Project Number 282910

ÉCLAIRE

Effects of Climate Change on Air Pollution Impacts and Response Strategies for European Ecosystems

Seventh Framework Programme

Theme: Environment

D2.2. Data on microbial N turnover and NO (N2O) and CO2 emissions

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JUELICH

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Dissemination Level		
PU	Public	☒
PP	Restricted to other programme participants (including the Commission Services)	☐
RE	Restricted to a group specified by the consortium (including the Commission Services)	☐
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

1. Executive Summary

Deliverable 2.2 aims at quantifying the effect of soils re-wetting after summer drought on NO (and N_2O) emissions in the Mediterranean climate zone. Controlled laboratory experiments have been performed to improve our understanding of microbial and soil-physical processes contributing to NO and N_2O peak emissions.

Intact soil cores were sampled from an agricultural site in the Mediterranean area (Madrid, Spain) where a long lasting experiment on the effects of different tillage practices in plant productivity and soil quality have been performed since 1994.

An automatic incubation system was developed for the laboratory, and intact soil cores were investigated for 45 days under different tillage systems, fertilization loads and precipitation patters and monitored at sub-daily resolution for NO, N_2O, CO_2, CH_4 and NH_3 gaseous losses.

Results indicate that changing precipitation patterns in Mediterranean areas may have opposite effects on soil NO and N_2O pulses. A sudden soil re-wetting after a drought period attenuated soil NO fluxes as compared to more gradual soil re-wetting. On the other hand, larger precipitation episodes after drought triggered larger soil N_2O losses than continuous but small rains. Traditional soil tillage decreased NO emissions while increased N_2O loss rates as compared to no tillage practices.

2. Objectives:

According to previous studies, drying re-wetting cycles have been shown to result in peak emissions of NO from soils, with emissions during these periods estimated to contribute about 20% of the global soils emission and dominating annual budgets in some ecosystems. The frequency of rain events is forecasted to change significantly in future climates and consequently emissions will likely change as well. Thus, this task aimed at quantifying the effects of different rain patterns on the NO (and N_2O) emissions from soils affected by summer drought. Improved information of mechanisms leading to pulse emissions due to drying-wetting cycles will increase our prediction capability of soil emission under changing rain patterns.
This deliverable is linked to the objective 2 from WP2: "To provide data on NO emissions after rewetting events as basis to improve the mechanistic understanding and predictive capability, through novel laboratory experiments". This laboratory incubation is intended to improve our predictions of soil NO emissions and the resulting data will be used for improvement of mechanistic parameterisations in the frame of ecosystem modelling (WP3, D3.3).

3. Activities:

- Construction and implementation of a fully automatic incubation and gas sampling system (Figure 1) for measurement of intact soil cores by applying the dynamic chamber approach and acid trapping principle. The system is capable of measuring NO, N_2O, CO_2 and CH_4, at sub-daily resolution and NH_3 volatilization losses by acid trapping. It has a total capacity of 18 soil cores and can be coupled to different analytical instrumentation. Incubation temperature, air flow rate and air relative humidity can also be controlled and monitored continuously. Pulse emissions would have been missed or incompletely captured if a manual incubation system would have been used, dealing to over- or underestimations of cumulative fluxes, due to the fast temporal dynamics of soil emissions after re-wetting.

