



Tom Bruulsema, Plant Nutrition Canada



Soil Fertility and Plant Nutrition Symposium 15 September 2021 The Role of the Fertilizer Industry in Enhancing Nutrient Use Efficiency



Stewardship Needs Science

Providing science-based support for sustainable management of plant nutrition.

Learn more



Outline – Fertilizer Industry's Role Enhancing NUE

- 1. Nutrient Use Efficiency what is it?
 - NUE vs FUE
 - Efficient vs effective
- 2. Integration & Collaboration
 - Enhancing NUE is a shared responsibility
 - 4R Nutrient Stewardship focuses industry role
- 3. Measuring & reporting performance
 - Nutrient balances, legacies, and soil fertility surveys



Nutrient Use Efficiency

$NUE = rac{nutrient \ output}{nutrient \ input}$

nutrient output \productivity



Nutrient use efficiency can be defined and calculated in many ways

NUE term		Calculated from	Typical levels for N (maize or wheat)	
Partial factor productivity	PFP	Y/F	40-90	
Agronomic efficiency	AE	(Y-Y ₀)/F	15-30	
Partial nutrient balance	PNB	R/F	>90% = deficiency <70% = surplus	
Recovery efficiency	RE	(U-U ₀)/F	40-65% (whole-plant) 33% (grain only)	

Y = yield, F = fertilizer, R = removal, U = uptake



After Dobermann, 2007; Fixen et al., 2014

Example maize N response: Elora, Ontario, Canada 2013

N rate , kg/ha	Grain yield , t/ha	PFP , kg grain /kg N	AE , kg grain /kg N	PNB	RE	Net return to applied N, \$/ha
0	4.7					
90	9.4	104	52	82%	67%	\$ 770
150	11.4	76	45	75%	65%	\$ 1,070
220	13.0	59	38	64%	65%	\$ 1,258
260	13.3	51	33	56%	57%	\$ 1,252

With increasing N rate: yield increases, all forms of NUE decrease.

Net \$ return has an optimum rate





Efficiency and productivity compared across cropping systems

Nitrogen balance by region (kg/ha/yr), 1997-2006				
	North China (wheat-maize double crop)Midwest U.S.Wo Ken input rotation)		Western Kenya (low input maize- based)	
Input N	588	155	7	
Output N	361	145	59	
Output/Input	61%	94%	840%	



Vitousek et al. 2009. Science 324:1519-1520





Inhibitors impact nitrous oxide loss more than NUE



Thapa et al. (2016) Effect of enhanced efficiency fertilizers on nitrous oxide emissions and crop yields: a meta-analysis. Soil Sci Soc Am J 80:1121–1134 Abalos et al. (2014) Meta-analysis of the effect of urease and nitrification inhibitors on crop productivity and nitrogen use efficiency. Agric Ecosystems & Environment 189: 136–144

- 4-10% yield gain
- 12-15% NUE gain
- 20-46% less N₂O

Mean effect size (%) and 95% confidence interval for technologies applied to urea

A carbon credit could motivate more inhibitor use

Benefit of inhibitors to yield, NUE, & GHG emissions **Ontario grain corn scenario 10** N₂O emission factor, kg CO₂eq per kg of urea-N **11.4** 2020 Ontario average grain yield, t/ha 193 2020 Ontario average N rate, kg/ha 200 corn price, \$/t, net of drying, etc 1.45 fertilizer N price, \$/kg **170** carbon price, \$ per tonne of CO₂eq yield increase 7% 14% **NUE** increase **GHG** reduction 33% vield increase, \$/ha \$ 160 reduced N rate, \$/ha \$ 18 GHG reduction, \$/ha Ś 133



Western Lake Erie Watershed

Year	Outputs, kt P ₂ O ₅ crop removal	tputs, kt P ₂ O ₅ Inputs, kt P ₂ O ₅ rop removal fertilizer manure		PUE
1987	.92	103	17	76%
2016	136	73	22	143%

- Cropland PUE almost doubled.
- Loss of dissolved P to the lake also doubled.
- Unintended consequence of conservation tillage with broadcast application of P fertilizer.





Jarvie et al., 2017, J Environ. Qual. 46(1):123-132

Nutrient use efficiency & nutrient losses

- Nitrogen use efficiency is desirable, and contributes to sustainability.
- Increasing nutrient use efficiency reduces potential for losses.
- BUT some big issues may arise from small losses.
 - Nitrous oxide greenhouse gas and ozone depletion
 - Dissolved phosphorus harmful algal blooms
- Improving NUE is an important first step.
- More can be done with source, timing, and placement as well.



