# Wheat Cover Crop Management Impacts Corn Yield and Nitrous Oxide Emission

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## Introduction

- According to the US Environmental Protection Agency (USEPA), agricultural soil management is the main source of nitrous oxide ($N_2O$) emission, contributing 78% of total $N_2O$ emissions.
- Winter cereal cover crops (WCCCs) are recommended as the best in-field management practice to minimize nutrient loss to Illinois water and the Gulf of Mexico (https://www2.illinois.gov/sites/agr/Resources/NutrientLoss/Pages/default.aspx).
- WCCCs including wheat (*Triticum aestivum* L.) are often terminated 3-4 weeks prior to planting corn (early April). Delaying the termination increases N uptake and decreases N leaching potential but could immobilize N during corn growing season due to increased C:N ratio of wheat (Adeyemi et al., 2020).
- Literature is scant on the effect of wheat termination (early vs. late or cover crop removal) on corn yield and $N_2O$ emission during corn growing season in the Alfisols of Midwestern USA.

## Objectives

To evaluate the effect of wheat termination management vs. a no-cover crop control on (I) corn leaf area index (LAI) and grain yield; (II) soil nitrate-N, ammonium-N, and total N dynamics; (III) soil volumetric water content (VWC) and temperature trends; (IV) soil $N_2O$ emission; and (V) yield-scaled $N_2O$ emissions.

## Experimental Design and Treatments

Treatments were laid out in a randomized complete block design (RCBD) with 4 replicates in 2020 and 2021. The treatments were (I) fallow (no-cover crop control); (II) early termination (3-4 week before planting corn); (III) late termination (at corn planting; planting green); and (IV) residual removal (Fig. 1A-B; Fig. 2A).

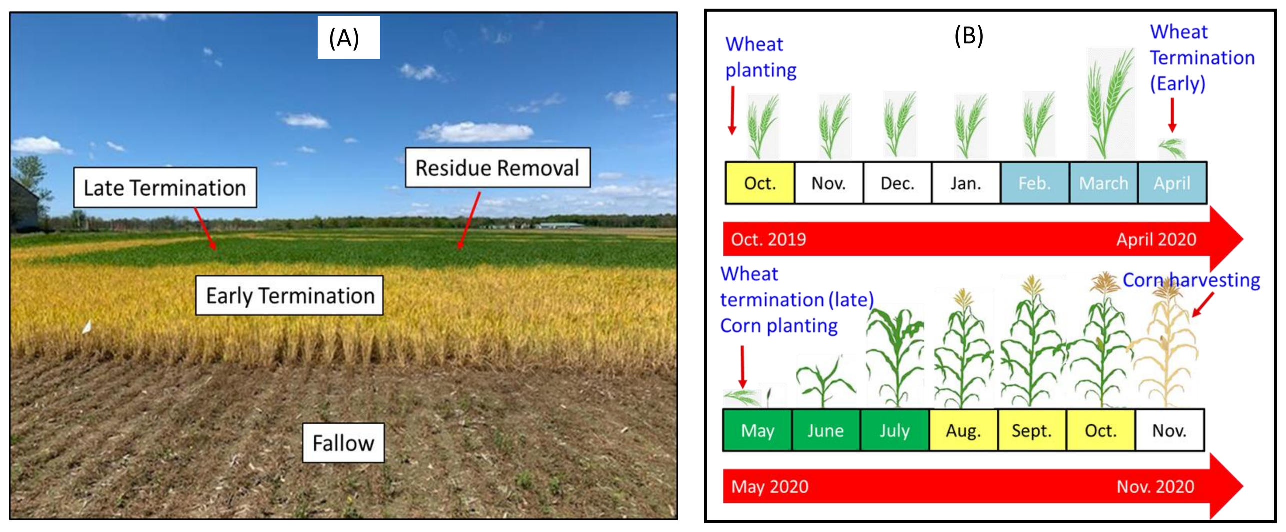


**Figure 1.** Field plot showing cover crop management treatments (A) and schematic of dates for planting wheat, terminating wheat, planting corn, and harvesting corn from Oct. 2019 to Nov. 2020 (B).