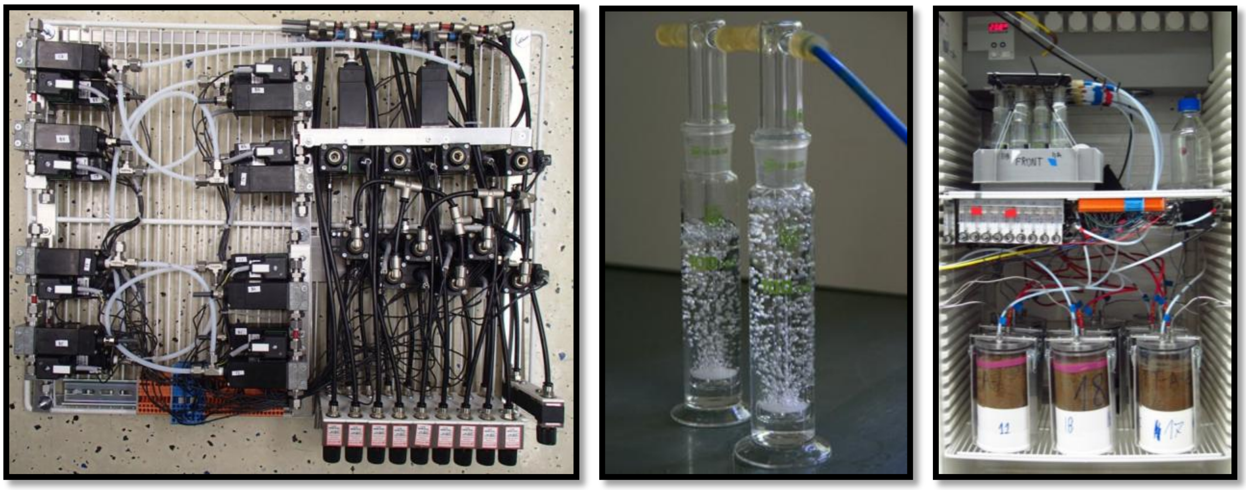

Figure 1: Layout of the automatic incubation and gas sampling system

- Soil sampling campaign in the experimental site “La Canaleja”, Madrid, Spain, an agricultural area located in a semi arid Mediterranean climate. A total of 80 intact soil cores were collected including traditional and no tillage systems, taking advantage of a long lasting experiment on the effects of different tillage practices in plant productivity and soil quality (Lammerding et al., 2011).
- Calibration of the acid trap method for NH_3 volatilization losses evaluation, by forced evaporation of different amounts of NH_3 within the automatic system.
- Laboratory soil core incubations. Intact soil cores were incubated following a factorial design, including three different factors: 1) Tillage system 2) fertilization load and 3) rain pattern. Rain pattern treatments included a homogeneously distributed rain after drought (2 mm a day during 45 days), and two treatments simulating three rain events with changing intensity (50, 30 and 10 mm). Note that all the treatments received the same amount of precipitation (90 mm) over 45 days of incubation and only the rain changed. Details on the experimental design are shown in Figure 2. Each single core (4 replicates) was incubated for 45 days and investigated at sub-daily resolution for NO, N_2O, CO_2, CH_4, NH_3 gaseous losses and N leaching.

✓Full factorial design → 18 (x4)

Tillage system:	Traditional / No tillage
Fertilization load (kg-N/ha)**:**	0 / 50 / 100
Rain pattern:	Constant / increasing / decreasing

✓Layout of Precipitation Events

	Day 0		**Day 15**		**Day 30**		**Day 45**
Decreasing intensity	50 mm		30 mm		10 mm		end
Increasing intensity	10 mm		30 mm		50 mm		end
Homogeneously distributed	2 mm / day						end

Figure 2: Experimental design with layout of precipitation events

4. Results:

After successful implementation, the automatic incubation and gas sampling system at KIT has shown to be capable to accurately measure emissions of NO and greenhouse gases.

NO emissions from no-tillage soil cores were on average 27% greater than those from traditional tillage soil cores (p=0.026). The difference was consistent across all combinations of fertilizer load and rain pattern (Figure 3), indicating the effect of changing soil physical conditions through tillage on the soil NO emissions. As expected, increasing fertilization load led to increasing cumulative NO emissions from the soil (Figure 3). Rain distribution after drought had a significant influence on the cumulative soil NO fluxes. A heavy rain event (50 mm within one day) after the drought period lowered soil NO fluxes as compared to other rain treatments (constant and increasing) involving a more gradual moistening of the soil after summer drought (Figure 3).

