Dynamics of greenhouse gases in central italian meadows: a high-resolution analysis using licor gas analyzers

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INTRODUCTION

Managed meadows significantly impact the soil-atmosphere exchanges of key climate gases, including nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2), which are influenced by environmental conditions and soil microbial activity. Although these meadows can initially absorb CH_4 and N_2O, they typically become net sources over time.

OBJECTIVES

This study aims to:
Analyse dynamics of CO_2, CH_4, and N_2O fluxes in a managed grassland system from a meadow (60% ryegrass, 40% clover) across phenological stages, environmental factors, and grazing practices to establish a baseline for sustainable land management.

MATERIAL & METHODS

- **Instruments:**

High-resolution GHG monitoring was conducted using LI-COR 7810 for CO2 and CH4 and LI-COR 7820 for N2O portable gas analysers equipped with Smart Chambers.

- **Smart Chambers:**

The chambers' design, featuring automated bellows and a patented pressure vent system, ensured precise gas mixing without turbulence ; crucial for capturing the dynamics of soil gas exchanges .

Fig 1: Smart chamber with LiCor 78xx

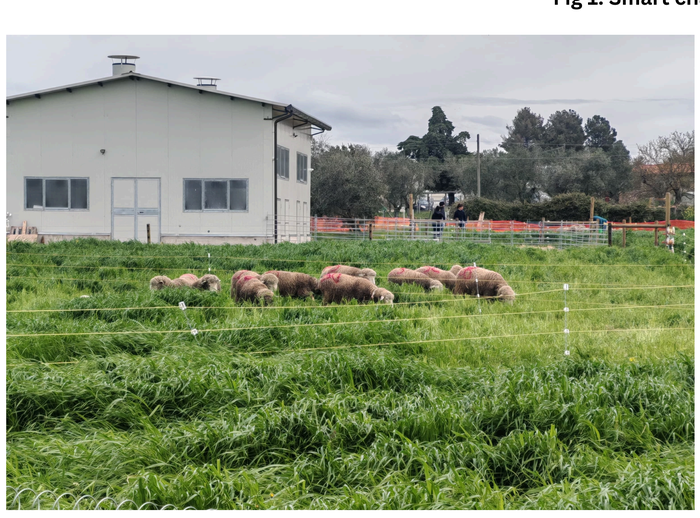


Fig 2: Field Grazing Under Monitored Pasture Management

- **Measurements:**

The study was conducted at the farm of University of Tuscia located in central Italy across five phenological stages: Pre-seeding (autumn), Growing (late winter), Pre-pasture (early spring), Mid-pasture (middle spring), and Post-pasture (late spring). Measurements were taken over two consecutive days per analyzer, with consistent sampling points to maintain spatial coherence. The site was divided into rotational and continuous grazing plots.

- **Grazing Activity:**

The experimental site was divided into two grazing systems: continuous and rotational. The continuous grazing area consisted of three large paddocks, with six sheep in each (18 animals total), grazing continuously throughout the study. The rotational grazing area was subdivided into 18 smaller paddocks, where other group of 18 sheep grazed in sub-groups of six animals across three paddocks at a time, moving every four days. It took 24 grazing days to complete one full cycle through all 18 paddocks (mid-spring), after which the rotation began again from the first set, initiating a second complete cycle during the same grazing period.