## Acknowledgements

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## Materials and Methods

- Wheat (var. Agrima 446) was planted on October 8th and 14th of 2019 and 2020 respectively at 4.75 million plants $ha^{-1}$. Wheat was top-dressed with 34 kg N $ha^{-1}$. Wheat above- and belowground biomass were collected and analyzed for C and N content by combustion method (Table 1).

**Table 1.** Wheat above- and belowground biomass and their C:N ratio as influenced by termination management (early, late, and residue removal).

| Wheat termination management | Aboveground biomass (Mg $ha^{-1}$) | | Aboveground C:N ratio | | Belowground biomass (Mg $ha^{-1}$) | | Belowground C:N ratio | |
|---|---|---|---|---|---|---|---|---|
| | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 | 2020 | 2021 |
| Early | 3.78 | 3.42 | 35.81 | 25.68 | 0.81 | 0.57 | 61.46 | 54.71 |
| Late | 6.94 | 6.41 | 57.37 | 37.74 | 1.26 | 0.85 | 72.75 | 71.18 |
| Residue Removal | 6.68 | 6.37 | 58.96 | 36.74 | 1.22 | 0.81 | 70.26 | 68.88 |

- Plots were 10m long and 3.3m wide. A no-till drill was used to plant corn (Dekalb "DKC64-35RIB") at 74,100 seeds $ha^{-1}$ on 12 May 2020 and 2021.
- 112 kg N $ha^{-1}$ was applied at planting in the form of liquid urea ammonium nitrate (28-0-0). An extra 112 kg N $ha^{-1}$ was applied at sidedress timing (corn V4-V5 stage) on 18 June 2020 and June 16 in 2021.
- Soil samples were collected using a soil probe (0-15 cm depth) prior to (for Phospholipid Fatty Acids) and over the corn growing seasons of 2020 and 2021 for nitrate-N and ammonium-N analysis.
- Closed vented chambers made of aluminum were constructed for the gas sampling. The chambers were placed in between the corn rows on anchors fixed to the soil (Fig. 2B).
- Air samples were collected a total of 19 times in 2020 and 2021 during the duration of the corn growth using syringes at 0, 15, 30 and 45 minutes each sampling day and analyzed for $N_2O$ using gas chromatography (GC) (Fig. 2C).
- $N_2O$ emission rates were calculated by regressing $N_2O$ concentration (ppm) vs. time.
- The cumulative $N_2O$ emissions were estimated by linear interpolation between sampling periods.
- Yield-scaled $N_2O$ emissions were calculated as ($N_2O$ fluxes/corn grain yield) as suggested in Venterea et al. (2011).
- Soil VWC and temperature were measured at each $N_2O$ emission sampling date.

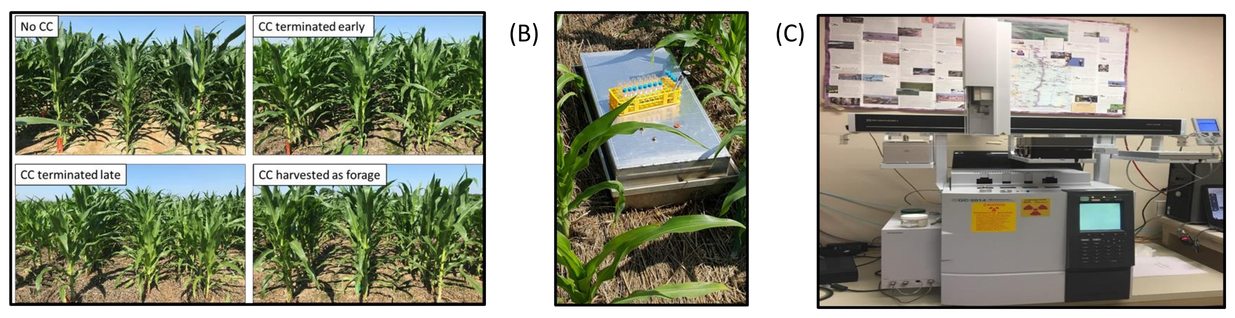


**Figure 2.** Corn in each cover crop treatment (A), gas chamber (B), and a GC (C) used to analyzed $N_2O$ concentration.

