Effects of different types of organic fertilizers on greenhouse gas emissions from sugar beet soils

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Reduction of chemical fertilizers and effective use of organic fertilizers constitutes a sustainable strategy to recycle nutrients, increase soil carbon stocks and mitigate climate change. However organic fertilizers strongly influence microbial processes leading to the release of nitrous oxide (N2O).

The aim of this study was to evaluate differences in N_2O emissions among different organic amendments (manure, compost, and digestate) applied in sugar beet field.

MATERIALS & METHODS

- The experimental sites located in Paimio Finland
- Manure, digestate, and compost were incorporated into the soil before sugar beet sowing.
- Greenhouse gas emissions for carbon dioxide (CO_2) and nitrous oxide (N_2O) were measured using a static chamber method using a Gasmet FTIR field analyzer (GT5000 Terra).
- The study was done on seasons 2022-2025 and the measurements were made once a week during the growing seasons.
- At the beginning of the growing season, a permanent 60 x 60 x 20 cm steel collar was embedded in the soil of each experimental member to a depth of approximately 10 cm.
- During the measurements, a 60 x 60 x 40 cm steel cover was placed on top of the collars, and the gas accumulation in the chamber was measured for 5–10 minutes.
- The greenhouse gas fluxes were calculated from the linear rate of change of the gas accumulated in the chamber and were reported in mmol CO2 m^{-2} h^{-1} and µmol N_2O m^{-2} h^{-1}.
- Cumulative emissions for greenhouse gases were calculated for nitrogen and carbon by interpolating emissions between different measurement times, i.e. it was assumed that the amount of emissions would increase/decrease linearly between measurement times. The emissions for each day were then added together, resulting in cumulative emissions for the entire growing season.

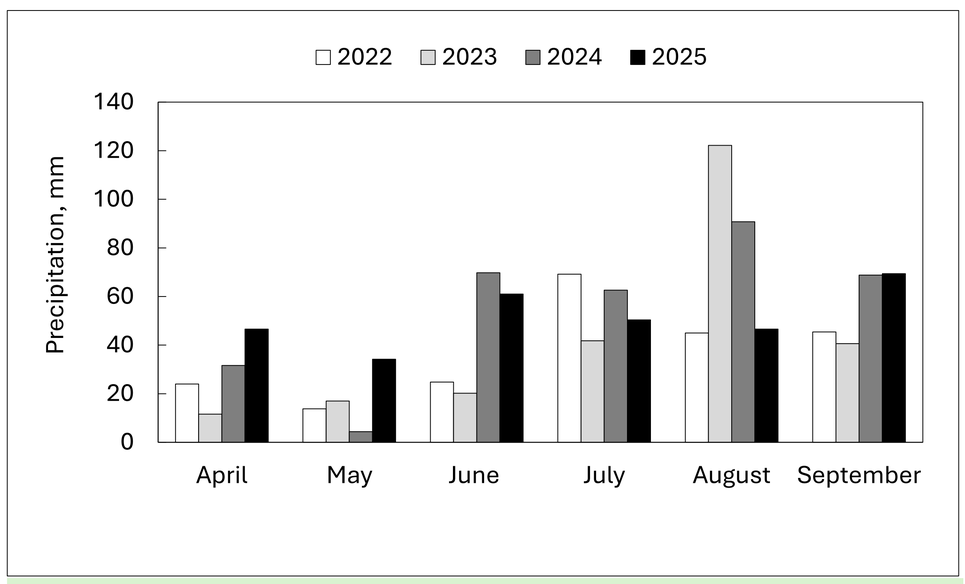

Figure 1. Monthly perecipitation (mm) during the growing seasons of 2022-2025 in Paimio, Finland.

RESULTS

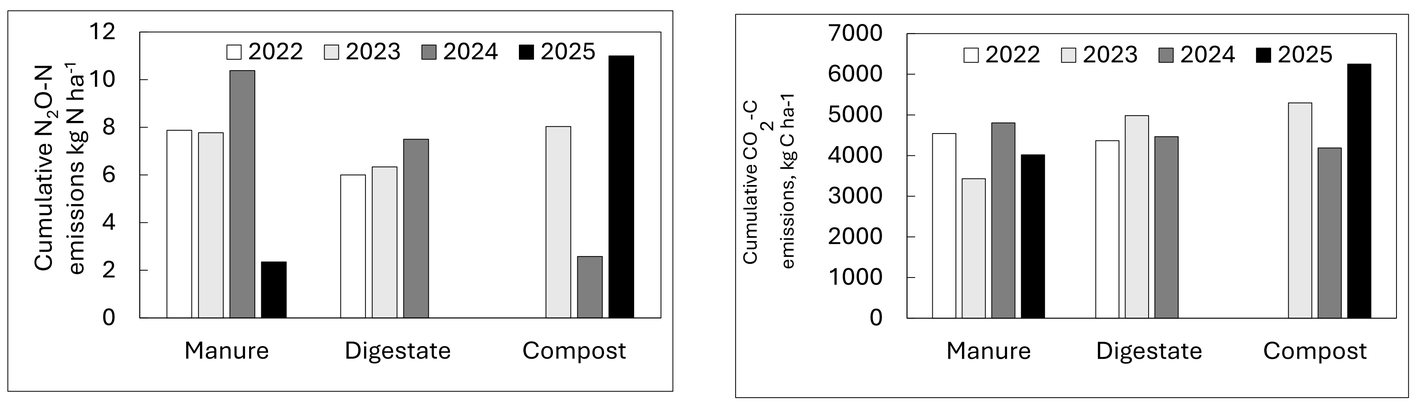

Figure 2. Cumulative growing-season N_2O and CO_2 emissions from sugar beet fields receiving cattle manure, digestate residue, or compost in Paimio, Finland, during 2022–2024.

