

Soil Phosphorus, Soil Test Recommendations and Phosphate Fertilizer Management

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Acknowledgements

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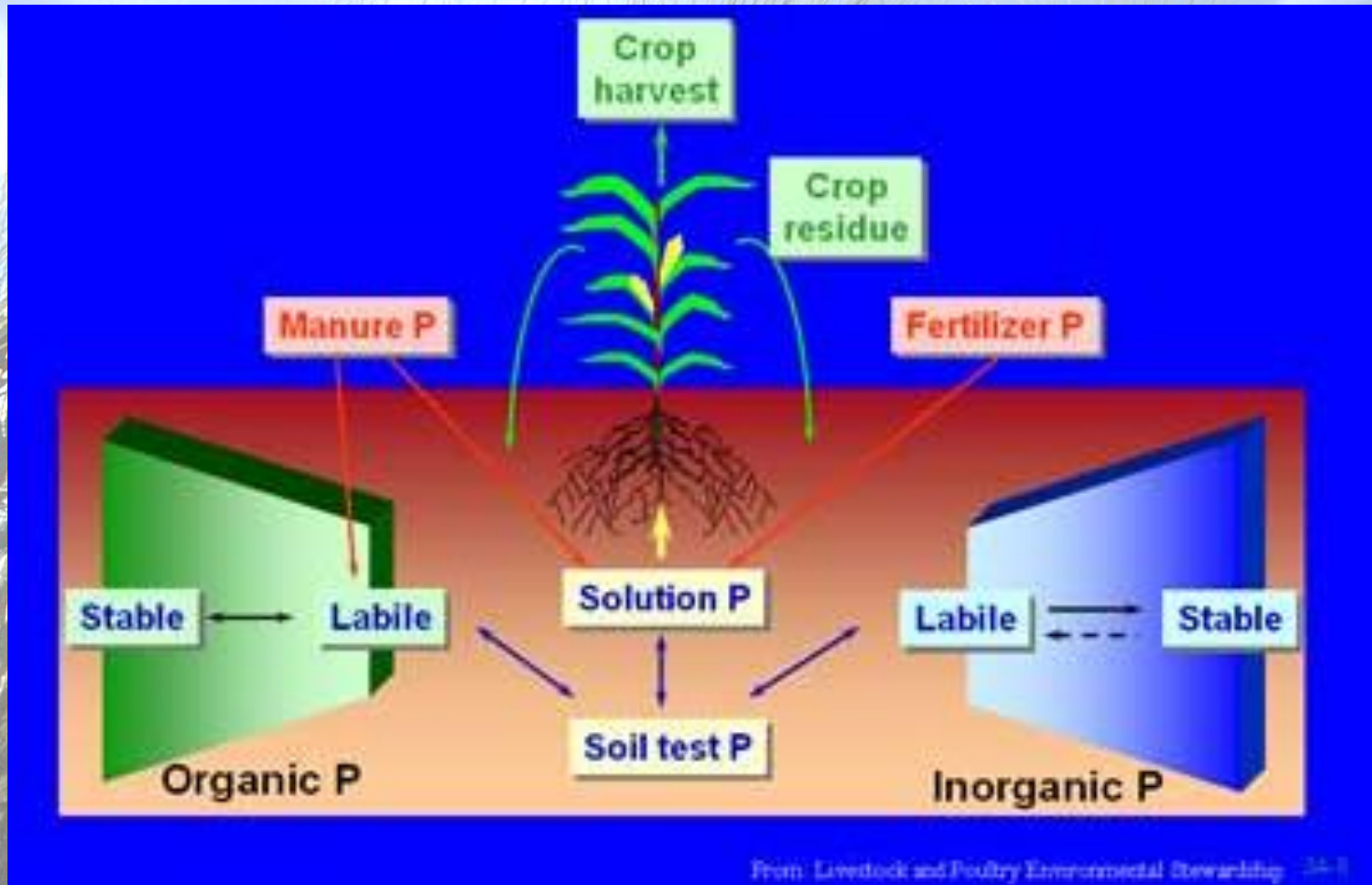
Phosphorus Overview

- Second most widely deficient nutrient - Why?
 - Soils low in P minerals in the parent material
 - Very low solubility in the soil of phosphate
- 2 anionic forms available for plant uptake;
 - pH dependent
 - primary orthophosphate (H_2PO_4^-)
 - secondary orthophosphate ($\text{HPO}_4^{=}$)
- Compared to N & K, plant content is smaller
 - Plants contain 0.1 - 0.5% P
- P forms organic compounds in the plant
- P is mobile in plants

Function in Plants

- Photosynthesis and respiration
- Energy storage and transfer
- Cell division and enlargement
- Critical for early vigorous growth
- Stimulates root and tiller development
- Disease resistance
- Promotes reproduction (maturity & seed formation)
- P accumulates in the seed transfer of heredity traits
- Winter hardiness

Soil Phosphorus



A Good Nutrient Soil Test

- Needs extensive field and laboratory research.
- Needs to provide a measure of the nutrient proportional to what a plant utilizes.
- Able to identify responsive vs non-responsive soils based on soil test critical level and/or other related properties.
- Able to predict nutrient application rate for responsive soil.
- Able to identify excessive nutrient levels.

Limits of a Nutrient Soil Test

- One time snap shot of nutrient levels that must be able to take the entire crop growing season into account
- Misconception – nutrient measure equals availability; Soil analysis is an inventory of nutrient levels in the soil
- Requires continuous verification, evaluation and updates
- Field research related to management changes crops, varieties, nutrient sources, rates, time of application, placement, tillage, etc.
- Laboratory improvements: procedures, detection limits, multiple nutrient extraction

Calibration, Interpretation & Recommendation

Soil Test Calibration:

- Process by which a soil test provides a means to measure soil nutrient levels.

Soil Test Interpretation:

- Guidelines to identify nutrient levels: deficient, marginal, adequate or excessive.

Soil Test Nutrient Recommendation:

- Process by which soil test calibration curve provides the basic nutrient requirement.
- Any factor that enhances or limits crop growth will increase or decrease crop nutrient requirements.

Soil Test Calibration

- Gain information about a soil and provide a fertilizer recommendation that is economically and environmentally sound.
- Nutrient soil test must be calibrated with crop yield response across many different soil types
- May use crop nutrient removal
- Often regionally specific
- Costly and time consuming
- Soil test methods will vary between laboratories

Soil Test Calibration Research

Field trials - Variables:

- Crops, varieties, fertilizer products, time of application, fertilizer placement, tillage
- Regions - soil types, climate, soil moisture, irrigation
- Soil samples

Laboratory soil test methods - Chemistry:

- Chemical extraction solutions
 - Acids, bases, neutral salts
 - Anion and cation displacement

Correlation - How good is the relationship:

- Crop response - Fertilizer rate relationship
- Soil test - Crop response relationship
- Soil test - Fertilizer rate relationship
- Linear, Non-linear, Spline, etc
- As the soil test increases, the recommended fertilizer rate decreases

