Fertilizer Industry Innovations Supporting Climate Mitigation

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Fertilizer Industry Innovations Supporting Climate Mitigation

- **Use**
  - 4R practices
  - Soil & crop management
- **Manufacturing**
  - Energy efficiency
  - Blue & Green ammonia
- **Enablers**
  - Science
  - Policy & stakeholders

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GHG emissions from food systems & fertilizer

- Global food systems – 31% of GHGs arising from human activity
- Fertilizer manufacture & use – 2.5%
- North America manufacture & use – 179 Mt CO_2e
  - @ \$50/t of CO_2e = ~\$9B
- Canada: Fertilizer Emissions Reduction Target – 30% by 2030
  - Assumed 20% improvement in NUE relative to flat production trend

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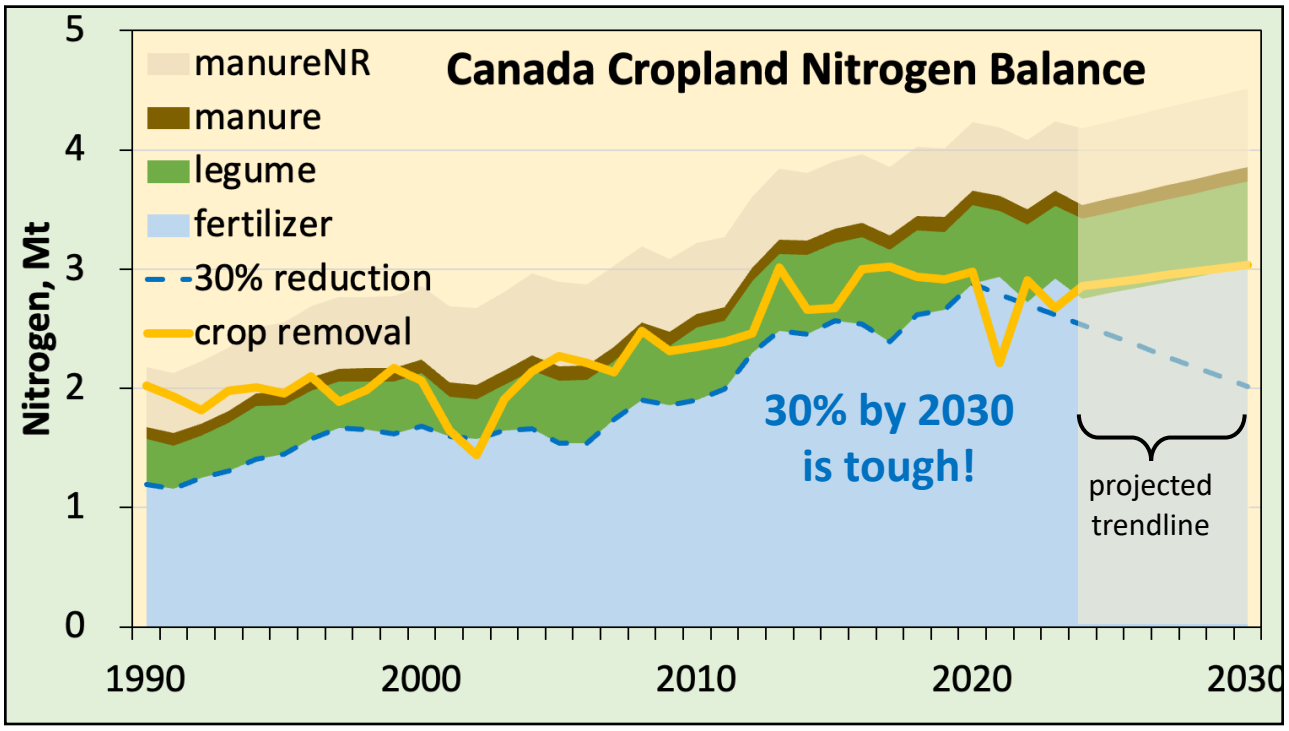

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Fertilizer Use

TWO STRATEGIES:

1. Improve N use efficiency
   - Reduces N surplus and ALL N losses per unit of yield
   - 4R & soil & crop management; biostimulants?
2. Target N_2O pathways
   - 4R EEFs reduce N_2O emission per unit of N applied
   - Biological Nitrification Inhibition? (Subbarao & Searchinger, 2021)
   - $N_2O \rightarrow N_2$ – NosZ enzyme from biogas waste? (Hiis et al., 2024)

CERTIFIED BIOSTIMULANT

"This certification does not guarantee a product works."

