Building Soil Sustainably

Sean Smukler

Gulf Islands Food Co-op:

February 2, 2019

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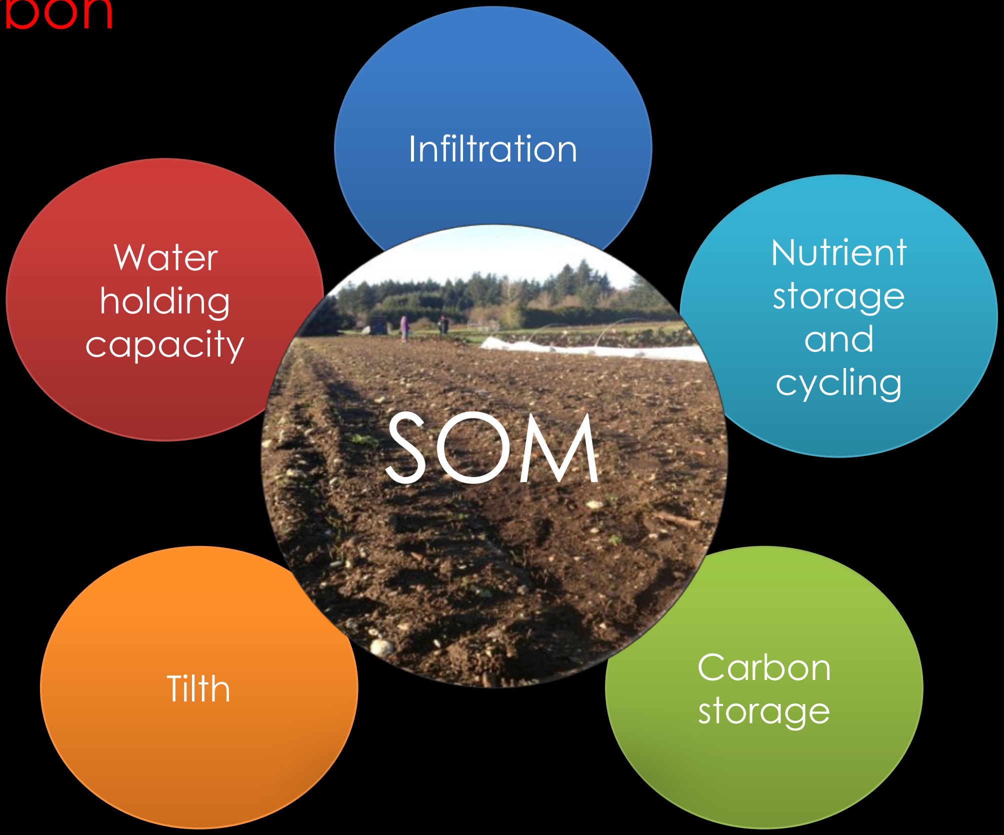
Explore

The Plan

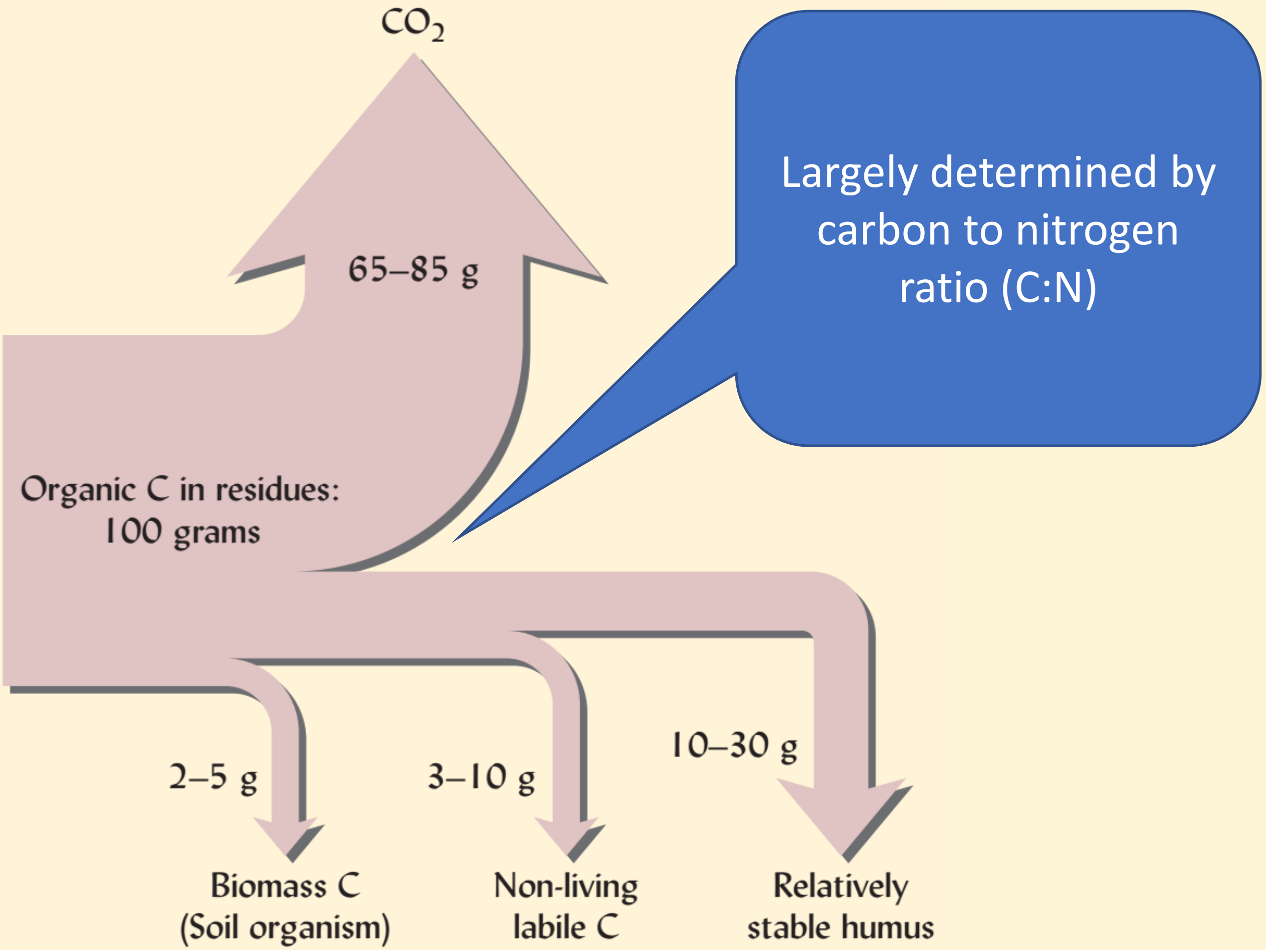
- The Basics
  - Soil Organic Matter
  - Organic nutrient management 101
- Current research
  - Improving organic nutrient management

Benefits of Soil Organic Matter (SOM)

50% is Carbon



The Fate of Carbon in the Soil



Weil and Brady (2017). The Nature and Properties of Soils. Pearson Education. 15 Edition.

Carbon Sources?

Plants Need Nutrients

and they don't care where they get it from

Pedro Sanchez

http://blog.cimmyt.org/

The Objectives of Nutrient Management

Maximize crop yield and quality

Efficiency

Minimize costs

Minimize environ-mental impacts

Maximize long-term benefits

Essential Nutrients

Macronutrients

- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)

Secondary Nutrients

- Calcium (Ca)
- Magnesium (Mg)
- Sulphur (S)

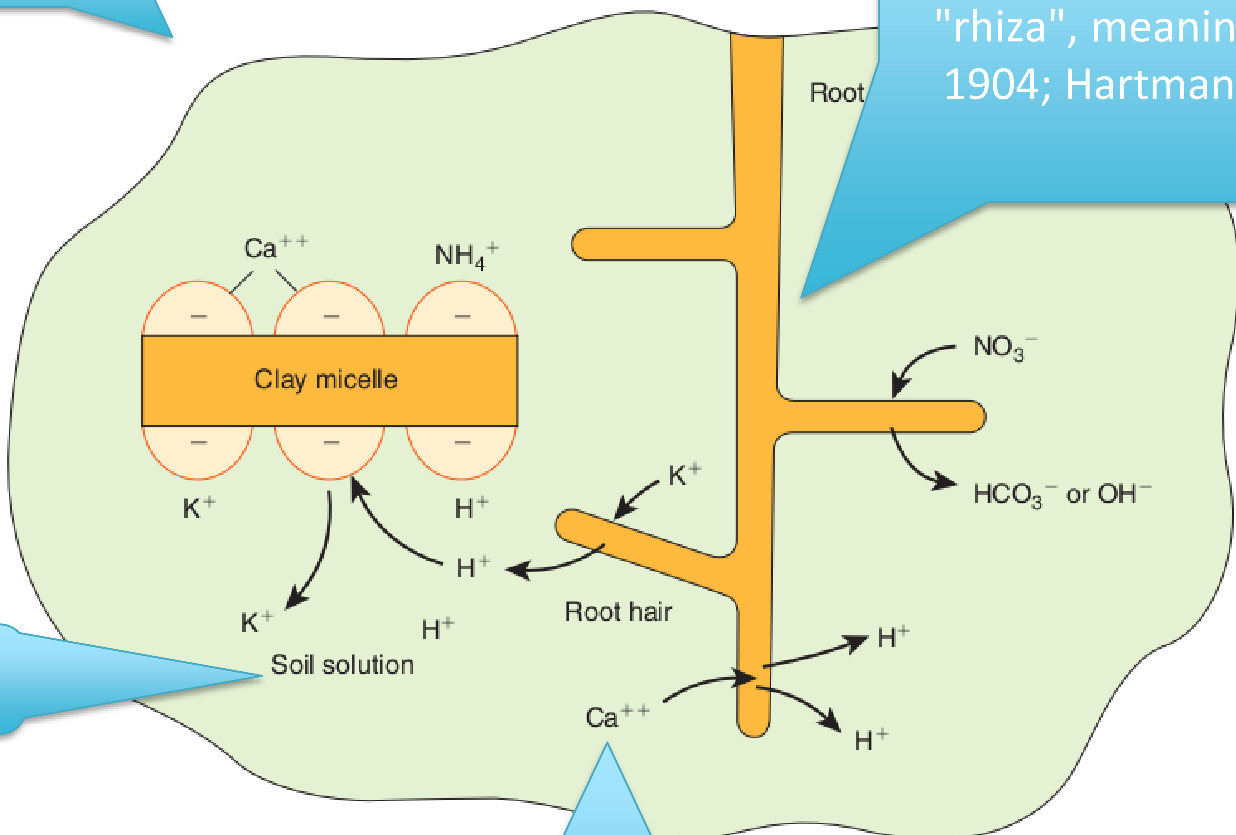
Micronutrients

- Boron (B)
- Copper (Cu)
- Iron (Fe)
- Manganese (Mn)
- Molybdenum (Mo)
- Zinc (Zn)

Plant Nutrient Uptake

"Rhizosphere" is the plant-root interface, a word originating in part from the Greek word "rhiza", meaning root (Hiltner, 1904; Hartmann et al., 2008).