Soil Test Interpretation

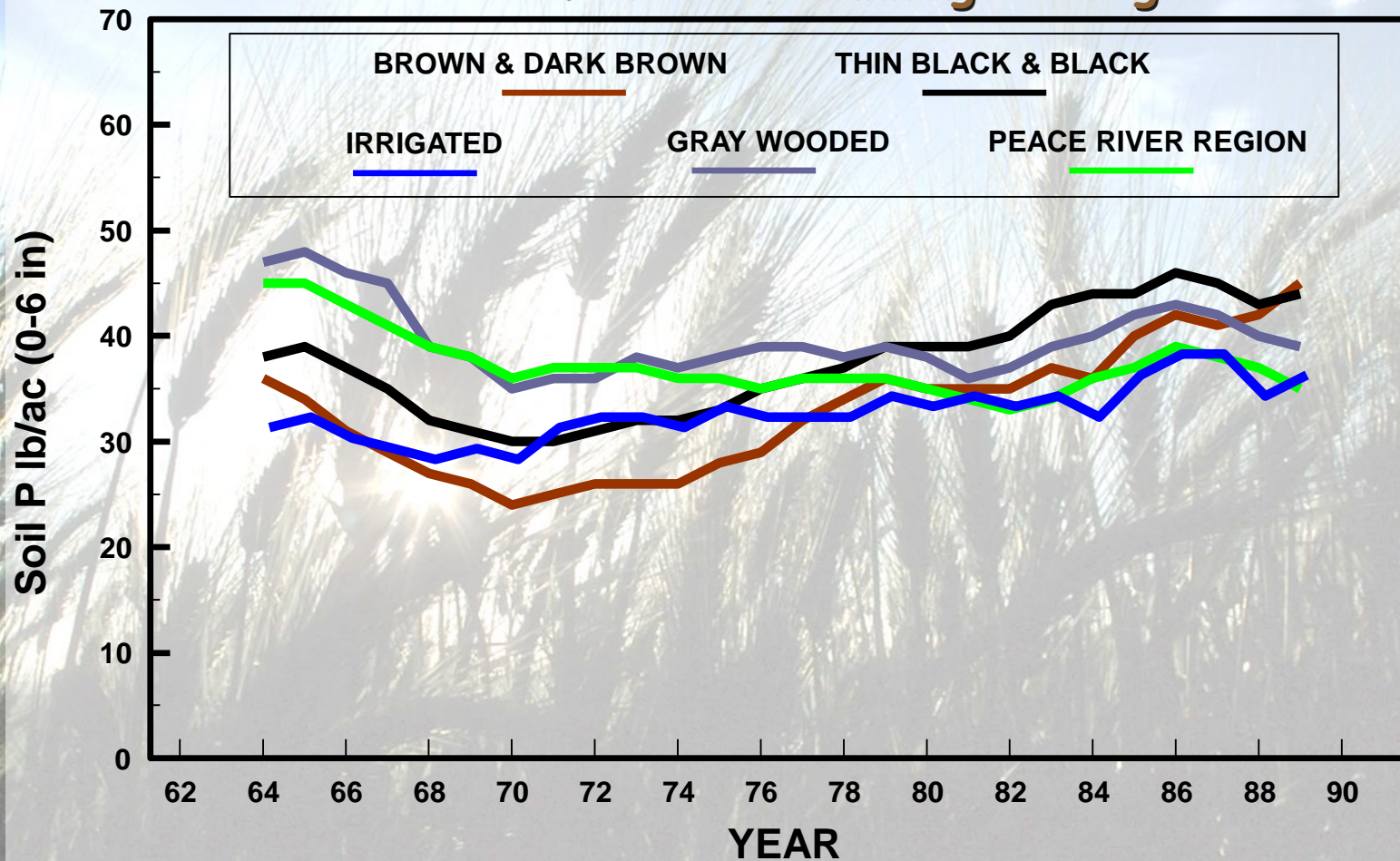
Interpretation directly related to philosophy and recommendation

Philosophies

- Sufficiency - Deficiency Correction:
Deficient, Marginal, Adequate, Excessive, Toxic
- Replacement - Crop Removal
- Build and Maintenance:
Application of nutrients in excess of crop removal

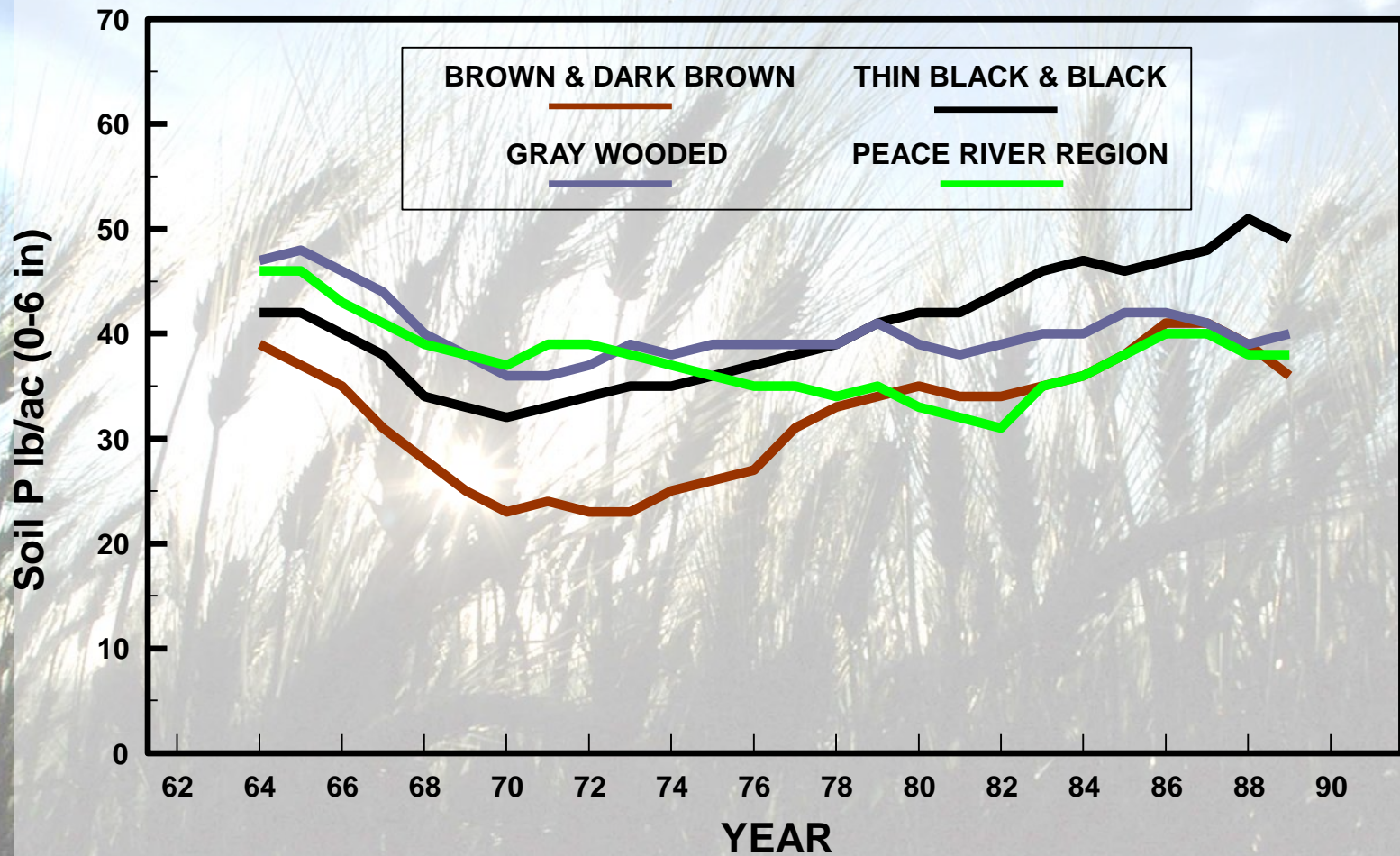
Soil Test Phosphorus

Five Year Running Averages - Stubble



Soil Test Phosphorus

Five Year Running Averages - Fallow



P Fertilizer Trials in Alberta

1969-73 (J. Robertson, UofA)