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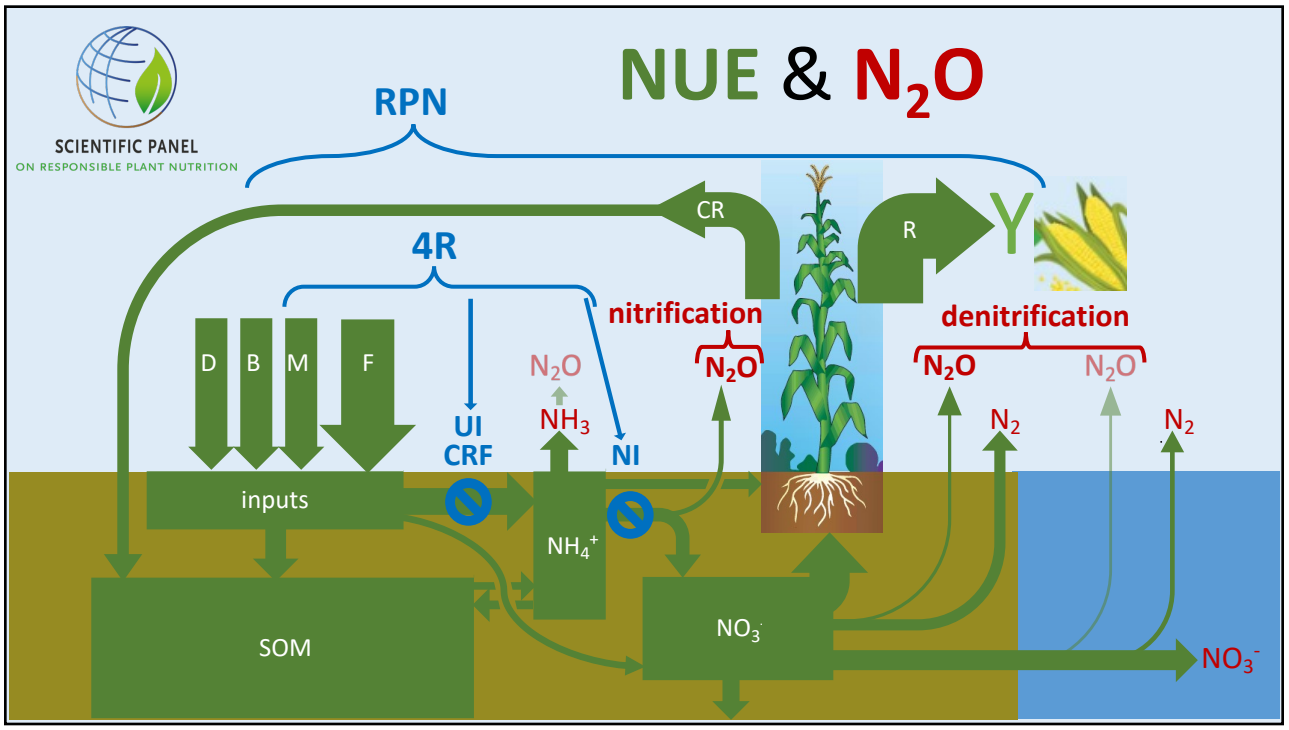

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Average decrease in N_2O emissions and increase in crop yield due to management practices according to meta-analyses of global literature.

Practice	N_2O emission, % decrease	Crop yield, % increase
Fertilizer rate	9	-4
Fertilizer timing	0	4
Fertilizer placement	14	5
EEF source	35	6
Cover cropping	5	12
Biochar	40	13

Madaline Young, Gerard Ros, and Wim de Vries. 2021. Impacts of agronomic measures on crop, soil, and environmental indicators: A review and synthesis of meta-analysis. Agriculture, Ecosystems & Environment 319: 107551. doi: 10.1016/j.agee.2021.107551.

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Average decrease in N_2O emissions and increase in crop yield due to EEFs according to meta-analyses of global literature.

Practice	N_2O emission, % decrease	Crop yield, % increase
EEF on corn	25	4
EEF on wheat	29	5
EEF on rice	25	8
Nitrification inhibitors (NI)	44 to 49	2 to 5
Urease inhibitors + NI	31 to 49	1 to 3
Controlled-release fertilizer	19 to 33	-3

Fan, D. et al. 2022. Global Change Biology
Grados, D. et al. 2022. Environmental Research Letters
Thapa, R. et al. 2016. Soil Science Society of America Journal
Yao, Z. et al. 2024. Global Change Biology

Are EEFs the silver bullet?

Reduce emissions >30%

Increase yield up to 5%

Cost the farmer $

Returns inadequate: only ~20% adoption

Need to incentivize, requiring MRV

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Enablers – Industry Engagement

- 4R Research Fund, 4R acre reporting, 4R Advocates, 4R certification
- Quantification Protocol for Nitrous Oxide Emissions (NERP)
- Verified and tradeable carbon outcomes (Scope 3)
- New Research engagement (multidisciplinary):
  - NICCEE – Nitrogen Innovation Center for Clean Energy and Environment (Xin Zhang, UMCES)
  - CanN_2ONet (Wagner-Riddle), AgriScience, NIR revision
- Farmer data sovereignty:

Field to Market

Field to Market CANADA

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Manufacturing – energy efficiency & emissions

- GREET 2023 (USDOE)
  - GHG emission of NH_3 production = 2.3 t CO_2e per t (12% less than 2007)
  - Agrees with Fertilizer Canada 2023 benchmarking of 2.4 t CO_2e per t
  - Emission factor for ammonium nitrate manufacturing reduced 80%
  - Nitrogen comprises 83% of the fertilizer manufacturing GHG footprint for corn

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Manufacturing – blue & green ammonia

- Announced projects for 46 (blue) & 109 (green) Mt annual capacity
- Small modular units (FuelPositive, Talus Renewables, Nitricity, etc.)

Blue – CCS

Green – renewable

Photo credit: Dr. M. Tenuta

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Conclusions & future aspirations

1. Available technologies can reduce GHG emissions from fertilizer
   - BUT even a 30% reduction requires public support through carbon credits and farmer capacity to share data
2. Nationally determined commitments are absolute
   - Continued intensification demands an intensity-based approach
3. Beyond 2030 there will be demand to reduce beyond 30%
   - Need yet more innovation in NUE, fertilizer forms, and inhibition technologies

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