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Can I reduce greenhouse gas emissions in my corn crop and increase profitability?

There is a shared responsibility for balancing more sustainable cropping practices with profitability. We know that improving nitrogen (N) management is important for the environment and on-farm economics, and we have reviewed a number of studies to guide on-farm practices to help reduce greenhouse gas (GHG) emissions.

The simple answer

Yes, you can significantly increase profitability and reduce GHG emissions. These management practices can reduce emissions by up to 100% and reduce nitrate leaching.

- Add urease and nitrification inhibitors to N fertilizers
- Inject/incorporate N fertilizers
- Split applications of N at planting and at sidedress
- Use the most economic rate of N

A little more information

Around the world, countries have agreed to a shared goal of reducing GHG emissions to limit the effects on changing the climate. In Ontario, agriculture accounts for roughly 2% of carbon dioxide (CO_2) emissions, 34% of methane (CH_4) emissions, and 69% of nitrous oxide (N_2O) emissions. Nitrous oxide is a GHG that is almost 300 times more potent than CO_2.

Corn and cereal production in Ontario is responsible for the majority of N_2O emissions, mainly from N fertilizer application. Reducing emissions requires a reduction in N losses and can reduce the amount of N fertilizer required. Doing both will improve yield and farm profitability.

Corn responds to high rates of N fertilizer, but less than half of the N applied is used by the plant. The majority is lost through different pathways. Using 4R practices will reduce these losses.

The full story

Protecting N source

Adding urease and nitrification inhibitors to nitrogen fertilizers can prevent high concentrations of losable forms of N from pooling in the soil, allowing the release of plant available forms of the nutrients to coincide with crop uptake.

- Urease inhibitors (UI) work with urea and UAN fertilizers to slow down the microbial conversion of urea to ammonium (NH_4+). A high concentration of NH_4+ in the soil, depending on pH, can rapidly convert to ammonia (NH_3) gas, which can be lost to the atmosphere and gone as a fertilizer source. Ammonia is an indirect source of N_2O and reduces air quality.
- Nitrification inhibitors (NI) work with N fertilizers to slow down the conversion of NH_4+ to nitrate (NO_3-), a process called nitrification. High concentrations of NO_3- in the soil can be lost through leaching or conversion to N_2O or N_2 gas through denitrification. Both nitrification and denitrification are leaky processes, meaning N_2O or N_2 can be lost through the conversion process.

A 2017 study demonstrated that:

- adding UI+NI to broadcast urea can increase yield by 8 bu/ac and reduce NH_3 losses by 75%
- adding UI+NI to injected UAN can increase yield by 13 bu/ac and reduce NH_3 losses by 90%

Adjusting N rate

An Ontario study in 2020 found that a decrease in N fertilizer rate from 170 to 150 kg/ha reduced N_2O emissions by 10.6%, with no impact to yield. This rate reduction can be accomplished without affecting yield by minimizing losses of applied fertilizer and increasing Nitrogen Use Efficiency (NUE) through the 4R principles of management.

If you need help calculating the most economical rate of N, check out Ontario's Corn N Calculator at gocorn.net or on OMAFRA's Agrisuite at agrisuite.omafra.gov.on.ca.

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Split application timing

When N fertilizer is applied in a split application, the N supply is a better match to the corn's uptake curve. Applying less ahead of planting prevents early season losses, with less available to be lost during a stage of corn growth that requires little N. A 2014 Elora study compared sidedressed UAN at V8 to pre-plant applications and found that N_2O emissions decreased by 58% in a typical year, with no significant impact on yield.

Injecting or incorporating beneath soil surface

Urea-based N fertilizers sitting on the soil surface are most at risk of loss through volatilization. Volatilization of urea fertilizer is reduced by more than 50% when it is injected instead of broadcast applied. High pH soils under hot, dry and windy conditions can rapidly lose N to NH_3 volatilization, even when banded at a shallow depth. High pH soils are common in Ontario and placement of nitrogen below the soil surface will reduce losses.

Stacking the 4Rs

Maximizing your return on investments in N fertilization involves a combination of 4R practices.

- Inject/incorporate N fertilizer (Right place)
- Use urease and nitrification inhibitors (Right source)
- Split application at planting and sidedress (Right time)
- Adjust N rates based on changes in management (Right rate)

A 2020 research model from Banger et al. shows that stacking these 4R practices in Ontario corn production can result in:

- 3-4% increase in yield
- 42-57% reduction in N_2O emissions
- 94-98% reduction in NH_3 losses

Field trials in Woodslee, ON showed that applying injected UAN with N inhibitors compared to a broadcast urea system can result in:

- 33 bu/ac increase in corn yield
- 9% reduction in N_2O emissions
- 100% reduction in NH_3 losses

The bottom line

Nitrogen is managed in many ways between fields and farms depending on equipment, labour, time and economics. A 4R approach to management is always a best practice and can have significant economic benefits when the price of N fertilizer is high. Table 1 illustrates that using a 4R management plan for N application is much more profitable, even with high prices for UAN fertilizer compared to urea. This example uses data from Drury et al. (2017) in a no-till corn scenario.

Table 1. Net revenue of corn produced with a 4R nitrogen management strategy compared to a traditional nitrogen management strategy.

	Traditional N Application	4R Management for N Application
N Source, Rate, Placement	Urea: 141 lb N/ac broadcast, not incorporated	UAN: 141 lb N/ac side-dressed, injected
N Fertilizer	$166.38	$225.60
+ UI + NI		$14.10
Side-dressed, injected		$15.00
Total N Cost	$166.38	$244.70
Corn Yield	172.3 bu/acre	204.8 bu/acre
Gross Revenue	$1,206.10	$1,433.60
Net Revenue	$1,039.72	$1,188.90

Fertilizer prices current as of January 1, 2023 and assumes UAN @ $1.60/lb N, Urea @ $1.18/lb N, UI+NI @ $0.10/lb N, Corn @ $7/bu