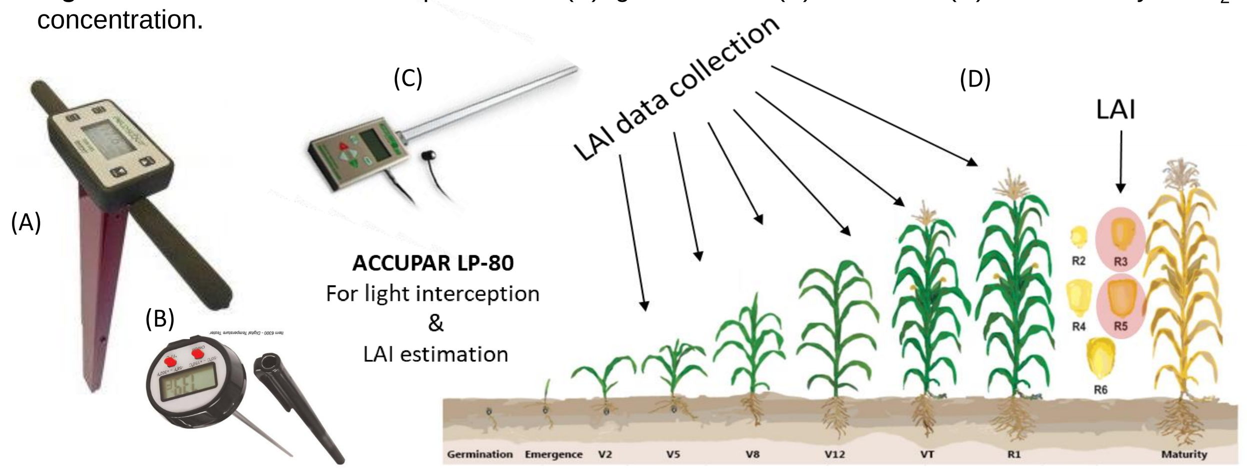


**Figure 3.** TDR 350 (A), soil thermometer (B), ACCUPAR LP-80 for measuring LAI (C) during the corn growth stages (D).

## Results and Discussion

*Corn grain yield was similar among all treatments in 2020 but lower in residue removal treatment in 2021 reflecting on lower LAI in that year (Fig. 4A-B).*

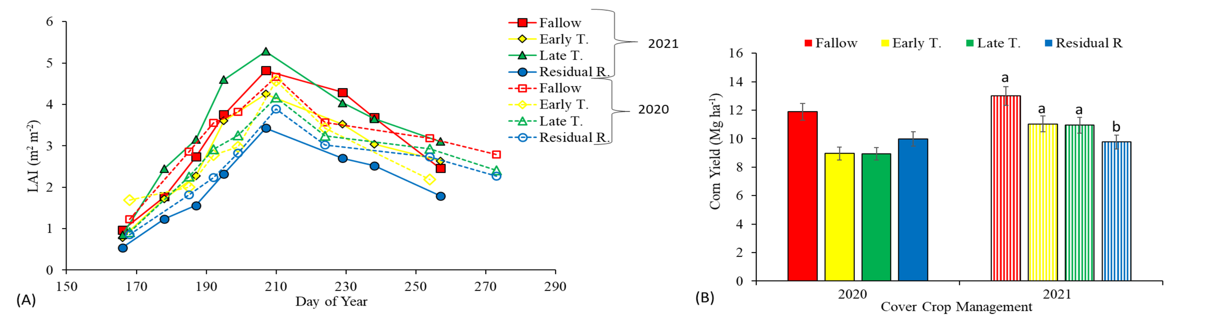


**Figure 4.** Corn leaf area index (LAI) (A) over the corn growing season and corn yield (B) in 2020 and 2021 as influenced by wheat management compared to a no-cover crop control (Fallow).