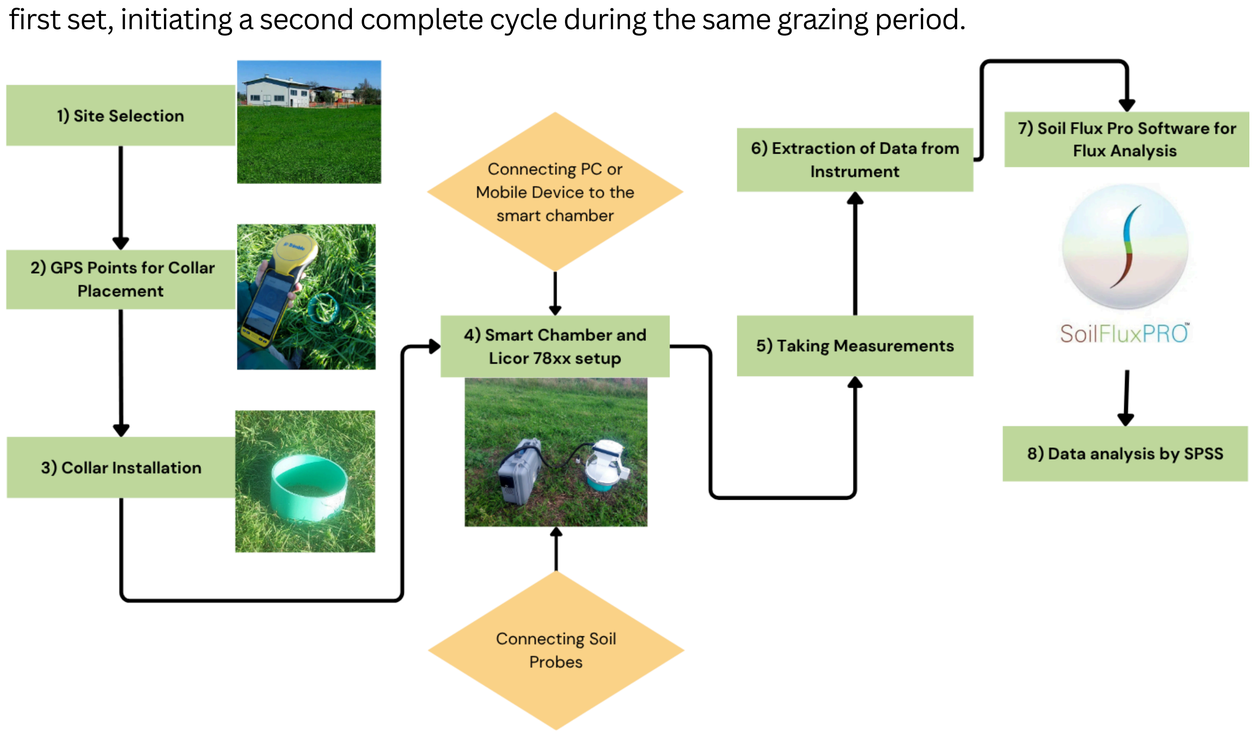
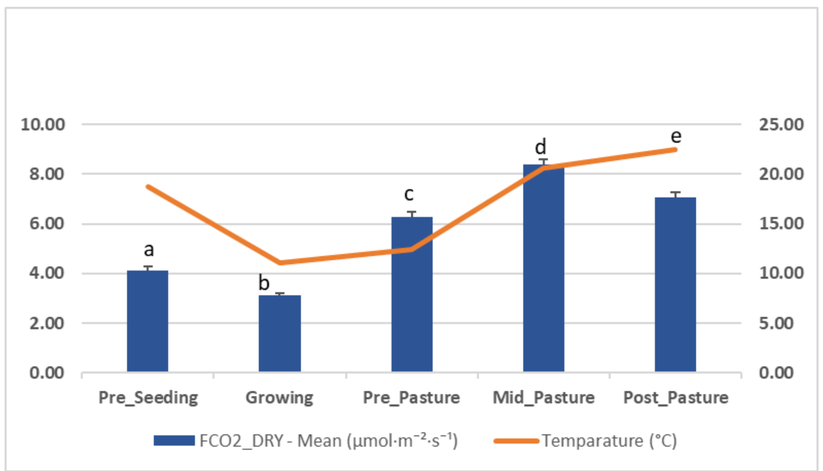


Fig 3: Flowchart Of Data Collection

PRELIMINARY RESULTS



- CO_2 emissions peaked during the Growing and Mid-pasture stages, indicating higher microbial and root respiration during active plant growth. Patterns suggest a strong relationship with rising temperatures during these periods, as confirmed by temperature measurements

