Nutrient Dynamics in AgroEcosystems

Guelph Organic Conference

Jan. 26th 2007

Guelph

D. Lynch, NSAC

Nutrient Sources in Organic Systems

N_2 Fixation

Feeds/ Grazing

Composts

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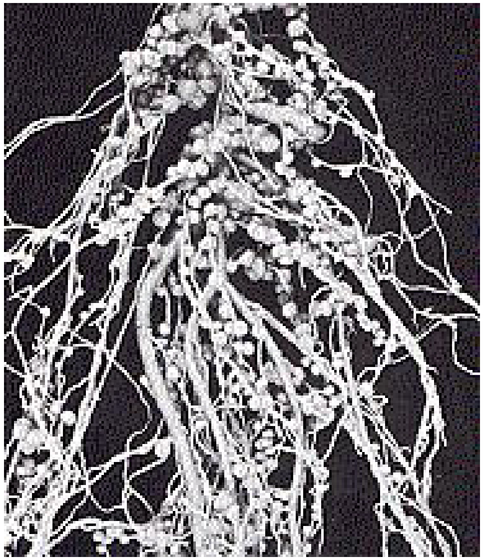
Biological Nitrogen Fixation

Biological nitrogen fixation (BNF): $N_2 \longrightarrow NH_3$



Legume BNF-N in agroecosystems:

1880: Cultivated legumes represented 20-30% of all cultivated land in Western Europe

Provided 40-150 kg N/ha and up to 75% of crop N requirements.

1960: BNF-N only 50% of global crop N

2000: BNF-N only 20% of global crop N

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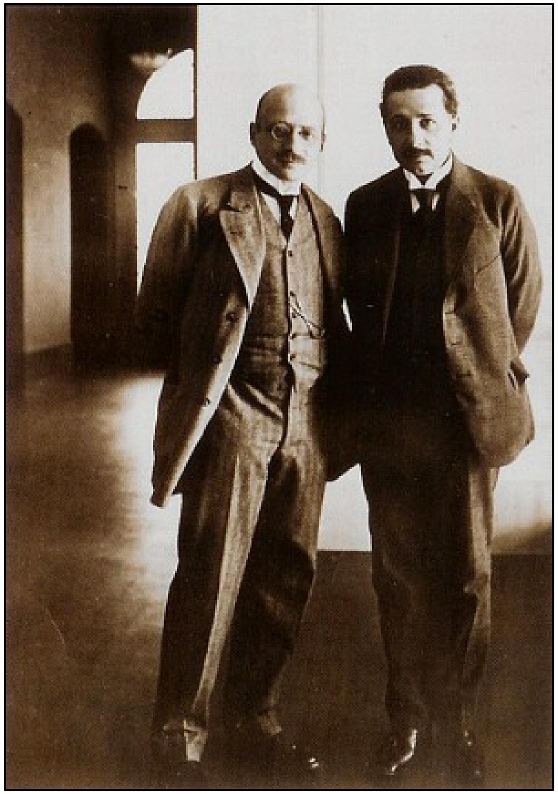
The ‘Most Important Invention’



Kaiser Wilhelm Institute for Physical Chemistry, Berlin, 1914

(D. Charles, 2005)

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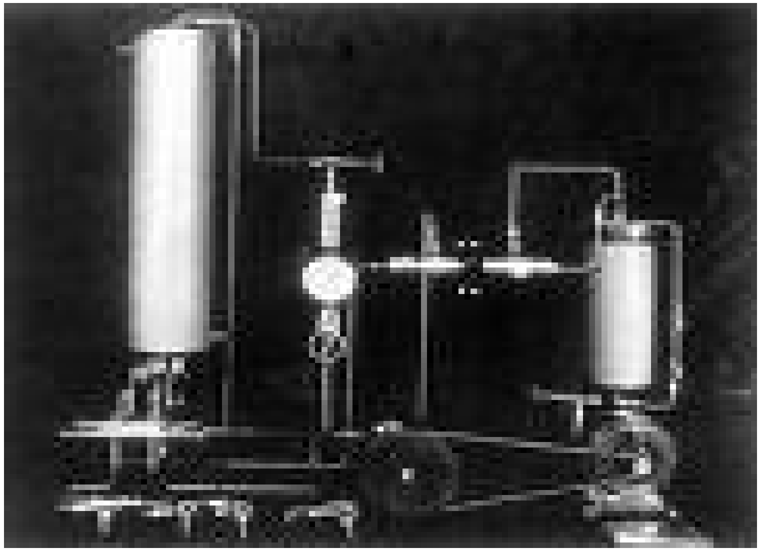
The 'Most Important Invention'