- 38 sites
- Evaluate response of spring wheat
- Calibration of P soil tests

1971-75 Risk Adjusted Yield Potential (RAYP)

- 125 sites
- Evaluate response of barley and canola
- Calibration of P soil tests

1990-93 (R. McKenzie, AARD)

- 427 sites
- Evaluate response of wheat, barley and canola
- Calibration response to different soil P tests

P Trials in Alberta (1990-93)

	% Response					
	Wheat		Barley		Canola	
1991	78	(48)*	89	(47)	82	(38)
1992	89	(51)	96	(54)	77	(43)
1993	82	(49)	89	(46)	89	(36)

* total sites

(McKenzie et al. 1993)

91-93 Soil test P calibration trials

Table 5. Summary of responsive and non-responsive sites by soil zone based on yield differences

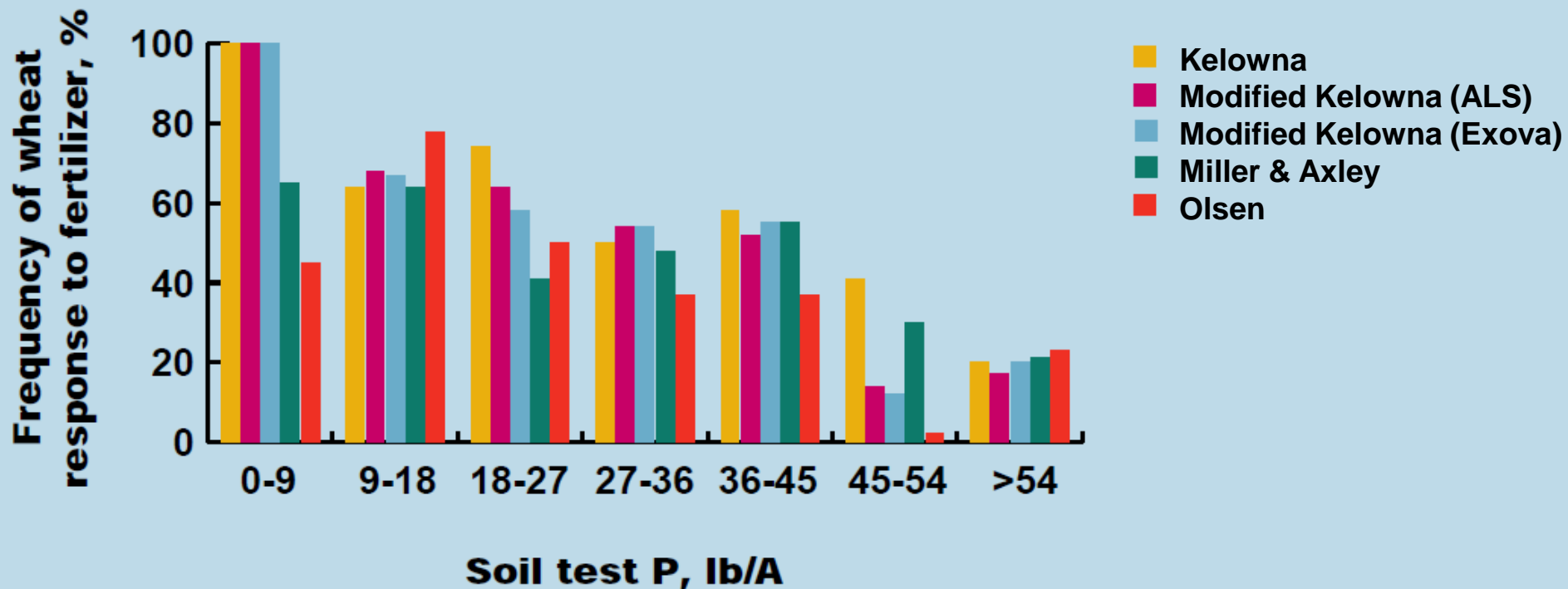
Crop	Type of response*	Brown	Dark Brown	Thin Black	Black	Gray Wooded (Central)	Gray Wooded (Peace River)	Total sites
Wheat	Response	9	10	14	21	10	10	74
	Marginal response	1	10	9	8	6	9	43
	No response	6	8	3	6	3	2	28
Barley	Response	9	14	19	32	14	13	101
	Marginal response	5	12	14	3	2	6	42
	No response	2	0	4	4	3	3	16
Canola	Response	3	2	1	9	6	8	29
	Marginal response	8	14	11	12	8	7	60
	No response	5	9	6	8	1	5	34

* Response: yield increase greater than 5 bu/ac. Marginal response: yield increase between 2 and 5 bu/ac. No response: less than 2 bu/ac yield increase.