*Majority of $N_2O$ emissions occurred after N fertilization prior to corn V10 growth stage (Fig. 5A-B).*

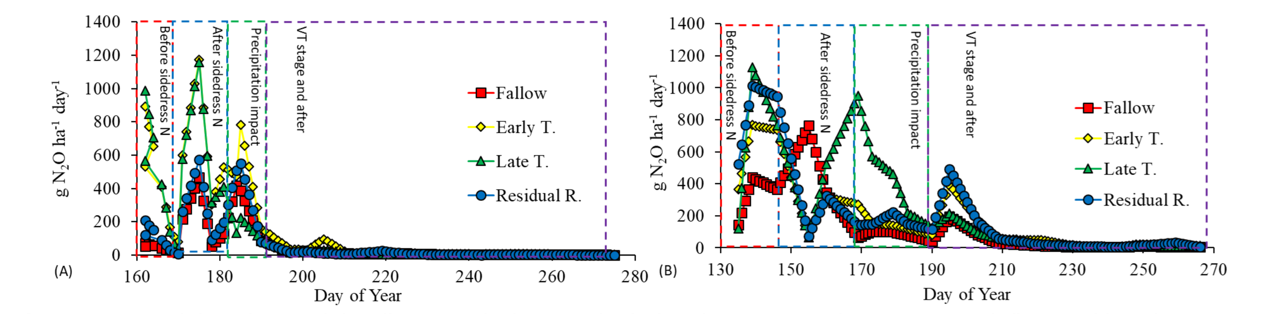


**Figure 5.** 2020 (A) and 2021 (B) soil $N_2O$ emission trends during the corn growing season as influenced by wheat management compared to a no-cover crop control (Fallow).

*Soil nitrate-N had its peak period after sidedressing N (Fig. 6A-B) coinciding with peak $N_2O$ emissions across the cover crop treatments (Fig. 4).*

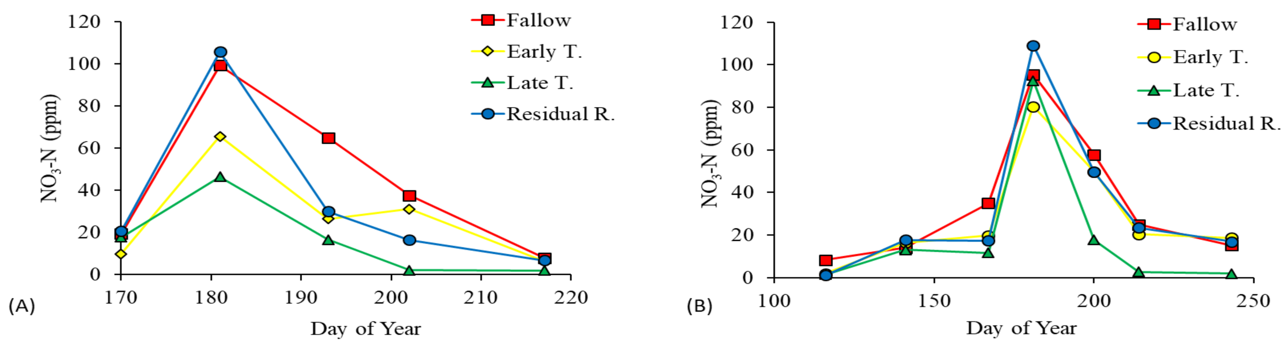


**Figure 6.** Soil $NO_3$-N over the corn growing season in 2020 (A) and 2021 (B) as influenced by wheat management compared to a no-cover crop control (Fallow).

