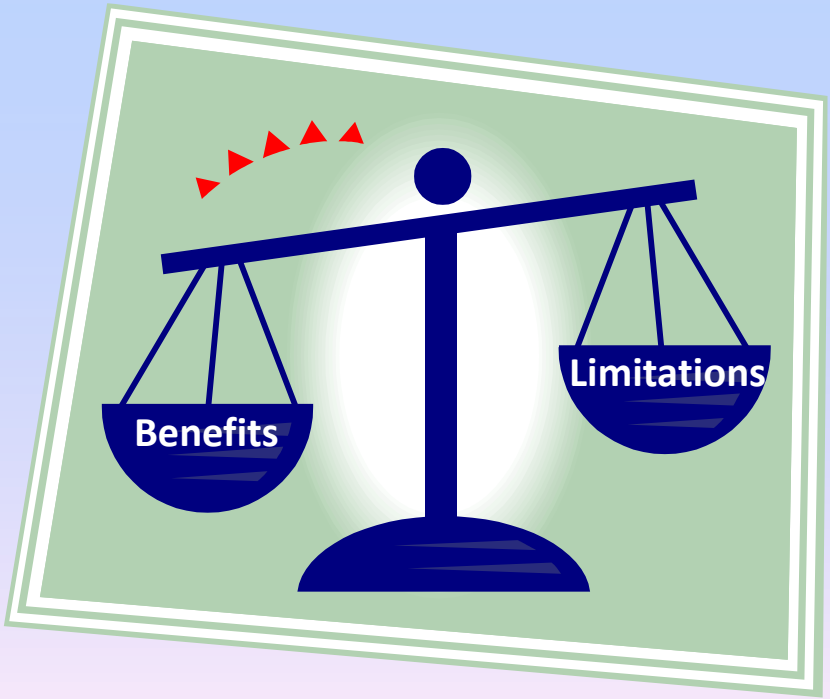
Soil Testing with (Real) Intelligence: Maximizing Benefits, Minimizing Limitations

Don Flaten, U of M Professor Emeritus, C.R.O.S.S.*



* Cranky Retired Old Soil Scientist

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Outline

Exploring questions … and sharing ideas about:

With crop producers' cost-price squeeze, 4R Nutrient Stewardship and soil testing are especially important now.

But how many farmers are routinely soil testing?

Why are some farmers not routinely soil testing?

How can we use sound science and "real" intelligence to improve soil testing's reliability, value, and farmer-confidence … to maximize soil testing's benefits and minimize its limitations?

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Fertilizer costs are high … but crop prices are not …

Manitoba Agriculture - Crop Production Costs 2026 Guidelines ($/Acre)

	HRS Wheat	Canola	Soybeans	Peas
Estimated Operating Costs				
Seed & Treatment	$ 32.00	$ 82.50	$ 90.00	$ 49.50
Fertilizer	$ 132.90	$ 150.30	$ 50.35	$ 34.02
Crop Protection	$ 50.25	$ 68.75	$ 23.25	$ 42.50
Other Operating Costs	$ 149.74	$ 148.86	$ 150.21	$ 158.08
Total Operating Costs	$ 364.89	$ 450.42	$ 313.81	$ 284.10
Land & Machinery Costs	$ 191.58	$ 191.58	$ 191.58	$ 191.58
Owners - Labour & Living	$ 28.00	$ 28.00	$ 28.00	$ 28.00
Total Costs	$ 584.46	$ 669.99	$ 533.39	$ 503.67
Estimated Revenue				
Target Price $ per bushel	$ 7.75	$ 14.25	$ 12.75	$ 6.00
Target Yield (bu/acre)	66	45	42	55
Gross Revenue / acre	$ 511.50	$ 641.25	$ 535.50	$ 330.00
Marginal Returns				
Over Operating Costs	$ 146.61	$ 190.83	$ 221.69	$ 45.90
Over Operating & Fixed	-$ 44.96	-$ 0.74	$ 30.11	-$ 145.67
Over Total Costs (Net Profit)	-$ 72.96	-$ 28.74	$ 2.11	-$ 173.67

Farmers are at the high stakes poker table … again

High fertilizer costs and modest crop prices for crops have increased the financial risks from inefficient use of fertilizer

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4R Nutrient Stewardship More Important Than Ever

4R Nutrient Stewardship

- ✓ Right rates
- ✓ Right sources
- ✓ Right placement
- ✓ Right timing

4R Soil Testing … every field, every year

- ✓ Right sampling
- ✓ Right analyses
- ✓ Right recommendations
- ✓ Right data management & use

A sound 4R Nutrient Stewardship strategy relies on soil testing every field/mgmt zone … every year … to:


Photo: Amy Mangin

1. Predict fertilizer and/or manure requirements for the next crop, based on existing reserves in soil and current goals for the fertility program in each field or management zone
2. Diagnose "unusualities" … e.g., areas of unusually good or poor crop growth
3. Evaluate/audit the current nutrient management plan for the most recent crop(s) … e.g., excess N fertilization or more N mineralization than immobilization
4. Monitor for long-term upward or downward trends in soil fertility and soil health … e.g., decreasing soil test P, increasing salinity or acidity

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But how many farmers are routinely soil testing?

According to Statistics Canada surveys, soil testing is a very popular practice in the Prairies, e.g. in 2021 the percentage of farmers who "tested soil for nutrient content" was:

- 92% in Manitoba
- 88% in Saskatchewan
- 84% in Alberta

But the percentages of farmers who "tested soil for nutrient content every year" was only:

- 62% in Manitoba
- 40% in Saskatchewan
- 36% in Alberta

Source: Statistics Canada Table: 32-10-0386-01 https://doi.org/10.25318/3210038601-eng

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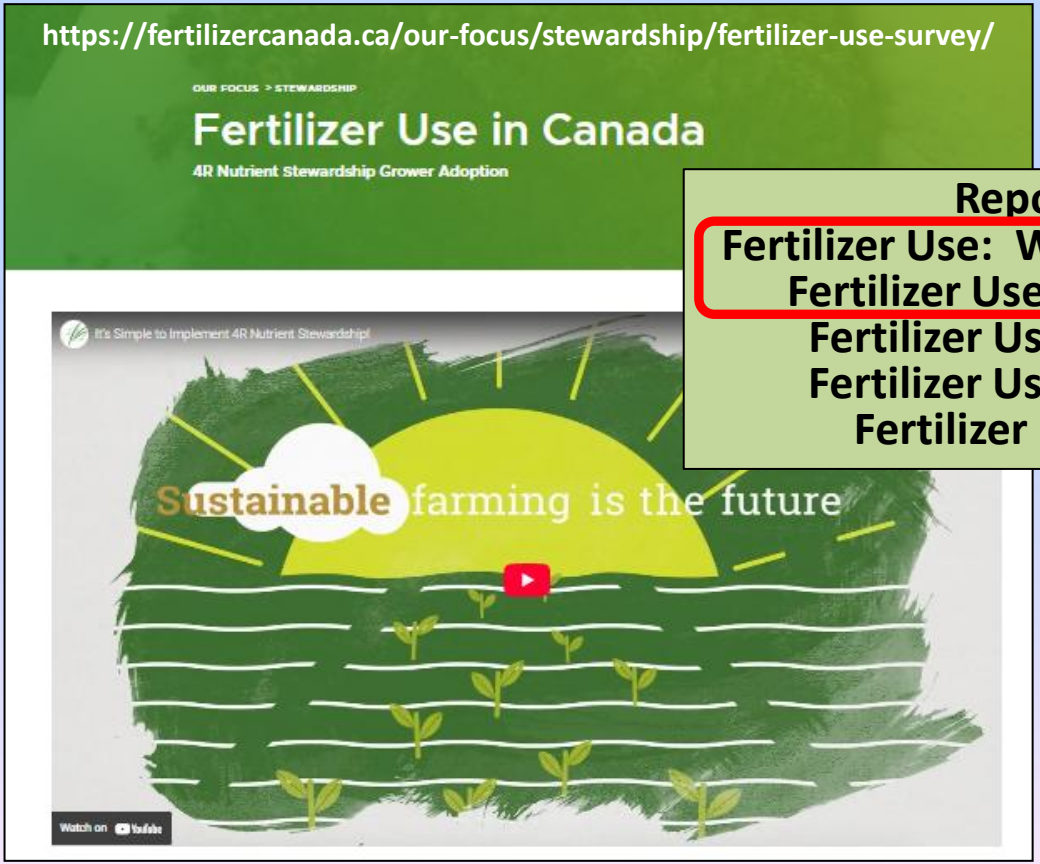
Fertilizer Canada's Detailed Survey of Fertilizer Use Conducted by Stratus Ag Research (Nov-Dec 2024)

https://fertilizercanada.ca/our-focus/stewardship/fertilizer-use-survey/



Reports

Fertilizer Use: Western Canada
Fertilizer Use: Manitoba
Fertilizer Use: Ontario
Fertilizer Use: Quebec
Fertilizer Use: PEI

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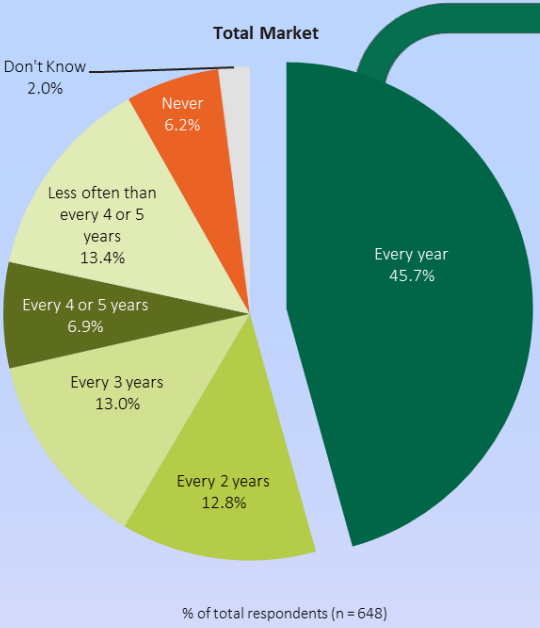
Fertilizer Canada's Detailed Survey of Fertilizer Use Conducted by Stratus Ag Research (Nov-Dec 2024)

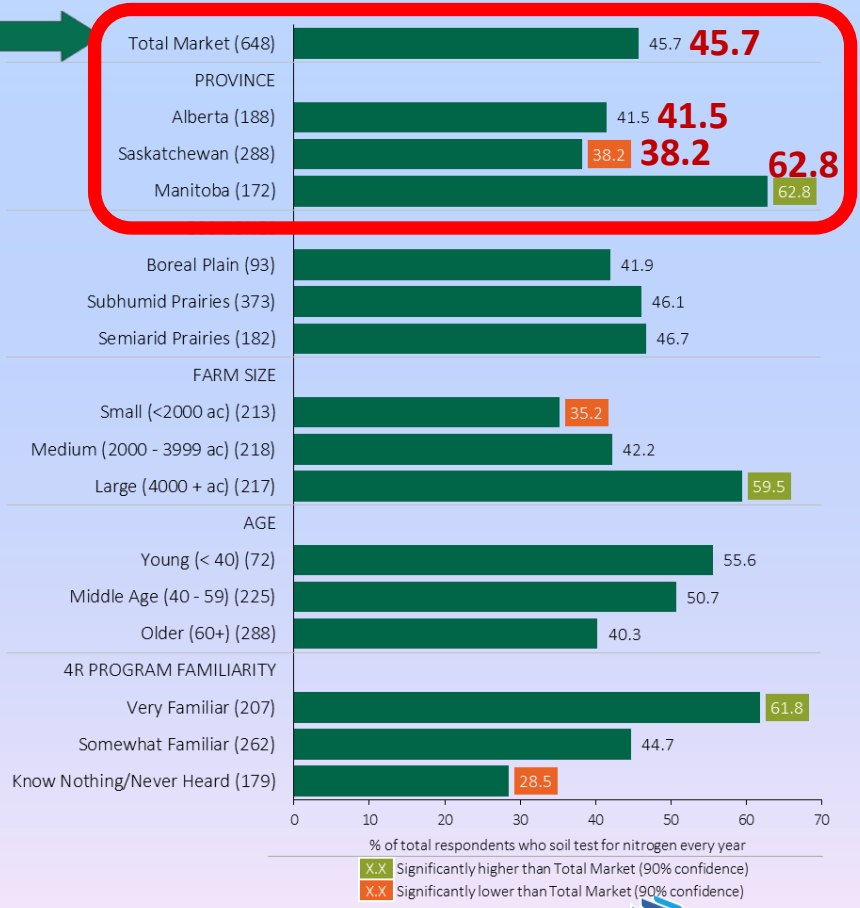
e.g., 4R Nutrient Stewardship in Prairie Canola Production

"Rate determination is the primary barrier to 4R compliance"

- **Most canola acres meet the "Advanced 4R" criteria for N source, timing and placement [… but not rate?]**
- **42% of canola acres meet the "Basic 4R" criteria for P**
- **26% of canola acres meet all "Basic 4R" criteria for both N & P**
- **63% of canola growers say they use the same fertilizer rate on all their canola fields**

% of Prairie Farmers Who Test Each Field for N Each Year





Source: Fertilizer Canada (2024) Survey of Fertilizer Use conducted by Stratus Ag Research

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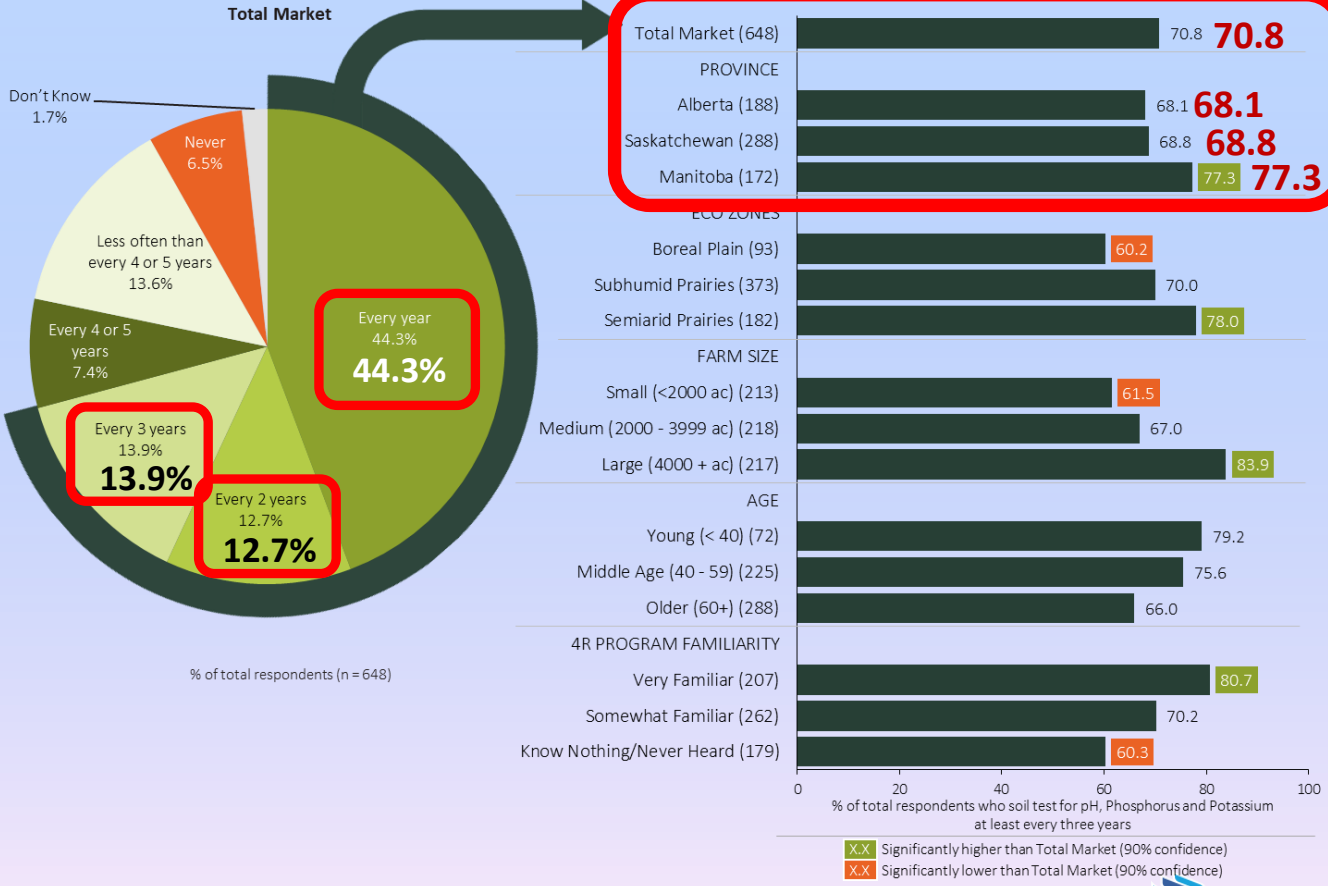
% of Prairie Farmers Who Test Each Field for P, K, pH (1-3 yrs)