Soil test P methods evaluated in P calibration trials in Alberta

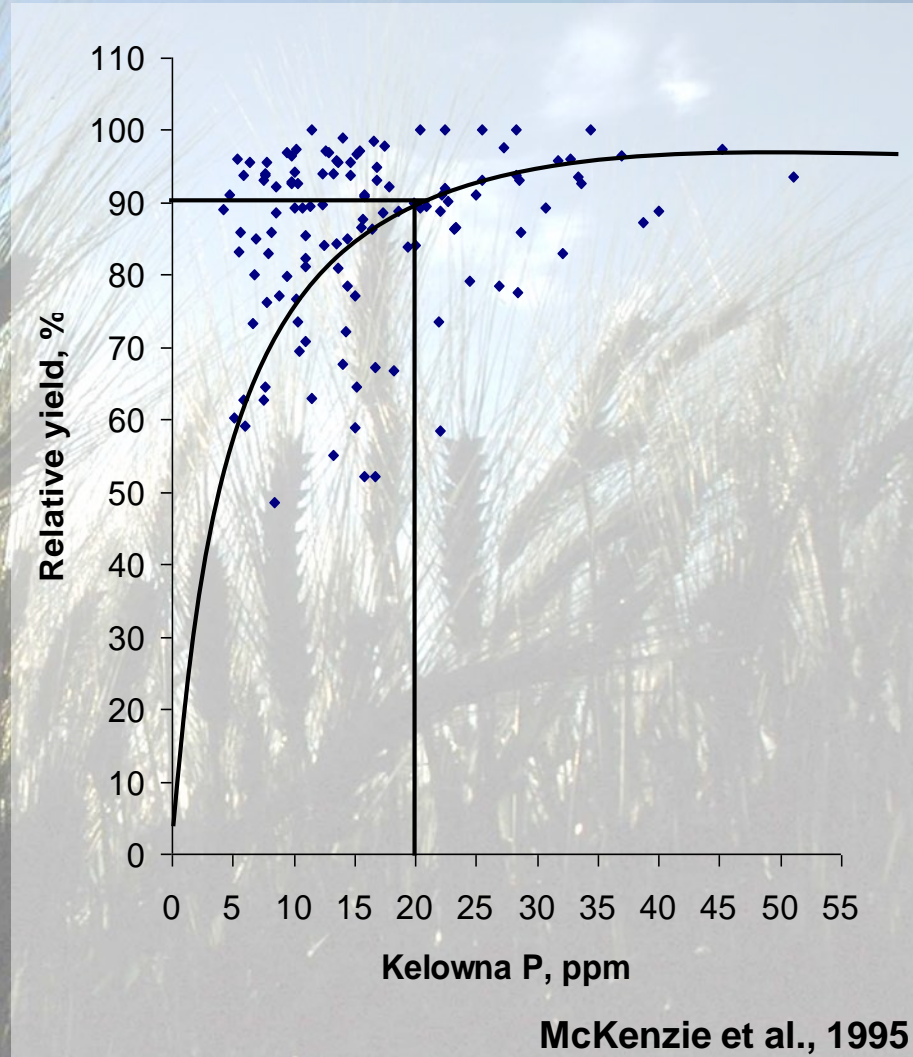
<u>Method</u>	<u>Extractant</u>
Miller and Axley	ammonium fluoride and sulfuric acid (0.03N NH_4F + 0.03N H_2SO_4)
Olsen	sodium bicarbonate (0.5M NaHCO_3)
Kelowna	acetic acid and ammonium fluoride (0.25N HOAc + 0.015N NH_4F)
Modified Kelowna (Exova)	acetic acid, ammonium fluoride and ammonium acetate (0.5N HOAc + 0.015N NH_4F + 1.0N NH_4Oac)
Modified Kelowna (ALS)	acetic acid, ammonium fluoride and ammonium acetate (0.25N HOAc + 0.015N NH_4F + 0.25N NH_4Oac)

Soil test P calibration trials in Alberta



Sufficiency Soil Test P Level for Canola

- Calibration curve indicates which soil test levels tend to limit yields.
- The results of this calibration data set from Alberta show a critical level (sufficiency) of 20 to 25 ppm (40 to 50 lb/A) P.
- This is the level of soil test P above which minimal response to applied P can be expected.



McKenzie et al., 1995

P Soil Tests Calibrated in Western Canadian Field Studies

- **Miller Axley**
- **Olsen (bicarbonate)**
- **Kelowna**
- **Modified Kelowna (Exova, ALS)**

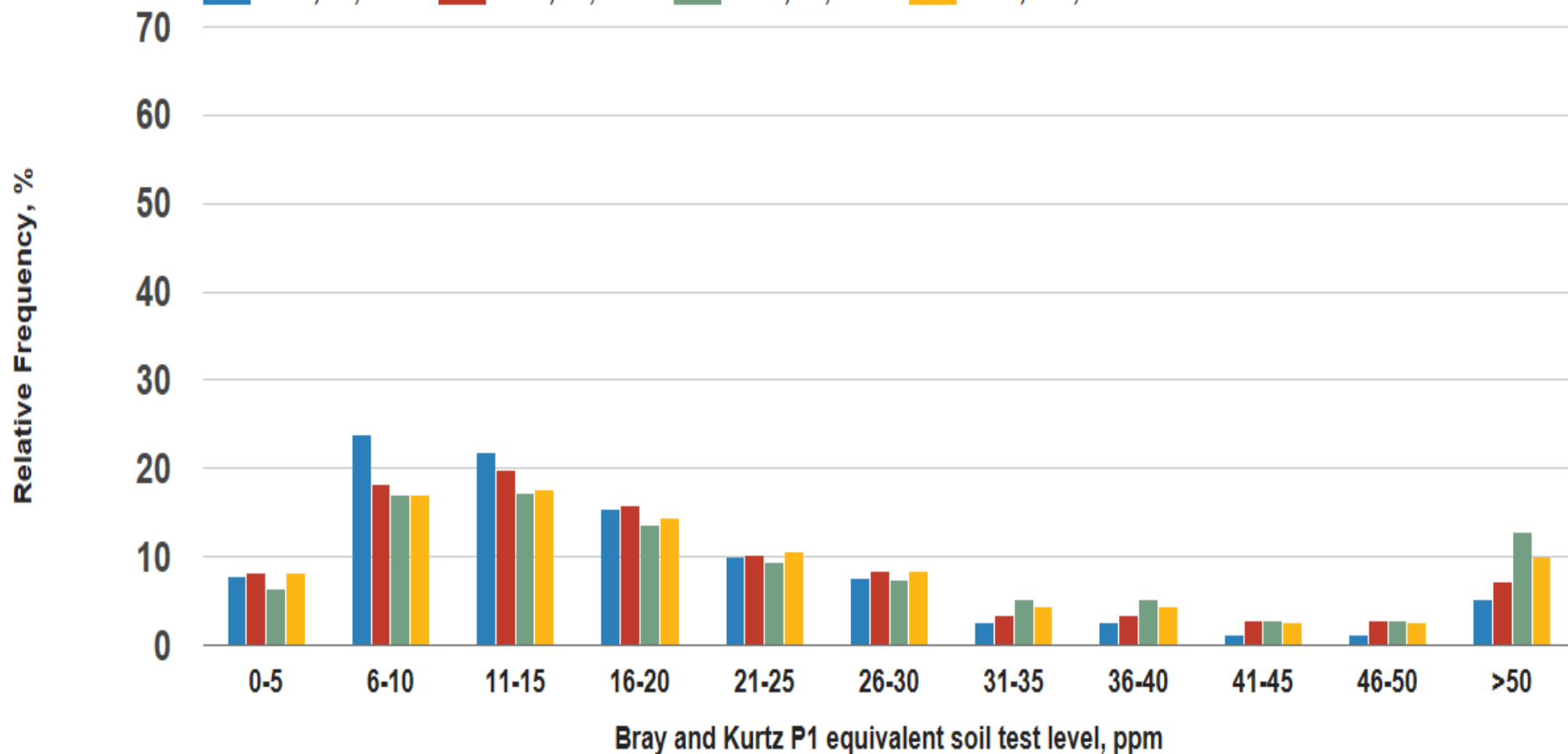
P Soil Tests Not Calibrated in Western Canadian Field Studies

- **Bray I (weak), Bray II (strong)**
- **Mehlich-1, Mehlich-3**
- **Morgan**
- **Many others**