Bulk soil



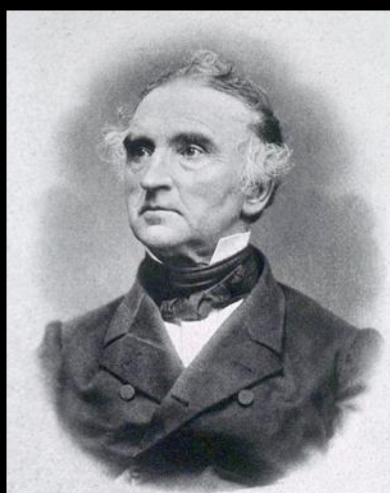
Soil Solution

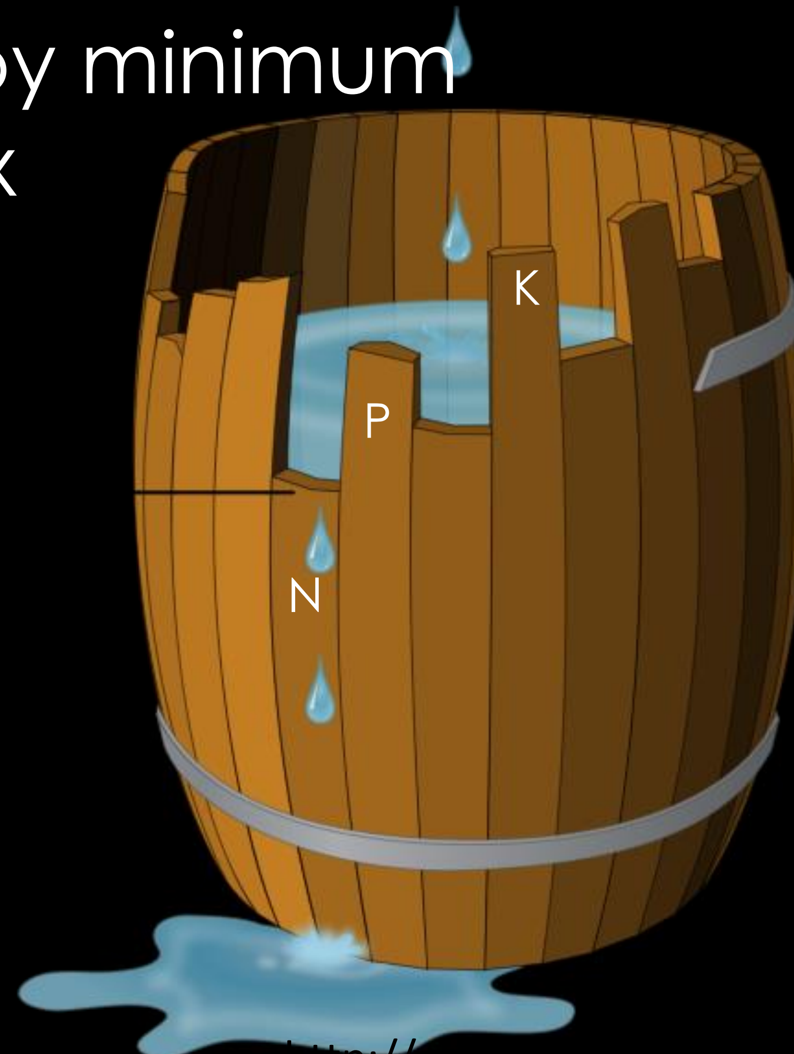
What happens to the soil when plants take up cations?

Plas ... Albany: Delmar Publishers.

Liebig's Law of the Minimum

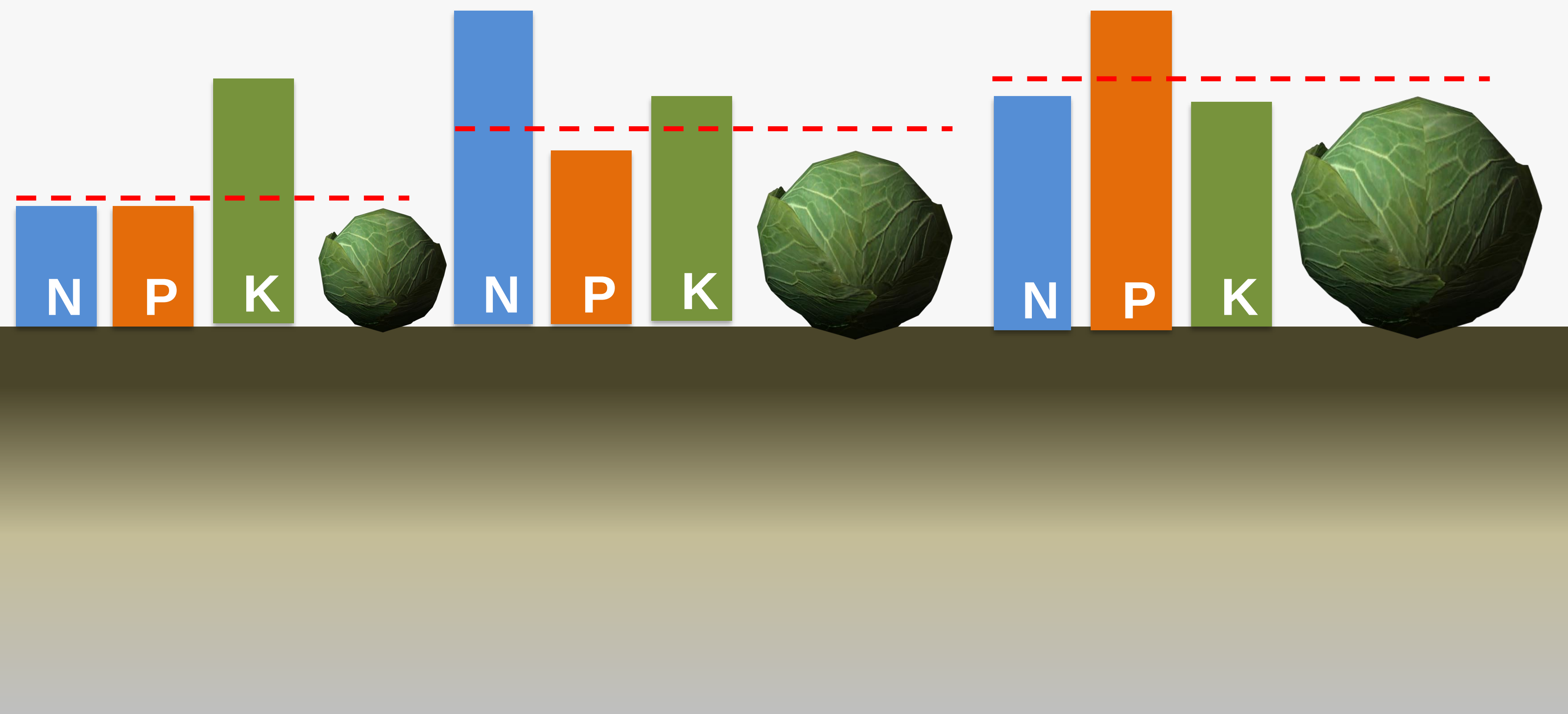
- Growth is controlled by minimum resources not the max



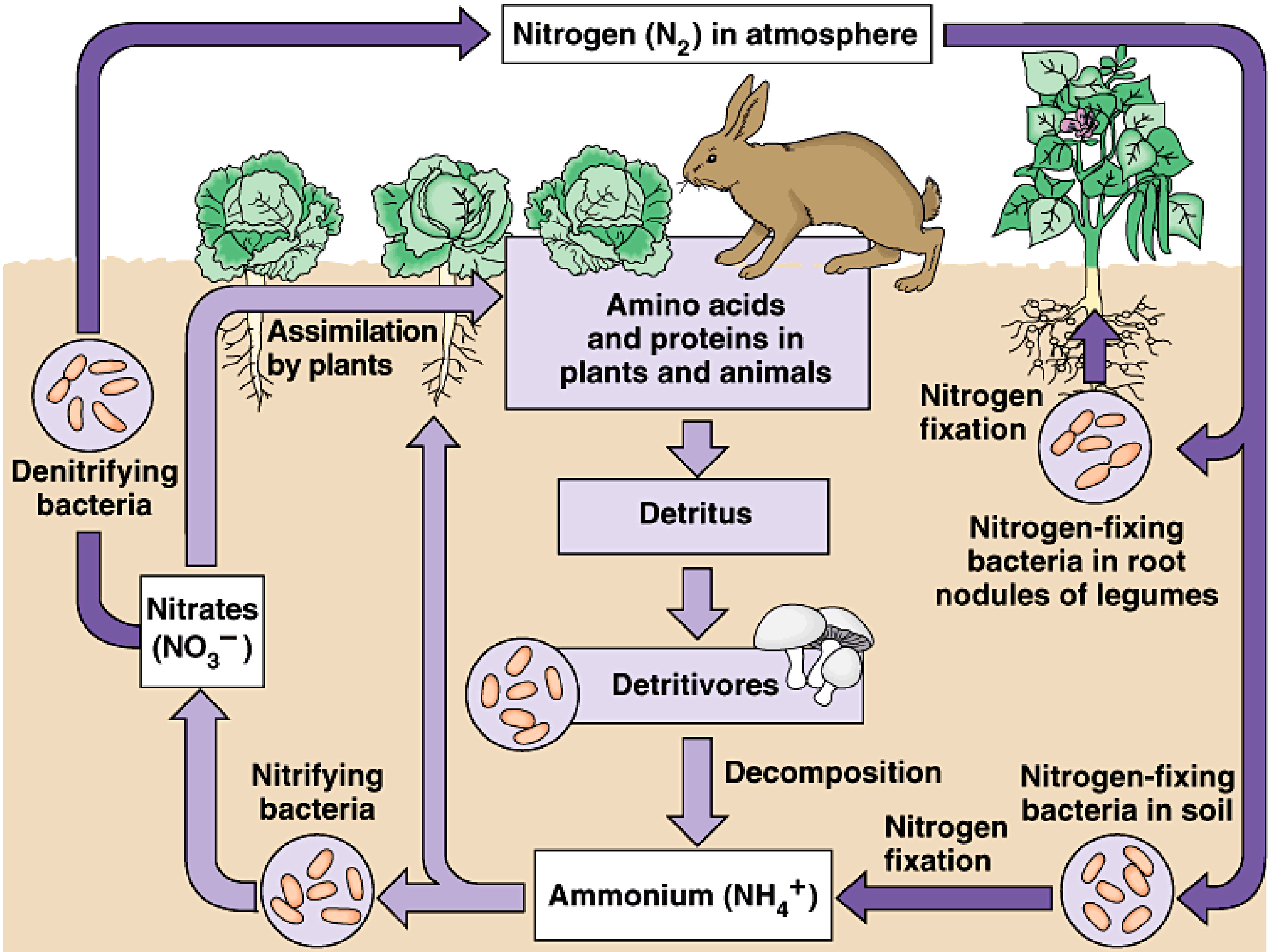


Carl Sprengel (1828) and later popularized by Justus von Liebig.