Source: Fertilizer Canada (2024) Survey of Fertilizer Use conducted by Stratus Ag Research

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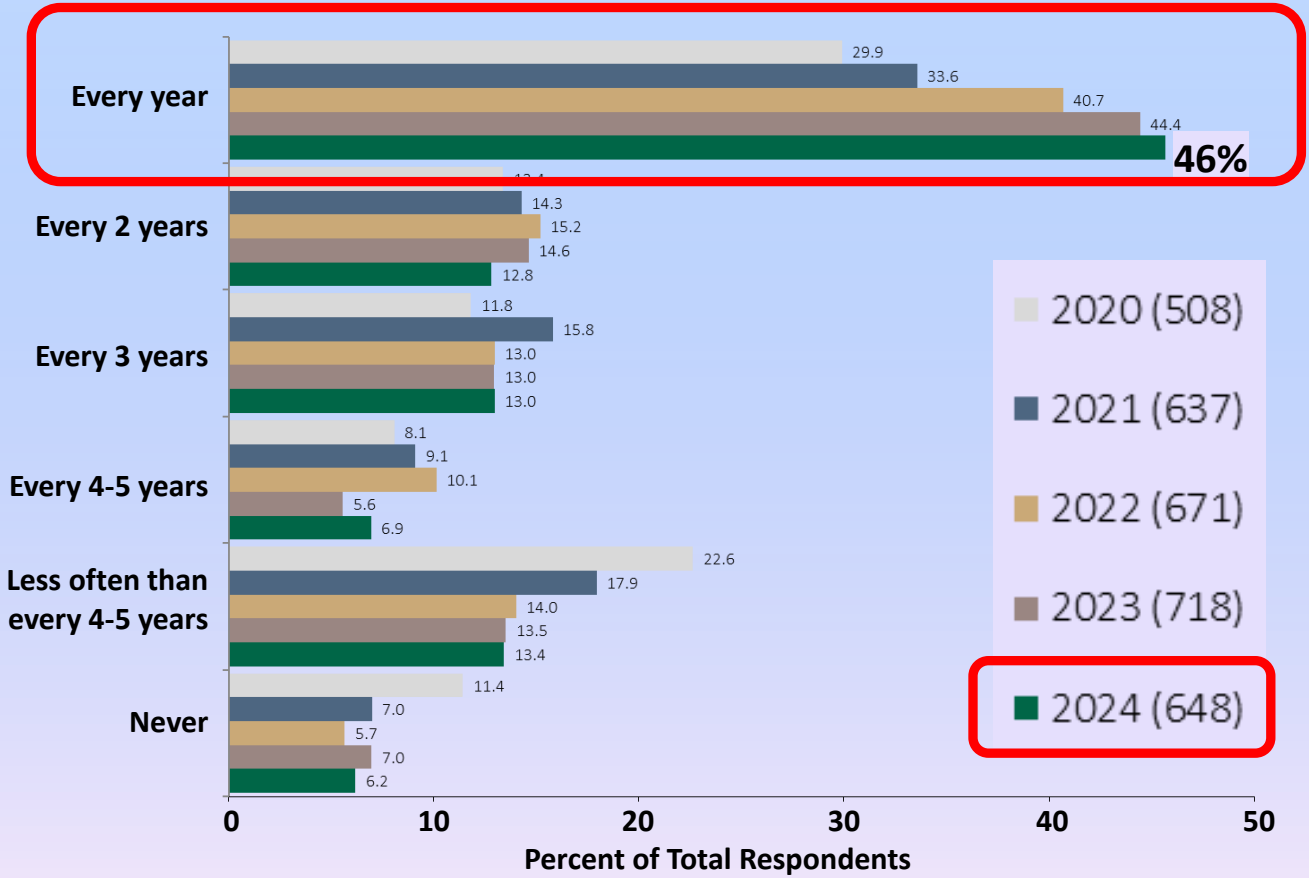
Frequency of Testing Each Field for N in Prairies



Source: Fertilizer Canada (2024) Survey of Fertilizer Use conducted by Stratus Ag Research

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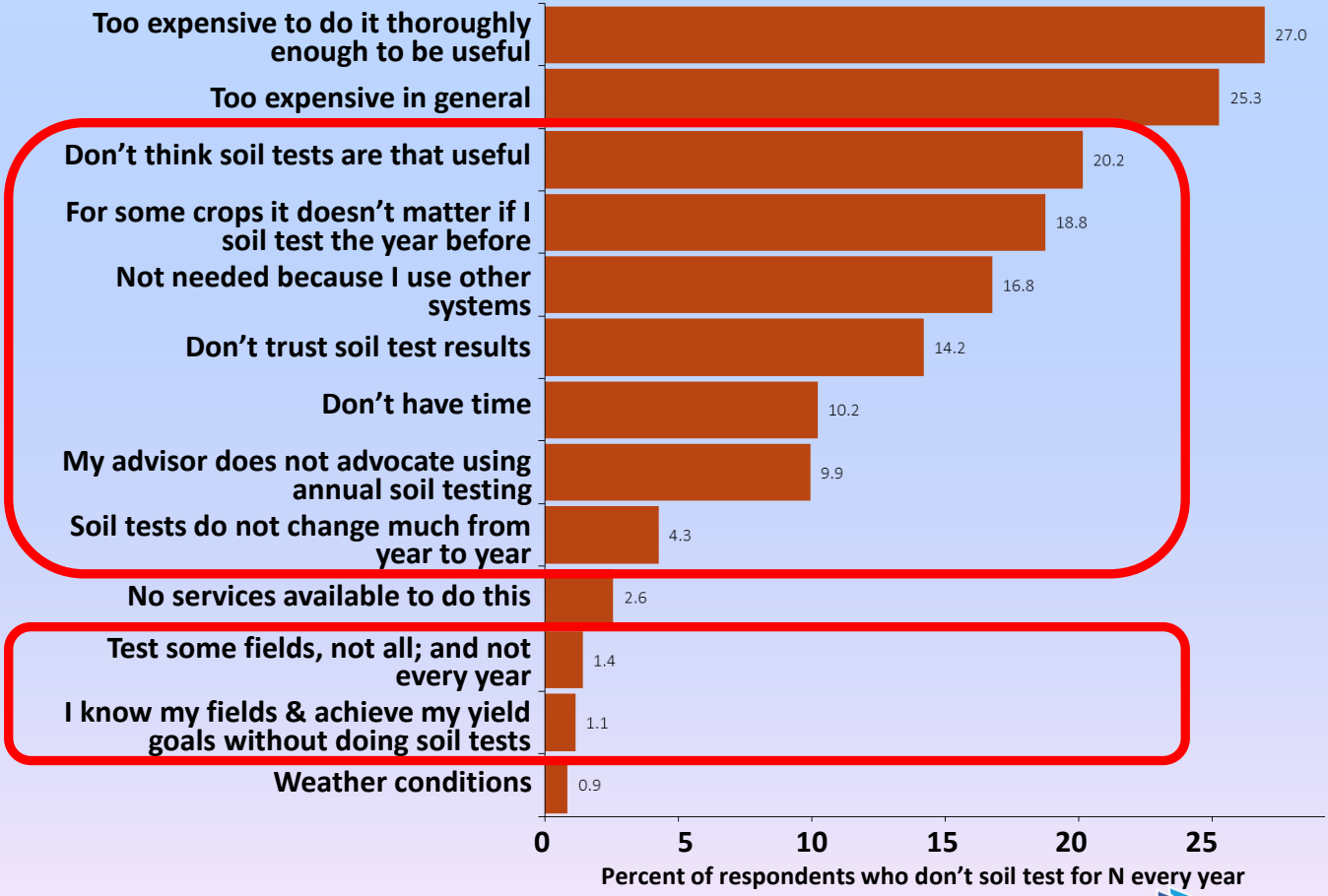
Reasons for Not Soil Testing for N Every Year in Prairies



Source: Fertilizer Canada (2024) Survey of Fertilizer Use conducted by Stratus Ag Research

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4R Nutrient Stewardship and 4R Soil Testing More Important Than Ever

What can we do to improve soil testing's reliability, value, and farmer-confidence?

4R Soil Testing … every field, every year

- ✓ Right sampling
- ✓ Right analyses
- ✓ Right recommendations
- ✓ Right data management & use

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Improving Reliability, Value, and Confidence in Soil Testing
Step 1: Right Sampling

Frequency of Sampling

- **Annual sampling is strongly recommended for nutrients such as N and S that are required and removed in large quantities, move with water, may be taken up from modest reserves. As a result, N and S might vary substantially from one year to another, depending on crop uptake and environmental conditions**
- **In theory, sampling every 2-3 years might be OK for nutrients such as P and K that are required in modest quantities, are not very mobile with water, and taken up from relatively large, stable reserves … but yearly sampling improves ability to track trends**

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Improving Reliability, Value, and Confidence in Soil Testing
Step 1: Right Sampling

Sampling Depth

- **Sample to 6 inches for P, K, Cu, Zn, Fe & Mn … nutrients that are enriched and retained in topsoil due to plant uptake & decomposition followed by retention in topsoil … and move short distances to roots by diffusion, which requires a high density of roots**
- **Sample to 24 inches for water soluble nitrate-N, sulphate-S, or chloride … nutrients that are not retained strongly by soil, enabling them to move in the soil with water, i.e., up with evaporation & down with infiltration … and move to roots by mass flow, which does not require high density of roots**

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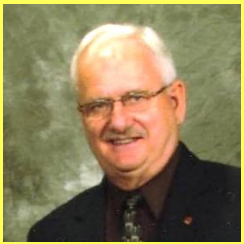
N Soil Test for a Topdressing Winter Wheat Trial Near Claresholm, AB (Spring & Summer 1979)

We established two replicated field trials for topdressing N on winter wheat in early spring 1979:

- **One trial was planted on a summerfallow field and one trial was planted on a stubble field**
- **We collected soil samples from 0-6 inch depth only … and soil tests showed that both sites tested similarly low in residual N**
- **Several rates of N applied to both trials, varying from 0-100 lb N/acre**
- **Yield response to 100 lb N/acre was 25 bu/acre on the stubble field, but only 2 bu/acre on the fallow field**
- **Why didn't the soil test work well?**
- **Dr. Jim Bole (AAFC) tried his best to get me back on track … explaining how crops could use nitrate-N in the 6-24 inch depth of soil, too**



Improving Reliability, Value, and Confidence in Soil Testing
Step 1: Right Sampling

Effect of Soil Sample Depth on Accuracy of Nitrate Soil Test (Soper, Racz & Fehr 1971)

Sample Depth	r^2 *	Grade
0-6”	0.32	32%=F
0-12”	0.64	64%=C
0-24”	0.84	84%=A
0-48”	0.78	78%=B+

* Correlation between uptake of N by barley and nitrate-N in soil for 22 experiments, 1962-1968

Source: R.J. Soper, G.J. Racz, and P. Fehr. 1971. Nitrate Nitrogen in the Soil as a Means of Predicting the Fertilizer Nitrogen Requirements of Barley. Canadian Journal of Soil Science 51:45-49.

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Effect of shallow vs. deep sampling on soil tests for residual N in Manitoba fields … Aggie students' projects

AGVISE 0-6" vs 0-24" soil nitrate-N analyses & fertilizer N recommendations for SOIL 4520 Soil Fertility class projects 2017-2019

	Soil Sample Depth					
	0-24"	0-6"	0-24"	0-6"	0-24"	0-6"
Fall 2017 - LaSalle	**Canola**		**Soybeans**		**Spring Wheat**	
Soil Analysis (lb N/ac)	72	33(66)*	52	25(50)	175	91(182)
Fertilizer Rec. (lb N/ac)	103	112	-	-	10	55
Fall 2018 - Brunkild	**Spring Wheat**		**Soybeans**		**Canola**	
Soil Analysis (lb N/ac)	42	15(30)	58	22(40)	60	27(54)
Fertilizer Rec. (lb N/ac)	201	213	-	-	135	141
Fall 2019 - Domain	**Per. Ryegrass**		**Spring Wheat**		**Canola**	
Soil Analysis (lb N/ac)	37	13(26)	43	7(14)	61	16(32)
Fertilizer Rec. (lb N/ac)	63	74	131	154	149	178

Avg Rec for 0-6" samples 132 lb N/ac
Avg Rec for 0-24" samples 113 lb N/ac

lower soil analysis than other depth
higher fertilizer recommendation

*number in parentheses is estimated total for 0-24" depth based on 0-6" sample

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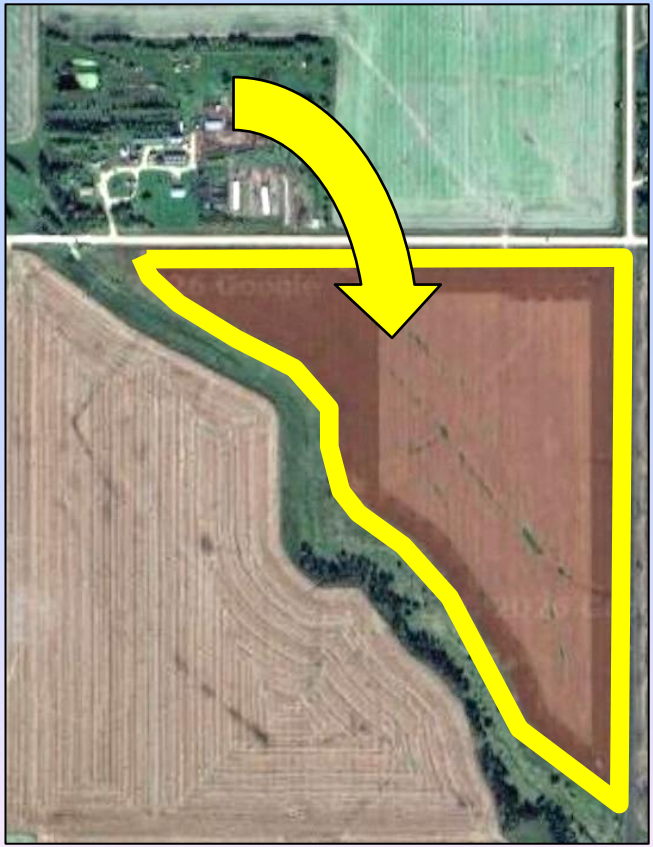
An example of why it's important to sample every field … every year