IPNI Soil Test Summary

Phosphorus sample distribution: Alberta, Saskatchewan, Manitoba

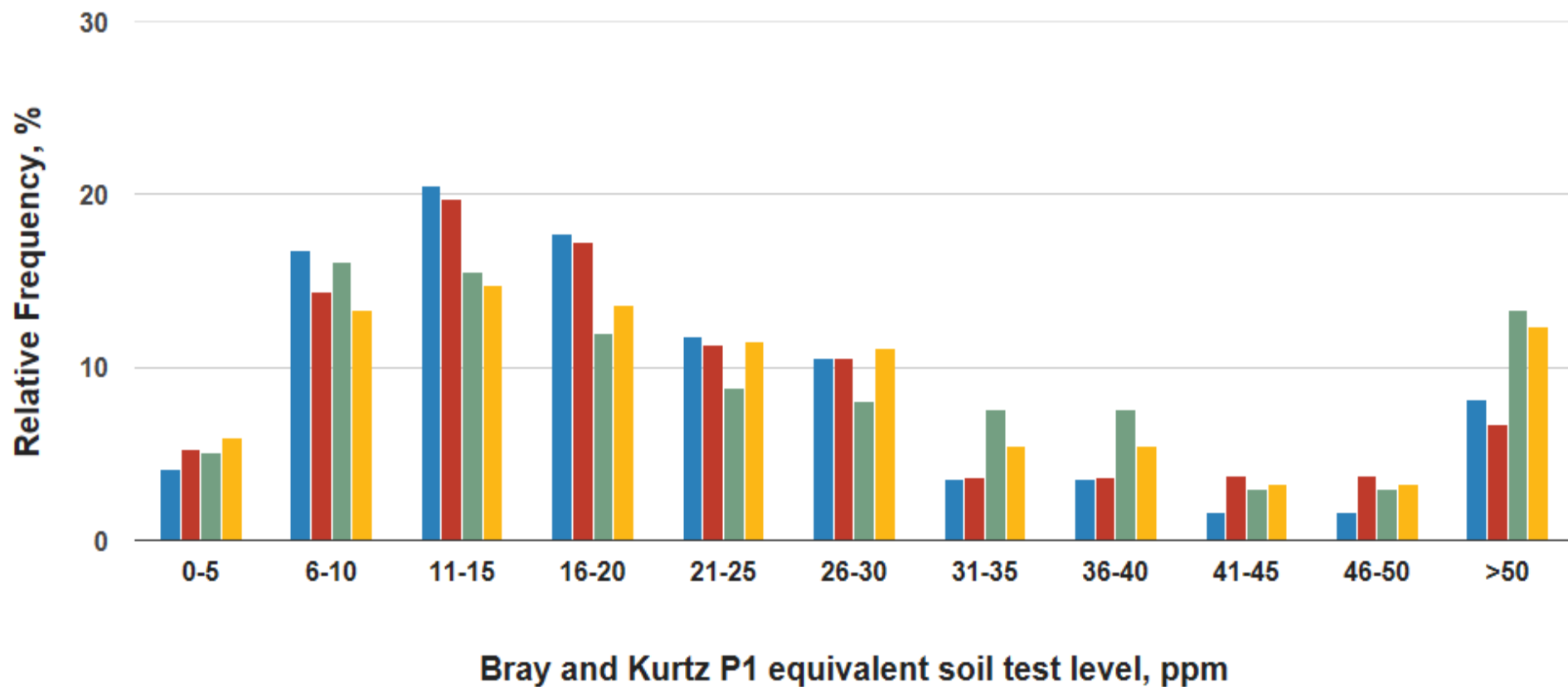
2001; 77,063 2005; 93,835 2010; 93,699 2015; 119,089



IPNI Soil Test Summary

Phosphorus sample distribution: Alberta

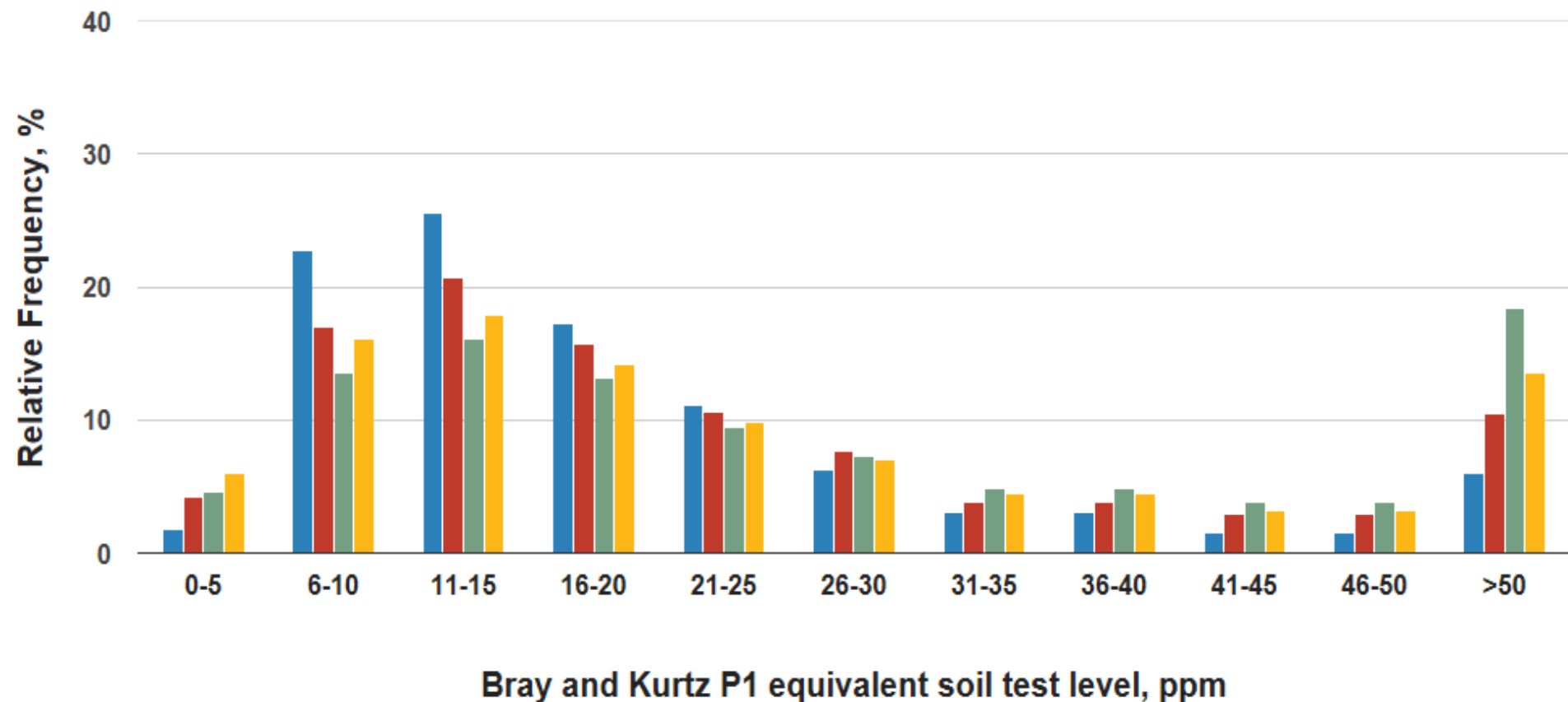
2001; 37,437 2005; 36,967 2010; 26,877 2015; 39,096



