

Can Nitrous Oxide Emissions Be Reduced by changing the timing of dairy manure application and amount of total nitrogen input to crops?

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INTRODUCTION

Nitrous oxide (N_2O) is a greenhouse gas with a Global Warming Potential 298 times greater than carbon dioxide. A large portion of N_2O is emitted from fertilizers & manure applied to agricultural soils (Fig. 1).

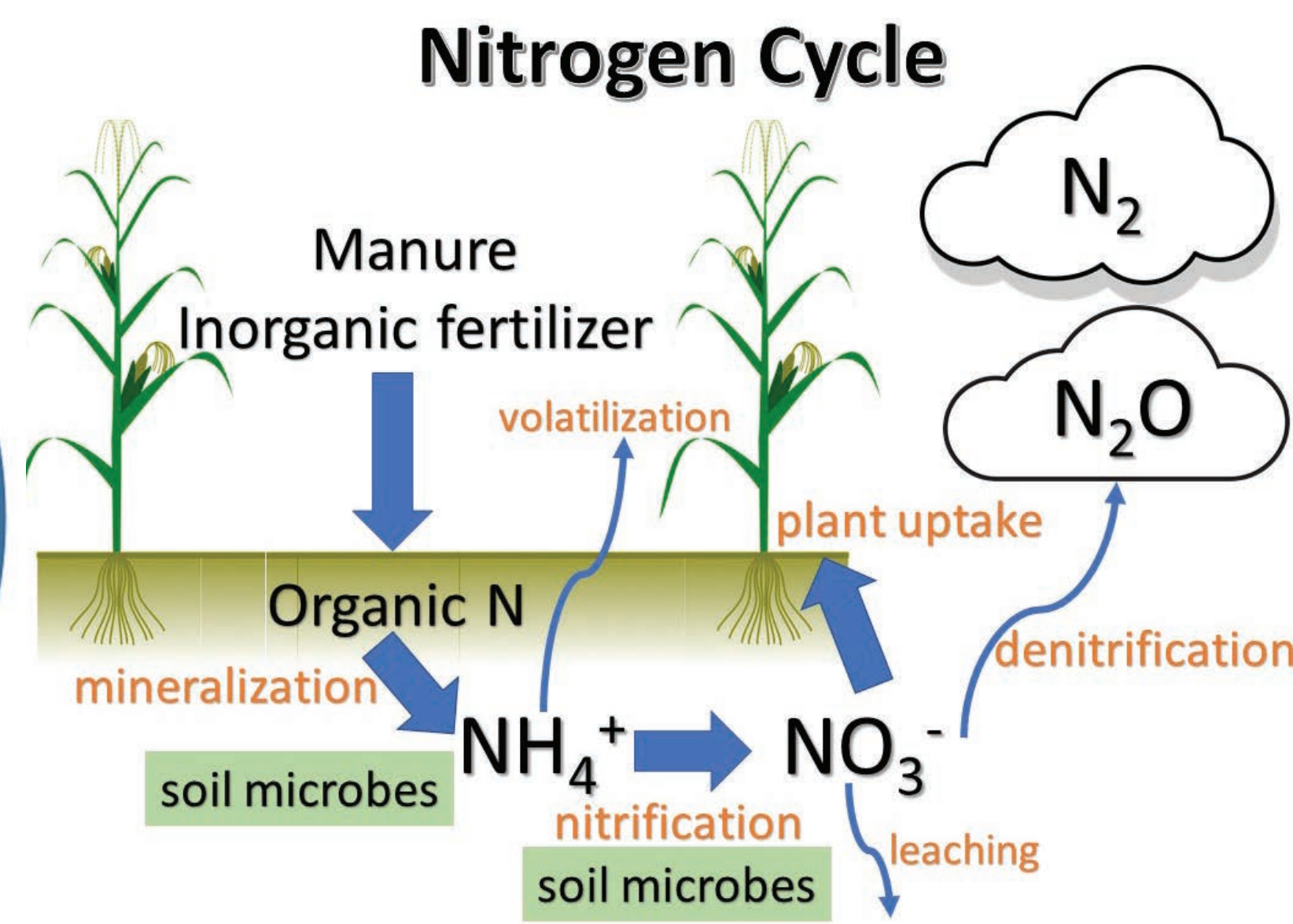
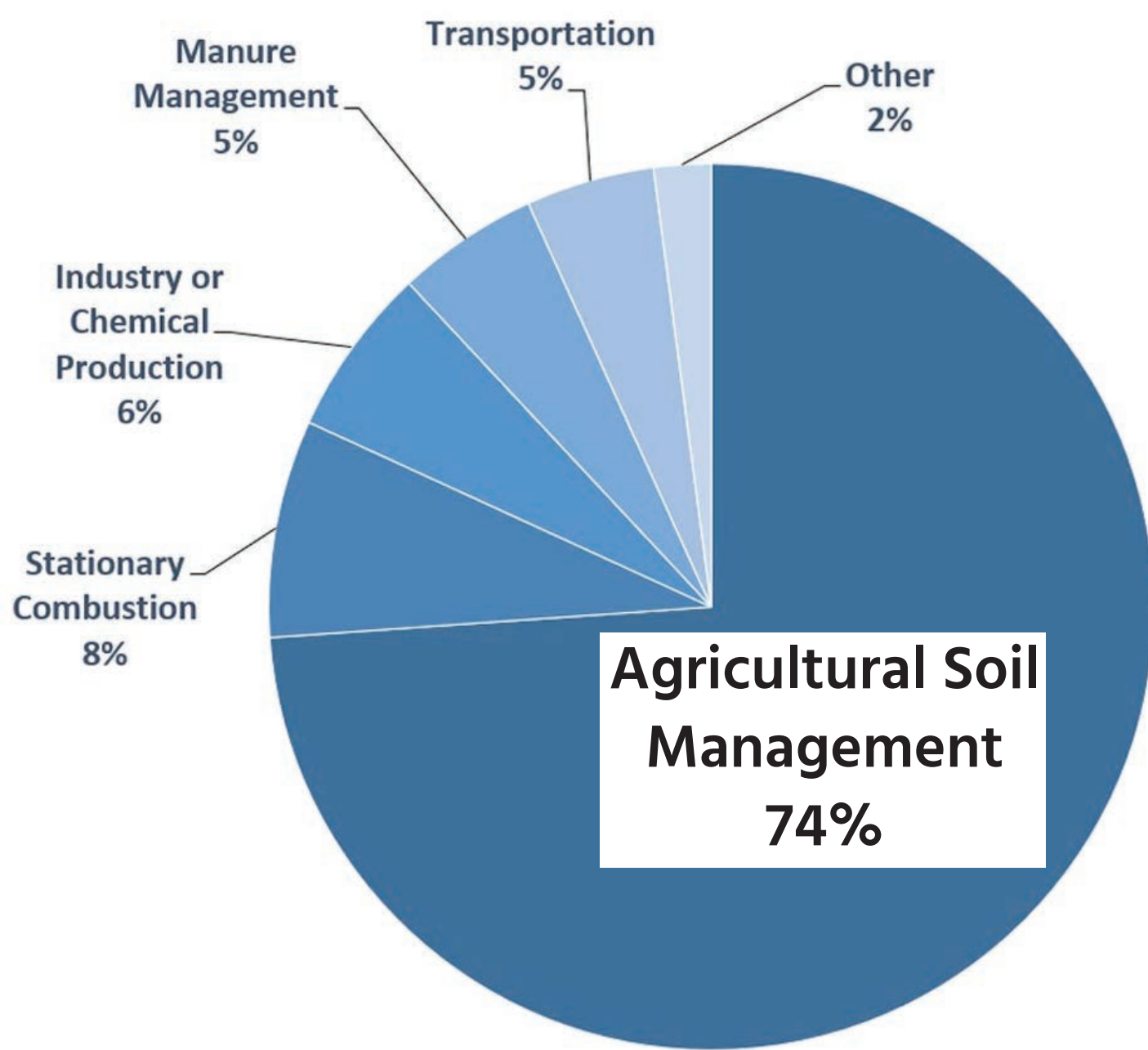