… including the field across the road from the farm yard, which had 175 lbs of residual N after growing a 50 bu/acre canola crop

… and was the field where grandpa used to haul the manure from the cattle overwintering pens

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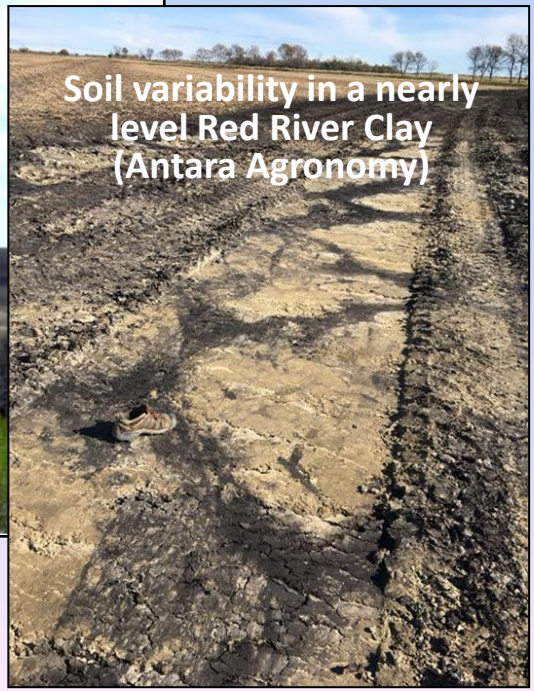
Improving Reliability, Value, and Confidence in Soil Testing
Step 1: Right Sampling

Soils are variable at large & small scales … take lots of subsamples

Soil variability in a rolling landscape in Western MB

Soil variability in a Red River Clay (UM Glenlea RS)



Improving Reliability, Value, and Confidence in Soil Testing
Step 1: Right Sampling

Soils are variable at large & small scales … take lots of subsamples

- For a 160 acre field, 2.5 billion lbs of root zone soil are represented by < 1 lb soil sample … and nutrient conc'n varies greatly within a field, especially if field has a history of fertilizer banding or manure app'n … so take at least 15-20 subsamples per field or zone

Nitrogen variability between individual soil sample cores collected near Fort Qu'Appelle, SK

SOIL TYPE	SOIL TEST EXTRACTABLE NITRATE-N (LB N/ACRE)		
	LOWEST	HIGHEST	AVERAGE
OXBOW LOAM	6	161	44
INDIAN HEAD CLAY	5	26	11

* Simmons 1985 (Sask. Ag. and Food)

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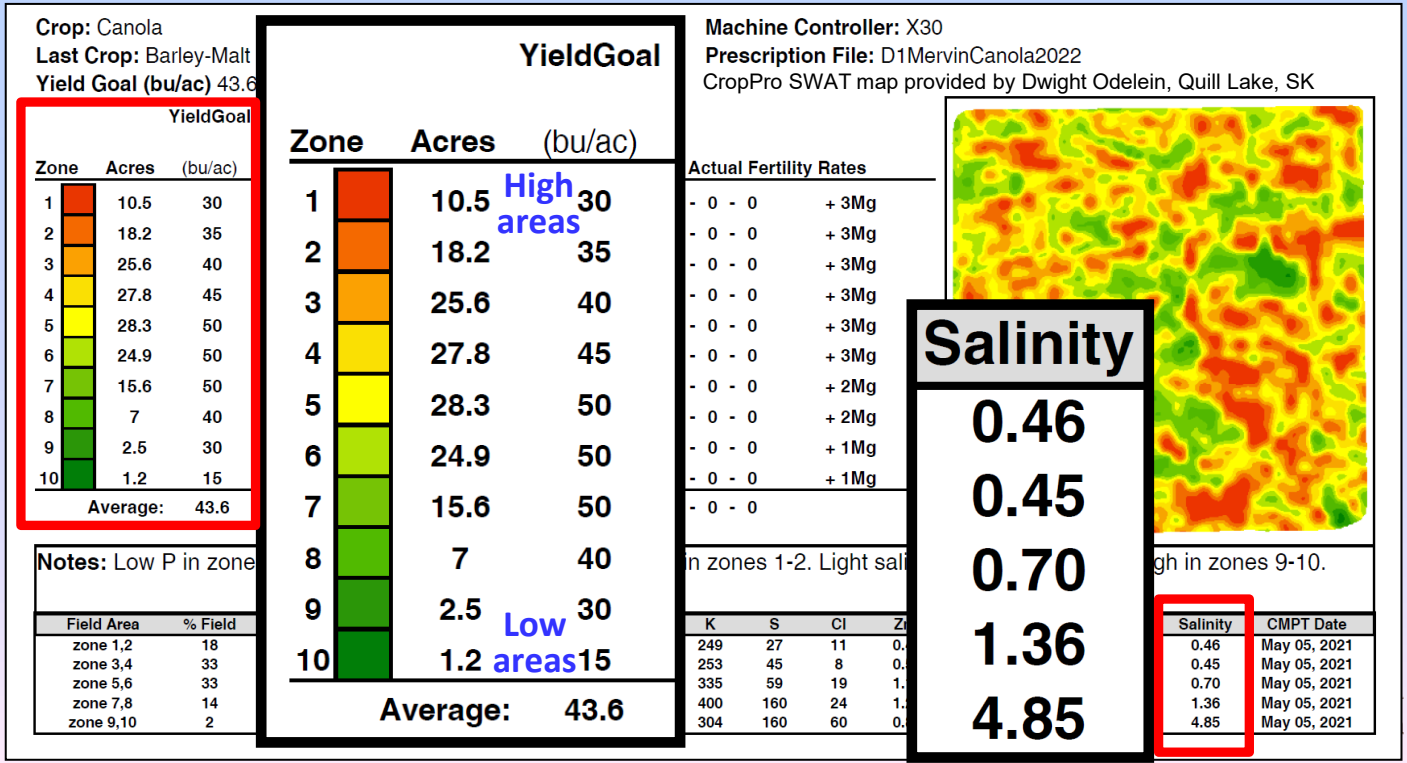
Improving Reliability, Value, and Confidence in Soil Testing
Step 1: Right Sampling

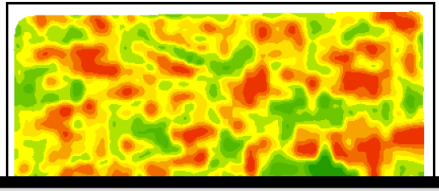
If the variability in soil fertility and yield potential are systematic … farmer may benefit from variable rate fertilization …



N fertility is often variable within fields eg. due to landscape

Crop: Canola
Last Crop: Barley-Malt
Yield Goal (bu/ac) 43.6

Machine Controller: X30
Prescription File: D1MervinCanola2022
CropPro SWAT map provided by Dwight Odelein, Quill Lake, SK



Zone	Acres	YieldGoal (bu/ac)	Canola Layer 1	MAP Layer 2	Urea Layer 3	Crystal Green Layer 4	Layer 5	Actual Fertility Rates	
1	10.5	30	5.3	30	160	60		82 - 39 - 0 - 0	+ 3Mg
2	18.2	35	5.1	30	170	60		86 - 39 - 0 - 0	+ 3Mg
3	25.6	40	4.9	35	180	50		91 - 38 - 0 - 0	+ 3Mg
4	27.8	45	4.8						
5	28.3	50	4.8						
6	24.9	50	4.8						
7	15.6	50	4.8						
8	7	40	5.1						
9	2.5	30	5.3						
10	1.2	15	4						
	Average:	43.6	4.9						

Field Area	% Field	N(20)		N(21)
zone 1,2	18	24	High areas	35
zone 3,4	33	21		33
zone 5,6	33	28		41
zone 7,8	14	17	Low areas	20
zone 9,10	2	75		63

Notes: Low P in zones 1-6

Field Area	% Field	N(20)	N(21)	OM %	pH	P	K	S	Cl	Zn	Cu	B	Texture	Salinity	CMPT Date
zone 1,2	18	24	35	4.0	7.9	8 (Olsen)	249	27	11	0.4	0.7	1.1		0.46	May 05, 2021
zone 3,4	33	21	33	4.3	7.8	11 (Olsen)	253	45	8	0.5	0.5	1.2		0.45	May 05, 2021
zone 5,6	33	28	41	5.5	7.7	12 (Olsen)	335	59	19	1.1	0.6	1.5		0.70	May 05, 2021
zone 7,8	14	17	20	6.2	7.8	27 (Olsen)	400	160	24	1.2	1.1	2.2		1.36	May 05, 2021
zone 9,10	2	75	63	5.4	8.0	45 (Olsen)	304	160	60	0.8	0.9	2.8		4.85	May 05, 2021

CropPro SWAT map provided by Dwight Odelein, Quill Lake, SK

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S fertility is also often variable within fields eg. due to landscape

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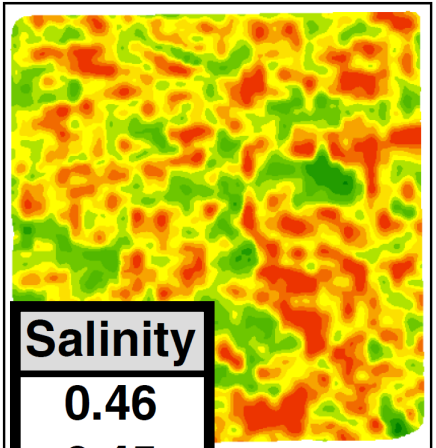
5	28.3	50	4.8	35	180	50		91 - 38 - 0 - 0	+ 3Mg
6	24.9	50	4.8	35	190	50		95 - 38 - 0 - 0	+ 3Mg
7	15.6	50	4.8	30	190	40		93 - 32 - 0 - 0	+ 2Mg
8	7							0	+ 2Mg
9	2.5							0	+ 1Mg
10	1.2							0	+ 1Mg
Average:								0	



Notes: Low P … es 1-2. Light salinity … gh in zones 9-10.

Field Area	S	Cl	Zn
zone 1,2	27	11	0.4
zone 3,4	45	8	0.5
zone 5,6	59	19	1.1
zone 7,8	160	24	1.2
zone 9,10	160	60	0.8

Salinity	CMPT Date
0.46	May 05, 2021
0.45	May 05, 2021
0.70	May 05, 2021
1.36	May 05, 2021
4.85	May 05, 2021

Field Area	S	
zone 1,2	27	High areas
zone 3,4	45	
zone 5,6	59	
zone 7,8	160	Low areas
zone 9,10	160	

Salinity
0.46
0.45
0.70
1.36
4.85

CropPro S…

Saline areas might have 30,000 lbs S/acre

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Soil test P also varies spatially within fields …
e.g., STP is often high in low areas of the landscape

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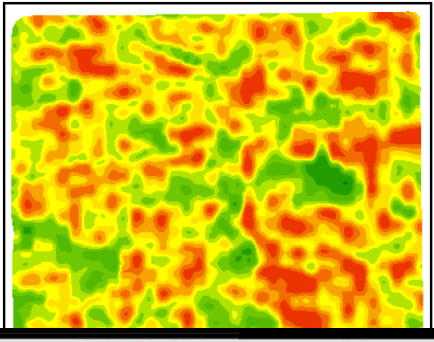
8	7	40	5.1	20	170	30		82 - 22 - 0 - 0	+ 2Mg
9	2.5	30	5.3	15	100	15		49 - 14	
10	1.2	15	4	15	50	15		26 - 14	
	Average:	43.6	4.9	32.5	177.4	49.1		89 - 36	



Notes: Low P in zones 1-6. Low chloride in zones 1-4. Low zinc i

Field Area	% Field	N(20)	N(21)	OM %	pH	P
zone 1,2	18	24	35	4.0	7.9	8 (Olsen)
zone 3,4	33	21	33	4.3	7.8	11 (Olsen)
zone 5,6	33	28	41	5.5	7.7	12 (Olsen)
zone 7,8	14	17	20	6.2	7.8	27 (Olsen)
zone 9,10	2	75	63	5.4	8.0	45 (Olsen)

Field Area		% Field	P
zone 1,2	High areas	18	8 (Olsen)
zone 3,4		33	11 (Olsen)
zone 5,6		33	12 (Olsen)
zone 7,8	Low areas	14	27 (Olsen)
zone 9,10		2	45 (Olsen)

CropPro SWAT map provided by Dwight Odelein, Quill Lake, SK

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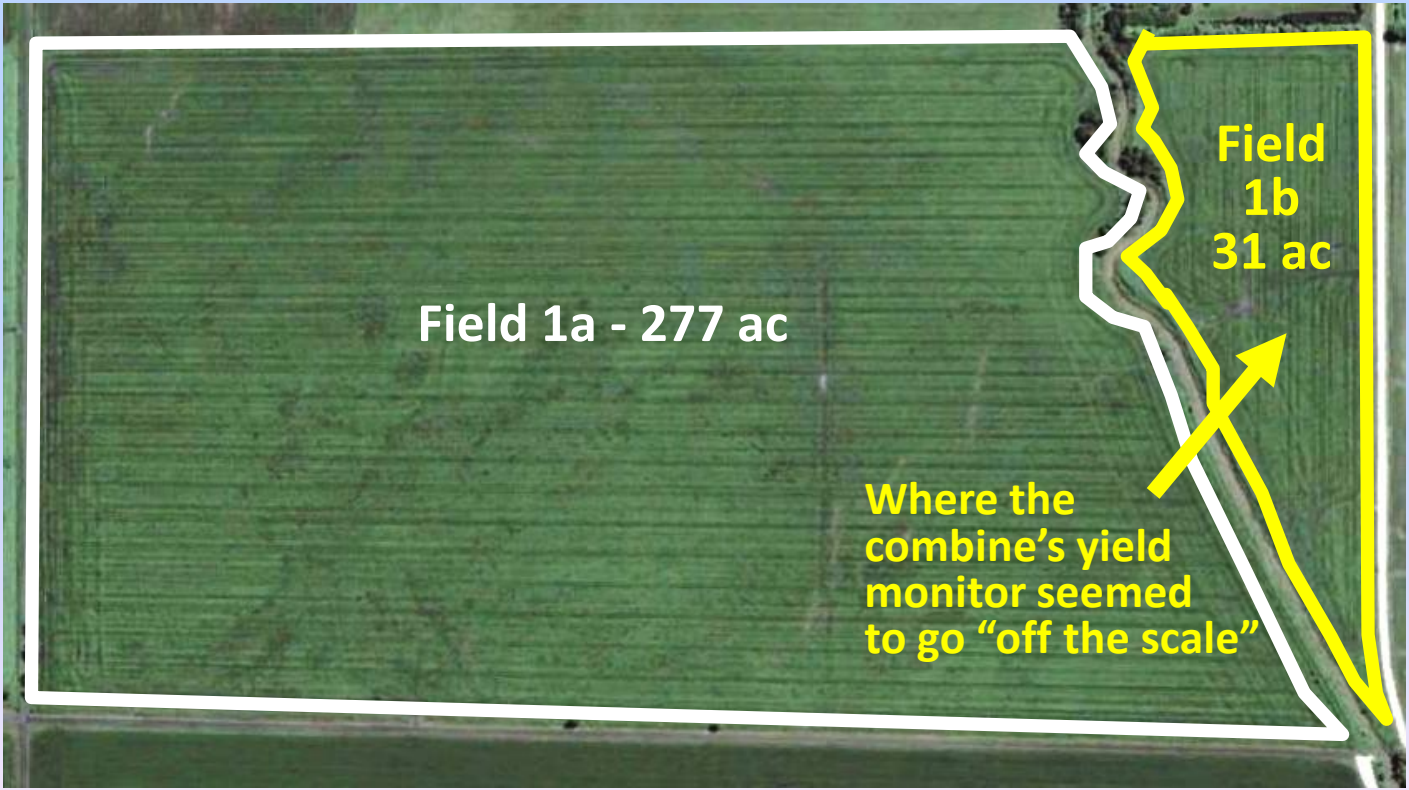
Soil fertility might also vary due to historical management … e.g., within a nearly level field of clay soil near Winnipeg