Haber-Le Rossignol apparatus for the synthesis of ammonia, 1909

Deutsches Museum, Munich

Synthetic nitrogen fixation:

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

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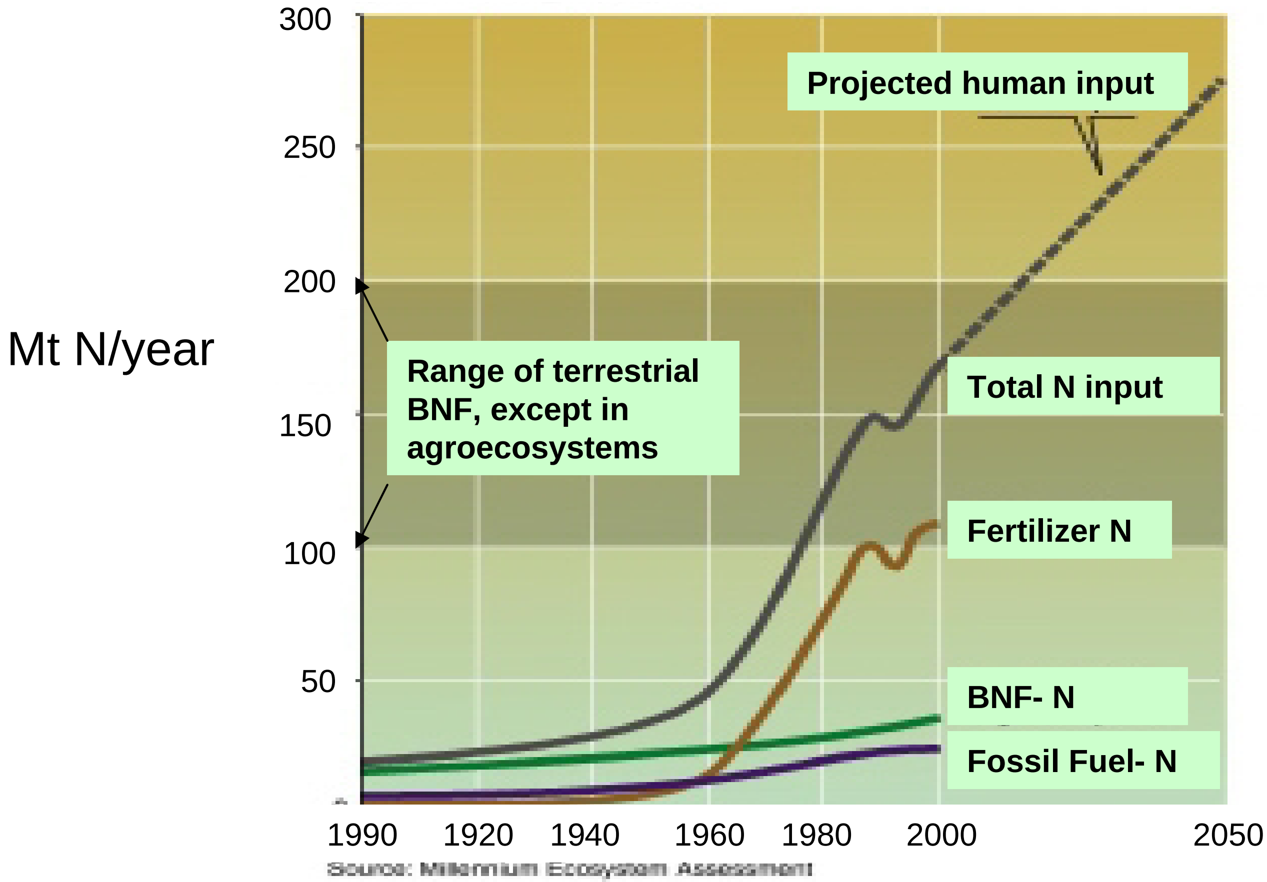
Changing the Global N Cycle