Figure 1. Distribution of nitrous oxide emissions in U.S. by source¹

Figure 2. N_2O is produced through microbial processes under certain conditions in the nitrogen cycle

Some farmers are sidedressing manure - applying manure to corn after emergence to reduce nitrogen losses (Fig. 2).

HYPOTHESIS

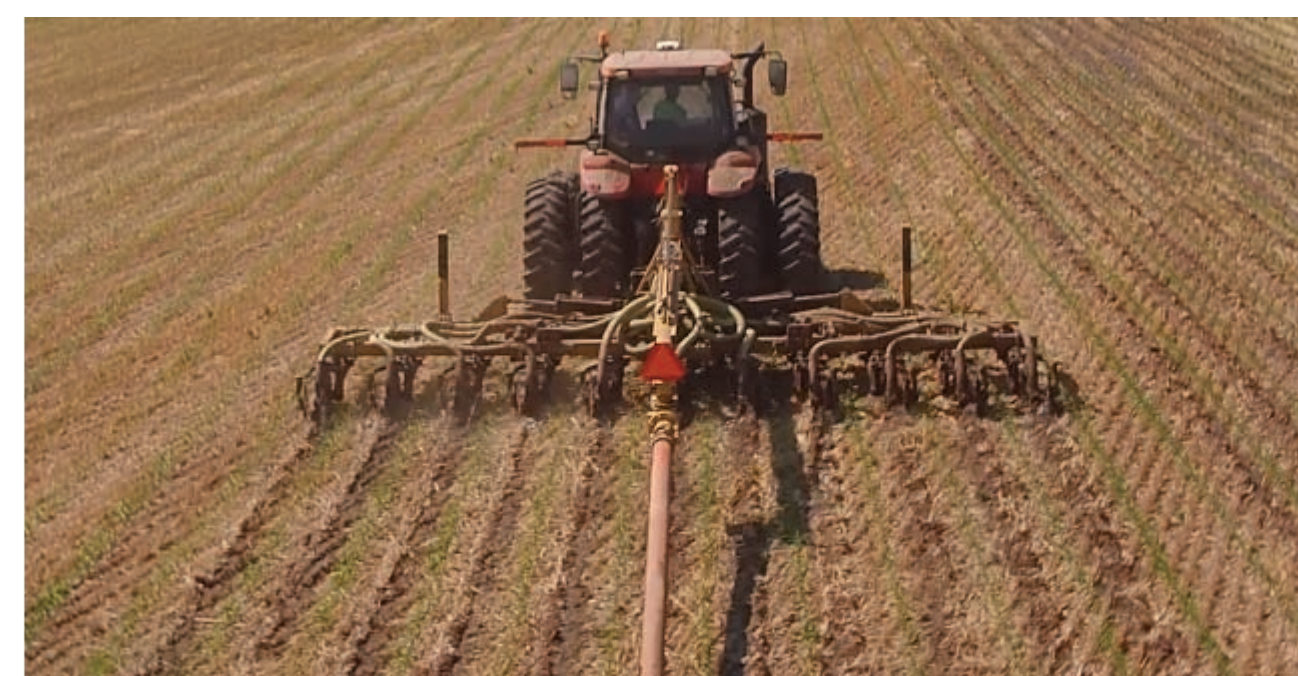
1. If animal manure fertilizer is split into two applications (prior to planting and sidedress) rather than applied all at once prior to planting and
 2. If the total amount of nitrogen added to crops is lowered,
- » then nitrous oxide emissions can be reduced.

METHOD

- » Cycles² - an agroecosystems computer simulation model
 - continuous corn rotation cropping system in Central Pennsylvania
 - liquid dairy slurry manure and inorganic UAN as fertilizers
 - Historical weather data (1980-2016) from Rock Springs, PA
 - Hagerstown soil
- » Manure managements simulated to compare N_2O emissions:
 - Timing
 - "Standard": 169 kgN/ha manure & 30 kgN/ha UAN prior to plant, and 56 kgN/ha sidedress UAN
 - 255 kgN/ha manure all applied at planting
 - 25%, 50%, 75% of Manure 169 kgN/ha sidedressed & same UAN
 - Timing & Rate
 - "Standard": 169 kgN/ha manure & 30 kgN/ha UAN prior to plant, and 56 kgN/ha sidedress UAN
 - 25%, 50%, 75% of Manure 169 kgN/ha sidedressed, 30 kgN/ha UAN at planting, and no sidedress UAN



Before corn is planted, manure is broadcasted to a field from a tractor and then incorporated into the soil³



After corn has emerged, new sidedress technology can apply liquid dairy manure with a drag hose⁴