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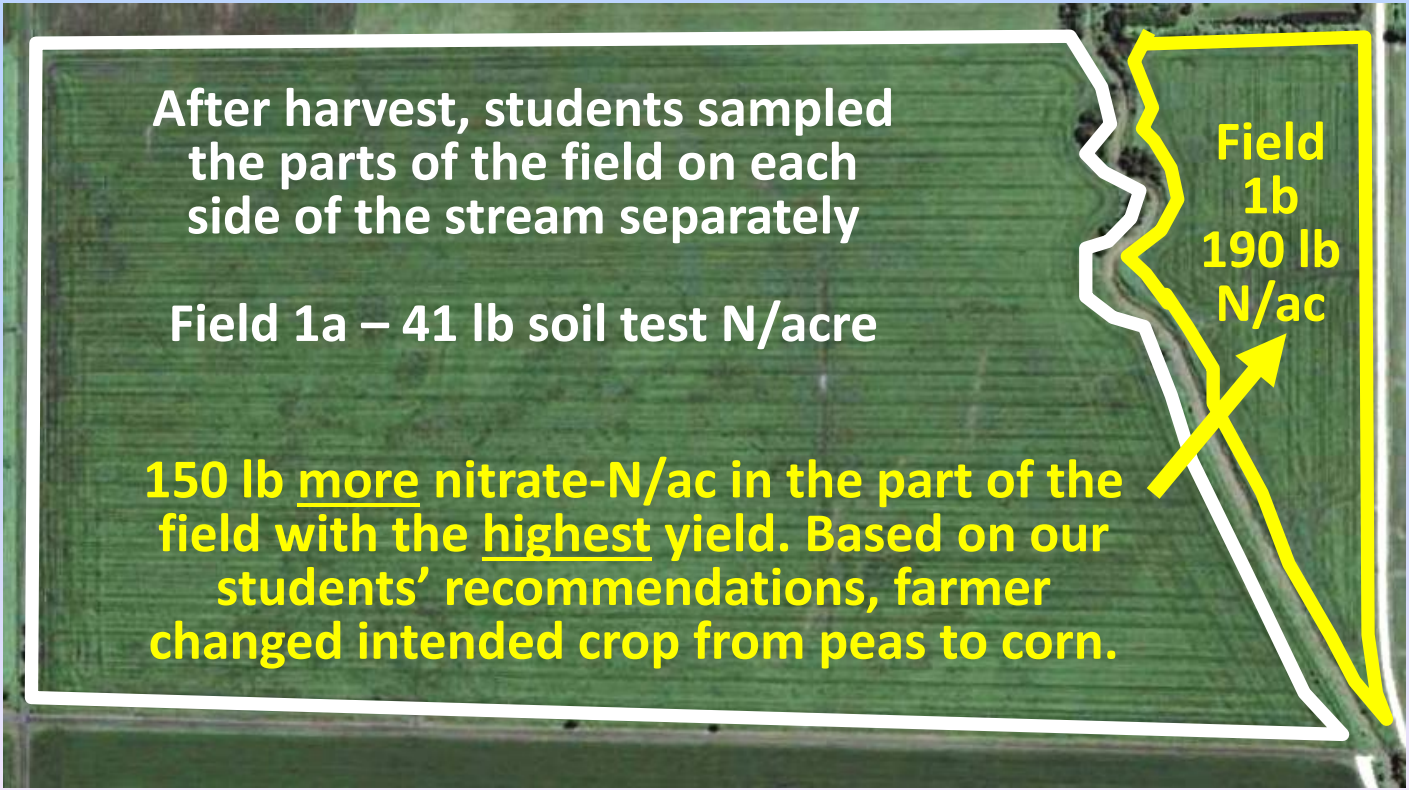


Improving Reliability, Value, and Confidence in Soil Testing
Step 1: Right Sampling

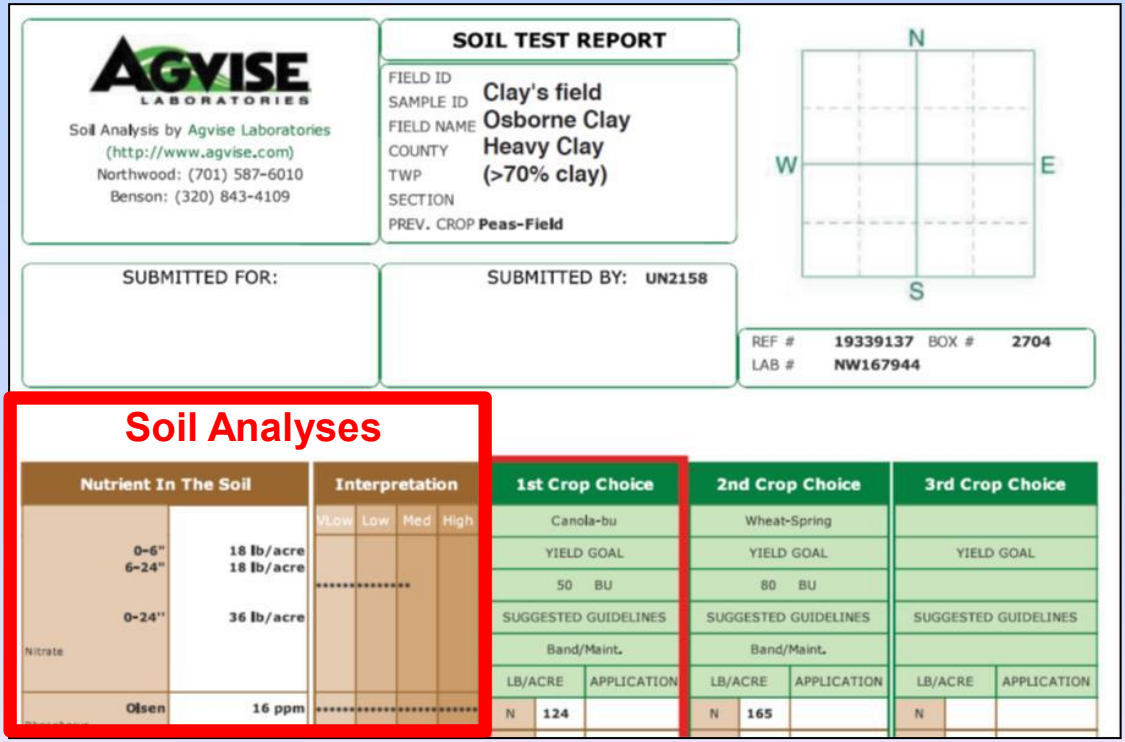
Time of Sampling:

- Fall sampling for residual nitrate-N is usually OK for the Prairies, but is not reliable in wetter regions of the world where leaching and denitrification losses are large (e.g., Southern Ontario or the U.S. Midwest)
- However, if fall weather in Prairies is unusually wet, sample and/or re-sample soil in spring

Handle Samples Carefully:

- Mix thoroughly and select a representative subsample
- Avoid contamination during sampling and handling
- Minimize unnatural mineralization gains, denitrification losses
- Handle sample as recommended by lab; consider effect of artificial drying and/or freezing

Improving Reliability, Value, and Confidence in Soil Testing
Step 2: Right Analysis



AGVISE LABORATORIES

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID
SAMPLE ID Clay's field
FIELD NAME Osborne Clay
COUNTY Heavy Clay
TWP (>70% clay)
SECTION
PREV. CROP **Peas-Field**

N W E S

SUBMITTED FOR:

SUBMITTED BY: **UN2158**

REF # **19339137** BOX # **2704**
LAB # **NW167944**

Soil Analyses

Nutrient In The Soil		Interpretation			
		VLow	Low	Med	High
0-6"	18 lb/acre				
6-24"	18 lb/acre				
0-24"	36 lb/acre				
Nitrate					
Olsen	16 ppm				

1st Crop Choice			2nd Crop Choice			3rd Crop Choice		
Canola-bu			Wheat-Spring					
YIELD GOAL			YIELD GOAL			YIELD GOAL		
50 BU			80 BU					
SUGGESTED GUIDELINES			SUGGESTED GUIDELINES			SUGGESTED GUIDELINES		
Band/Maint.			Band/Maint.					
LB/ACRE		APPLICATION	LB/ACRE		APPLICATION	LB/ACRE		APPLICATION
N	124		N	165		N		

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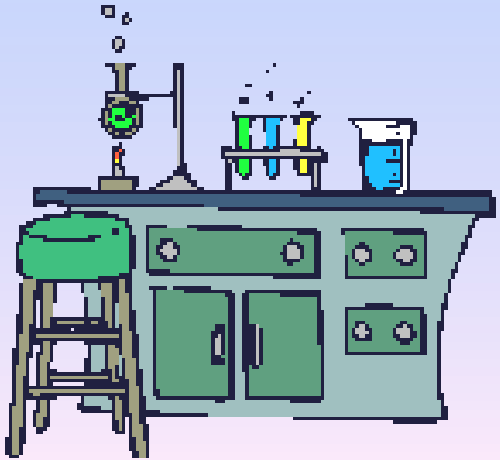
Analysis of Soil Nutrient Content, cont'd.

Most appropriate type of analysis varies with nutrient, regional climate & soil characteristics. Pools of nutrients typically measured by chemical extraction for Western Canadian soils are as follows:

- **Water – for extracting plant available forms that are readily soluble (ie. not precipitated), not adsorbed, and move easily to plant roots by mass flow & not lost between sampling & crop demand, eg. nitrate-N, sulphate-S, chloride and perhaps boron …**
  but does not measure N and S mineralized from organic matter



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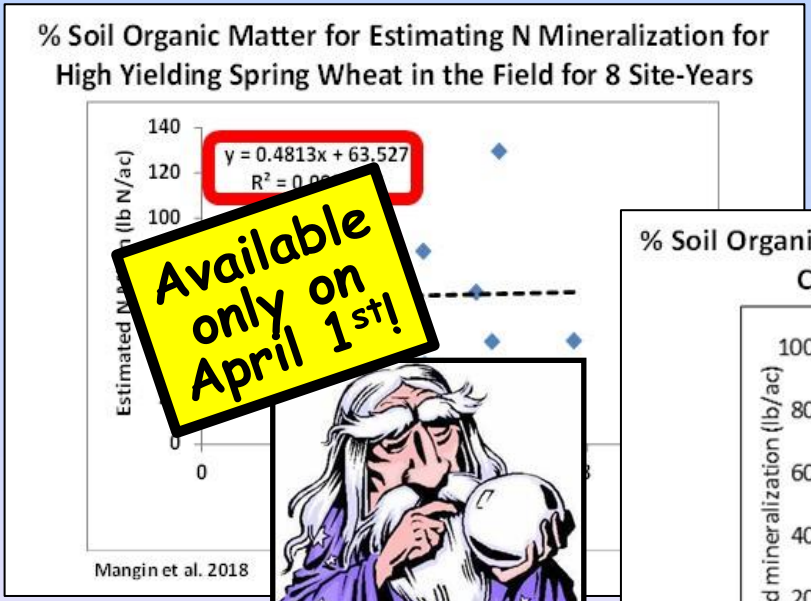
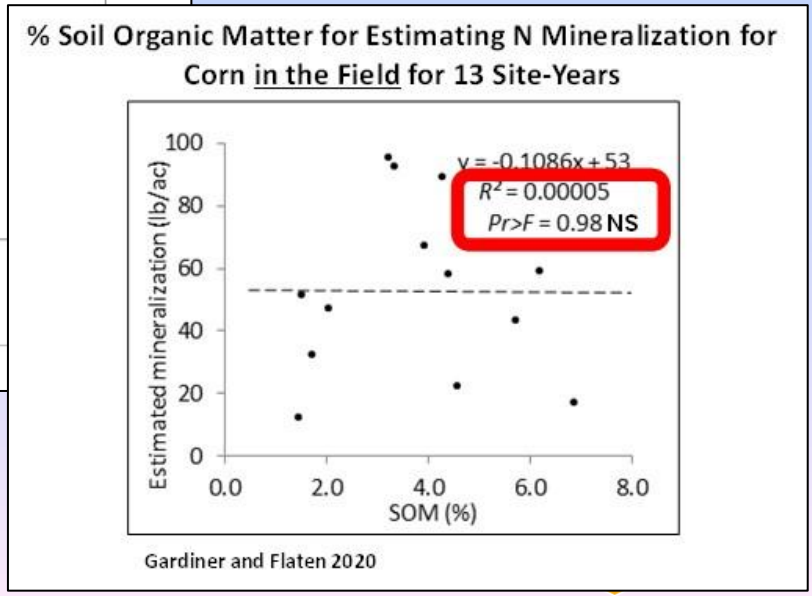
Predicting N mineralization from % Soil Organic Matter doesn't work either … due to variable & unpredictable differences in organic matter composition, seasonal weather conditions, and agronomic practices





Available only on April 1st!

AGVISE LABORATORIES

Crystal Ball Services

Analysis of Soil Nutrient Content, cont'd.