IPNI Soil Test Summary

Phosphorus sample distribution: Manitoba

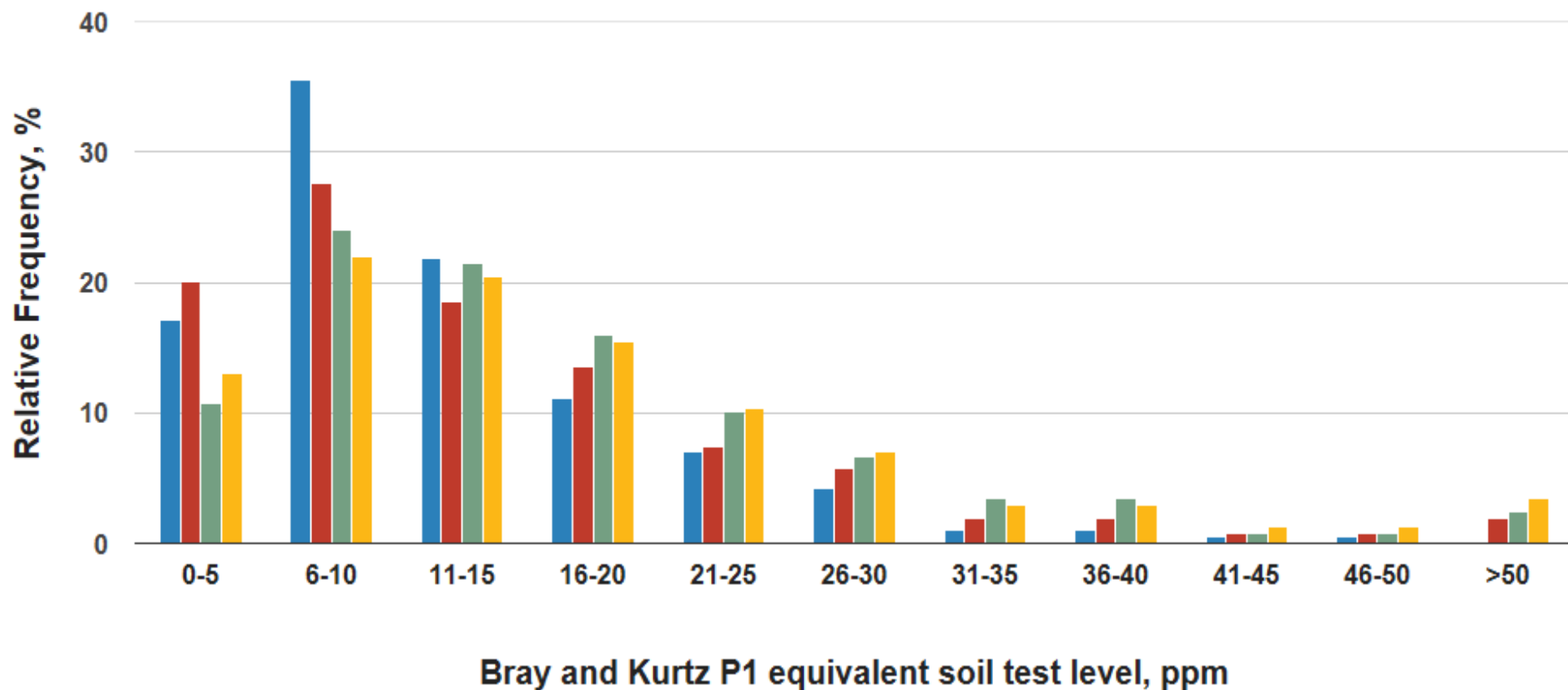
2001; 14,999 2005; 36,155 2010; 42,392 2015; 43,286