Liebig's Law of the Minimum



The Nitrogen Cycle



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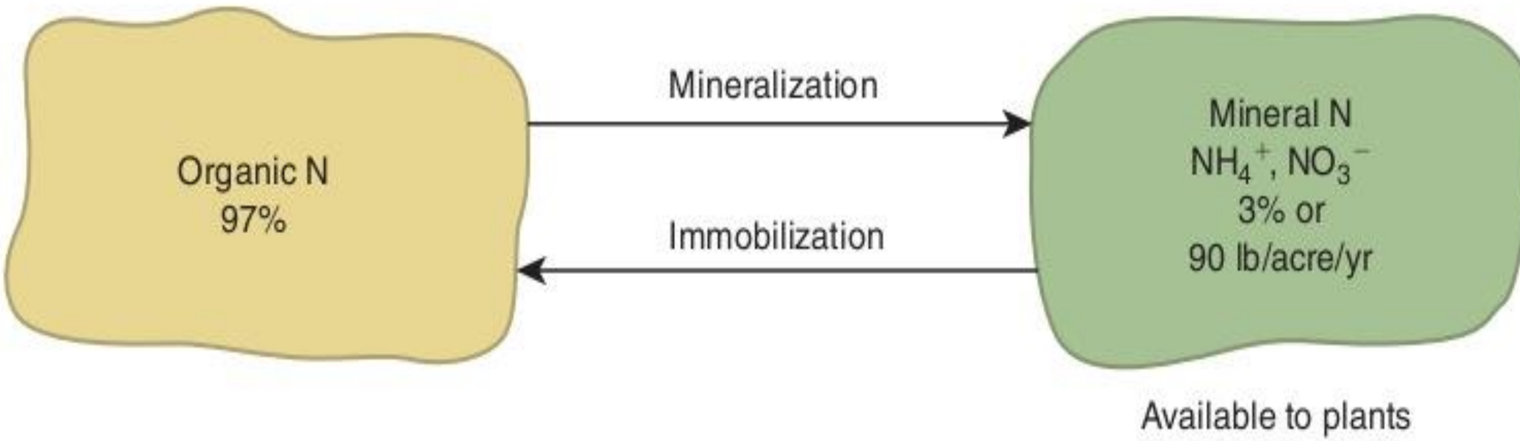
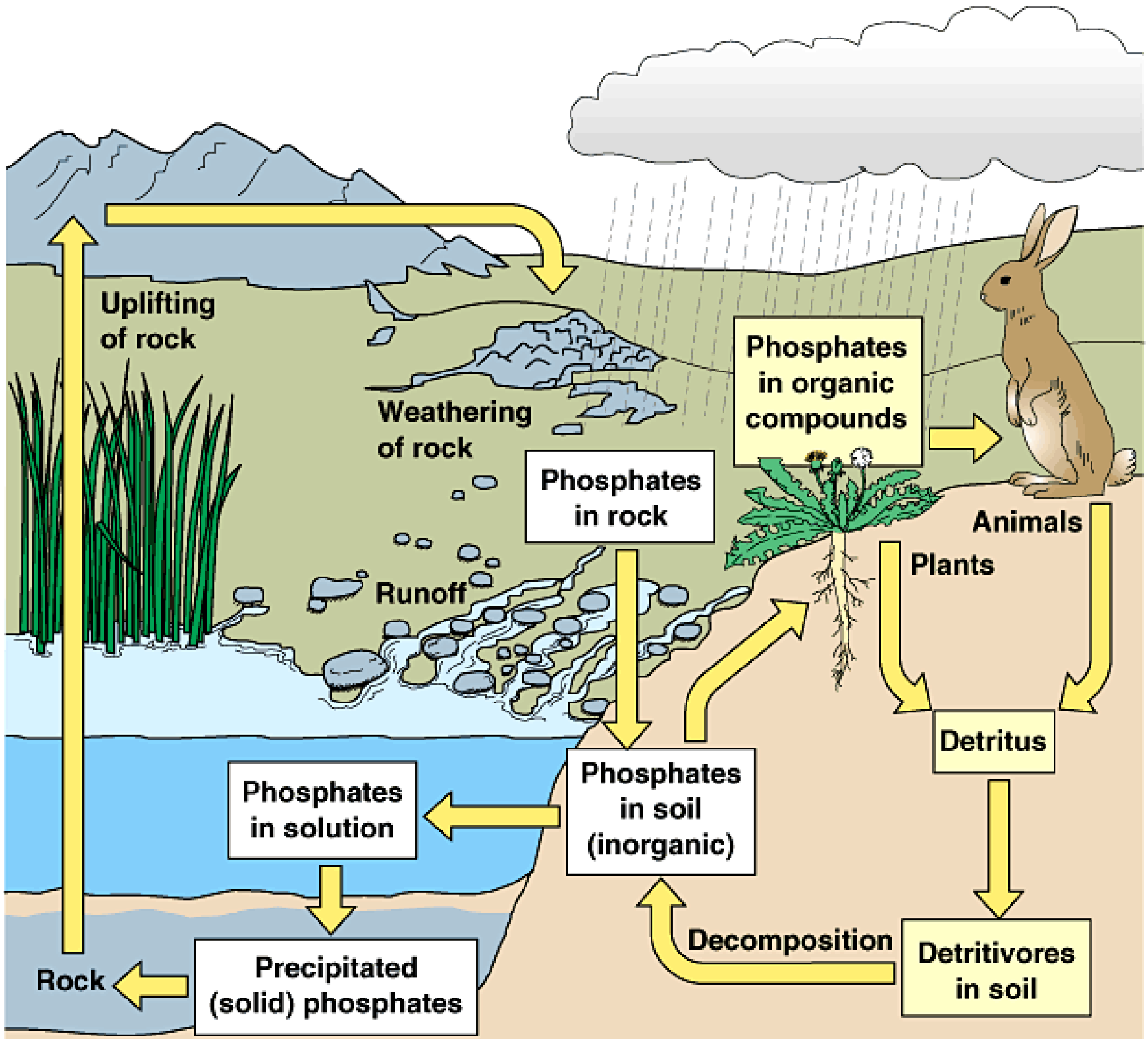
Forms of Nitrogen



The Phosphorus Cycle



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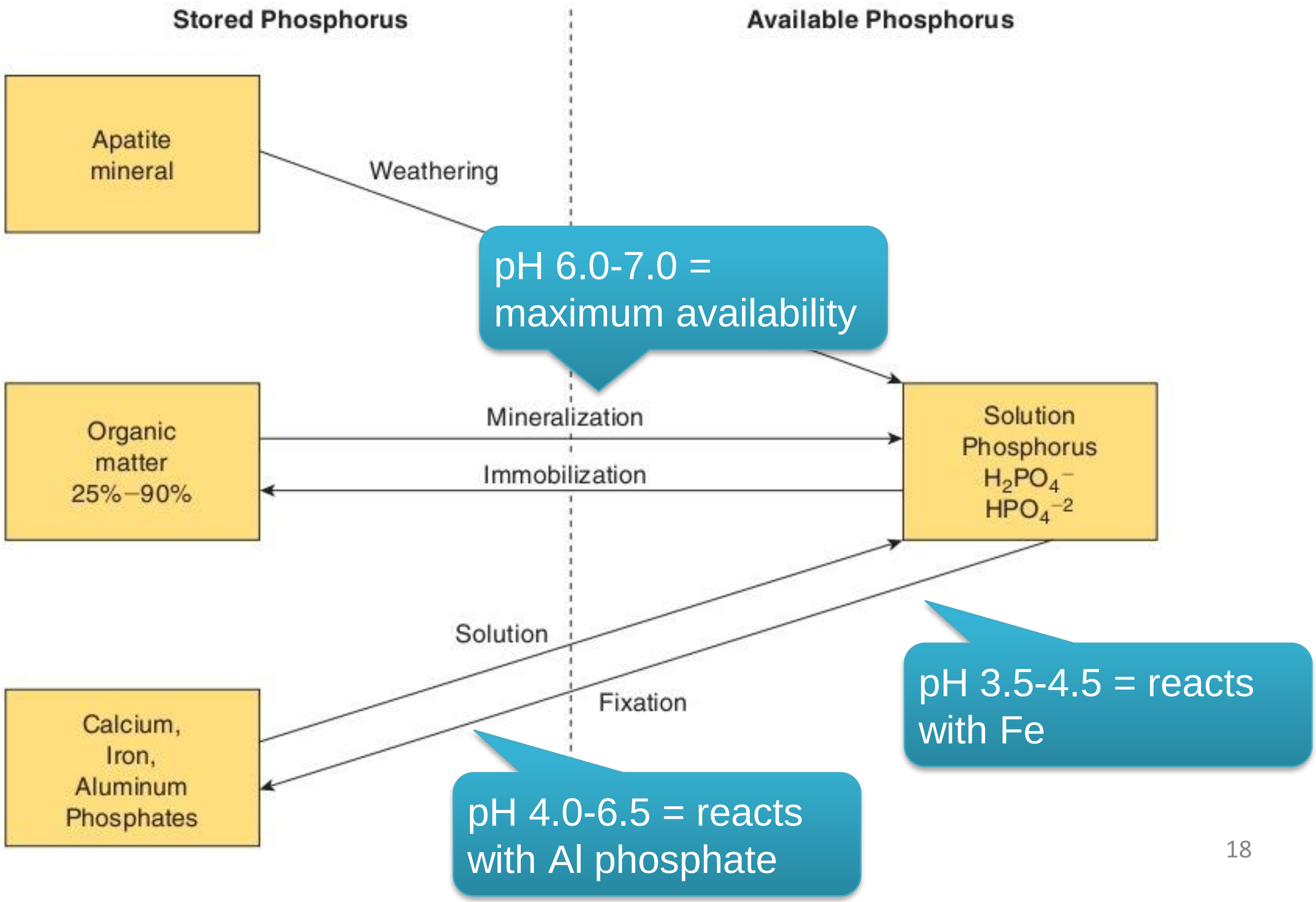
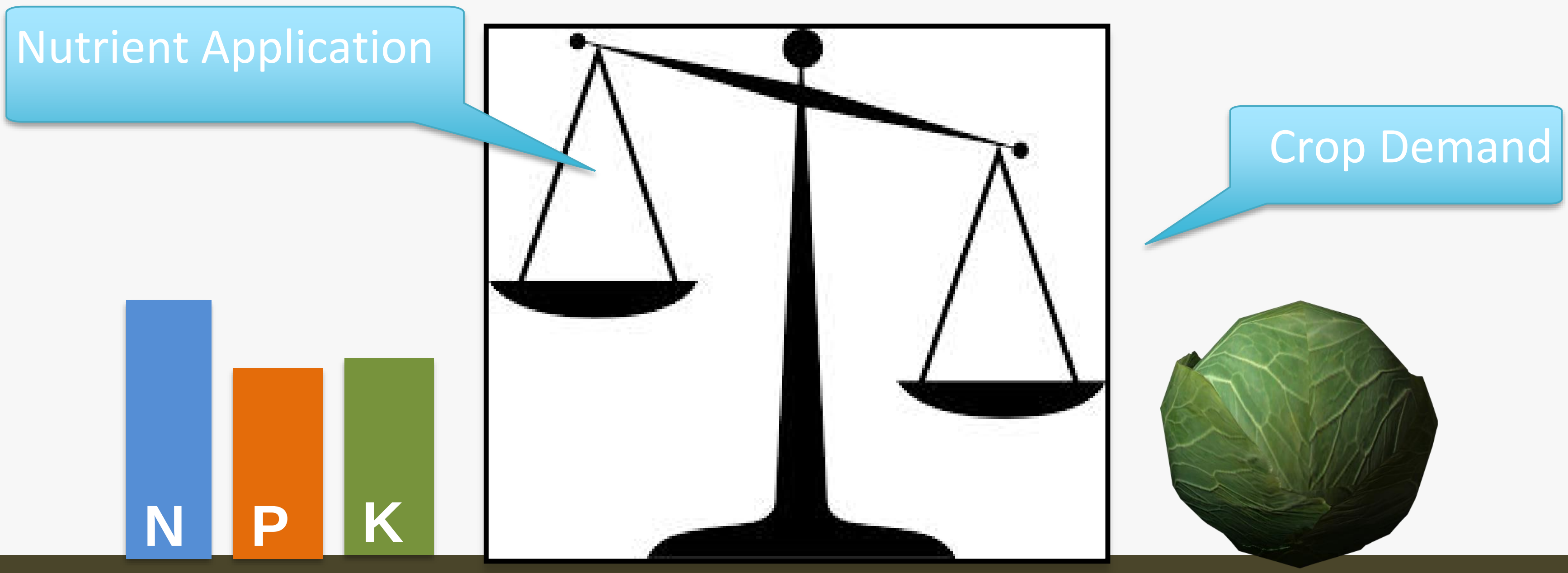
http://bioh.wikispaces.com/