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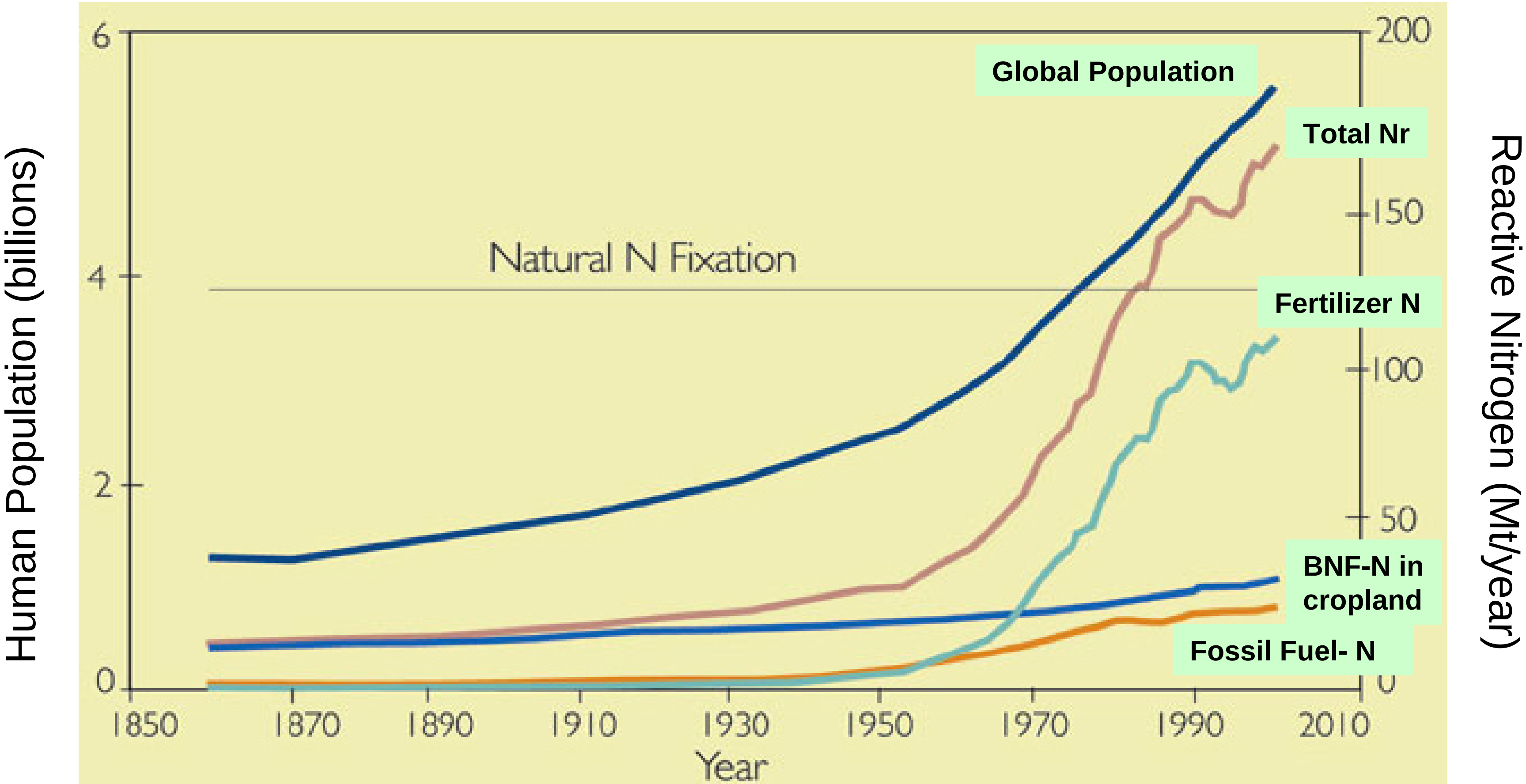
Global Population and Reactive N (N_r) Trends