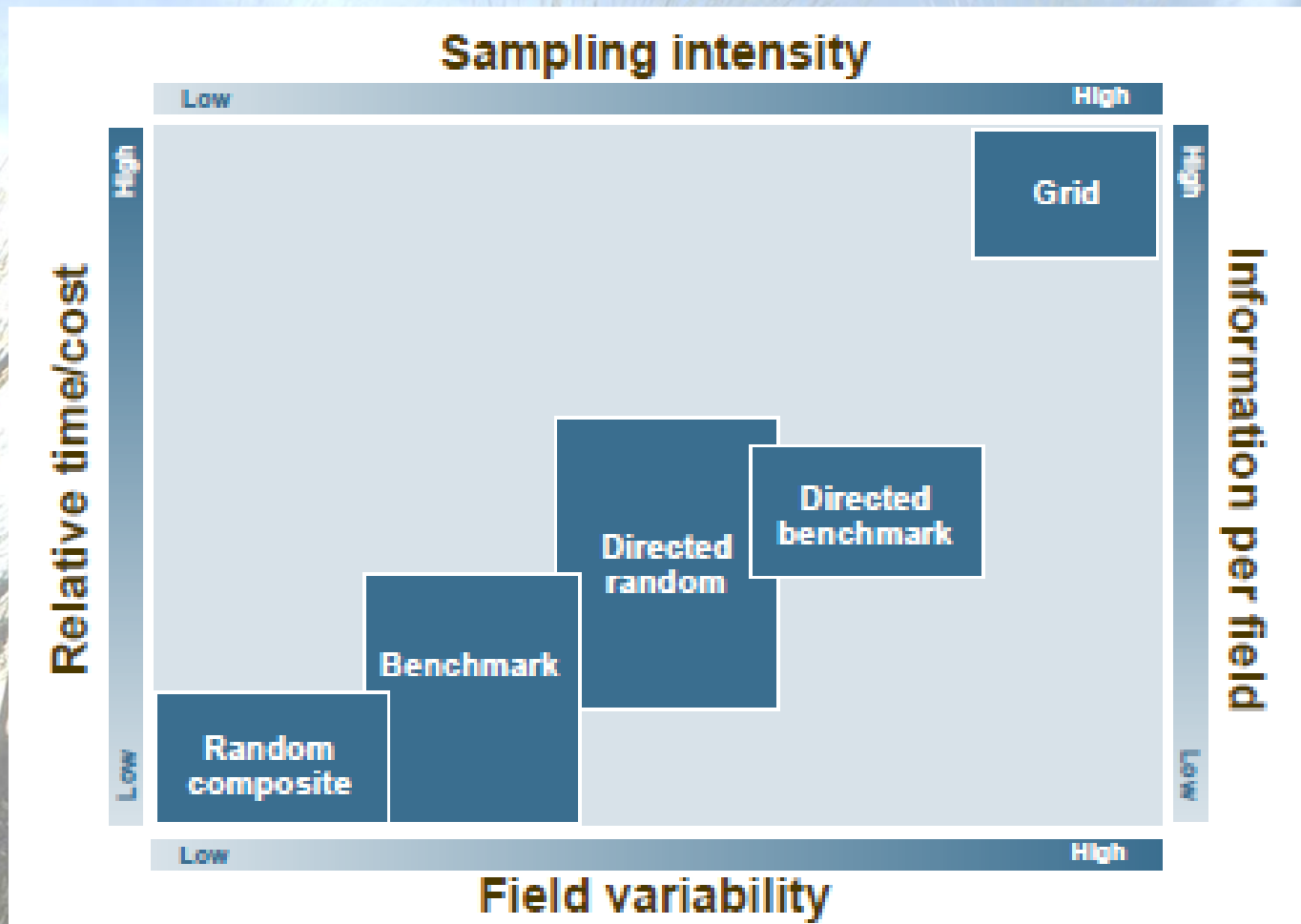
IPNI Soil Test Summary

Phosphorus sample distribution: Saskatchewan

2001; 24,627 2005; 20,713 2010; 24,430 2015; 36,707



Soil Sampling & Soil Testing



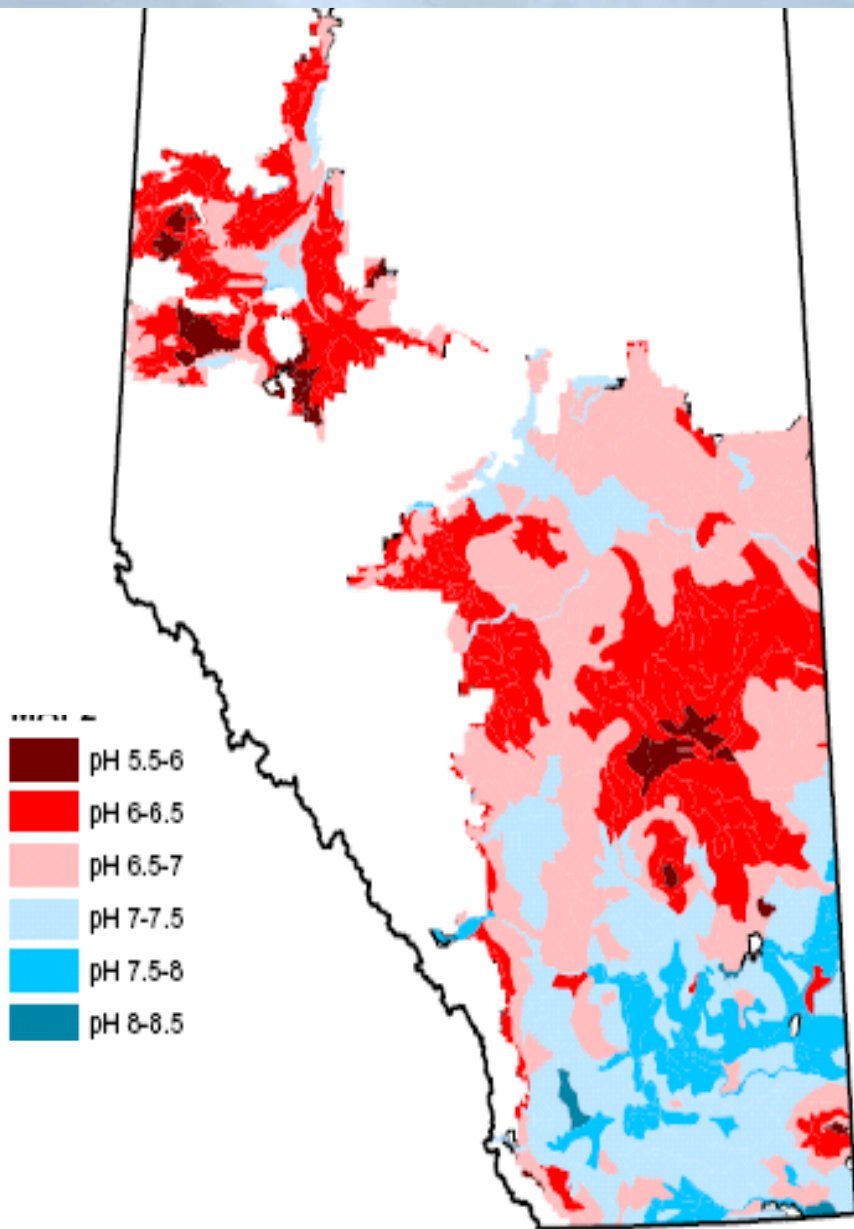
Nutrient Recommendations

Factors Influencing Recommendations

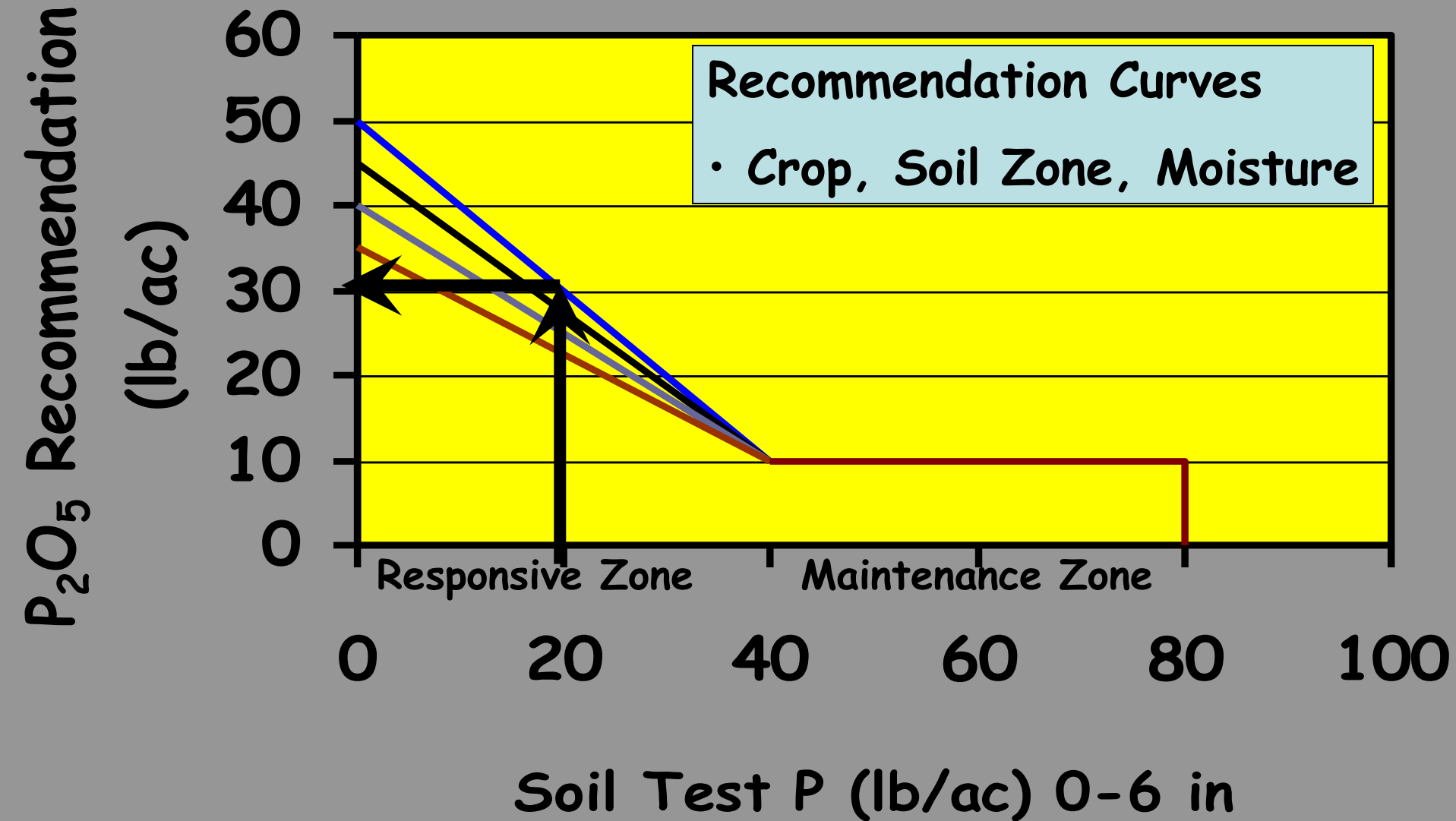
- Soil Nutrient Level
- Crop
- Agro-Climatic Zone
- Growing Season Precipitation
- Soil Texture
- Soil Moisture
- Soil Organic Matter
- Soil pH
- Soil Salinity