Forms of Phosphorus (P)

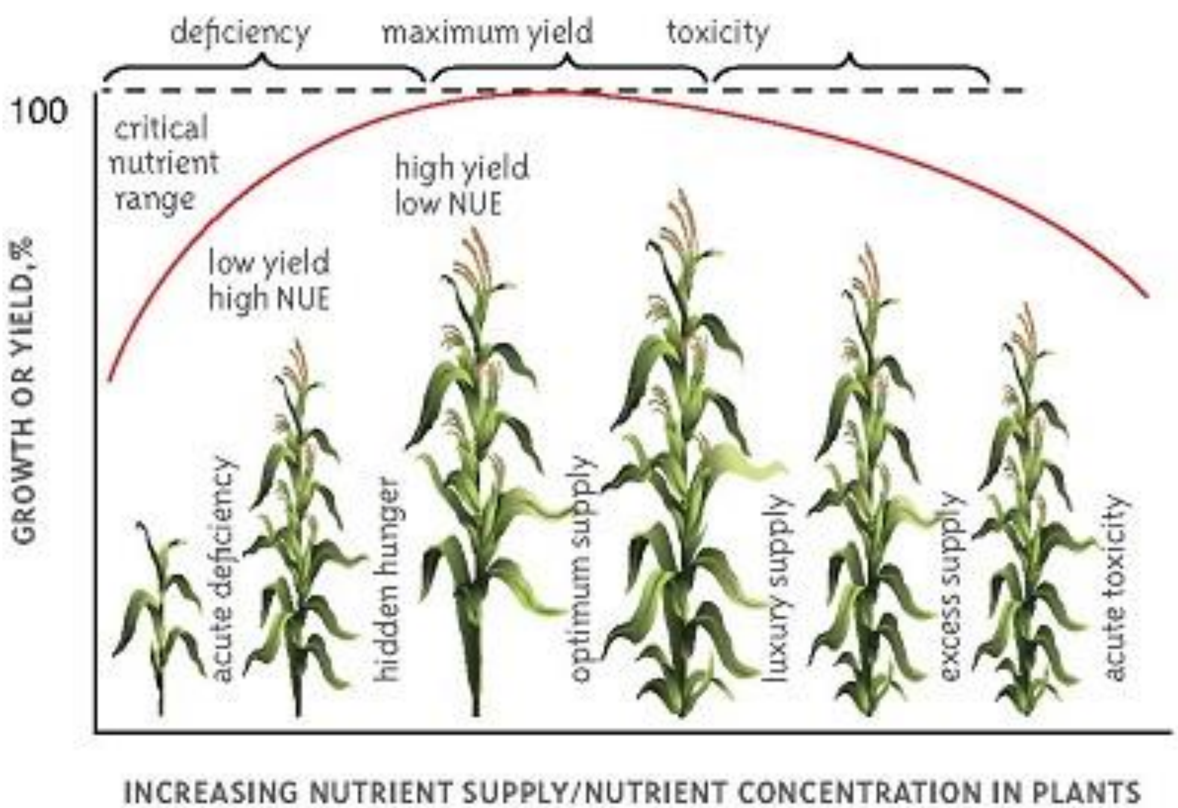



KUBOTA
Improving Nutrient Management

Balancing Nutrients



Not Enough to Too Much



The Most Basic Balance: Crop Removal

Fertilizer

N
300 kg/ha

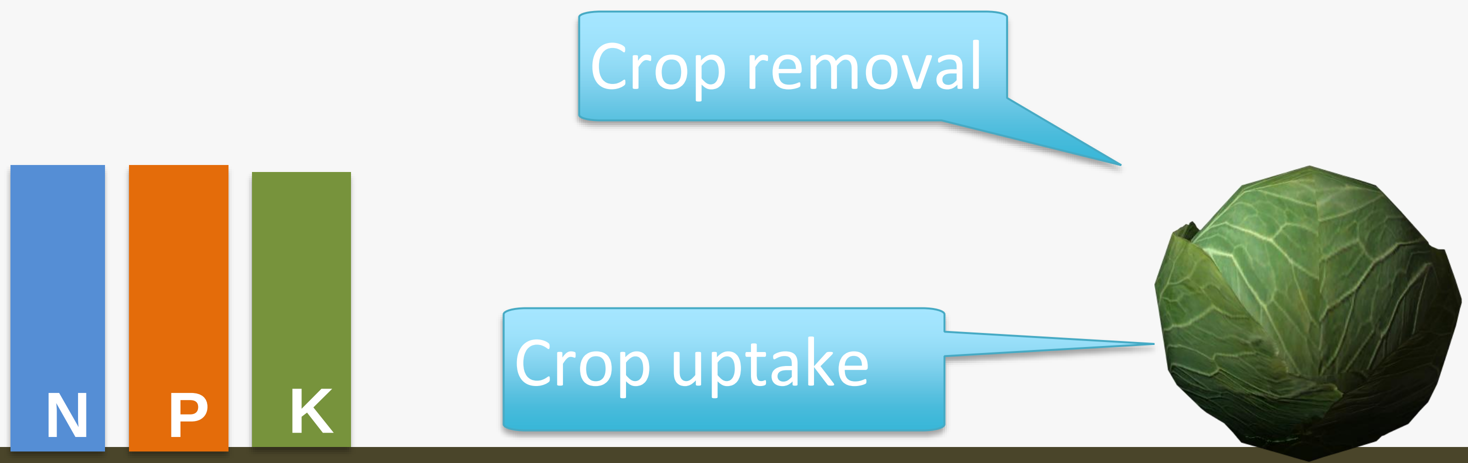
Crop

Crop Yield
10,000 kg/ha

Crop N
Content
3%

Crop N
Removal
300 kg /ha

Planning Nutrient Applications



Plant Needs

Pounds per Acre					
Grains		**N**	**P_2O_5**	**K_2O**	**S**
Spring Wheat	uptake[1]	76 - 93	29 - 35	65 - 80	8 - 10
40 bu/A *(2690 kg/ha)*	removal[2]	54 - 66	21 - 26	16 - 19	4 - 5
Winter Wheat	uptake	61 - 74	27 - 34	64 - 78	9 - 11
50 bu/A *(3360 kg/ha)*	removal	47 - 57	23 - 28	15 - 19	6 - 8
Barley	uptake	100 - 122	40 - 49	96 - 117	12 - 14
80 bu/A *(4300 kg/ha)*	removal	70 - 85	30 - 37	23 - 28	6 - 8

Uptake and Removal

- "Total nutrient uptake refers to the quantity of nutrients accumulated in the above ground or harvested portion of the plant at the time of sampling usually at the physiological maturity or when uptake is at its maximum."

- "Nutrient removal refers to the quantity of nutrient removed at the time of harvest."

http://www.ipni.net/

More Complex Balance: Soil tests

Soil

Soil Organic N
100 kg/ha

Soil Inorganic N
20 kg/ha

Soil N
21 kg/ha

Fertilizer

N
279 kg/ha

Crop

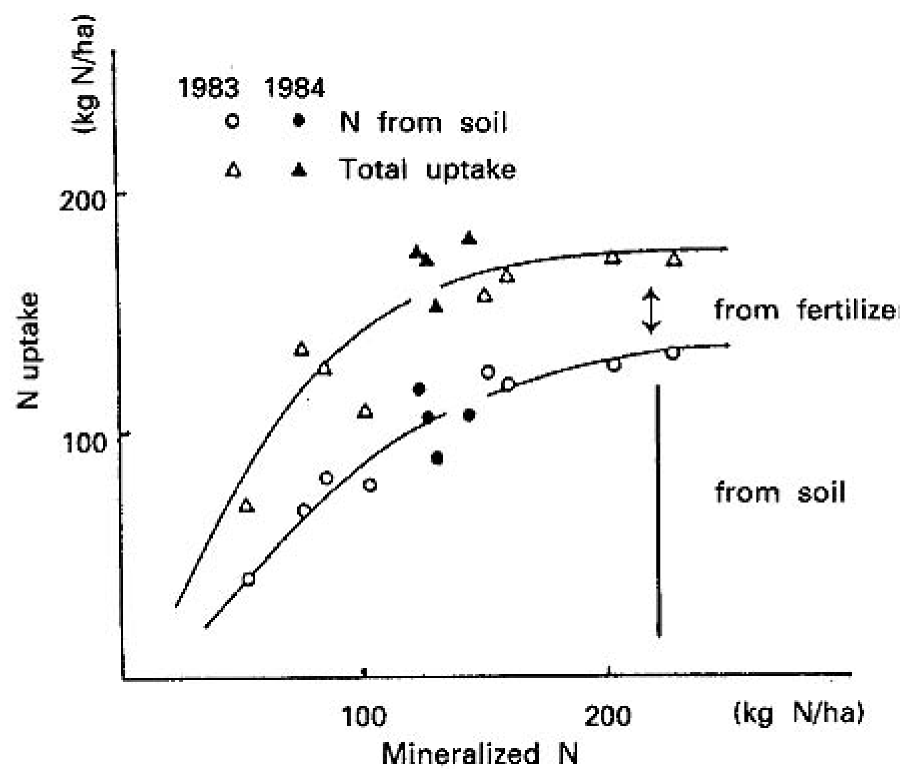
Crop Yield
10,000 kg/ha

Crop N Content
3%

Crop N Removal
300 kg /ha

Mineralization Rates

- 1 to 3.5% of the organic soil N is mineralized each year (Weil, 2017)
- Temperature
- Moisture
- Organic matter composition
- Soil acidity and high salt