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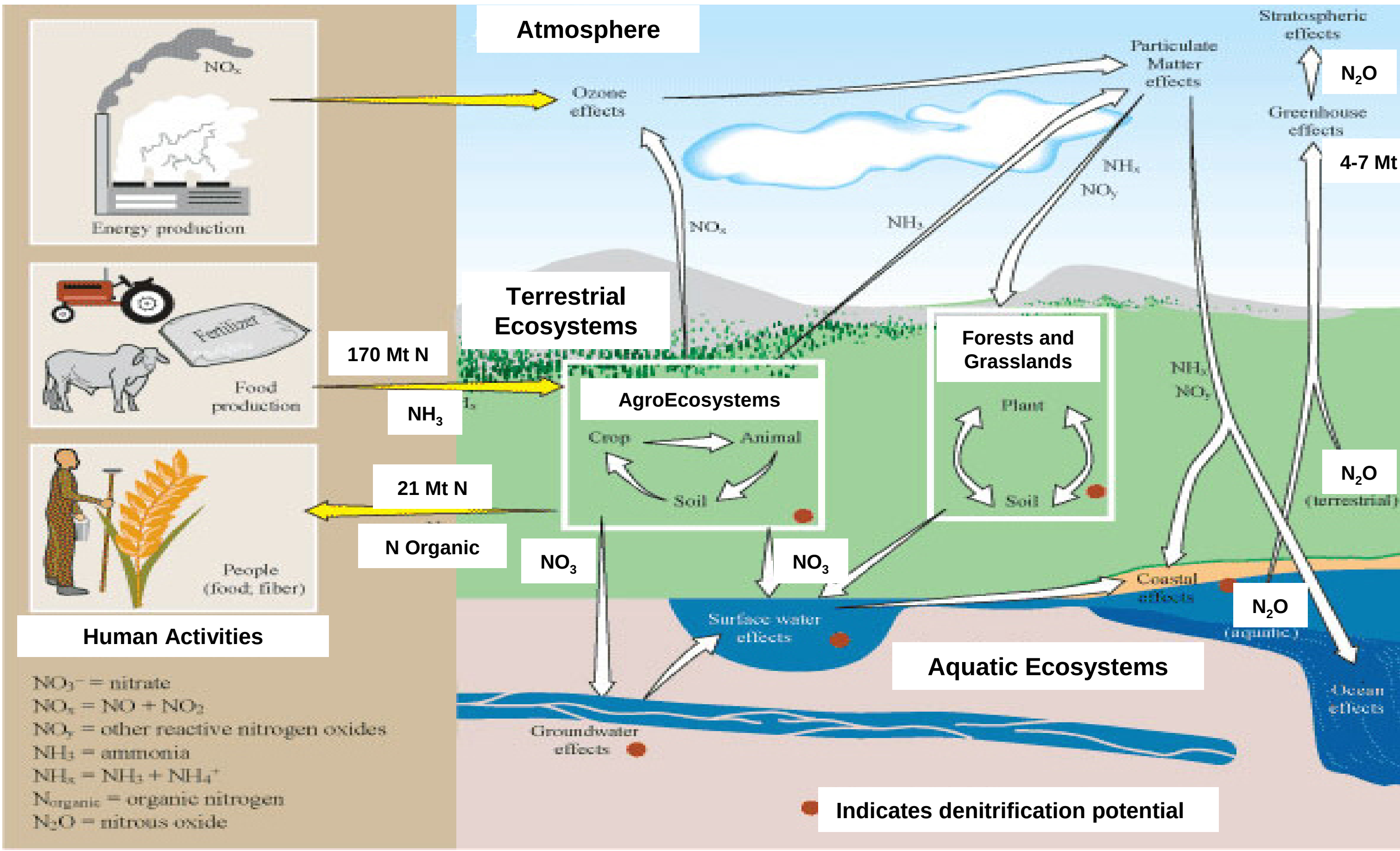
The Nitrogen Cascade