Most appropriate type of analysis varies with nutrient, regional climate & soil characteristics. Pools of nutrients typically measured by chemical extraction for Western Canadian soils are as follows:

- Water – for extracting plant available forms that are readily soluble (ie. not precipitated), not adsorbed and move easily by mass flow & not lost between sampling & crop demand, eg. nitrate-N, sulphate-S, chloride and perhaps boron … but does not measure N and S mineralized from organic matter
- **Sodium bicarbonate (Olsen test) is generally recommended for extracting "labile" P in Prairie/Northern Great Plains soils, but acetic fluoride (modified Kelowna test, with a high concentration of weak acid) is also acceptable in SK & AB**

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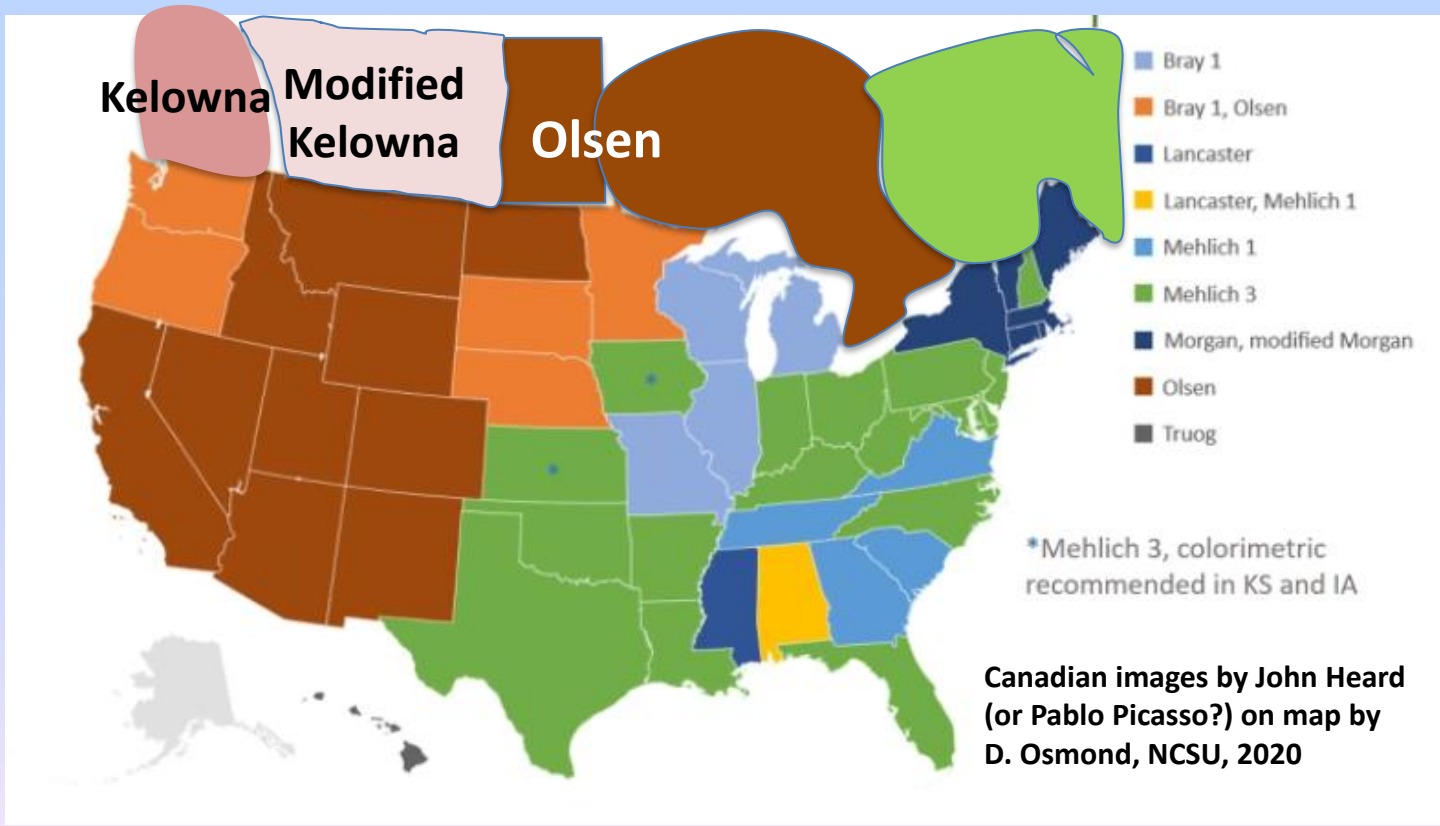
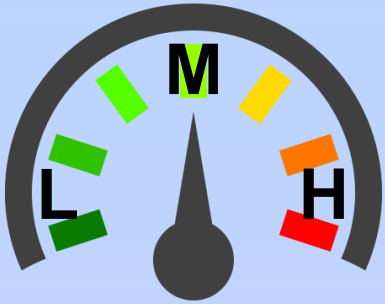
Standard Recommended Soil Tests for P in Canada and U.S.



Canadian images by John Heard (or Pablo Picasso?) on map by D. Osmond, NCSU, 2020

Analysis of Soil Nutrient Content



www.iconfinder.com

- P & K soil tests provide a relative index or gauge (eg. H,M,L) of plant available nutrients, based on probability of fertilizer response
- "ppm" values should not be converted to lb of P or K available to crop per acre (e.g., soil test P & K ppm values vary with extractant)

Approximate soil test P sufficiency ranges for crops in the Northern Great Plains*

Table 3. Approximate soil test phosphorus sufficiency ranges[a] for crop production in Northern Great Plains soils using various soil testing methods.

Soil Test Method	Very Low to Medium	Medium to High	High to Excessive
	parts per million (ppm) or mg/kg[b]		
Olsen (Sodium Bicarbonate)	<10	10 to 20	>20
*Mehlich-3	<20	20 to 40	>40
*Bray-1 (Weak Bray)	<15	15 to 25	>25
*Bray-2 (Strong Bray)	<27	27 to 40	>40
*Miller-Axley	<13	13 to 22	>22
Modified Kelowna (Enviro-Test)[c]	<15	15 to 25	>25
Modified Kelowna (Norwest)[d]	<15	15 to 27	>27
Kelowna	<15	15 to 30	>30
Water	<3	3 to 5	>5

***Assuming that the soil tests are suitable for the soil … e.g., that these acidic extracts are not used on high pH, calcareous soils, where they are neutralized**

https://fertilizercanada.ca/wp-content/uploads/2019/07/4R-P-fertilizer-mgmt-Chapter-5-P-Rates-final.pdf

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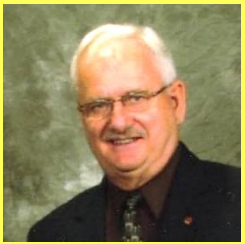
P Soil Test for a Perennial Forage Trial near Nanton, AB (1978-1979)

This field trial was designed to evaluate conversion of an annual crop field to sainfoin, a non-bloating perennial legume forage suitable for cattle grazing

- **Although the field was regarded as having a history of regular fertilization, the soil tests that I collected & submitted in Spring 1979 showed extremely low Bray soil test P levels**
- **Soil pH was very high … above pH 8**
- **Was the P soil test correct?**
- **Again, Dr. Jim Bole (AAFC) tried to get me back on track … explaining how this soil's lime neutralized the low conc'n of HCl acid in the Bray extract and he recommended remedial training at U of M**



Analysis of Soil Nutrient Content, cont'd.

Most appropriate type of analysis varies with nutrient, regional climate & soil characteristics. Pools of nutrients typically measured by chemical extraction for Western Canadian soils are as follows:

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- Sodium bicarbonate (Olsen test) or acetic fluoride (modified Kelowna test, with a high concentration of weak acid) is recommended for extracting "labile" P
- **Dissolved salts (e.g., ammonium acetate) that displace "exchangeable" potassium, calcium, and magnesium (K^+, Ca^{2+}, Mg^{2+}) … cations that are held loosely on the soil surfaces**
- **Chelate-extractable metallic micros (eg. DTPA-Cu, Zn, Mn, Fe)**

Other soil measurements … OM, pH, CEC, CCE, EC, etc

			Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
						% Ca	% Mg	% K	% Na	% H
Org.Matter	5.7 %									
Carbonate(CCE)	7.5 %									
0-6"	0.57 mmho/cm		0-6" 8.0		50.1 meq	(65-75) 61.9	(15-20) 35.4	(1-7) 2.3	(0-5) 0.4	(0-5) 0.0
6-24"	0.64 mmho/cm		6-24" 8.5							
Sol. Salts										

- Org. Matter is an indicator of soil quality or health, but SOM varies substantially with sample location and depth and very slowly with time
- Carbonates (e.g., calcium carbonate equivalent or CCE) are a useful measure of the soil's lime content, e.g., for tying up P & micronutrients and increasing the risk of iron deficiency chlorosis (IDC) in soybeans and flax
- Soluble Salts (EC) indicate the presence of salinity & also risk of iron deficiency chlorosis in (IDC)
- Soil pH indicates presence of acidity (pH<7) or alkalinity (pH>7)
- Cation Exchange Capacity (CEC) indicates the soil's capacity to hold positively charged nutrients (e.g., NH_4^+, K^+, Ca^{2+}, Mg^{2+}) … <u>but regular soil fertility tests only estimate CEC and high CCE or EC inflates estimated CEC, especially in Prairie soils</u>
- Base Saturation is not important unless your soil is acidic … also, the B.S. values are inflated by high CCE or EC

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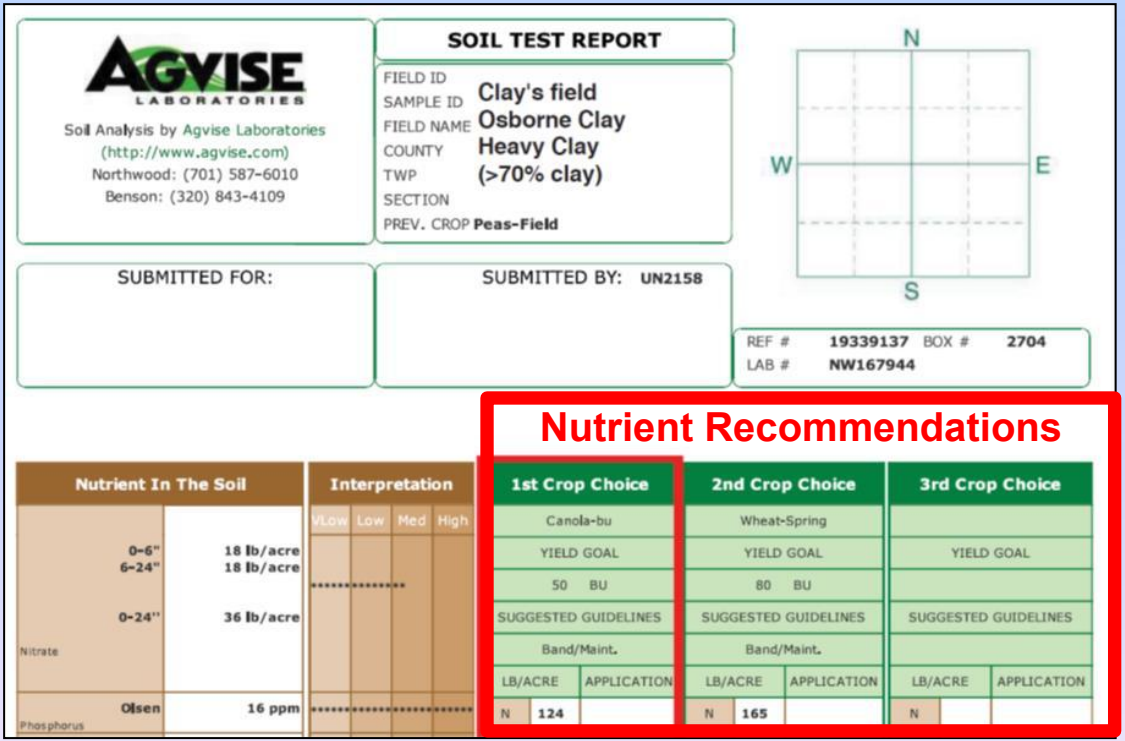
Improving Reliability, Value, and Confidence in Soil Testing
Step 3: Right Recommendations



AGVISE LABORATORIES

Soil Analysis by Agvise Laboratories
(http://www.agvise.com)
Northwood: (701) 587-6010
Benson: (320) 843-4109

SOIL TEST REPORT

FIELD ID
SAMPLE ID Clay's field
FIELD NAME Osborne Clay
COUNTY Heavy Clay
TWP (>70% clay)
SECTION
PREV. CROP **Peas-Field**

N
W E
S

SUBMITTED FOR:

SUBMITTED BY: **UN2158**

REF # **19339137** BOX # **2704**
LAB # **NW167944**

Nutrient Recommendations

Nutrient In The Soil		Interpretation				1st Crop Choice		2nd Crop Choice		3rd Crop Choice	
		VLow	Low	Med	High	Canola-bu		Wheat-Spring			
0-6"	18 lb/acre					YIELD GOAL		YIELD GOAL		YIELD GOAL	
6-24"	18 lb/acre					50 BU		80 BU			
0-24"	36 lb/acre					SUGGESTED GUIDELINES		SUGGESTED GUIDELINES		SUGGESTED GUIDELINES	
Nitrate						Band/Maint.		Band/Maint.			
						LB/ACRE	APPLICATION	LB/ACRE	APPLICATION	LB/ACRE	APPLICATION
Olsen	16 ppm					N 124		N 165		N	
Phosphorus											

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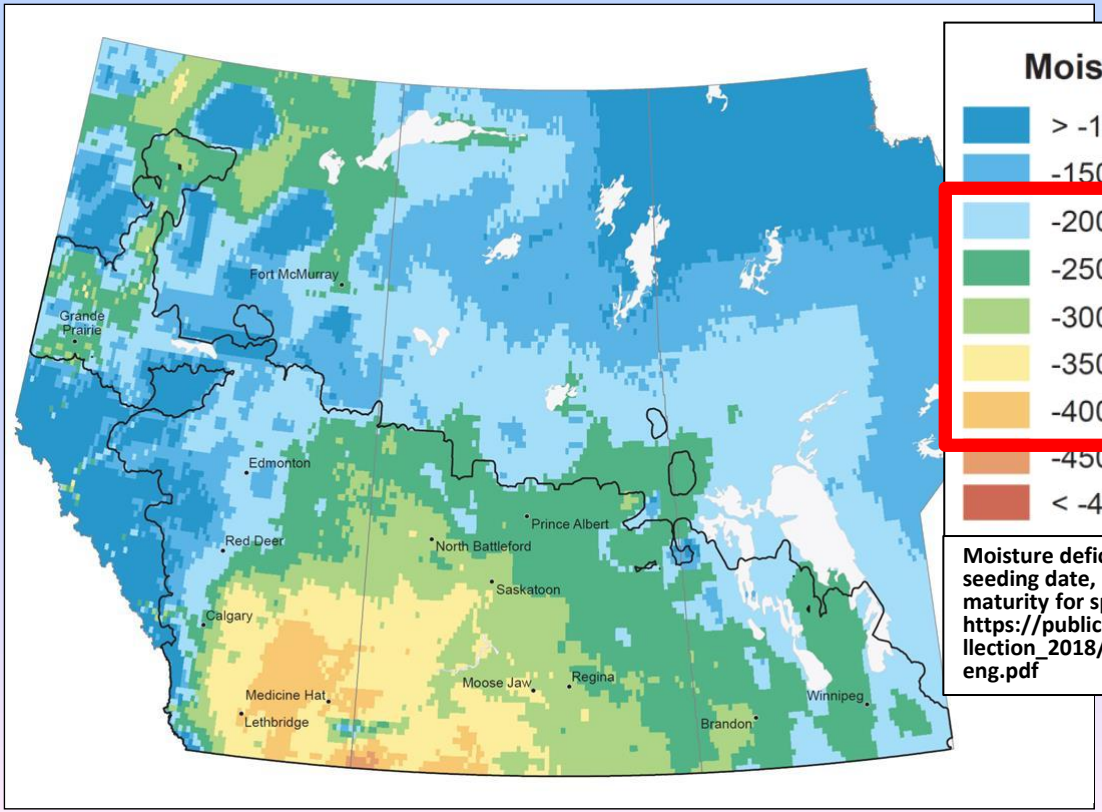
Nutrient Recommendations

- Recommendations for fertilizer must be locally relevant … e.g., correlated with crop yield responses to fertilizer in the region where the crop is grown, e.g., accounting for moisture supply



Moisture Deficit (mm)

> -100	<4”
-150 to -100	4-6”
-200 to -150	6-8”
-250 to -200	8-10”
-300 to -250	10-12”
-350 to -300	12-14”
-400 to -350	14-16”
-450 to -400	16-18”
< -450	>18”

Moisture deficits were accumulated from seeding date, until estimated crop maturity for spring wheat. Source: AAFC https://publications.gc.ca/collections/collection_2018/aac-aafc/A59-63-2010-eng.pdf

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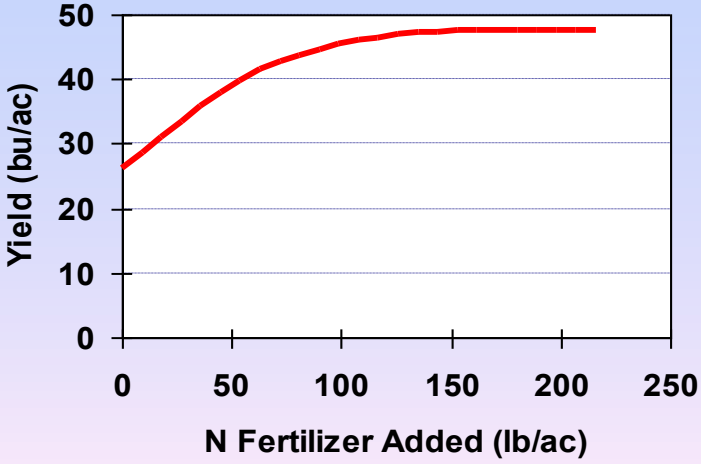
Nutrient Recommendations, cont'd.

