Effects of Cover Crops on N_2O Emission in Southern Manitoba

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Figure 1.. Aerial Photo of the Ian N. Morrison Research Farm located in Carman. Credits Claudia Sparza.

Introduction

- Climate change, driven by human-induced greenhouse gas (GHG) emissions, has led to significant shifts in global weather patterns and rising temperatures. Agriculture plays a dual role as both a contributor to and a solution for mitigating these impacts. Effective nitrogen (N) management is crucial, as N cycling processes influence soil health and GHG emissions, particularly nitrous oxide (N_2O).Cover crops (CCs) offer a sustainable approach to enhancing agroecosystem resilience. They improve soil organic carbon, reduce erosion and nutrient loss, and support biodiversity while contributing to nutrient cycling. Overwintering CCs, such as winter rye and barley, are particularly effective in reducing runoff and soil degradation during high-rainfall periods. This research investigates the potential of CCs to optimize N management, mitigate N_2O emissions, and promote sustainable agricultural practices.

Objectives

- Evaluate the impact of fall-seeded cover crops in annual rotations on N_2O emissions.
- Quantify N_2O emissions based on cover crop type (overwintering vs. non-overwintering).
- Assess the effects of overwintering and non-overwintering cover crops on N_2O emissions during thaw periods
- Investigate whether the termination of overwintering cover crops increases N_2O emissions.
- Evaluate the Effect of Cover Crop Rotation on Gran Yield.

Methodology

- Nitrous oxide (N_2O) emissions were measured using the static vented chambers method. Each chamber consisted of a rectangular collar (15 cm × 45 cm × 20 cm) and a lid (45 cm × 20 cm) with a vent tube for temperature and pressure regulation. Gas samples were collected with syringes and stored in evacuated vials. Sampling occurred four times per site within a 60-minute period (20-minute intervals), starting during the spring thaw (late March to early May) and continuing until late October.
- Samples were analyzed using a gas chromatograph, and N_2O fluxes were calculated using the HMR package in R software. Growing-season area-scaled cumulative N_2O emissions ($\sum N_2O$, g N ha^{-1}) were determined through linear interpolation between sampling dates. Daily fluxes were graphed, while cumulative emissions were used to identify interactions between crop and cover crop treatments across the 4-year study. Greenhouse gas intensity (GHGI) was calculated as the ratio of global warming potential (kg N_2O ha^{-1} CO_2-equivalents per $season^{-1}$) to grain yield (kg ha^{-1}).
- Hand harvesting of each year's crop at physiological maturity helped figure out dry yields (kg ha 1) of total biomass, grain, and residue.
- The study followed a Randomized Complete Block Design (RCBD) with site as a blocking factor and crop rotation as the treatment parameter, forming a 4 × 2 × 4 factorial structure (4 treatments, 2 sites, 4 years). Data were analyzed using a Generalized Linear Mixed Model (PROC Glimmix) to evaluate treatment effects via ANOVA. Random effects accounted for site-year interactions, and Tukey adjustments were applied for mean comparisons at P<0.10. Although statistical power was below 0.8, the significance threshold was justified based on sample size and variability. Yield was estimated using the same factorial structure and experimental design. However, the power analysis for yield provided sufficient sensitivity to justify the use of a significance threshold of P=0.05.

Figure 2 and 3. Example of field equipment used for extracting N_2O on the field composed of field sheets, evacuated vials, syringes and static vented gas chambers.

Study Sites

This study had two trial sites in each of four years in Manitoba, one at the University of Manitoba Ian N. Morrison Research Farm located in Carman (49.501246, -98.028420) and the other at the Glenlea Research station (49.648966, -97.119009) of the University of Manitoba. Briefly, treatments were main effect of a 4-year rotation with and without cover cropping, and four sub-effects of rotation/cover crop types the experimental design is a randomized complete block design with plots

