explained ~1% of the variability.
- **In conventional tillage, no significant link between N_2O background fluxes and soil temperature nor WFPS was found.**
- **No clear pattern (e.g. daily cycle) in N_2O background flux was identified.**

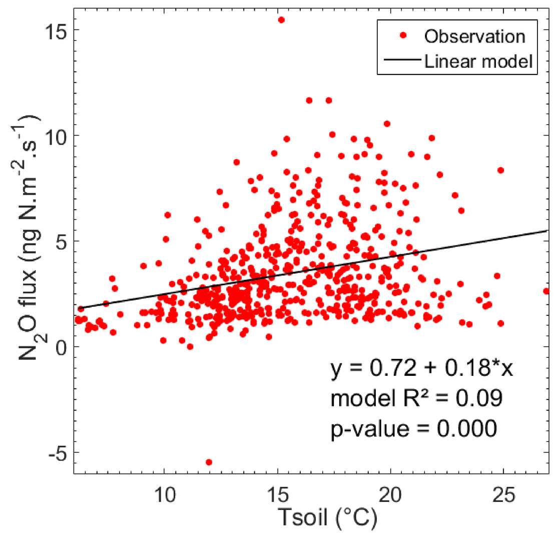

Fig. 4: Regression analysis of N_2O background flux with soil temperature in reduced tillage.

Conclusions

Using automated dynamic closed chambers, we measured CO_2 and N_2O emissions in a maize crop during 4 months and compared fluxes in parcels under conventional tillage and reduced tillage.

1. **Reduced tillage**, by limiting **incorporation of crop residues** to the uppermost soil layer, **created more favorable conditions for CO_2 and N_2O emissions**.
2. **N_2O emission peaks** triggered by an increase of WFPS **can happen long after fertilization** (2 months), highlighting the **need for continuous measurements**.
3. **N_2O background fluxes** in reduced tillage showed to be **slightly influenced by soil temperature**, however no daily pattern was identified. **Need is for more measurements with high temporal resolution** to identify background flux dynamics.
4. The use of our homemade **automated system of closed chambers** was well suited for this kind of experiment.

Acknowledgments

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