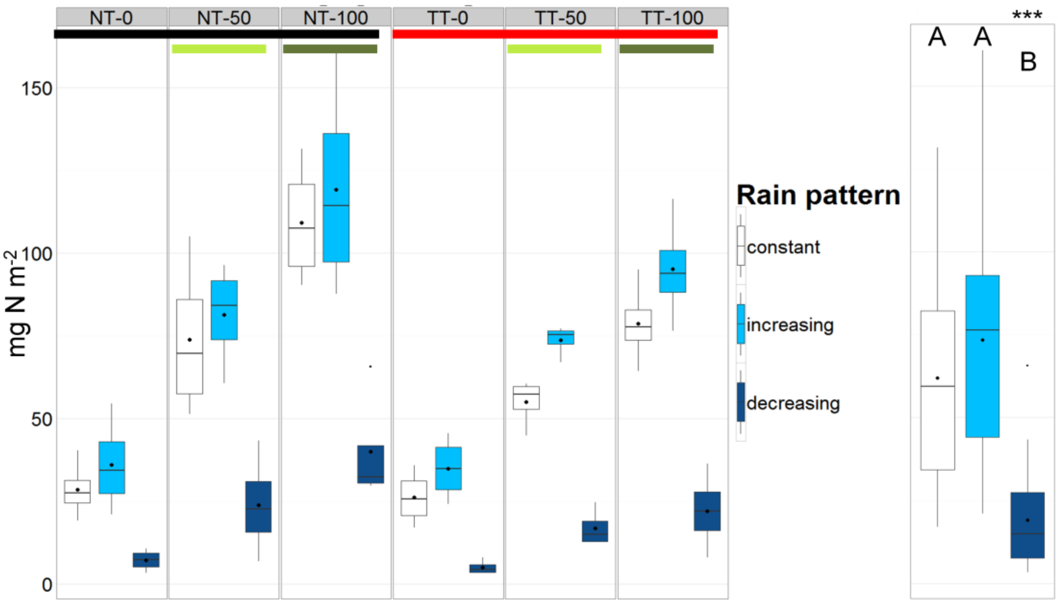

Figure 3: Box-whisker plots for cumulative NO emission after 45 days of incubation**.** Left hand panel shows mean NO emissions according to tillage and fertilization (N=4). *NT* denotes no tillage, *TT* denotes traditional tillage. 0, 50 and 100 indicate the fertilization load (kg N ha^{-1}). The right hand panel shows mean soil NO emissions (N=24) according to the rain patterns considered. Different letters indicate significant differences.

Tilled soil cores showed on average a two-fold higher N_2O emission rate than cores not subjected to tillage. Fertilization effect was clearly observed only in the traditional tilled soil cores (Figure 4), whereas as the effect of N load on non-tilled soils was not as evident. Daily and small precipitation events (2 mm) after a drought period provoked lowered soil N_2O emissions as compared to heavier re-wetting pulses (10 or 50 mm rain episodes, Figure 4).

Soil NO and N_2O emission rates were highly dependent on water status of the soil. Thus, only NO was emitted from the soil for water filled pore space values below 25 %. On the other hand, soil NO emissions were negligible above a threshold of approximately 70 % water filled pore space and only N_2O was emitted.