*Fallow treatment consistently had low yield-scaled $N_2O$ emissions (Fig. 7A-B) reflecting on low N balances in this treatment (data not shown). Yield-scaled $N_2O$ emissions were consistently higher in late termination treatment than that of fallow (Fig. 7A-B).*

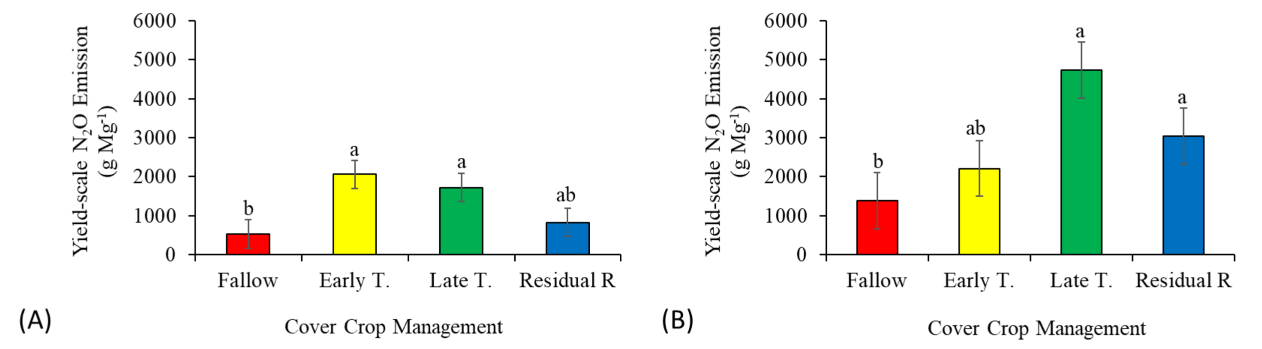


**Figure 7.** Yield-scaled $N_2O$ emission as influenced by wheat management compared to a no-cover crop control (Fallow) in 2020 (A) and 2021 (B).

*LAI peak (maximum LAI during the growing season) explained 51% of corn grain yield variability (Fig. 8).*

*Average soil VWC prior to corn V10 growth stage (Avg. VWC peak) explained 74% of soil $N_2O$-N emissions indicating when N is supplied in high amount (>224 kg N $ha^{-1}$ in current study), soil VWC drives $N_2O$-N emissions.*

*Gram + bacteria was negatively (explained 59% of variability) related to cumulative $N_2O$-N emissions indicating opportunities for DNA sequencing to find genes that are suppressing denitrification.*

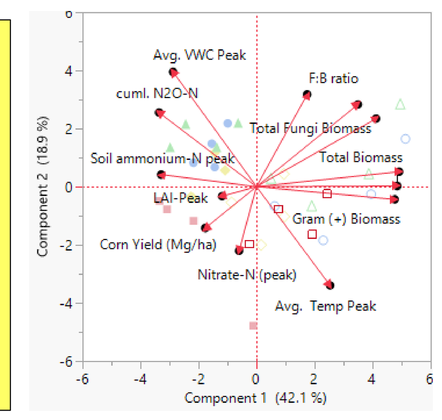


**Figure 8.** Principal Component Analysis for exploring factors that influence soil cumulative $N_2O$ emissions and corn yield in 2020 and 2021. Squares represent "Fallow"; Diamonds represent "early termination"; Triangles represent "Late termination; and Circles represent "Residue Removal treatments. Empty shapes are data from 2020 and shapes with color are data from 2021.

## Conclusion and Future Research

- Wheat cover crop prior to corn increased soil VWC which created a microclimate leading to increased soil $N_2O$ emissions.
- Future research should assess the tradeoffs between N losses (emissions and leaching) with soil C sequestration for better recommendations.
- Current models should be re-evaluated for crediting $N_2O$ emission loss to WCCCs.

## References

- Adeyemi et al. 2020. Effect of wheat cover crop and split nitrogen application on corn yield and nitrogen use efficiency. Agronomy 10, no. 8: 1081.
- Illinois Nutrient Loss Reduction Strategy: November, 2014 Press Release. https://www2.illinois.gov/sites/agr/Resources/NutrientLoss/Pages/default.aspx (accessed 30 Oct. 2021)
- Venterea et al. 2011. Fertilizer source and tillage effects on yield-scaled nitrous oxide emissions in a corn cropping system. JEQ 40:1521-1531.