(Saito and Ishii 1987)

An Agronomic Balance

Soil

Soil Organic N
100 kg/ha

Soil Inorganic N
20 kg/ha

Soil N
21 kg/ha

All Sources

Cover Crop N
50 kg/ha

Compost N
50 kg/ha

Fertilizer N
179 kg/ha

Crop

Crop Yield
10,000 kg/ha

Crop N Content
3%

Crop N Removal
300 kg /ha

Cover Crops

Table 1.—Nitrogen fate after rapid phase of cover crop decomposition is completed.[1,2]

Cover crop (%N in DM)	Growth stage	Biomass DM	Cover crop N uptake	N fate: N in soil organic matter	N fate: Plant-available N (PAN) NH_4-N + NO_3-N
		(lb/a)	(lb/a)	(lb/a)	(lb/a)
Common vetch (3% N)	vegetative	3,000	90	40	50
Cereal rye (2% N)	stem elongation	3,000	60	40	20
Cereal rye (1% N)	heading	8,000	80	107	-27

Sullivan and Andrews, 2012 Estimating plant-available nitrogen release from cover crops D.M. PNW 636

- Air Management
- Agroforestry
- Biodiversity
- Climate Action
- Soil & Nutrients
  - Mapping and Classification
  - Nutrient Management
  - Soil Management
- Strengthening Farming
- Agricultural Waste Management
- Water

Agricultural Soil & Nutrients

Effective soil management is critical for producing field crops. It begins with knowing basic physical and chemical properties of your soils from soil mapping and classification.

Soil and Nutrients for Crops

Soil Mapping and Classification

Knowing about soil at a given location is important for making decisions about land use and management. A variety of factors influence the soil properties at a given location, and the properties influence many aspects of soil and nutrient management.

- View resources for soil mapping and classification

Soil Management

The objective of soil management is to maintain soils in a physical, chemical and biological condition favourable for crop growth, while minimizing the risks to the environment from potential effects of erosion.

- Learn about soil management for crops

Nutrient Management

Nutrient management is about supplying crops with the appropriate amount, form, placement, and timing of nutrients (whether as manure, commercial fertilizer, or other nutrient sources) to optimize crop growth and minimize environmental risks.

- Learn more about nutrient management

Home » Organic Fertilizer and Cover Crop Registration

Organic Fertilizer and Cover Crop Registration

Thank you for your submission.

This free online tool compares the nutrient value and cost of cover crops, organic and synthetic fertilizers and compost. Use this Excel Calculator to develop well balanced and cost effective nutrient management programs for your farm. Developed by Nick Andrews, Dan Sullivan, Jim Julian and Kristin Pool.

Small Farms and Gardens Calculator: 1000 sq ft units (.xls)

This version works with fertilizers only and has a conversion sheet for estimating nutrients on a square foot basis.

Larger Farms Calculator: Acre units (.xls)

This version works with fertilizers and cover crops and makes calculations on a per acre basis.

Go back to the form

Plant Available Nitrogen (PAN)

Total nitrogen x mineralization rate + ammonium + nitrate

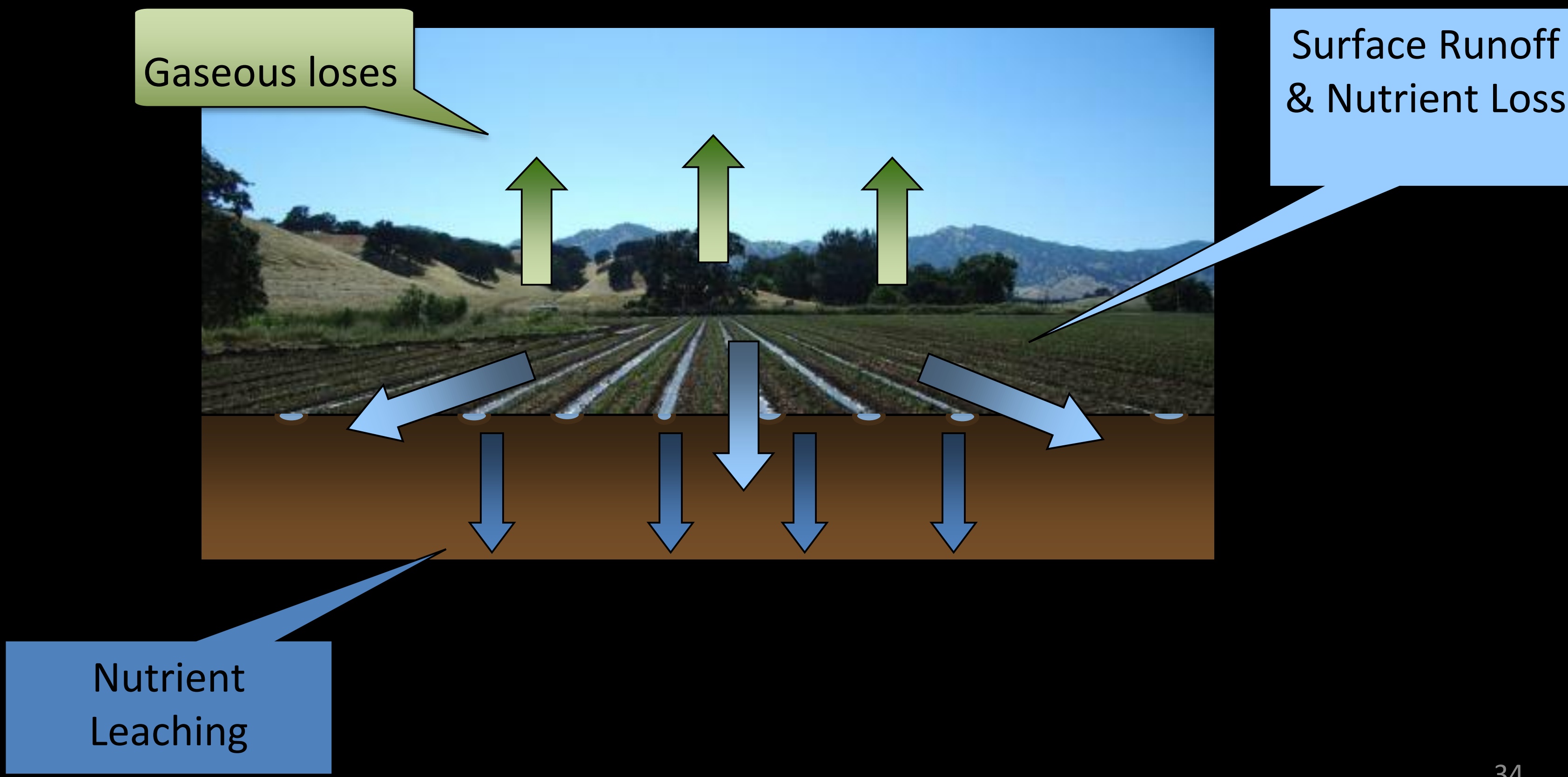
< 25:1
mineralization
(15-30%)

Compo		C:N Ratio	Total Nitrogen (%)	Ammonium (ppm)	Nitrate (ppm)
Food S		12	2	716	251
Poultry	[illegible]	12	4	10,177	362
On-Farm Composts	4	14	1	355	657
Beef	2	19	2	8	150
Fish	2	23	1	532	477
Horse	2	30	1	865	86

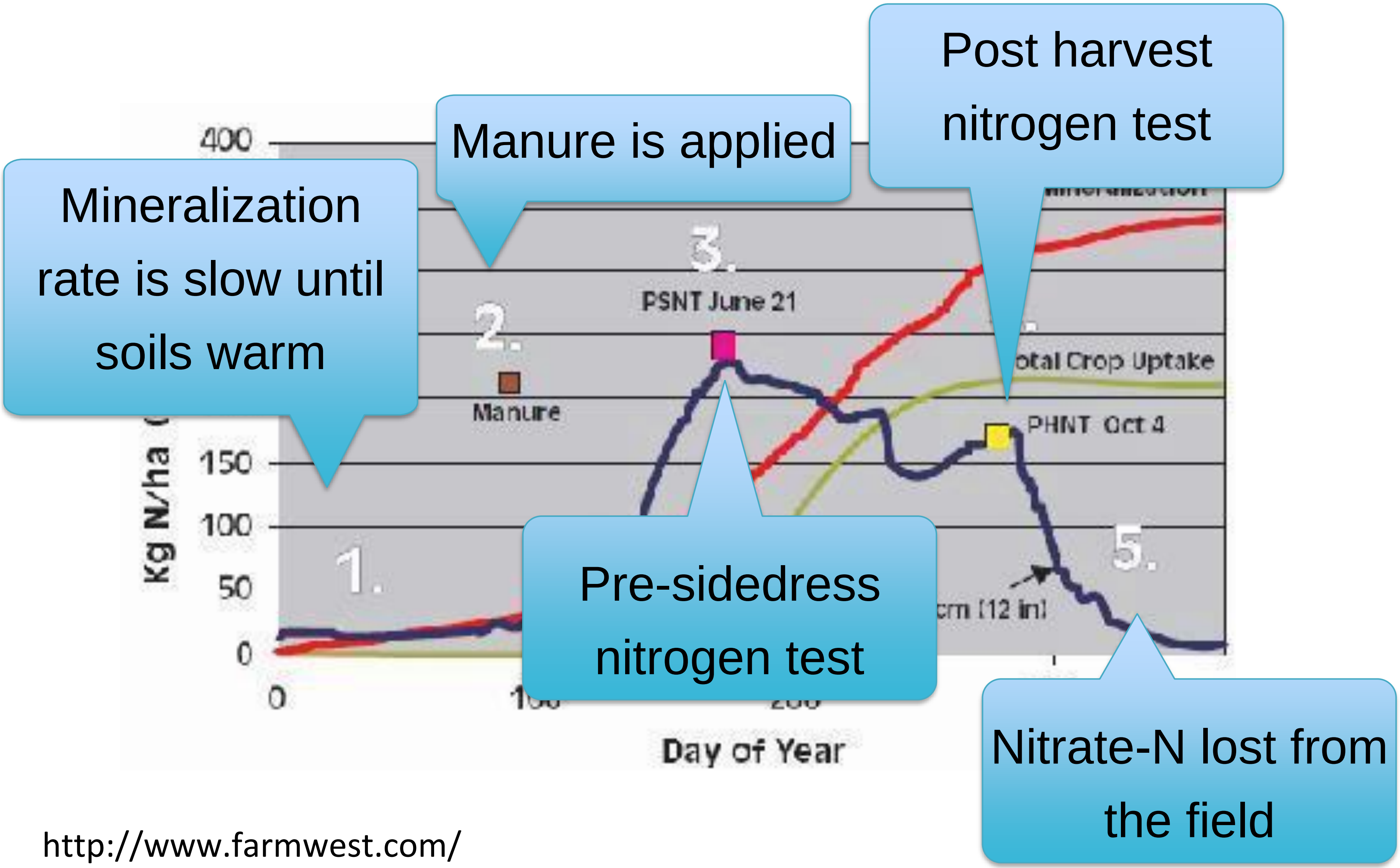
Organic Sources of Fertilizers

	Percentage, Dry Weight Basis		
Organic Material	N	P_2O_5	K_2O
Bat guano	10.0	4.0	2.0
Blood meal	12.0	2.0	1.0
Fish meal	10.0	6.0	—
Cotton seed meal	6.0	3.0	1.5
Soybean meal	7.0	1.2	1.5
Bone meal, raw	3.0	22.0	—
Bone meal, steamed	1.0	15.0	—
Wood ashes	—	1.0	4.0

