Study the influence of environmental drivers on N2O emissions under semi-controlled conditions using a rainfall simulator

Maëlys Cadel, Isabelle Cousin, Marine Lacoste, Lionel Cottenot, Agnès Grossel

Study the influence of environmental drivers on N_2O emissions under semi-controlled conditions using a rainfall simulator

marine.lacoste@inrae.fr, lionel.cottenot@inrae.fr

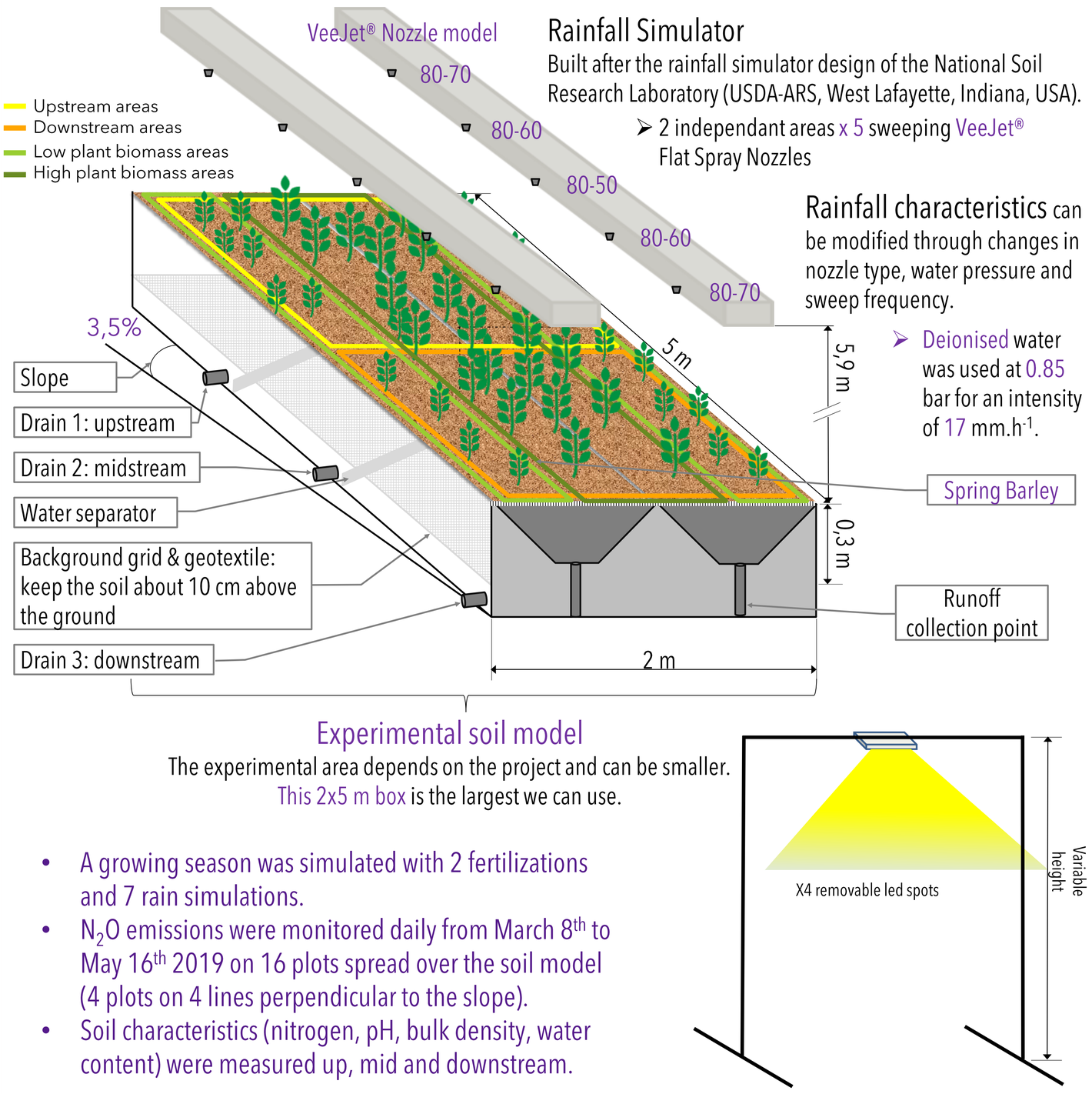
Maëlys Cadel[1,2]
Isabelle Cousin[1]
Marine Lacoste[1]
Lionel Cottenot[1]
Agnès Grossel[1]

[1] INRAE, Info&Sols, 45075, Orléans, France
[2] ANDRA, Centre de Meuse/Haute-Marne, OPE, 55290 Bure, France

1. Context

- N_2O emissions, the third anthropogenic greenhouse gas, is a major environmental issue.
- Objectives:
  - In semi-controlled conditions, reproduce the behaviour of a drained agricultural field, with soil N_2O emissions similar to field observations.
  - Analyse the relationships between the dynamics of N_2O emissions and water functioning of a cultivated fertilized soil.
  - Better understand N_2O production hotspots and hot moments to help reducing uncertainty in N_2O emissions estimation.

2. The rainfall simulator hall



Rainfall Simulator

Built after the rainfall simulator design of the National Soil Research Laboratory (USDA-ARS, West Lafayette, Indiana, USA).

- 2 independant areas x 5 sweeping VeeJet® Flat Spray Nozzles

Rainfall characteristics can be modified through changes in nozzle type, water pressure and sweep frequency.

- Deionised water was used at 0.85 bar for an intensity of 17 $mm.h^{-1}$.

Experimental soil model

The experimental area depends on the project and can be smaller.
This 2x5 m box is the largest we can use.