RESULTS

Comparison of daily average N_2O emissions

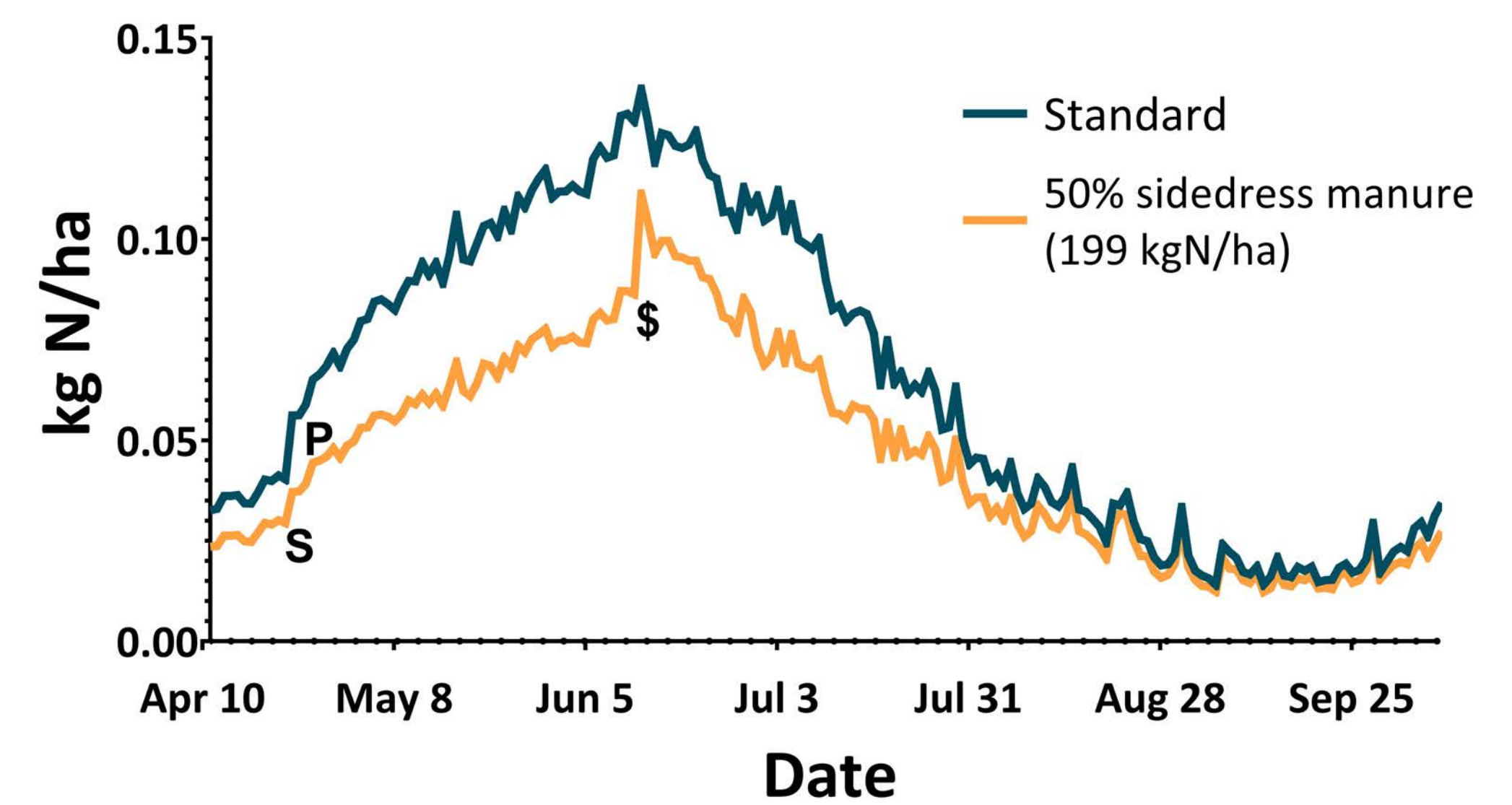


Figure 3. Daily average N_2O emissions (1980-2016) scenarios: all manure applied prior to planting vs. 50% sidedressed at 199 kgN/ha rate. S indicates when manure fertilizer was applied, P indicates when corn was planted with starter UAN fertilizer, and \$ indicates when sidedress manure or UAN was applied.