Nutrient Losses



Modeling Timing with NLOS



http://www.farmwest.com/


UBC Research
Sustainable Agricultural Landscapes Lab Nutrient Management Research

UBC Farm Organic Amendments Trial

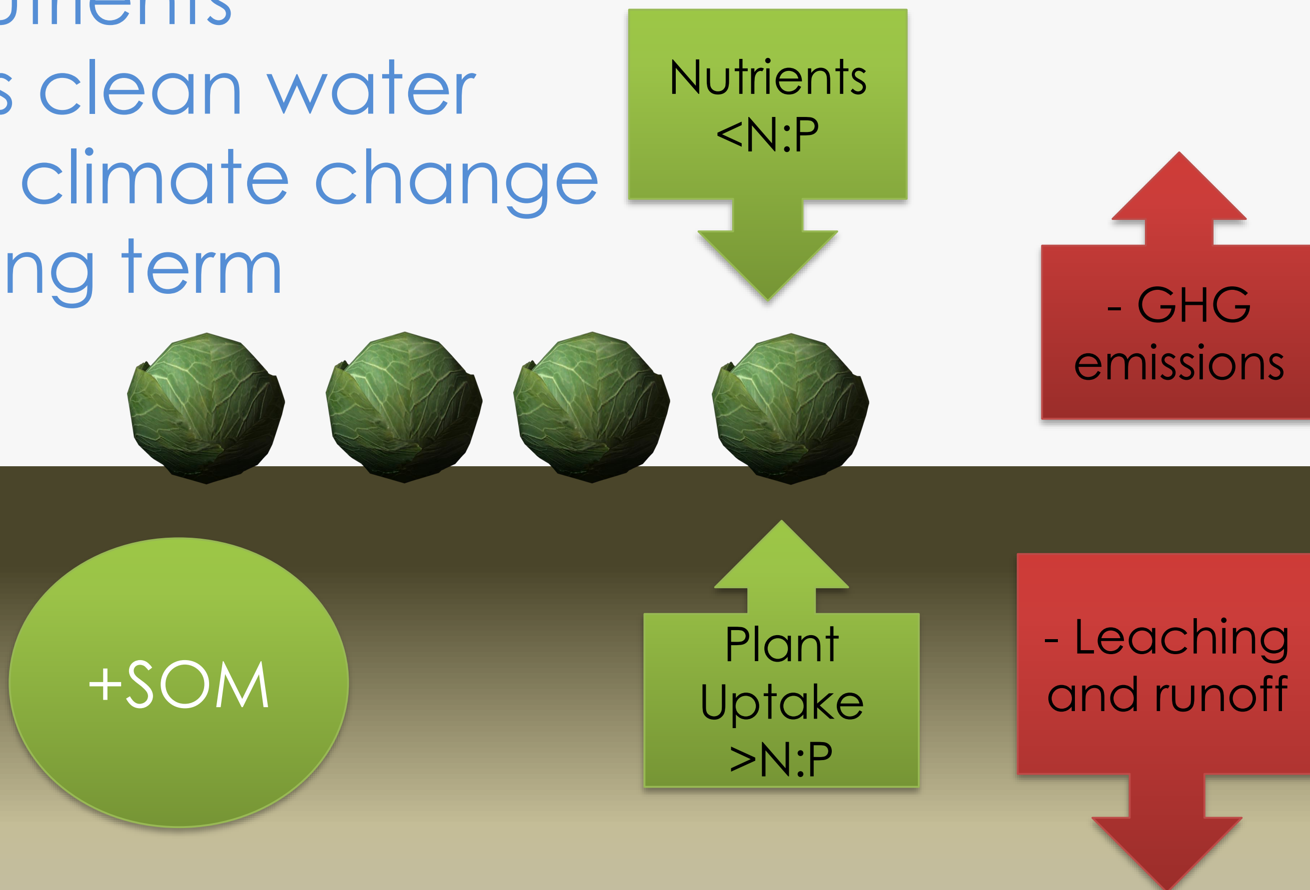
Objective

How can we use manures and composts to maximize N availability and limit P over-fertilization and other environmental impacts?

Gabriel Maltais-Landry

Sustainable Nutrient Management

- Provides food
- Cycles nutrients
- Maintains clean water
- Mitigates climate change
- For the long term



Organic amendments at UBC farm

Four treatments

- **Low Compost:** municipal compost matching P removal
- **High Compost:** municipal compost matching crop N demand
- **Manure:** poultry manure matching crop N demand
- **Hybrid:** control + blood meal to match crop N demand

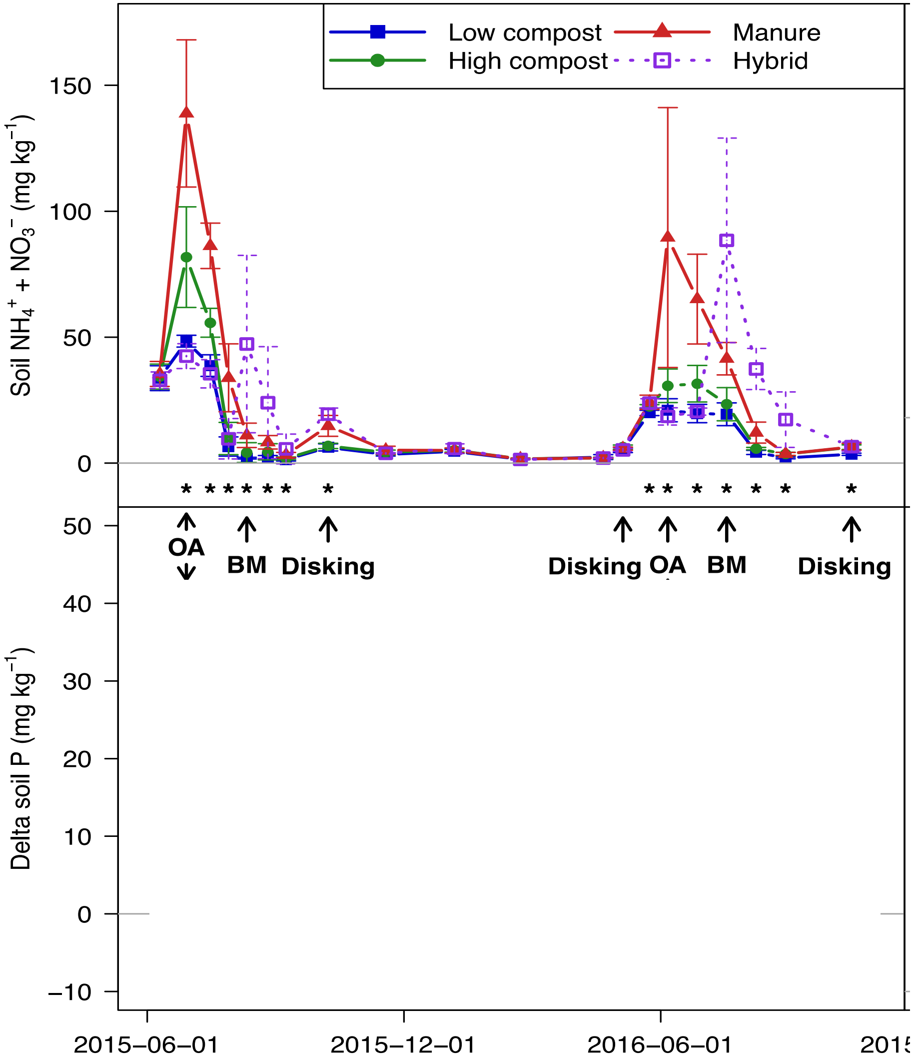
Maltais-Landry, G. and Smukler, S. In prep.
gabriel.maltais.landry@gmail.com

Nutrient budgets for 2015 (kg ha^{-1})

	Inputs		Target	
	$N_{available}$	P	N demand	P removal
L. Compost	20	25	150	25
H. Compost	150	170		
Manure	150	130		
Hybrid	150	25		

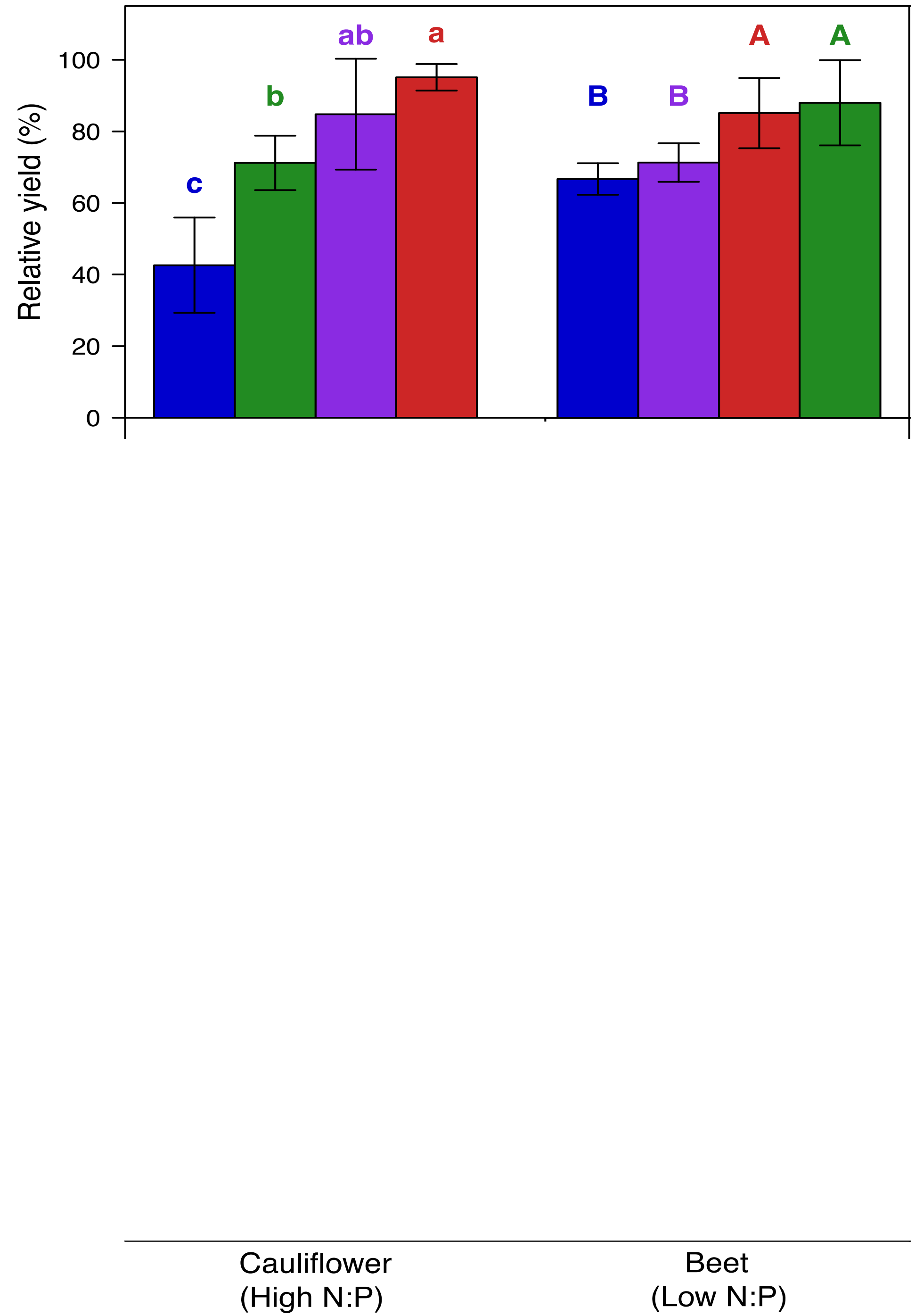
Maltais-Landry, G. and Smukler, S. *In prep*