Results and Discussion

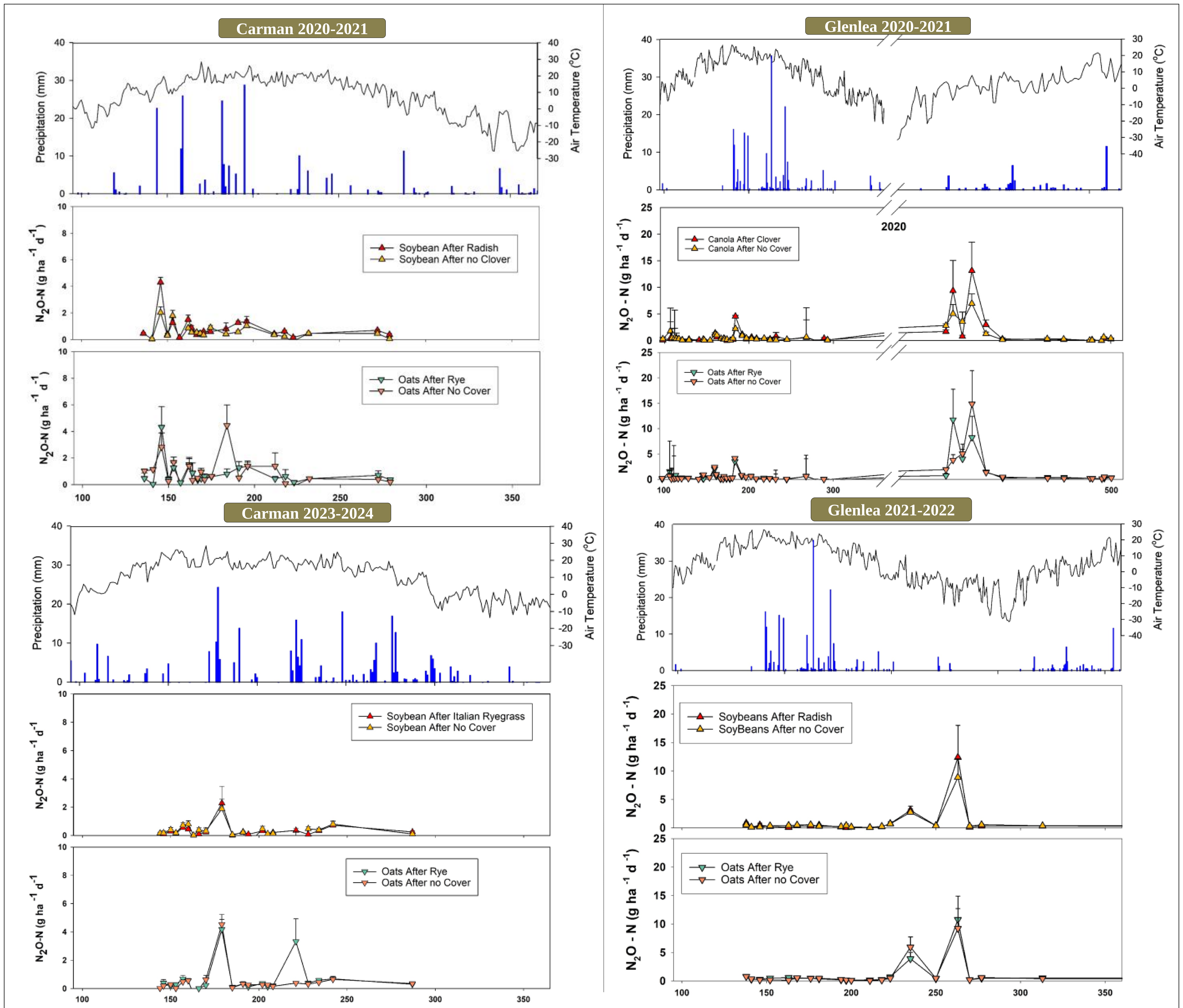
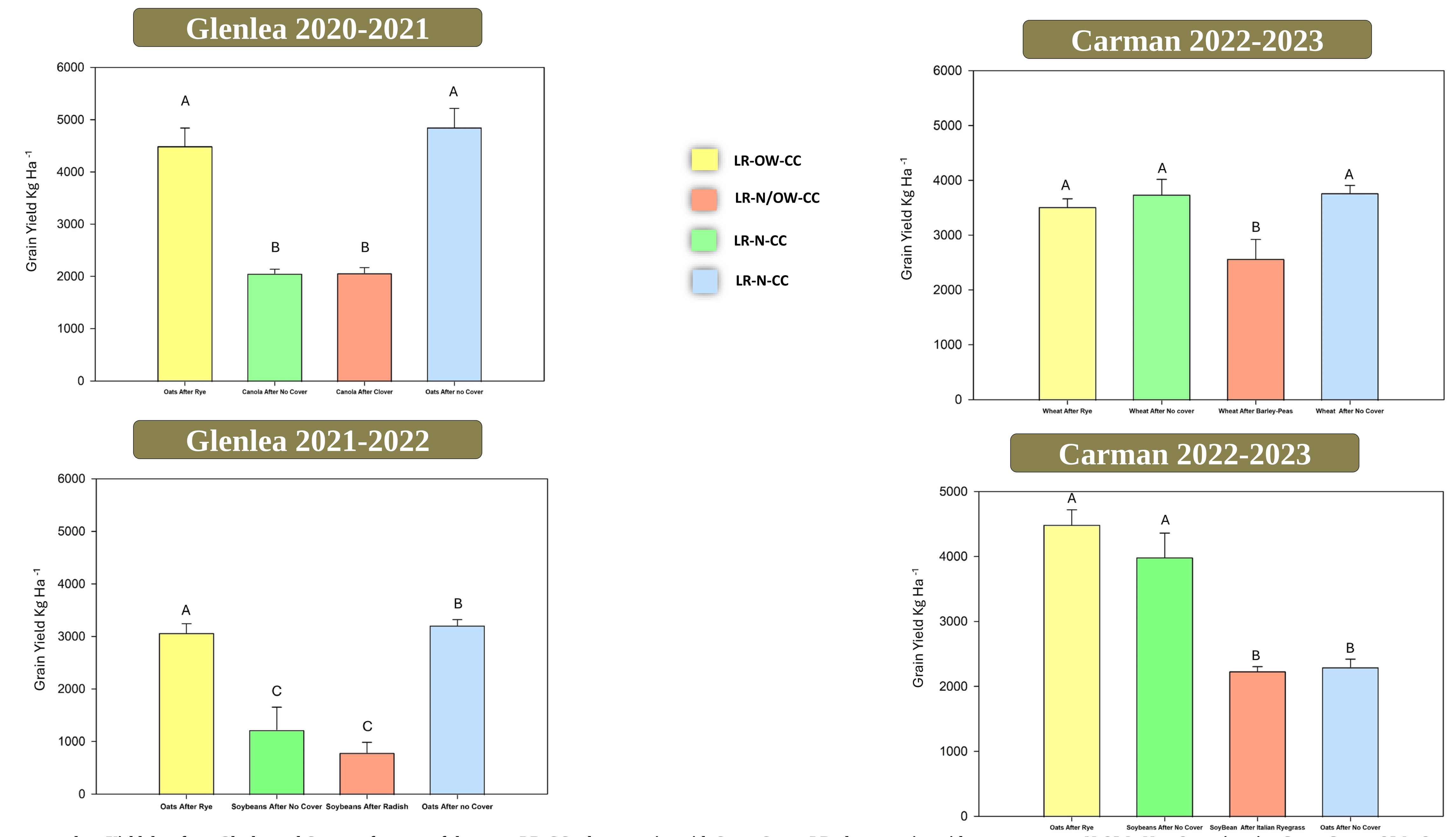