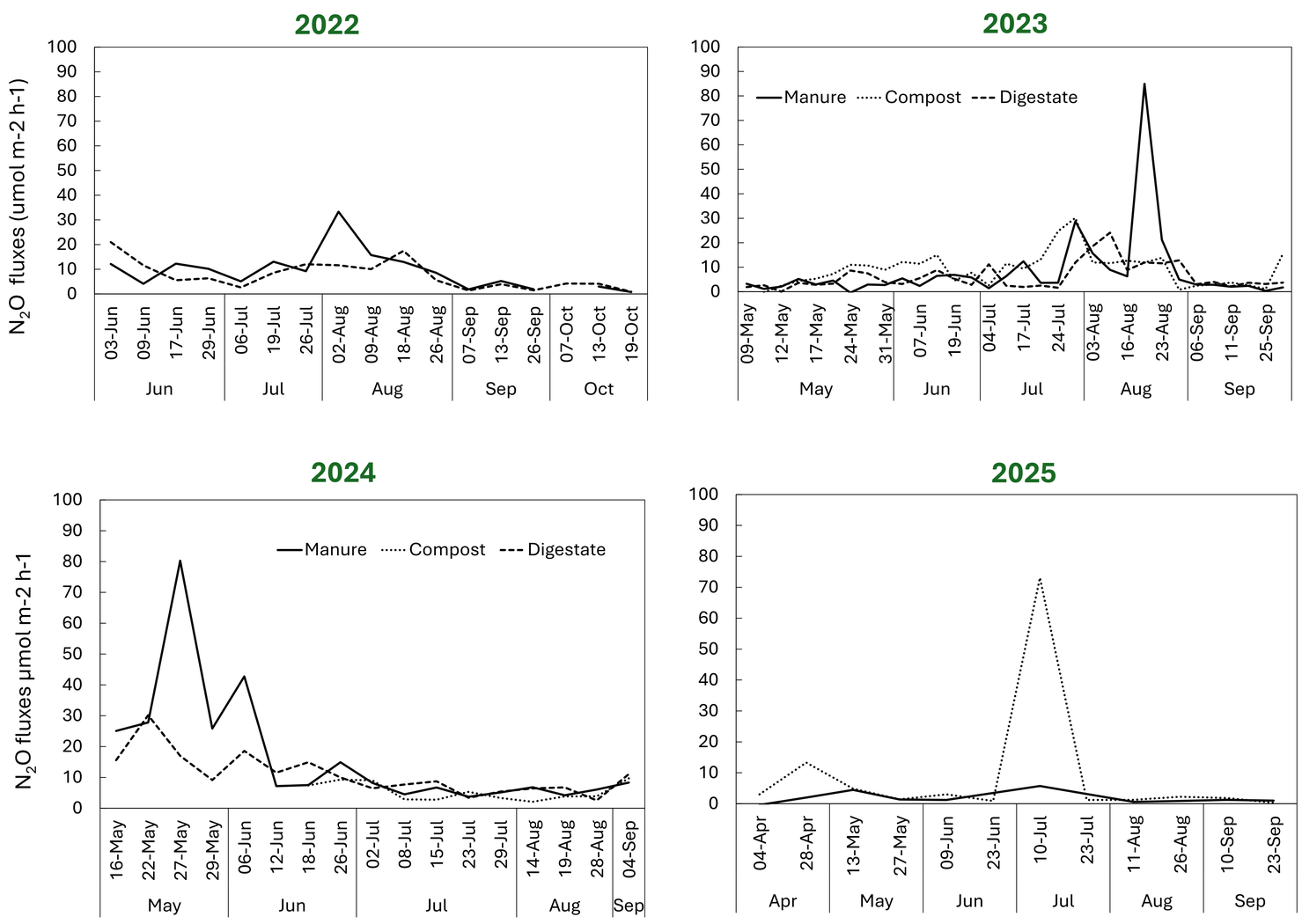

Figure 3. Nitrous oxide (N_2O) emissions (µmol m^{-2} h^{-1}) from a sugar beet field under cattle manure, digestate residue, and compost treatments during the growing seasons of 2022–2024 in Paimio, Finland.

CONCLUSIONS

- Cattle manure produced more frequent N_2O emission peaks than the other organic amendments during study years (2022–2024). Consequently, cumulative N_2O emissions were generally higher in cattle manure-treated plots, whereas emissions from digestate residue and compost remained relatively stable in 2022–2024.
- The different emission patterns observed in 2025 may be related to differences in compost maturity and the deeper incorporation of cattle manure compared with previous years.
- The highest N_2O emission peaks generally coincided with periods of elevated rainfall, suggesting a possible influence of soil moisture on N_2O emissions.

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