Nutrient Dynamics



Maltais-Landry, G. and Smukler, S. *In prep*

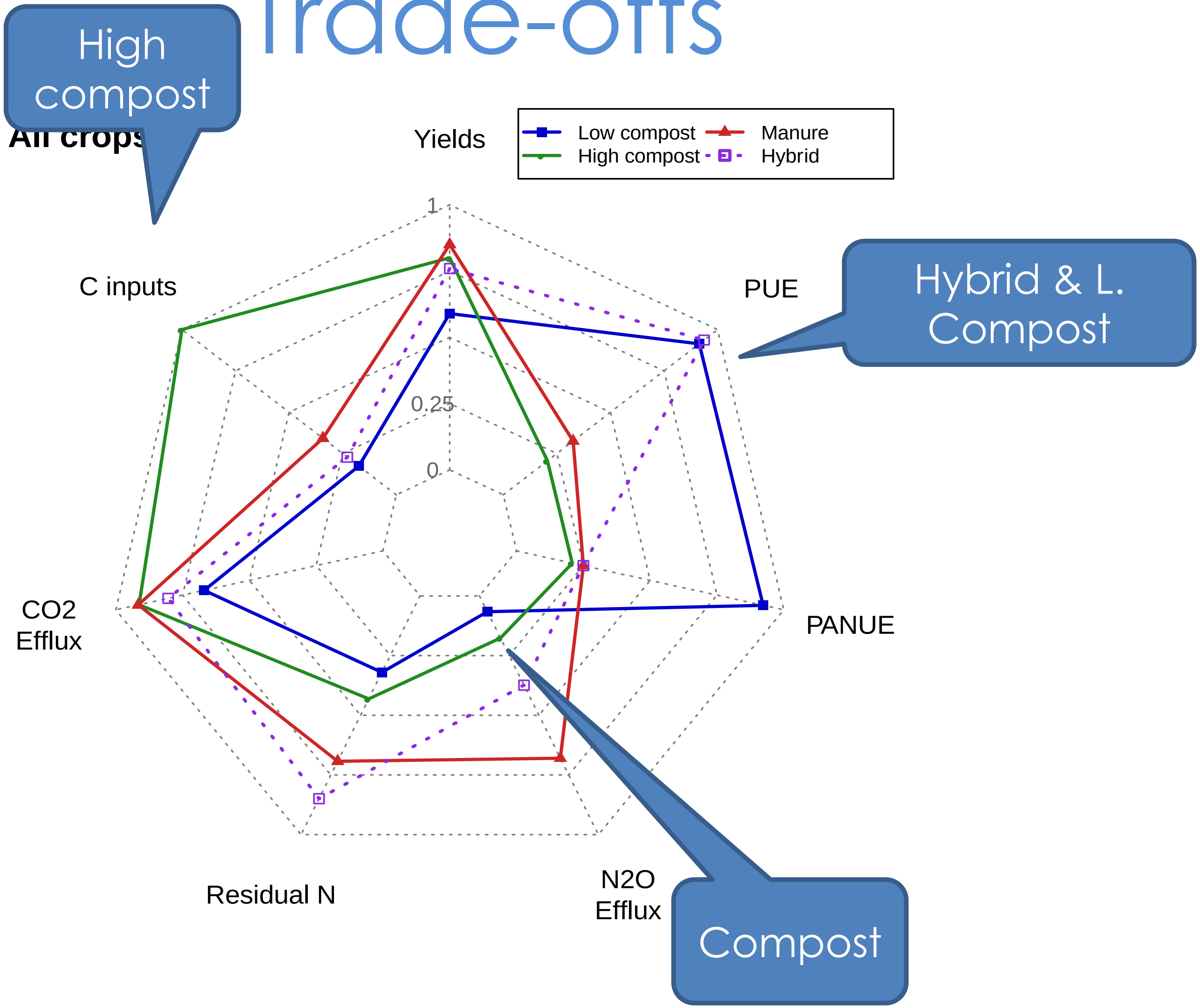
Crop Yields



- Low compost
- High compost
- Manure
- Hybrid

Maltais-Landry, G. and Smukler, S. *In prep*

Trade-offs



Maltais-Landry, G. and Smukler, S. *In prep*

Conclusions and Next Steps

- A hybrid system can balance N:P without yield reductions
- Emissions are reduced (in field) by the use of compost
- Multiple crops continue to be a challenge

Current Research Questions

- What combinations of organic amendments (compost, cover crop, fertilizer, etc.) are most likely to meet crop demand?
- How can nutrient cycles in organic farming systems be modeled more accurately to help producers choose nutrient strategies to meet crop demands using available organic nutrient sources (compost, cover crop, fertilizer, etc.)?
- What are the trade-offs of these strategies in terms of economics, yield, and the environment?

Controlled, Experimental Research Sites

DeLisa Lewis, PhD
Farmer
UBC Research Associate

Two Sites

- Vancouver: UBC Farm:
- Duncan: Green Fire Farm

Trialing 4 strategies:

1. ***Control***: No application
2. ***Calculated***: Target N with compost
3. ***Precision***: Target P with compost, meet N demand with organic fertilizer
4. ***Typical***: Business as Usual

Regional Field Trials

- Overview
  - 19 farms in 3 regions
  - Trialing 3 strategies:
    - *Calculated*: Target N with compost
    - *Precision*: Target P with compost, meet N demand with organic fertilizer
    - *Typical:* Business as Usual