Figure 4 Carman 2020-2021, 5 Carman 2023-2024 ,6 Glenlea 2020-2021 and 7 Glenlea 2021-2022 growing seasons. This figures showcase the mean daily N_2O (g N_2O ha^{-1} d^{-1}). Affected by the cover crop Rotation.



Figures 8,9,10,11,12 corresponds to Yield data from Glenlea and Carman for some of the years. LR-CC = long rotation with Cover Crops, LR= long rotation without cover crops. N-OW= Non-Overwintering Cover Crops; OW= Overwintering Cover Crops.

Conclusions

- Fall-seeded cover crops in annual rotations reduced cumulative N_2O emissions compared to non-cover crop treatments. Overwintering cover crops consistently emitted lower cumulative N_2O (163.15 g N ha^{-1}) than non-overwintering cover crops (211.92 g N ha^{-1}). Overwintering Cover Crops and Non overwintering cover crops had significant interactions at a P value of 0.1 in 2023, while also keeping a significant difference with the no cover crop treatments in 2022 and 2022.
- Overwintering cover crops showed consistently lower N_2O emissions compared to non-overwintering types. Non-overwintering cover crops were associated with higher cumulative emissions, suggesting differences in their nitrogen dynamics.
- Neither overwintering nor non-overwintering cover crops significantly increased N_2O emissions during thaw periods. These findings suggest that cover crop type alone does not exacerbate thaw-related emissions.
- Termination of overwintering cover crops did not significantly increase N_2O emissions in this study. Results indicate that effective management of overwintering cover crops can minimize emission spikes during termination
- Long Rotation Overwintering Cover Crop treatments (LR-OW-CC) consistently yielded significantly higher or equal to non-cover crop treatments. Long Rotation Non-Overwintering Cover Crop treatments (LR-N/OW-CC) consistently yielded lower or equal to non-cover crop treatments at a P value of 0.05.

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