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Indicators of Sustainable Crop Nutrition

Enablers (process)

- Extension & professionals
- Infrastructure
- Research & innovation
- Stakeholder
 engagement



Outcomes (impact)

- 1. Farmland productivity
- 2. Soil health
- 3. Nutrient use efficiency
- 4. Water quality
- 5. Air quality
- 6. Greenhouse gases
- 7. Food & nutrition security
- 8. Biodiversity
- 9. Macroeconomic value











4R Nutrient Stewardship is an important component of Integrated Soil Fertility Management



Who needs to do what?



- Many participants in the agricultural value chain play important roles in responsible plant nutrition.
- The fertilizer industry has great influence on the 4Rs:
 - making the right source available,
 - providing recommendations for applying
 - at the right rate,
 - at the right time, and
 - in the **right place**.







4R Certification in Western Lake Erie Basin (WLEB)

We All Play A ROLE









4R Designation (AB-SK-MB) 4R Certification (ON & PE) - reached 2M ha in 2020 - goal of 6M ha by 2025



FERTILIZER CANADA

4R Practices for Spring Cereal,	Oilseed, and Pulse Rotations.		
Right Source	Right Rate	Right Time	Right Place
	Suites of 4R N Mar	agement Practices	
 Ammonium-based formulations for fall (UAN excluded due to nitrate content). Any N fertilizer in spring or in-season. Inoculate pulse crops. 	 » Set crop and field specific N rates using appropriate regional tools such as soil tests, nitrogen balance, response curves or provincial guidelines. » Consider field specific yield history and soil types in relation to yield potential of other fields on farm and in region and probabilities for weather variations when setting rates. Basic 4R's for 	 » Apply N after soil cools in fall; or » Apply N in spring before or at seeding. » No N application on frozen soil and/or snow covered ground. • Fertilizer N 	 » Apply in subsurface bands/ injection any acceptable time. » Broadcast and incorporate in spring. » Avoid fall broadcast of unprotected N. » Fall broadcast of enhanced efficiency N fertilizers are acceptable following label instructions regarding incorporation and timing.



The international Code of Conduct for the sustainable use and management of fertilizers

Principles of 4R Nutrient Stewardship are embedded in the FAO Code of Conduct, and in other Codes of Practice.



FARMERS INDUSTRY STAKEHOLDERS BUYERS CONSUMERS CODE CONTENTS ABOUT US CONTAC

Canadian Grain Farmers Code of Practice

Responsible Grain is a national, voluntary Code of Practice that will allow Canadian grain farmers to demonstrate their care and commitment to the environment.





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N use efficiency trajectories, 1961 to 2018



Trends in yield (N output) and N input (fertilizer, manure, legume fixation, and deposition) in cropland from 1961 to 2018. The slope of a line from any point to the origin indicates NUE (output/input). Sources: Zhang et al., 2015, and FAO (2021).







NuGIS Map



Deficits and surpluses in the USA cropland N balance

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NuGIS Map



Deficits and surpluses in the USA cropland P balance





Both South Africa and the USA show a legacy of past surplus phosphorus use.

Surplus P remains in the soil, unless there has been loss by erosion.





Soil Test Levels in North America



StS soil test summary HOMI Soil Test Levels in North America Create an account to customize your search. LOG OUT

https://soiltest.tfi.org/





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The Business Case for Establishing the National Index on Agri-Food Performance Affirming Canada's Agri-Food Sustainability Leadership

Version 1

JUNE 2021



"Canada does not have complete data to present a supply chainwide view of emissions, ...overlooking 4R Nutrient Stewardship practices used to reduce direct emissions."

4R Climate Smart Protocol (aka NERP)

The Climate-Smart Agriculture Action Plan

Helping stakeholders around the world work together to implement climate-smart agriculture



Summary – Fertilizer Industry's Role Enhancing NUE

- 1. Nutrient use must be effective as well as efficient.
- 2. Improving nutrient use efficiency depends as much on crop and soil management as on the 4Rs of nutrient application.
- 3. The influence of the 4Rs goes beyond NUE in mitigating specific environmental impacts (GHGs, eutrophication, etc.).
- 4. The agricultural retailer is well-positioned to play a role in collaborative data platforms verifying farm practice changes that improve sustainability performance.