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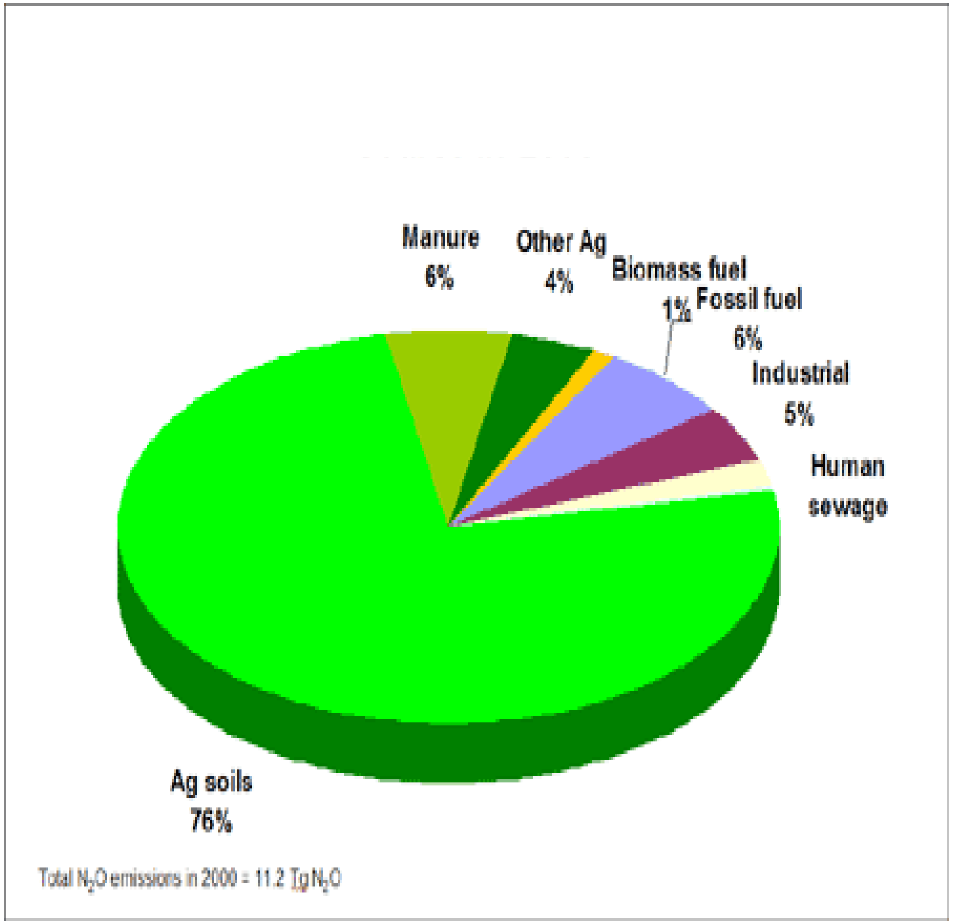
Galloway et al., 2003

Anthropogenic N_2O Sources



IPCC coefficient (1997, 2000):

1.25% of <u>ALL</u> N inputs emitted as N_2O

BNF-N assumed source of 22% of N_2O emmissions from Canadian agriculture.

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GHG and Organic Systems

Legumes

IPCC coefficients greatly overestimates N_2O emissions from legumes.