Recommendations also vary with goals of fertilization program:

- **Short term maximum economic yield or agronomic sufficiency**
  - **Yield responses to nutrients are often illustrated as precise curves … but fertilizer responses vary substantially with growing season moisture & temperature, crop variety/hybrid, etc. … so portraying a single response curve can be misleading … and the choice of a response "curve" can make a big difference to the recommendation … so we should not oversell accuracy of recommendations**



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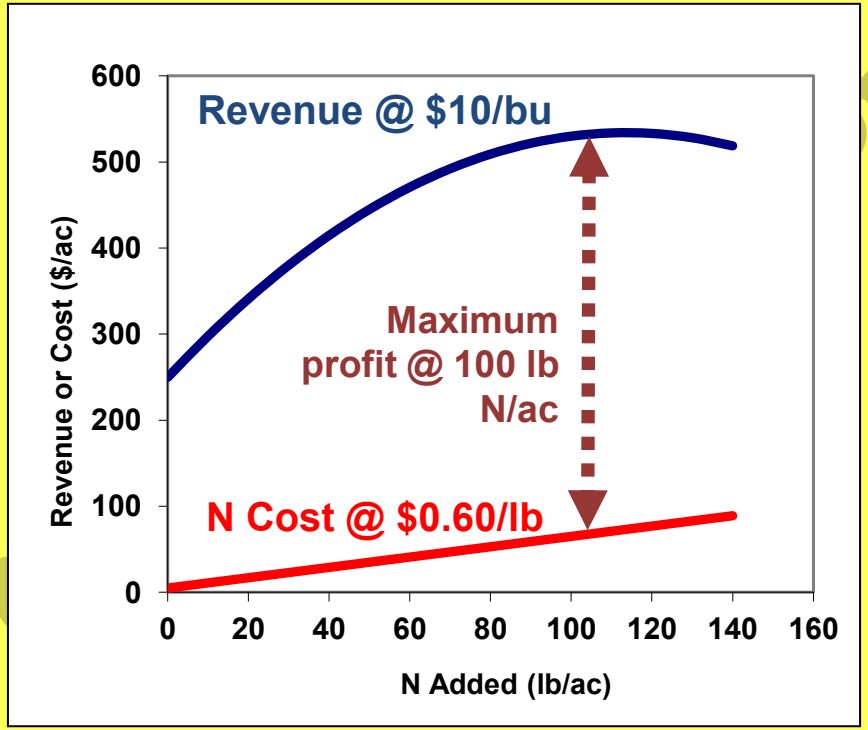
Calculating the Economic Optimum Rate of N Fertilizer

It "should" be easy to describe the crop's response to N using a quadratic equation … plus a linear equation for describing fertilizer cost … then use differential calculus to determine the N rate where profits are maximized (e.g., for canola)



But in the early 1990s, Dr. Manuel Cerrato, who had just finished his Ph.D. in Iowa State University, showed us that calculating the optimum rate of N was not that easy …

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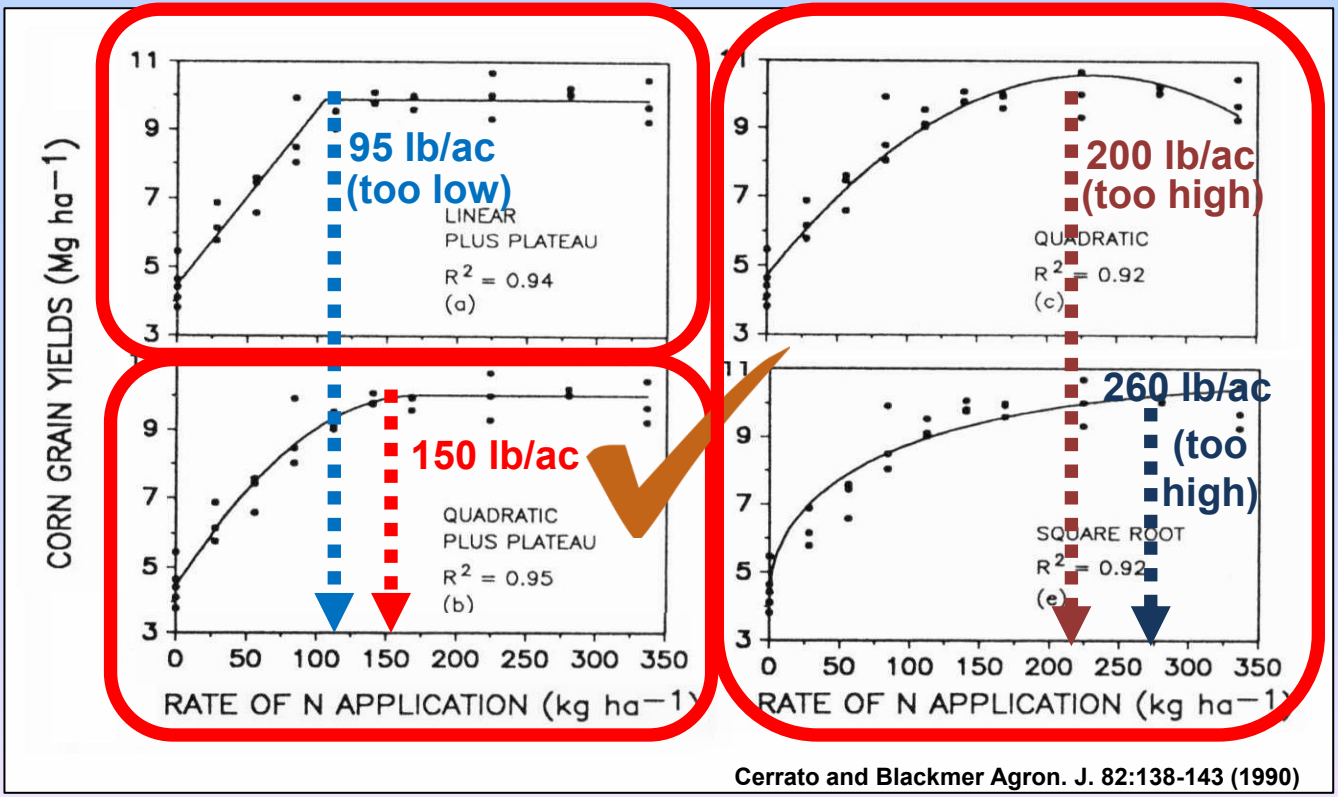
Maximum Economic Yield calculated with different response curves/models varied from 95-260 lb N/ac for the same corn response trial in Iowa … "best" was QPP (Cerrato & Blackmer 1990)



Cerrato and Blackmer Agron. J. 82:138-143 (1990)

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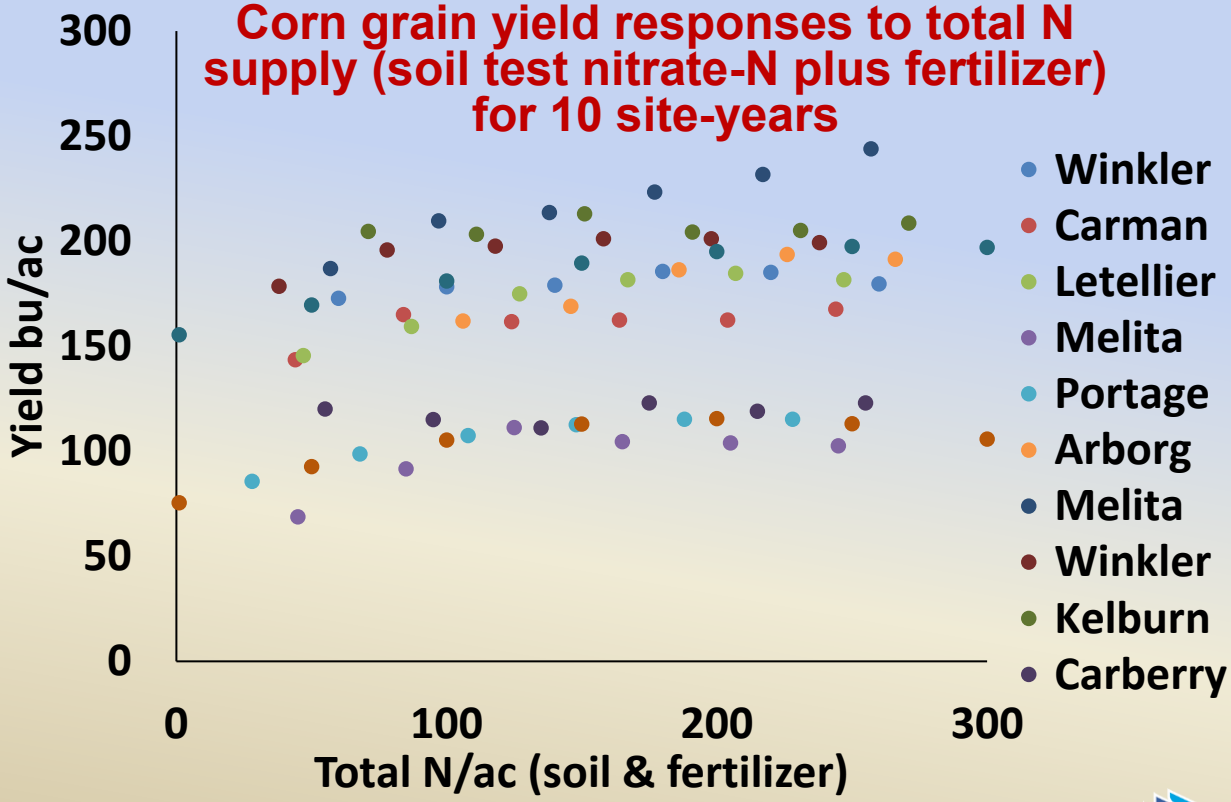
Most economic rate of N @ $4/bu corn and $0.40/lb N



(John Heard, MB Agriculture)

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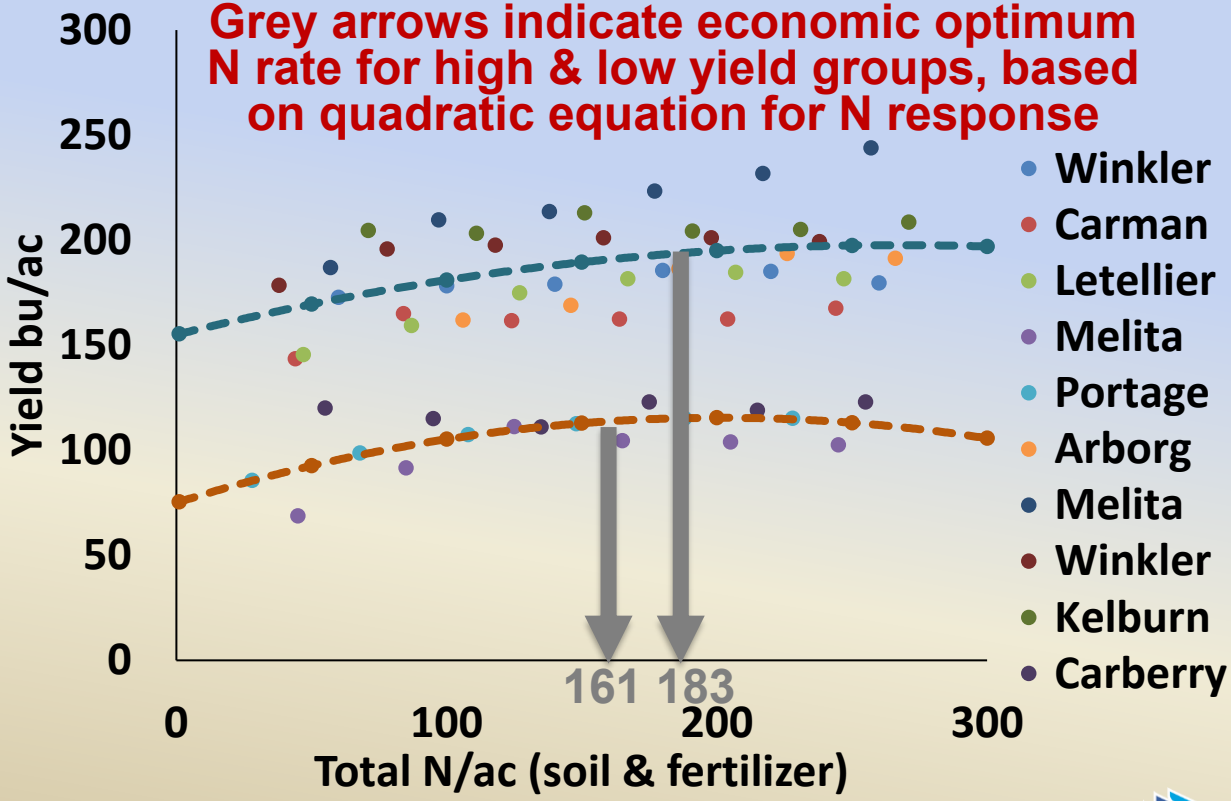