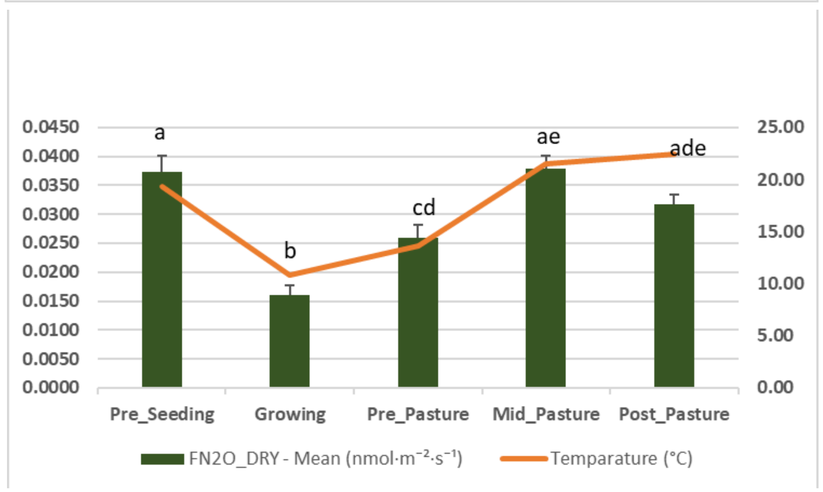
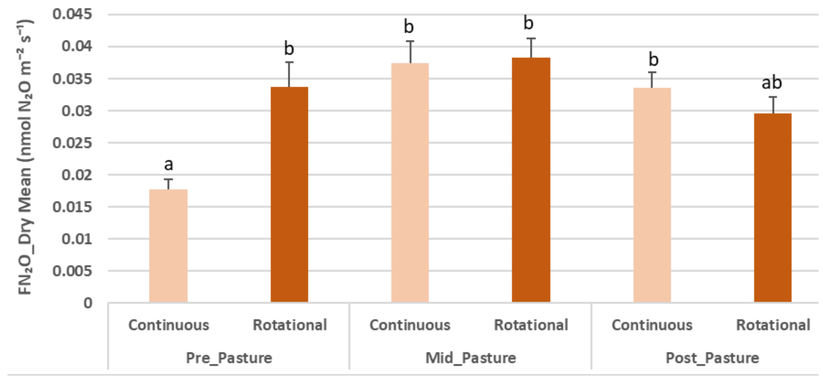


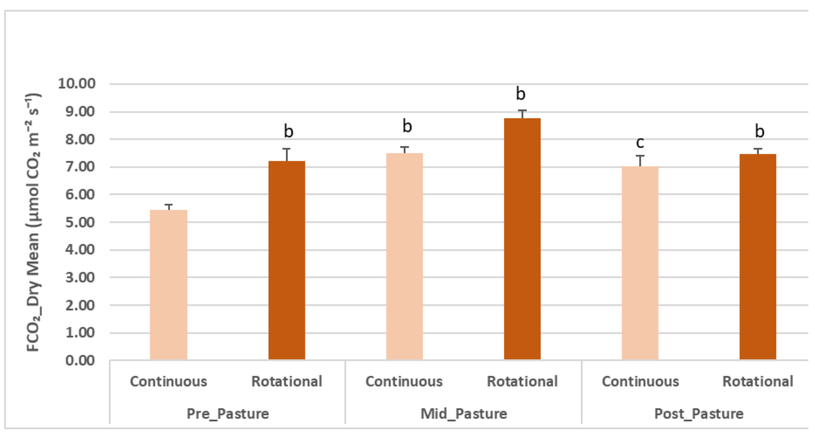
Fig 4(a) CO_2 and Fig 4(b) N_2O Fluxes Across Pasture Growth Stages with Corresponding Temperature Trends
Bars represent gas fluxes means ± standard error (SE), and the temperature line includes standard deviation (SD) to reflect variability. Different letters above bars indicate statistically significant differences in fluxes ($p < 0.001$), based on Tukey's HSD test.

- The highest N_2O fluxes were observed during the Pre-seeding and Post-pasture stages, likely driven by temperature and moisture conditions. A secondary peak during the mid-pasture stage may be attributed to increased nitrogen availability.

- CH_4 fluxes were negative across all stages, indicating consistent methane uptake by the soil.



- N_2O emissions were higher under rotational grazing, especially during Pre- and Mid-pasture stages. Early-season moisture may have boosted microbial nitrogen cycling, while grazing inputs like urine, manure, and soil disturbance likely increased nitrification and denitrification.



- CO_2 emission fluxes were also higher under rotational grazing, particularly during the Mid-pasture stages, likely due to increased plant regrowth and microbial respiration stimulated by recovery periods between grazing events.

Fig 5(a) CO_2 and Fig 5(b) N_2O Fluxes Under Continuous and Rotational Grazing Across Pasture Stages
Bars represent mean gas fluxes ± standard error (SE) for each grazing treatment across Pre-pasture, Mid-pasture, and Post-pasture stages. Different letters above bars indicate statistically significant differences in fluxes ($p < 0.001$), based on Tukey's HSD test.

CONCLUSION

The findings highlight the complexity of managing pasture systems for both productivity and environmental sustainability. The observed patterns suggest that emission outcomes alone do not fully reflect the ecological impact of grazing strategies. A holistic approach that considers long-term soil function, plant dynamics, and climate resilience is essential for informed decision-making in pasture management.

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