- A growing season was simulated with 2 fertilizations and 7 rain simulations.
- N_2O emissions were monitored daily from March 8th to May 16th 2019 on 16 plots spread over the soil model (4 plots on 4 lines perpendicular to the slope).
- Soil characteristics (nitrogen, pH, bulk density, water content) were measured up, mid and downstream.

Variable used for the experiment - N.B: diagrams are not to scale

3. Results

- The simulated rainfalls had a Christiansen coefficient > 90 %.
- N_2O fluxes ($gN\_N_2O.ha^{-1}.d^{-1}$)

	Min	Mean	Max
Before 2nd fertilization	0	12	43
After 2nd fertilization	0.4	33	177

- First N_2O peak observed after the 26 mm rainfall on all experimental plots.
- Second but lower N_2O peak observed after a 8.5 mm rainfall only for plots with higher plant biomass production.

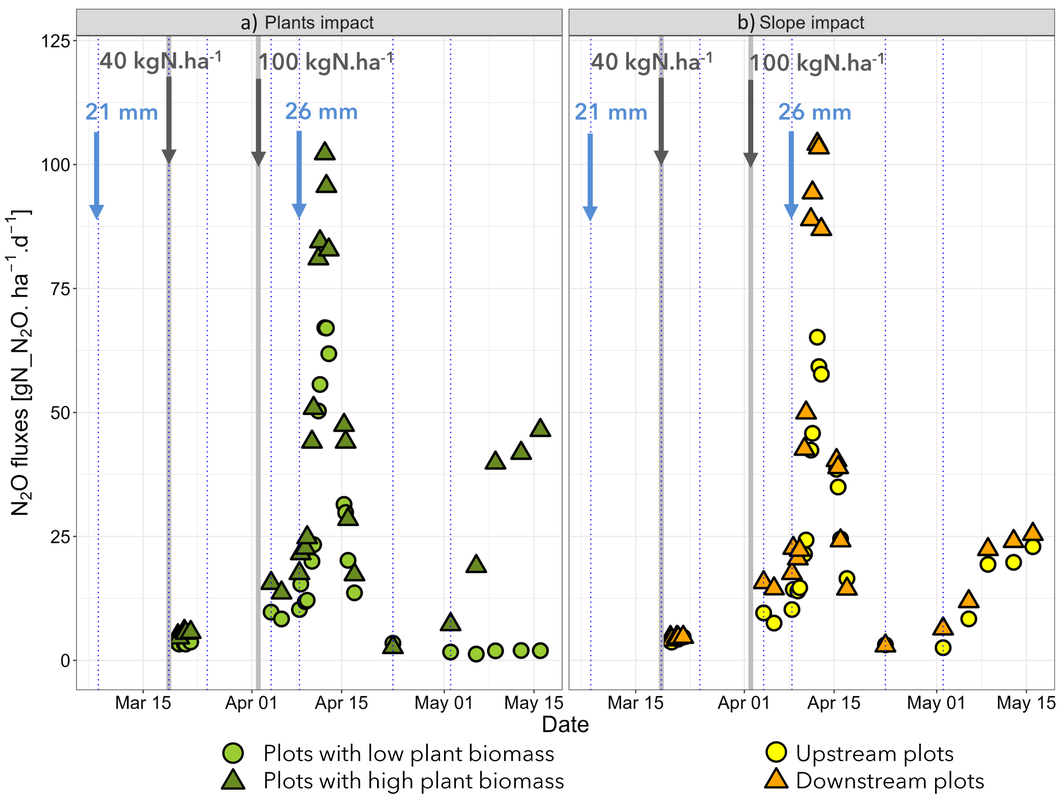


Fig. N_2O fluxes calculated from concentrations measured on the16 experimental plots. Mean fluxes a) on plots with low or high plant biomass and b) on plots upstream and downstream of the device. Blue dotted lines = rains (2 major rains indicated by blue arrows, others were of 8.5 mm) and the grey dotted lines = the two fertilizations (grey arrows = N inputs).

4. Conclusions

The use of the rainfall simulator hall (rainfall simulator + soil model) allowed to correctly reproduce the behaviour of a drained agricultural field, regarding N_2O emissions:

- The N_2O emissions were in accordance with field measurements on drained agricultural fields (Grossel et al., 2016, Gu et al., 2011).
- Slope affects water processes dynamics (lateral flows, accumulation of water at the bottom of the slope), inducing stronger emissions at the downstream positions.
- Higher N_2O emissions were observed for plots with higher plant production. It may be linked to i) limitation of soil compaction caused by rainfalls, which increased soil porosity and gas diffusion at the soil surface, and ii) higher organic matter inputs.

This work was supported by the ADEME (Agence de la Transition Ecologique, former Agence de l'Environnement et de la Maîtrise de l'Energie, France) through the HydroGES project (grant 1660C0003) and by the Labex Voltaire (ANR-10-LABX-100-01).

2nd Rainfall Simulator Workshop
"Towards harmonisation in the use of rainfall simulators"
22-24 May 2023, Coimbra, Portugal

References
Grossel, A., Nicoullaud, B., Bourennane, H., Lacoste, M., Guimbaud, C., Robert, C. & Hénault, C., 2016. The effect of tile-drainage on nitrous oxide emissions from soils and drainage streams in a cropped landscape in Central France. Agriculture, Ecosystems & Environment, 230, 251-260.
Gu, J., Nicoullaud, B., Rochette, P., Pennock, D. J., Hénault, C., Cellier, P. & Richard, G., 2011. Effect of topography on nitrous oxide emissions from winter wheat fields in Central France. Environmental Pollution, 159, 3149-3155.