Soil pH

- Affects the dominate form of soil phosphorus
- Crops have variable tolerance that will effect yield potential
- Affects the soil test extraction effectiveness



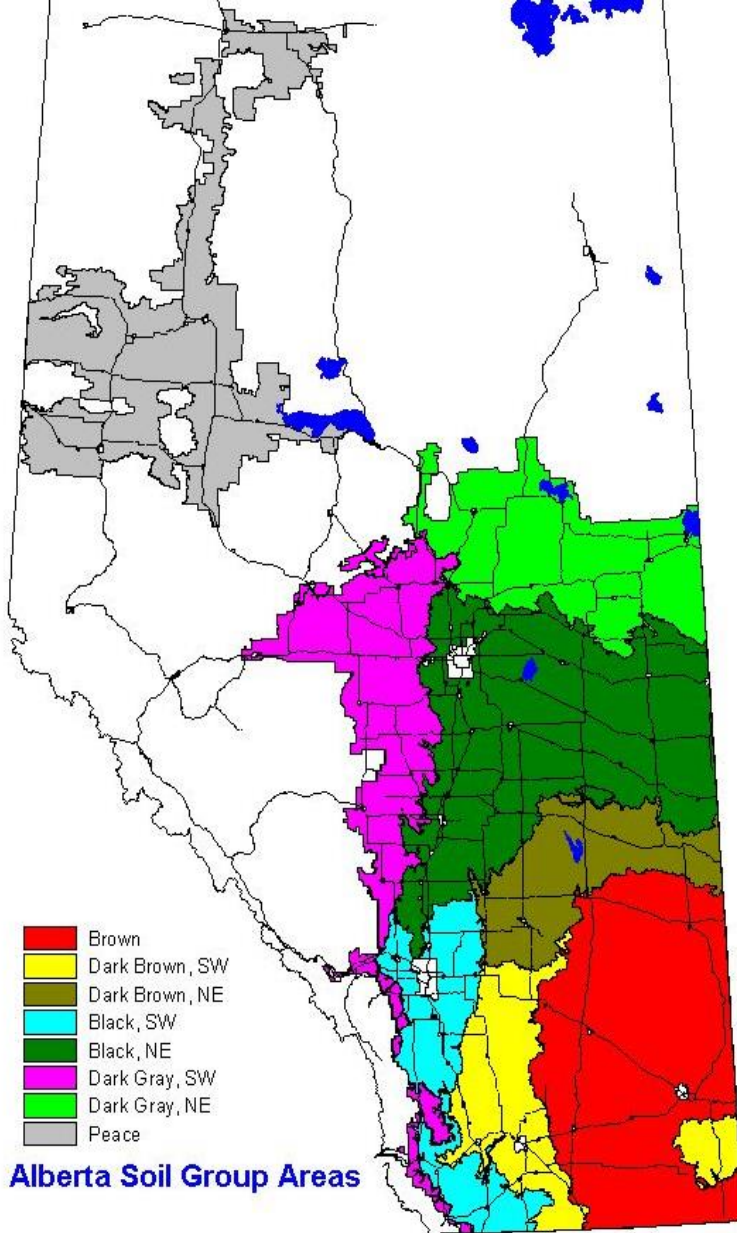
Phosphate Recommendation



Agro-Climatic Zones

Zones reflect differences

- Soils
- Climate
(pptn, temp, growing season)
- Crop management
- Yield potential
- Nutrient availability
- Nutrient requirements





FERTILIZER MANAGEMENT SURVEY

2014 CROP YEAR

2015 CROP YEAR

Phosphorus Fertilizer Use Survey

Spring Wheat

Phosphorus fertilizers were applied on 87% of Spring Wheat acres.

- | | |
|------------|---|
| Source: | MAP represents 86% of total phosphorus volume applied in spring wheat. |
| Timing: | 94% of Phosphorus volumes were applied at planting. |
| Placement: | At planting, the main placements were: 47% seed placed; 26% side banded. |
| Rate: | Average rate (including untreated) = 26.1 lbs./ac; average rate when used at planting = 26 lbs./ac. |

Barley

Phosphorus fertilizers were applied on 88% of barley acres.

- | | |
|------------|---|
| Source: | MAP represents 84% of total phosphorus volume applied in barley. |
| Timing: | 96% of Phosphorus volumes were applied at planting. |
| Placement: | At planting, the main placements were: 51% seed placed; 32% side banded. |
| Rate: | Average rate (including untreated) = 27.8 lbs./ac; average rate when used at planting = 30 lbs./ac. |

Canola

Phosphorus fertilizers were applied on 86% of canola acres.

- | | |
|------------|---|
| Source: | MAP represents 73% of total phosphorus volume applied in canola. |
| Timing: | 92% of Phosphorus volumes were applied at planting. |
| Placement: | At planting, the main placements were: 51% seed placed; 36% side banded. |
| Rate: | Average rate (including untreated) = 31 lbs./ac; average rate when used at planting = 31 lbs./ac. |

Peas

Phosphorus fertilizers were applied on 44% of peas acres.

- | | |
|------------|--|
| Source: | MAP represents 88% of total phosphorus volume applied in peas. |
| Timing: | 94% of Phosphorus volumes were applied at planting. |
| Placement: | At planting, the main placements were: 43% (27 AB) seed placed; 26% side banded. |
| Rate: | Average rate (including untreated) = 12 (20 AB) lbs./ac ; average rate when used at planting = 27 lbs./ac. |

Alberta Farm Fertilizer Information and Recommendation Manager (AFFIRM)

- Fertilizer recommendations based soil test calibrations from Alberta research.
- Able to utilize soil test results from several different laboratories.
- Access to current nutrient management knowledge based on Alberta research.
- Nitrogen fertilizer-crop response model that incorporates soil test and fertilizer nitrogen with spring moisture conditions and growing season precipitation.
- Balanced nutrient economic analysis model.
- Nitrogen mineralization estimates to improve fertilizer nitrogen recommendations for crop production.
- Field and whole farm optimization for nutrient management.

AFFIRM Enhancements

- Update Laboratories and Soil Test Calibrations
- New fertilizer products research
 - Enhanced Efficiency Fertilizers
ESN (coated urea) and other fertilizer products
- 4R Nutrient Stewardship
 - Product, Rate, Time, Place
- Incorporate nutrients from manure sources
- Linkage to AB Climate Information Services and
AB Soil Information Viewer

Key Messages

- P fertilizer is essential for optimum crop production.
- There is a need for P fertilizer in Alberta; 50 to 80% of provincial soils are severely to marginally deficient.
- Soil test P methods vary greatly among laboratories and in their ability to measure crop available soil P.
- Calibration of soil test P methods can be influenced by soil pH, texture and seedbed moisture.
- MAP, seed placed, spring application represents the majority of P fertilizer management;
Average application rates range from 12 to 31 lb/ac.
- AFFIRM will provide access to 4R Nutrient Stewardship for a range of laboratory soil test P methods.

Thank You

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