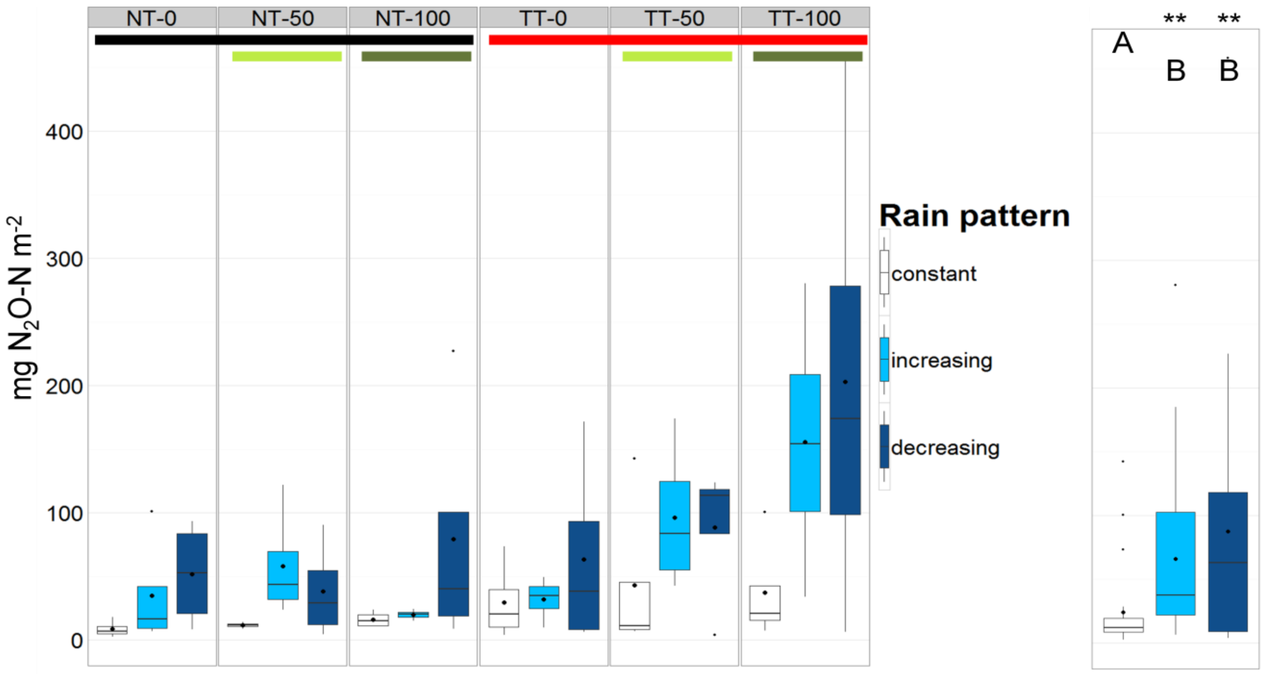

Figure 4. Box-whisker plots for cumulative N_2O emission after 45 days of incubation. Left hand panel shows mean N_2O emissions according to tillage and fertilization (N=4). *NT* denotes no tillage, *TT* denotes traditional tillage. 0, 50 and 100 indicate the fertilization load (kg N ha^{-1}). The right hand panel shows mean soil N_2O emissions (N=24) according to the rain patterns considered. Different letters indicate significant differences.

5. Milestones achieved:

MS7: "Description of drying-re-wetting effects on soil NO emissions". Expected delivery date: month 24 (September 2013). Actual submission date: month 36 (September 2014). Detailed data from the incubation experiment have been delivered to our colleagues responsible forTask 3.3.

6. Deviations and reasons:

In order to adequately capture the temporal evolution of NO, N_2O, CO_2 and CH_4 fluxes after re-wetting events, a laborious implementation of a measurement system capable to measure in an autonomous way and at sub-daily resolution was a requisite (see section 3, "Activities). This, together with the limited number of cores the system is able to house (18) and incubation length (45 days) has delayed the initially anticipated delivery of data by 12 months. This will likely provoke a subsequent delay in the activities in the frame of Task 3.3, deliverable 3.3 and MS13, but was unavoidable to obtain robust results.

7. Publications:

Publications are planned on the validation of the automatic incubation system and on the experiment results.

8. Meetings:

Zuazo, P; Diaz-Pines, E; Butterbach-Bahl, K. (2014,) Trace gas soil-atmosphere exchange processes after cyclical drying-wetting events in agricultural Mediterranean soils from Madrid

(Central Spain). Oral presentation on the “ECLAIRE Open Science Conference: Integrating Impacts of Air Pollution and Climate Change on Ecosystems”, Budapest, Hungary, October 2014.

9. List of Documents/Annexes: N/A