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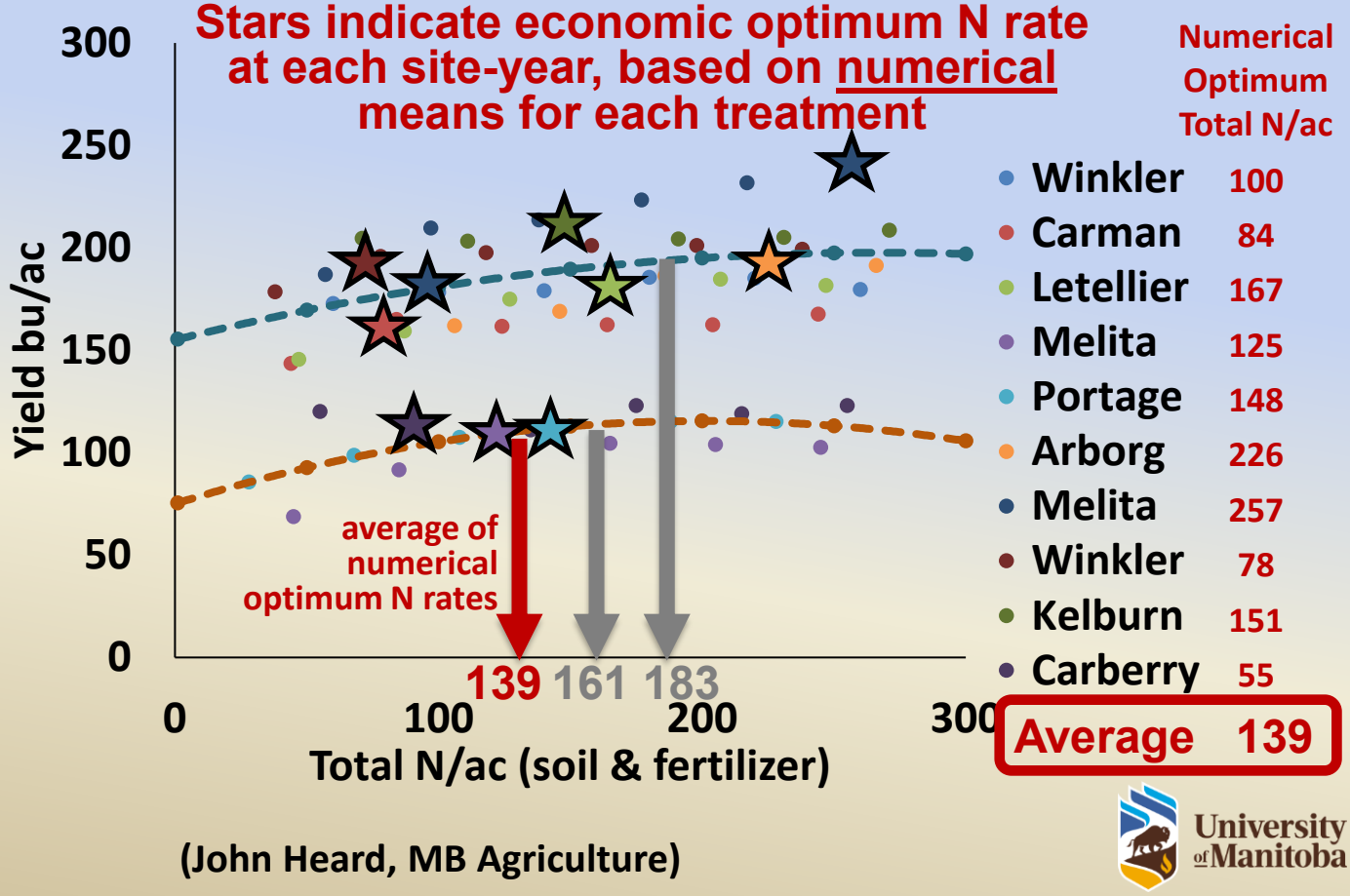

(John Heard, MB Agriculture)

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Most Accurate N Response Curves for High-Yielding Spring Wheat in Manitoba (Mangin et al. 2018)*

Site-Year	Wheat Variety	Statistical Model for N Response Curve				
		Linear - Plateau	Linear - Linear	Quadratic - Plateau	Quadratic	Linear
Brunkild 2016	Brandon	Best				
	Prosper		Best			
Carman 2016	Brandon					Best
	Prosper					Best
Brunkild 2017	Brandon				Best	
	Prosper		Best			
Carman 2017	Brandon					Best
	Prosper		Best			
Melita 2016	Brandon				Best	
	Prosper	Best				
Carberry 2016	Brandon					Best
	Prosper					Best
Melita 2017	Brandon					Best
	Prosper					Best
Grosse Isle 2017	Brandon	Best				
	Prosper				Best	

?

*Accuracy determined using Akaike Information Criterion (AIC) values for each model and site-year

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Nutrient Recommendations, cont'd.

- **For some nutrients (e.g., P) the short term yield response to fertilizer is so variable that it's best to view the response as a probability, not a response "curve"**

e.g. 45 years of P response trials on Sceptre clay site in Saskatchewan

Annual variations in phosphorus responses can be expected. The yield increases in wheat, due to 20 kg/ha (18 lb/ac) application of P_2O_5 on Sceptre Clay, which always requires additional phosphorus, are given in Fig. 8. Similar variations are encountered in other soils. These variations are unpredictable and are related to the phosphorus-release mechanisms in the soil.

- Guide to Farm Practice in Saskatchewan 1987

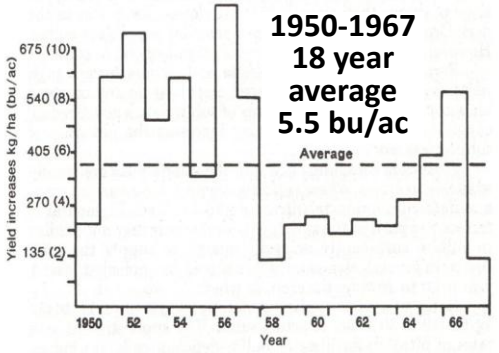
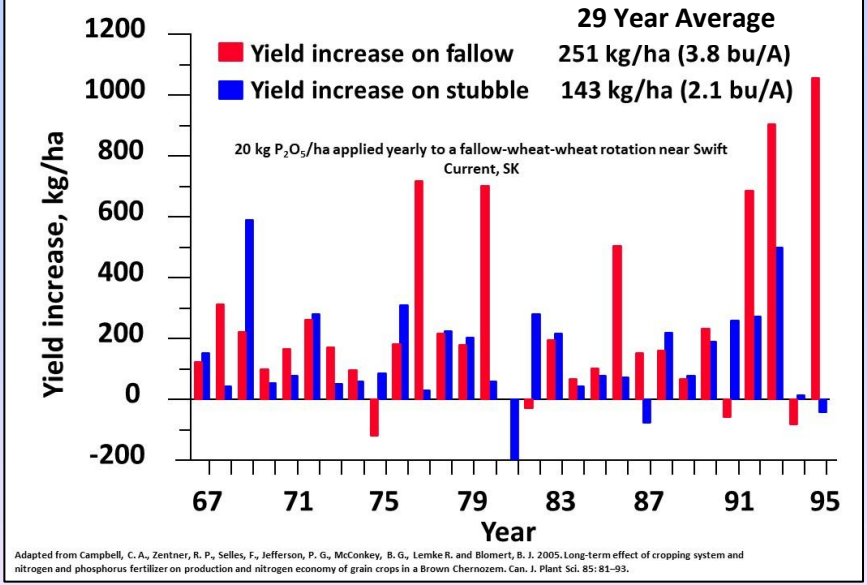


Fig. 8 — Average annual increase in wheat yield from 20 kg/ha (18 lb/ac) P_2O_5 on Sceptre clay



Adapted from Campbell, C. A., Zentner, R. P., Selles, F., Jefferson, P. G., McConkey, B. G., Lemke R. and Blomert, B. J. 2005. Long-term effect of cropping system and nitrogen and phosphorus fertilizer on production and nitrogen economy of grain crops in a Brown Chernozem. Can. J. Plant Sci. 85: 81–93.

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Nutrient Recommendations, cont'd.

- **For some nutrients (e.g., P) the short term yield response to fertilizer is so variable that it's best to view the response as a probability, not a response "curve"**

Manitoba P Response Probabilities for Cereals and Hay Crops

Available P (ppm Olsen)		Number of Experiments	% Responding to Fertilizer P
0-5	V. Low	15	100
5-12	Low-Med	50	62
12-18	Med-High	16	56
>18	High-VH	14	29
Overall		95	63

Hedlin, U of M,

e.g., in Prairie soils, probability of cereal crop response to fertilizer P drops below 50% at Olsen soil test P levels greater than ~ 15 ppm

Saskatchewan P Response Probabilities

Soil Test P 0-6 inch (ppm)	(lb/A)	Recommended Fertilizer Rate (lb P_2O_5/A)	Probability of Yield Response (%)
0-5	0-10	35-40	>75
5-10	11-20	30-35	50-75
10-15	21-30	25-30	50
15-30	31-60	15-20	25-50
>30	>60	0-15	less than 25

Nutrient Recommendations, cont'd.

Recommendations also vary with goals of fertilization program:

- **Short term maximum economic yield or agronomic sufficiency**
- **Specific target yield or yield goal (e.g., 2.0-2.25 lb soil + fertilizer N per bu for HRS wheat)**
- **Crop quality (e.g., more N for high protein HRS wheat, less N for low protein malt barley)**
- **Environmental protection (e.g., reduce nitrate leaching, N_2O emissions, excessive P in runoff)**
- **Building, maintaining, or depleting soil fertility over the long term (e.g., for P)**

Nutrient Recommendations, cont'd.

Recommendations aimed at short-term maximum economic yield or agronomic sufficiency often result in long term depletion of soil fertility (e.g., for P) … especially for today's high crop yields

P balance for 4 yr rotation following MB Soil Fertility Guide rec. for seed-placed P fertilizer for 10 ppm Olsen P				
Crop	Average* Yield (bu/ac)	P Applied ----------	P Removed** (lb P_2O_5/ac)	Annual Balance ----------
Spring Wheat	65	30	34	-4
Canola	50	20	39	-19
Oats	120	30	32	-2
Soybeans	40	10	35	-25
4 Year Total		90	141	-51

*P removal should be calculated for average yield ... not target yield

** Using 0.53, 0.78, 0.27, 0.87 lb P_2O_5/bu respectively for grain only

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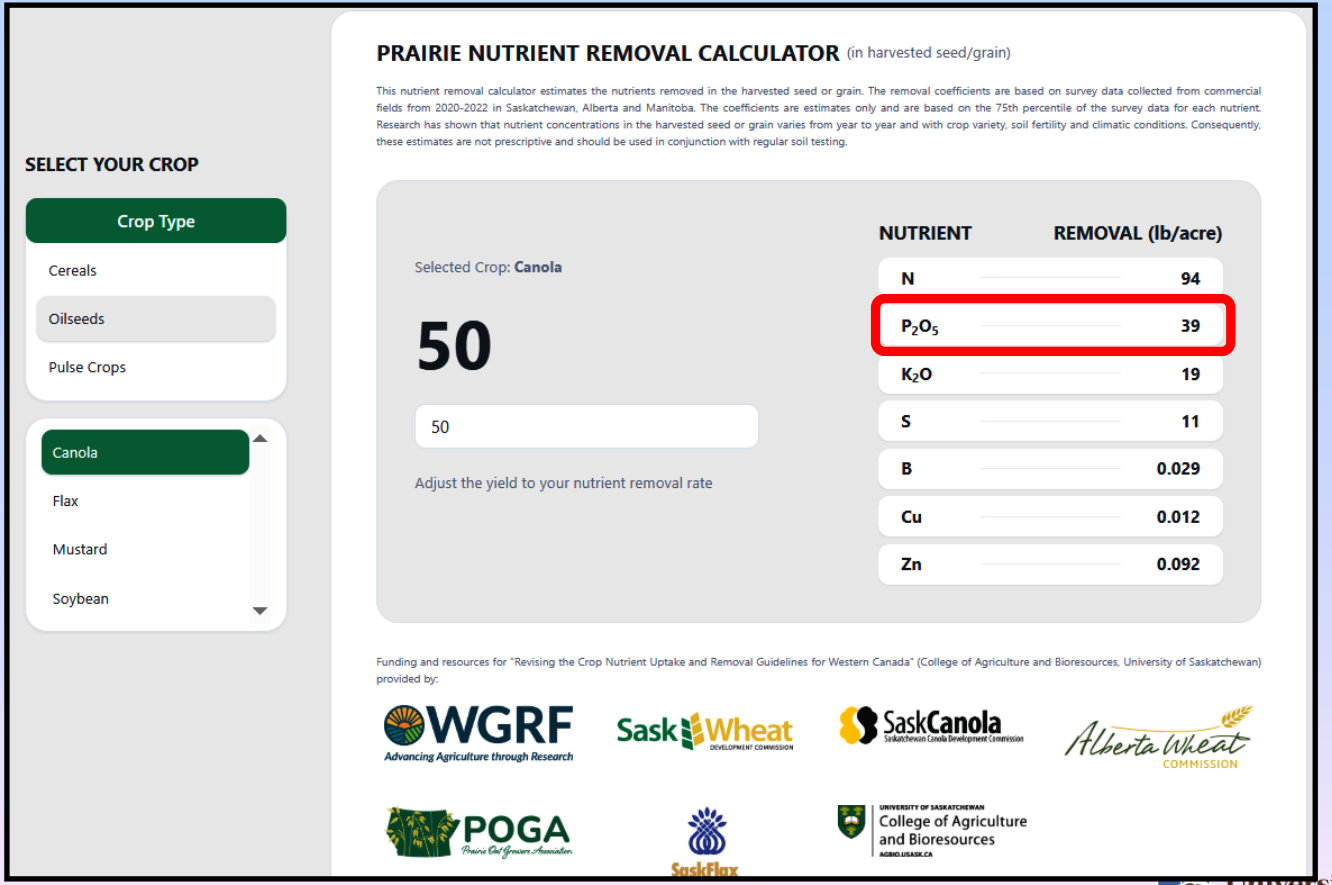
Prairie Nutrient Removal Calculator … an online tool to help manage soil fertility



https://prairienutrientcalculator.info/

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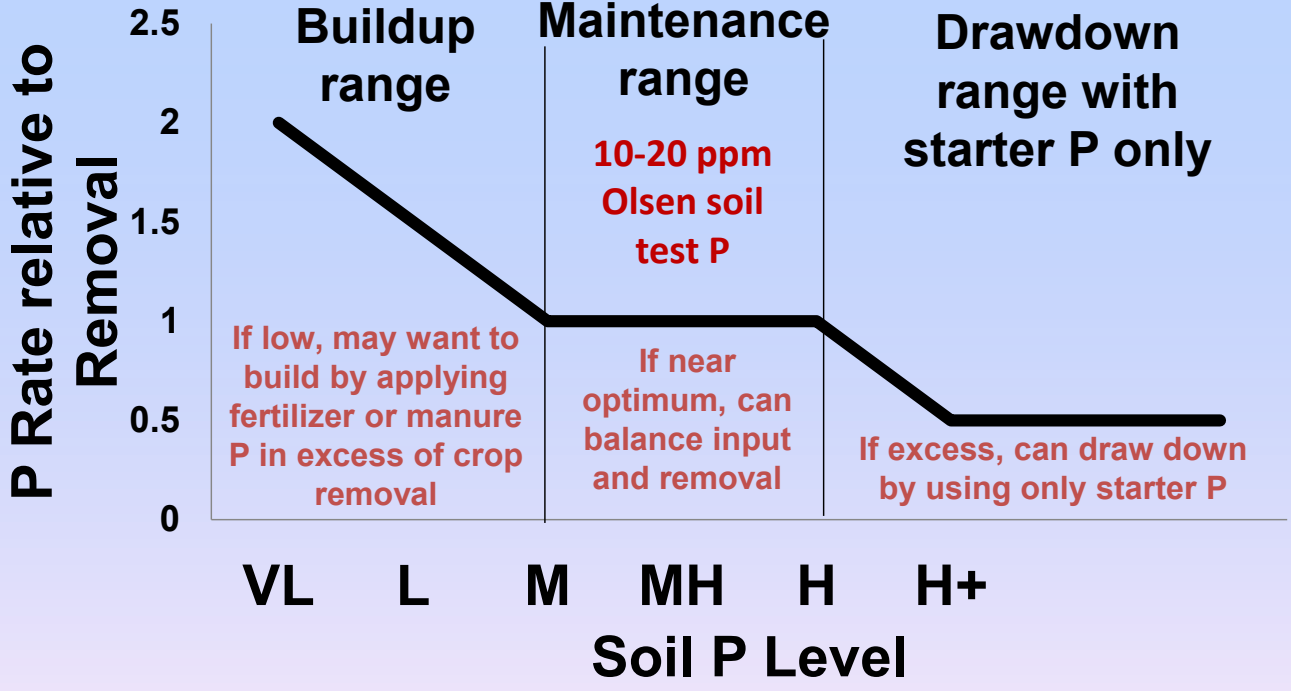
Nutrient Recommendations, cont'd.