Mineralization Rates

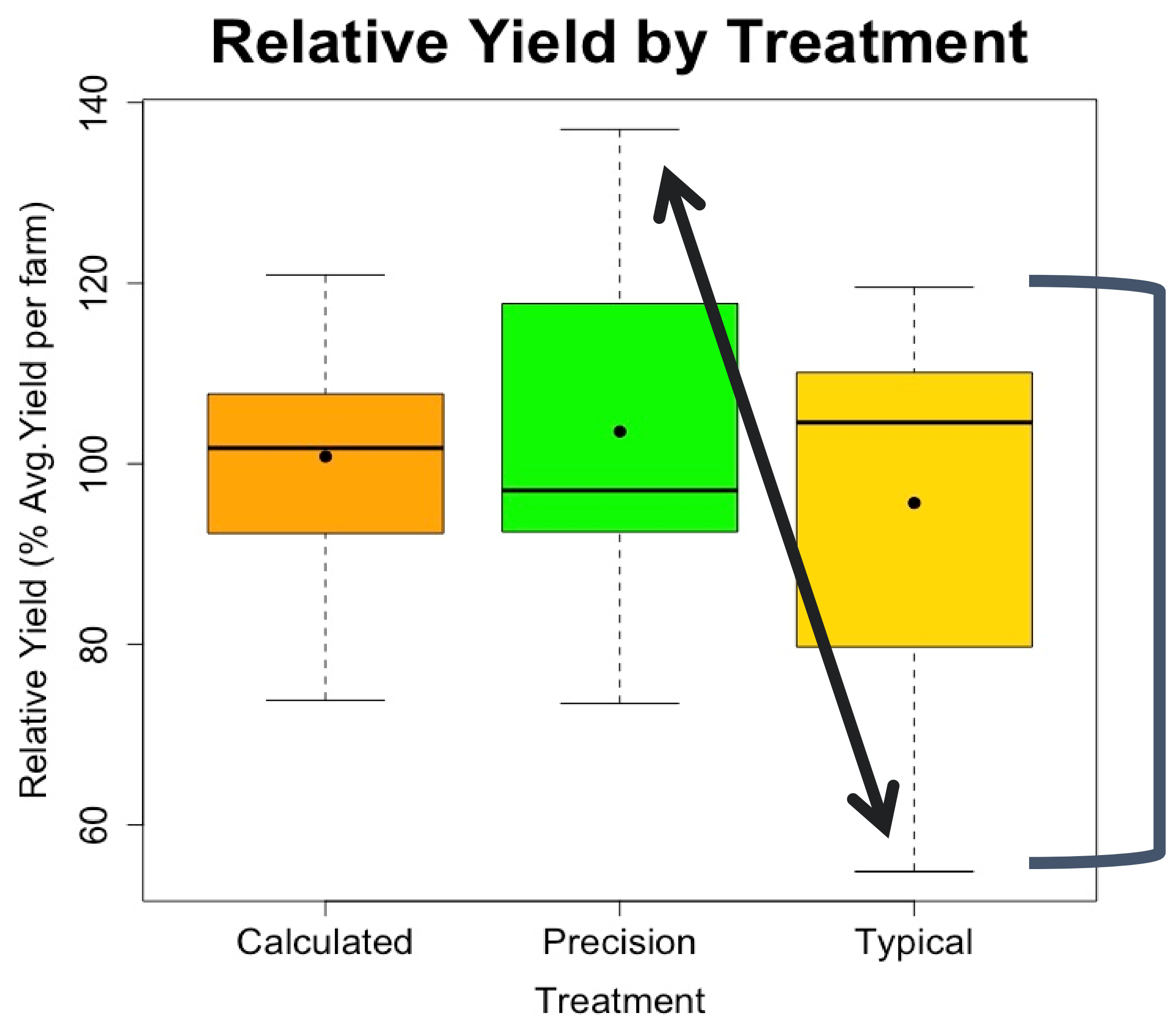
- 2018: 15%
- 2019: product-specific

Amy Norgaard
MSc Student

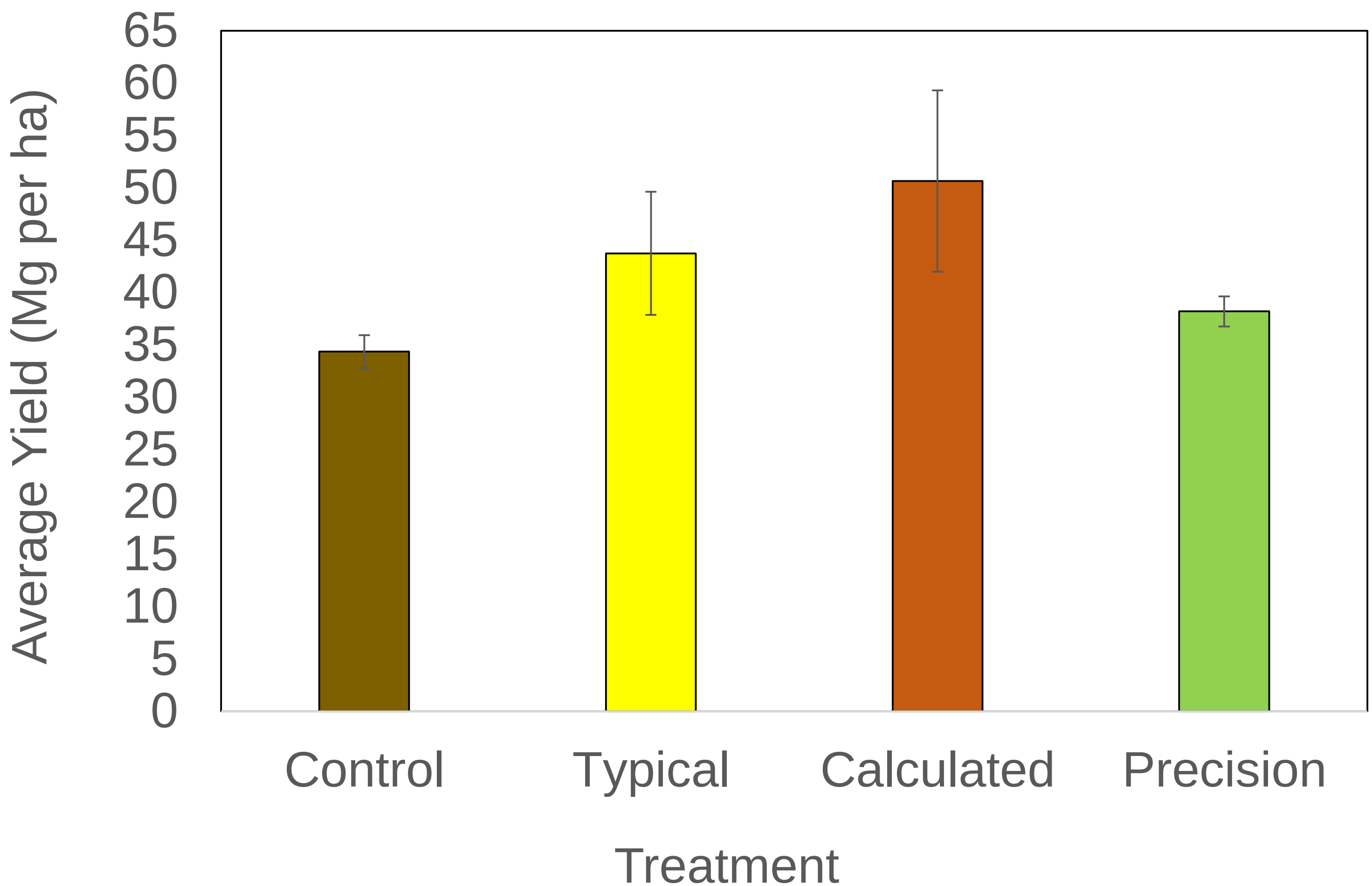
Evaluation of Trade-offs

Photo by Amy Norgaard

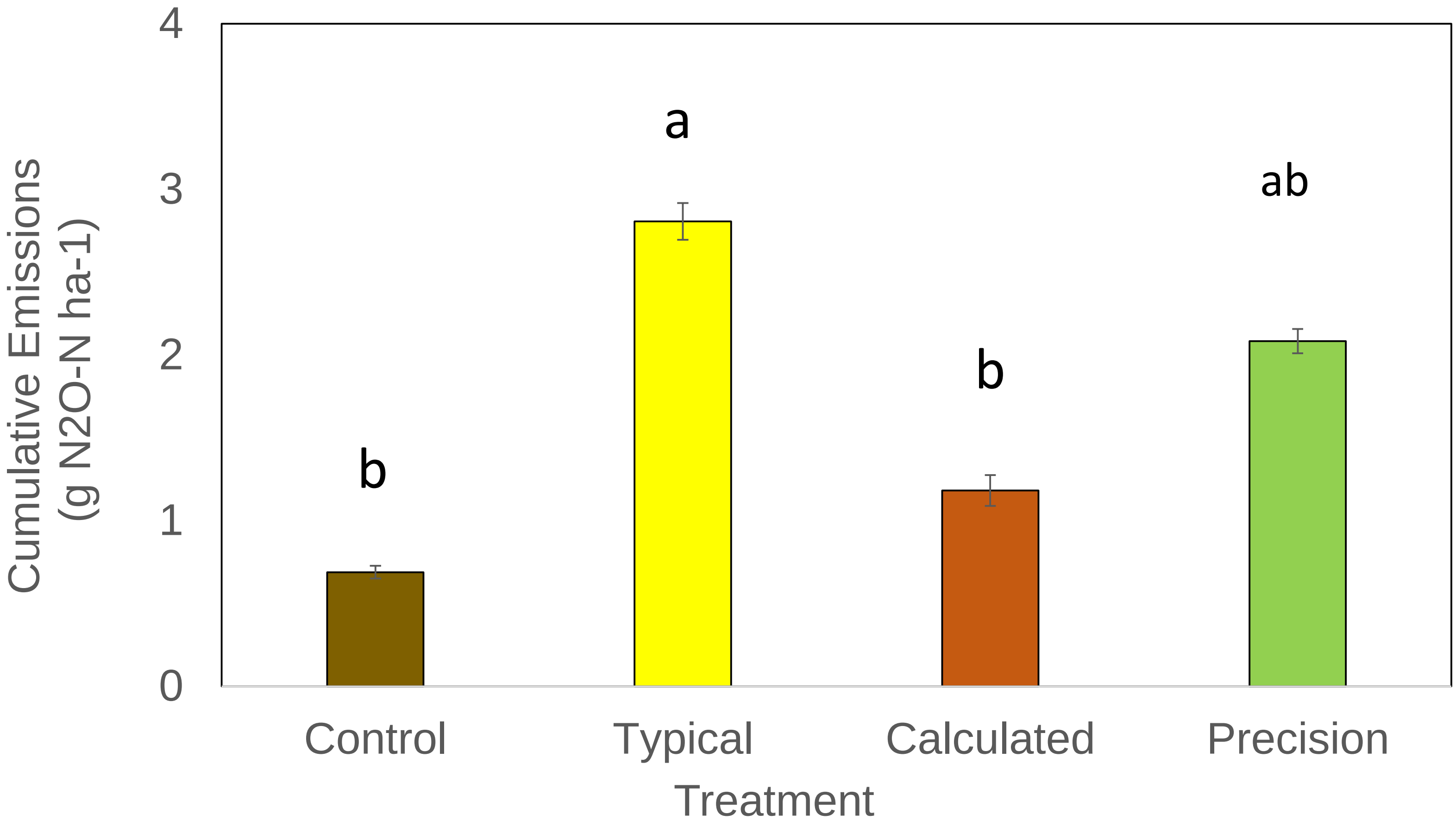
2018 Regional Preliminary Results (n=13)



UBC Farm Yields 2018



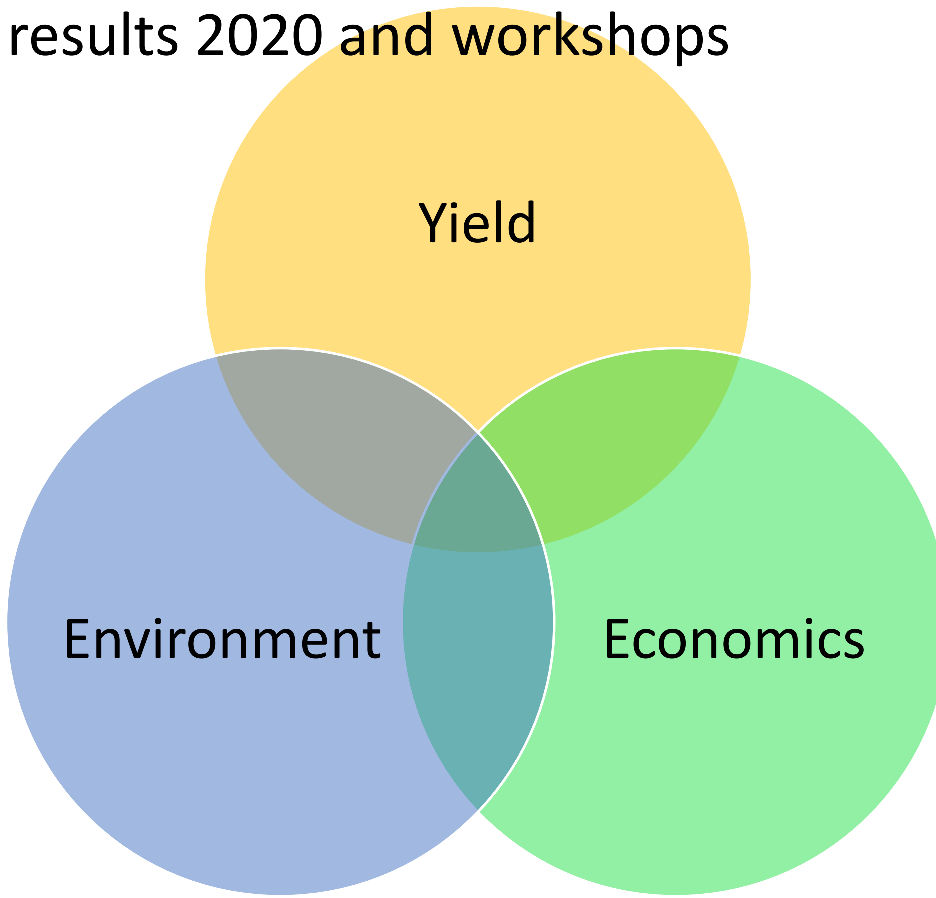
Nitrous Oxide Emission 2018



Next Steps

Timeline

- Data collection 2018 & 2019
- Final results 2020 and workshops



Questions

- Sean Smukler
  - sean.smukler@ubc.ca
- Sustainable Agricultural Landscapes Laboratory website
  - http://sal-lab.landfood.ubc.ca/