

# PhD School on Agriculture, Environment and Bioenergy

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(XXXIX cycle, 2023-26)

## Project draft

- 1. Field of interest:** Agronomy (AGR/02 - Agronomia e coltivazioni erbacee)
- 2. Project title:** Crop residue management effects on N<sub>2</sub>O emissions and soil organic carbon.
- 3. Tutor:** Prof Alessia Perego
- Co-tutor:** Prof Luca Bechini, Prof Giorgio Ragaglini
- 4. Relevance of the topic and state of the art**

In Mediterranean climatic conditions, nitrous oxide N<sub>2</sub>O emission is regarded as a relevant environmental issue. Among drivers, crop residue decomposition is recognized as a potential source of emissions along with the positive effect on soil organic carbon accumulation (Fiorini, et al., 2020; Abalos et al., 2022); however, existing research on the impact of residue incorporation timing, and the related soil water content and temperature conditions, on N<sub>2</sub>O emissions did not provide concluding evidence about the effects of factors involved. Retention of crop residue in the autumn on the soil surface instead of removal or incorporation with ploughing may result in decreased N<sub>2</sub>O emissions in winter and spring (Wagner-Riddle et al., 2017), but more studies are required to test this mitigation opportunity in the Mediterranean climate. An experimental field will be set up to carry out a comprehensive study of N<sub>2</sub>O emissions as driven by the soil water dynamics in interaction with residue retention timing, potential decomposition rate, C to N ratio of residue, mineral N availability (both ammonium and nitrate), and soil organic carbon evolution (measuring the total stock and the fractions of particulate organic matter POM and mineral-associated organic matter MAOM) with the monitoring of CO<sub>2</sub> emissions. In this frame, agronomic solutions will be compared for the management of crop residues aimed at reducing N<sub>2</sub>O emissions and increasing the soil organic carbon stock.

As a further step in the analysis, the measured variables will be effectively applied to calibrate simulation cropping system models to assess what-if management scenarios at larger temporal and spatial scales.

## 5. Layout of the project

### 5.1. Materials & Methods

The following activities will be carried out during the 3-year period:

- Definition of agronomic practices to be evaluated in a 3-year field experiment: crop rotation including autumn and spring-summer crops and crop residue management (removal, retain on soil surface with no-till practice, soil incorporation with ploughing).
- Monitoring of N<sub>2</sub>O and C<sub>2</sub>O emissions at hourly time step in the experimental site in Landriano, PV (Azienda Angelo Menozzi) in the Po plain. This activity will be carried out using the existing measurement system equipped with automatic and remotely manageable devices for the measurement of gas emissions from the ground through accumulation chambers.
- Frequent collection of ancillary data to get a full understanding of C, N, and water processes at different soil depths (e.g., 15, 30, 45, 60 cm): soil water content, soil temperature, NO<sub>3</sub>, NH<sub>4</sub>, POM, MAOM, crop residue amount on soil surface, and bulk

density. Fertilizer application, irrigation, and crop data about phenology, yield, leaf area index, dry matter partitioning at harvesting will be also recorded periodically.

- Simulation model calibration: results from the field experiment will support the modelling analysis, particularly the calibration of at least one process-based simulation model, being capable of a close representation of N and C cycling. Calibration will target the parameters related to N<sub>2</sub>O emissions, mineralization and immobilization of organic C and N.
- Modelling analysis of N<sub>2</sub>O emissions and soil organic carbon evolution in response of crop residue management at the sub-continental scale for Mediterranean climate: the model will be then upscaled to simulate the tested agronomic practices at regional scale using available database of soil properties (regional soil map) and long-term weather data.

## 5.2. Schedule and major steps (3 years)

The research will be articulated in the following activities and tasks.

Activity	Task	Year 1	Year 2	Year 3
Experiment set-up	Definition of crop rotation and agronomic management to test	X		
Experimental data collection	Gas emissions and soil data. Data will be collected in a database ready to be effectively used in the modelling analysis.	X	X	X
Calibration of cropping systems simulation models	Parameterization of the simulation model	X	X	X
	Model validation		X	X
Modelling analysis at sub-continental scale	Collection of existing data of soil properties and long-term weather data		X	X
	Definition of agronomic management practices		X	X
	Interpretation and discussion of simulated emissions and soc evolution			X
Thesis and article writing			X	X

## 6. Available funds

PROENV (ERANET, European Union), 99,000 euro (principal investigator Prof Alessia Perego, Marco Acutis).

## 7. Literature

Abalos, D., et al. "A review and meta-analysis of mitigation measures for nitrous oxide emissions from crop residues." *Science of the Total Environment* (2022): 154388.

<https://doi.org/10.1016/j.scitotenv.2022.154388>

Fiorini, A., et al. "Combining no-till with rye (*Secale cereale* L.) cover crop mitigates nitrous oxide emissions without decreasing yield." *Soil and Tillage Research* 196 (2020): 104442.

<https://doi.org/10.1016/j.still.2019.104442>

Wagner-Riddle, Claudia, et al. "Globally important nitrous oxide emissions from croplands induced by freeze–thaw cycles." *Nature Geoscience* 10.4 (2017): 279-283. <https://doi.org/10.1038/ngeo2907>