Therefore, some farmers may select the goal of building, maintaining, or depleting soil fertility over the long term (e.g., for P)



Adapted from OMAFRA Soil Fertility Handbook

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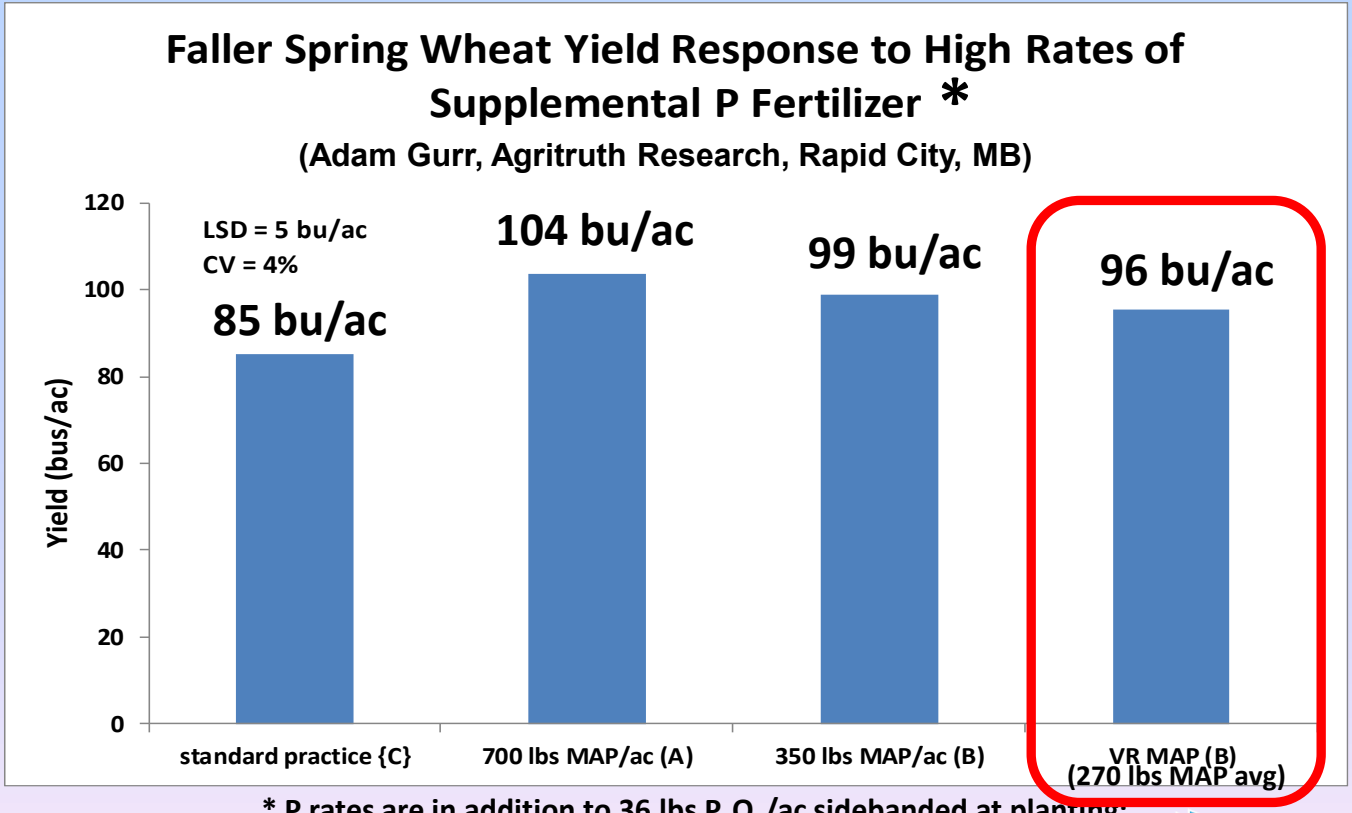
Crops respond to P fertilizer and soil P fertility: Adam Gurr's field trial with supplemental P … First year benefits after initial application in 2018



* P rates are in addition to 36 lbs P_2O_5/ac sidebanded at planting; yields are for the 1st year of study (2018)

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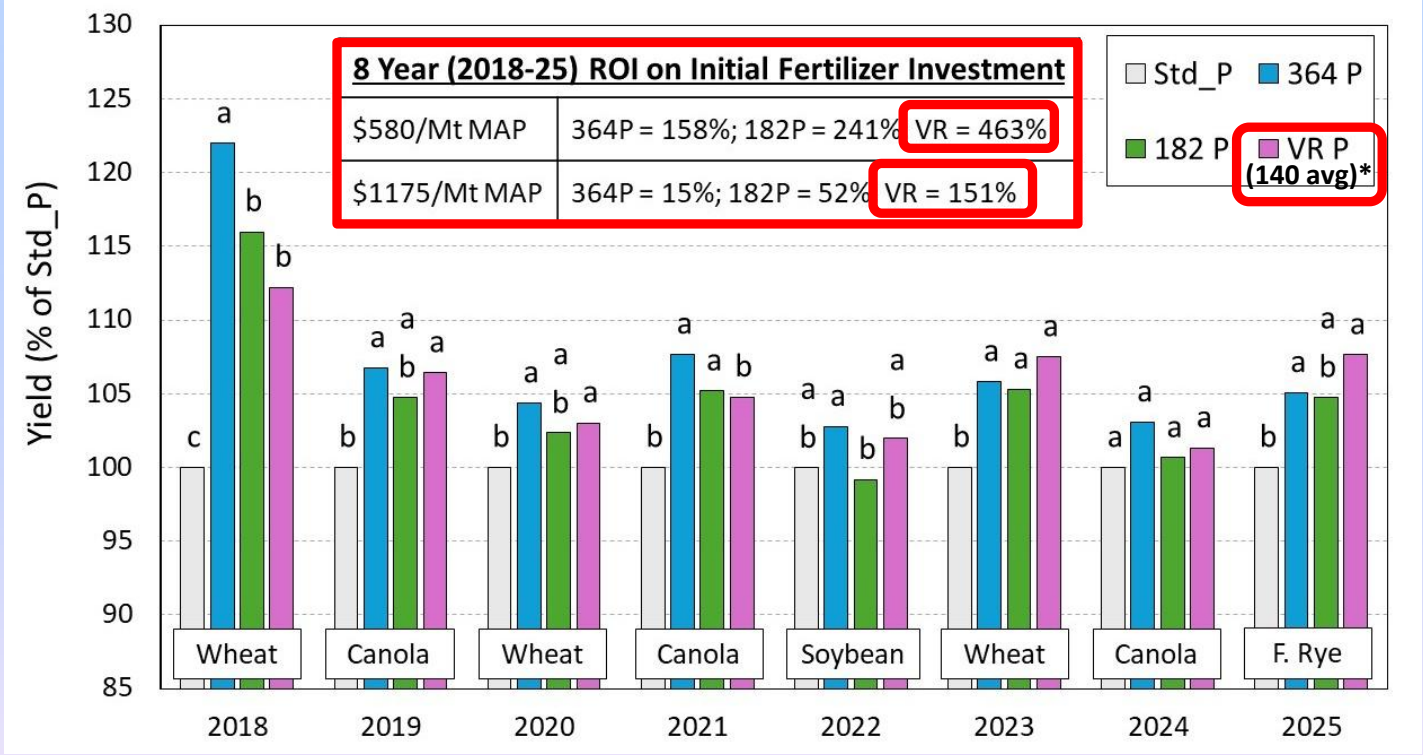
Crops respond to P fertilizer and soil P fertility: Adam Gurr's field trial with supplemental P … 8-year benefits after 1 "batch application" in 2018



* P rates are in addition to 36 lbs P_2O_5/ac sidebanded at planting; yields are for the 1st year of study (2018)

Agritruth RESEARCH

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Nutrient Recommendations, cont'd.

But the goals for nutrient management recommendations can and should be varied to address changes in fertilizer and crop prices, land ownership, and stage of farming career … additional factors that should be considered for every field, every year …

AGVISE

AGVISE Fertilizer Guideline Options in Tight Economic Times

In the current economic climate of high production costs for land, seed, fertilizer, chemical, fuel, and equipment, it

can decrease i

yield in the sh

the importan

fertilizer has

fertility specialists and ag economists alike. Both over- and under-fertilization reduce grower profits. While building soil test P may not be the best idea for next year,

you also need to make sure that you are applying enough P fertilizer to achieve high yields.

choose which fertilizer guideline is best suited to your equipment and management.

While building soil test P may not be the best idea for next year, you also need to make sure that you are applying enough P fertilizer to achieve high yields.

President's Corner 6

take soil samples in the winter or next spring. AGVISE sells in-cab hydraulic

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Improving Reliability, Value, and Confidence in Soil Testing
Step 4: Right Data Management & Use

To fully capitalize on the benefits of soil testing, <u>data</u> from soil testing must be transformed into useful <u>information</u>

A sound 4R Nutrient Stewardship strategy relies on soil testing every field/mgmt zone … every year … to:


Photo: Amy Mangin

1. <u>Predict</u> fertilizer and/or manure requirements for the next crop, based on existing reserves in soil and current goals for the fertility program in each field or management zone
2. <u>Diagnose</u> "unusualities" … e.g., areas of unusually good or poor crop growth
3. <u>Evaluate/audit</u> the current nutrient management plan for the most recent crop(s) … e.g., excess N fertilization or more N mineralization than immobilization
4. <u>Monitor</u> for long-term upward or downward trends in soil fertility and soil health … e.g., decreasing soil test P, increasing salinity, decreasing pH

"Drowning in data and starving for information," is a quote from Weyburn farmer Norm Flaten that I have used often.

- Les Henry, Grainews August 2013

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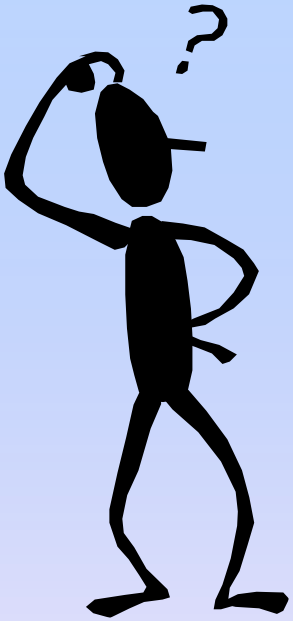
Improving Reliability, Value, and Confidence in Soil Testing
Step 4: Right Data Management & Use



- Ask the right questions at every stage in the soil & crop management cycle … from "advance" planning … to sampling, in-season monitoring, and post-harvest evaluation/audit
- Equipped with that information, collect, track, distill, and share data in a user-friendly and strategic manner … to fit each individual farmer and their farms, fields, and management zones … and to fit closely with their entire 4R Nutrient Stewardship "system"

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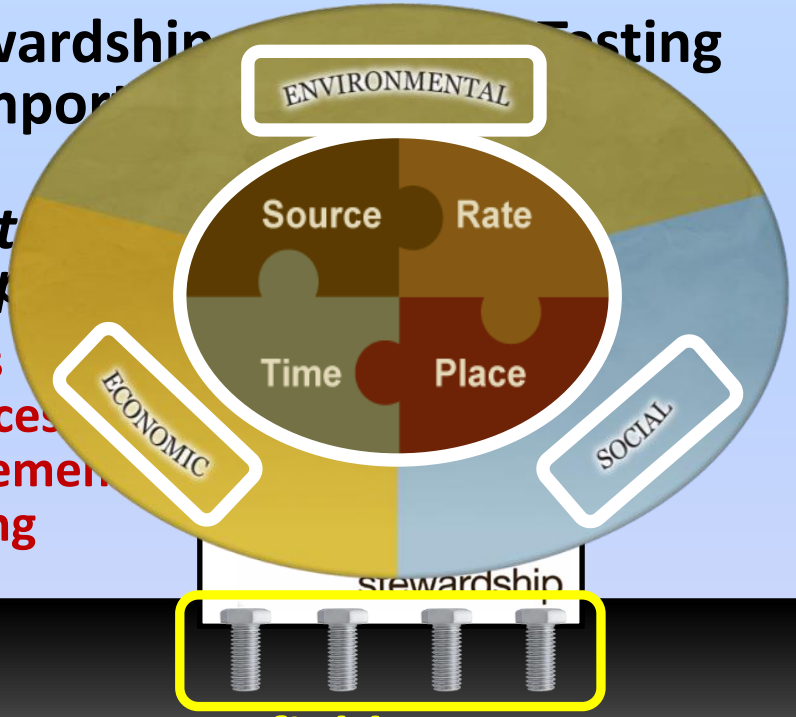
4R Nutrient Stewardshi… …esting More Impor…

4R Nutrient Stewardship

- ✓ Right rates
- ✓ Right sources
- ✓ Right placemen…
- ✓ Right timing



4R Soil Testing … every field, every year

- ✓ Right sampling
- ✓ Right analyses
- ✓ Right recommendations
- ✓ Right data management and use

My idea for a new, more efficient consulting group …

INCITE

Soil & Crop Management Consultants

We don't mince words or waste time with lots of questions ... we just tell you what's wrong with your farm and how you should fix it

For reasons that I don't understand, our business is struggling to find clients …

University of Manitoba

Summary: 4R Nutrient Stewardship & 4R Soil Testing More Important Than Ever

- methods for soil sampling, analyses, and recommendations should be matched with the soil, climate, and landscape characteristics for each region, field or management zone … as well as the farmer's agronomic & economic goals and current/expected weather & market conditions

4R Soil Testing … every field, every year

- ✓ Right sampling
- ✓ Right analyses
- ✓ Right recommendations
- ✓ Right data management & use

- use sound science & "real" intelligence to develop & implement a locally-relevant soil testing system that fits the local field, farm, and farmer for the upcoming growing season … to maximize benefits & minimize limitations

University of Manitoba

Summary: 4R Nutrient Stewardship & 4R Soil Testing More Important Than Ever

Thank you for your attention … any questions?

4R Soil Testing … every field, every year

- ✓ Right sampling
- ✓ Right analyses
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