Total N_2O Emissions

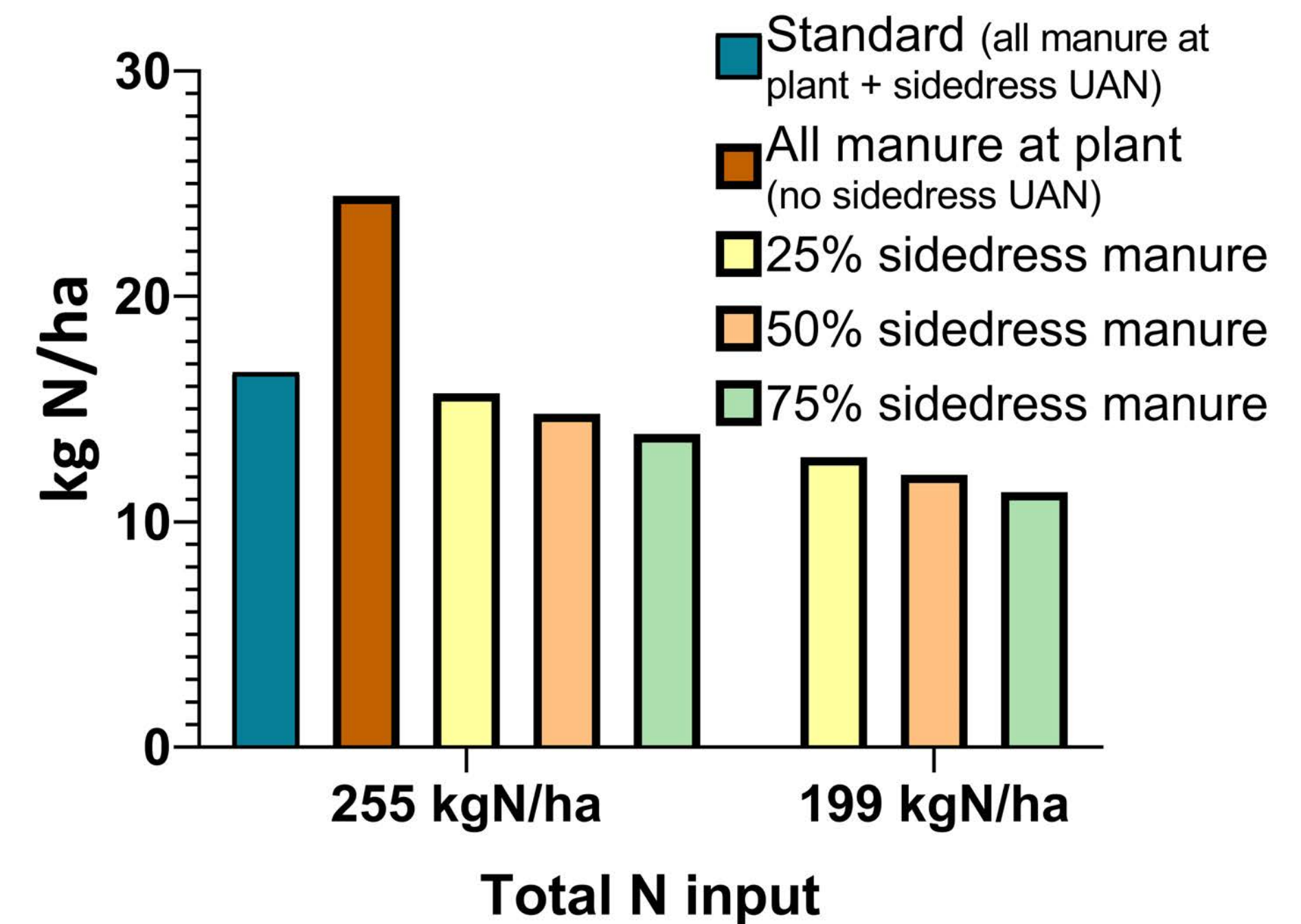


Figure 4. The average total kg N/ha from N_2O emissions decreases as a larger portion of manure is used for sidedress and as lower N rates are applied

Table 1. Percent change in N_2O emissions compared to Standard

N Rate	Manure Application Timing			
	(% change in emissions)			
	Prior to plant	25% sidedress	50% sidedress	75% sidedress
255 kgN/ha	+47	-6	-11	-16
199 kgN/ha*	N/A	-23	-27	-32

* No 56 kgN/ha sidedress UAN

CONCLUSION

Splitting animal manure fertilizer into two applications (before corn planting and as sidedress) and lowering nitrogen input can reduce nitrous oxide emissions and avoid overapplication while achieving similar grain yields (Fig. 4 and Table 1).

DRAWDOWN Solution: Nutrient Management

RECOMMENDATIONS

- More technological innovations to sidedressing equipment
- Encourage incentives to adopt manure sidedressing practices
- Discourage overapplication of manure and nitrogen fertilizers

ACKNOWLEDGEMENTS

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REFERENCES

- ¹ United States Environmental Protection Agency. (2019). Overview of Greenhouse Gases: Nitrous oxide emissions. <https://www.epa.gov/ghgemissions/overview-greenhouse-gases#nitrous-oxide>
- ² Kemanian, A. R., & Stöckle, C. O. (2010). C-Farm: A simple model to evaluate the carbon balance of soil profiles. *European Journal of Agronomy*, 32(1), 22-29. <https://doi.org/10.1016/j.eja.2009.08.003>.
- ³ Photo from Heather Karsten.
- ⁴ Ohio State University Extension. (2018). Sidedressing Manure into Newly Planted and Emerged Corn. <https://agcrops.osu.edu/newsletter/corn-newsletter/2018-14/sidedressing-manure-newly-planted-and-emerged-corn>.