Rochette et al., 2005.

Composting

Composting reduces GHG emissions compared with manure storage.

Pattey et al., 2005.

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GHG and Organic Systems

- Perennial orchard system:

  Emissions of benign N_2 compared to N_2O greatest for the organic plots.

- Appears due to shifts in soil microbial (denitrifier) community and higher soil organic matter.

Kramer et al., 2006. PNAS 103:4522-4527

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NITROGEN AND PHOSPHORUS DYNAMICS ON ORGANIC FARMS

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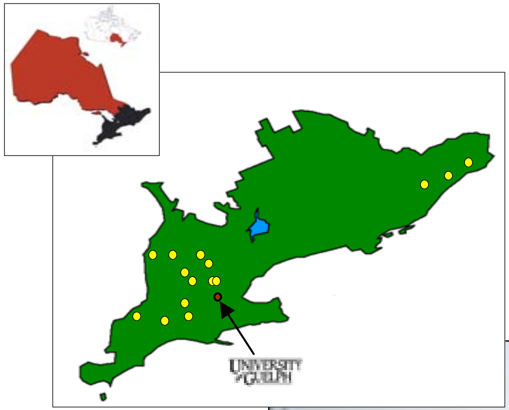
Sustainability of Dairy Systems

<u>Location</u>

15 organic dairy farms in Ontario

<u>Selection Criteria</u>

- >10 years certified
- farm at 'steady state'
- diversity of management



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N Flows – Organic Dairying

Feed 34

Kelp meal 0.2

Milk: 22

Meat: 3

Legume N_2 53

Manure 7

Seed 0.5

Deposition 6

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NPK Surplus – Organic Dairying

N	P	K	Location	# farms	
---kg ha^{-1} yr^{-1}---					
52	1	11	Ontario	*15*	
82	3	10	Europe	*60*	Watson et al., 2002

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NPK Surplus – Organic Dairying

- N surplus per hectare relatively low, while N efficiency (21%) was moderate
- Legume fixed N accounts for >60% of N inputs
- 30% or more of farms running P deficits, which was reflected in soil fertility data

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DAIRY SYSTEMS AND GHG EMISSIONS

- Emissions <18% ha^{-1} for more extensive, pasture-based farms (1.7 LU ha^{-1}), compared with confinement-based (2.0 LU ha^{-1}).

Casey and Holden, 2005. JEQ. 34: 429-436.

- Emissions per land area proportional to stocking rate, but per unit product inversely proportional to farm N efficiency.

Oleson et al., 2006. AEE 112: 207-220

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Legumes in Rotation

Unamended soil:

Tuber yields: ~30Mg ha^{-1}

Crop N uptake: 112 kg N ha^{-1}

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GHG and Organic Systems

Measuring GHG emissions in an organic and conventional rotation sequence (NSAC)

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GHG and Organic Systems

Main crop: Potato

Forages: Timothy or Clover

Management:

(i) Forage plowing date (F/S)

(ii) +/- N fertilizer

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Phosphorus and BNF

Phosphorus availability limits agroecosystem productivity by controlling BNF of legume crops.

Crews, T., 1993. Biogeochemistry 21:141-166.

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Phosphorus

Is soil phosphorus being depleted in organic systems?

- Soil test P levels deficient on organic farms throughout SK (Knight and Shirtliffe, U. of S.)
- Alfalfa depleted soil P in systems without fertilizer inputs (Entz et al., U. of M.)
- 30-50% of dairy farms running P deficits (Roberts et al., U. of Guelph)

Phosphorus

Phytoextraction of rock phosphate P (Arcand et al., U. of Guelph)

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CONCLUSION

1) Increase use of cultivation-induced BNF

2) Increase Nr (and P) recycling within agroecosystems

3) Increase the efficiency of N (and P) use in crop and animal agriculture

4) Reduction of food waste

5) Adoption of less meat-intensive, rational diets

Acknowledgements

Canada Research Chairs Program

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