Review of 4R P Fertilizer Management in the Northern Great Plains

Don Flaten and Cynthia Grant
University of Manitoba

AGVISE Soil Fertility Seminar
Portage la Prairie
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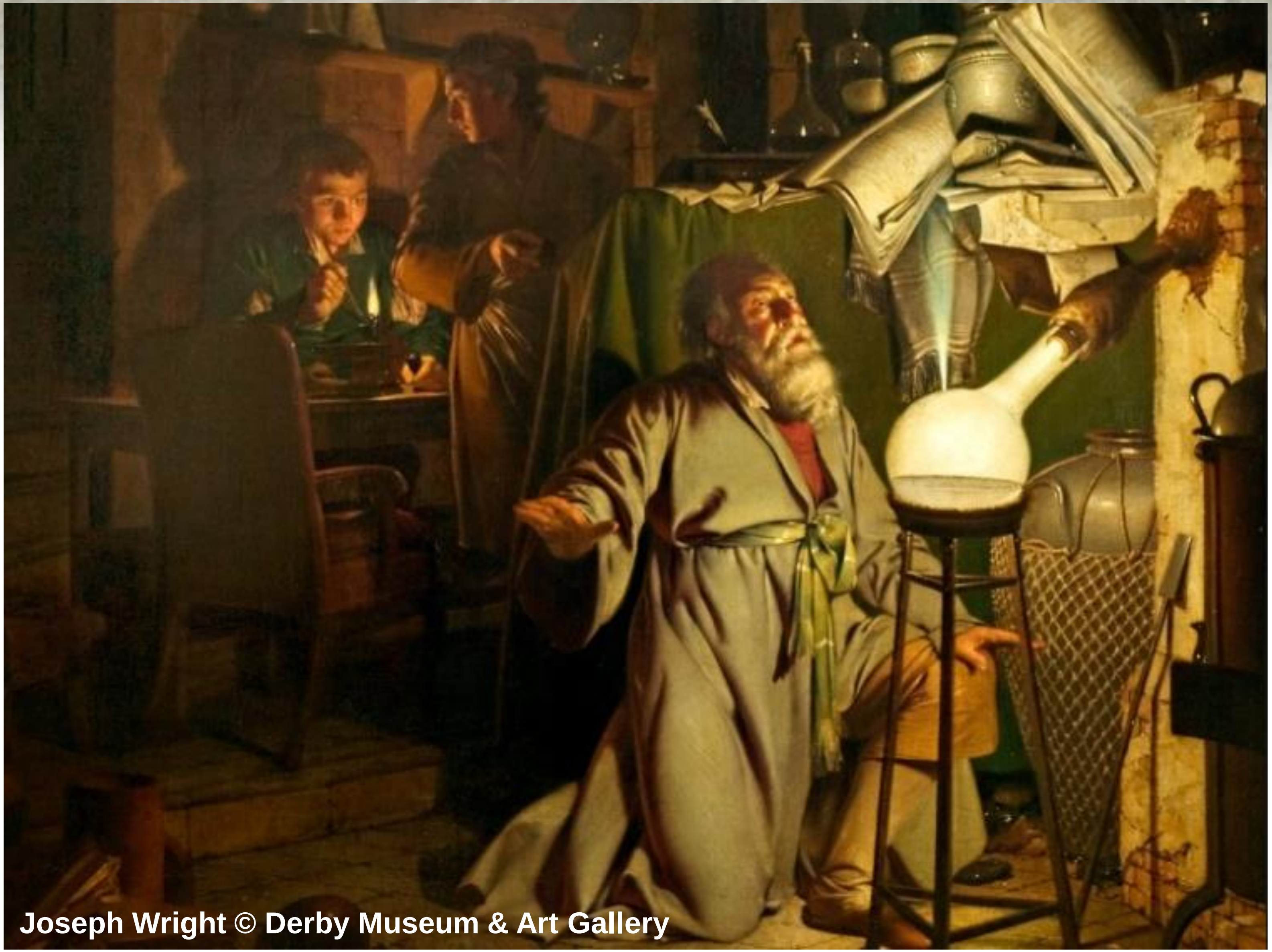
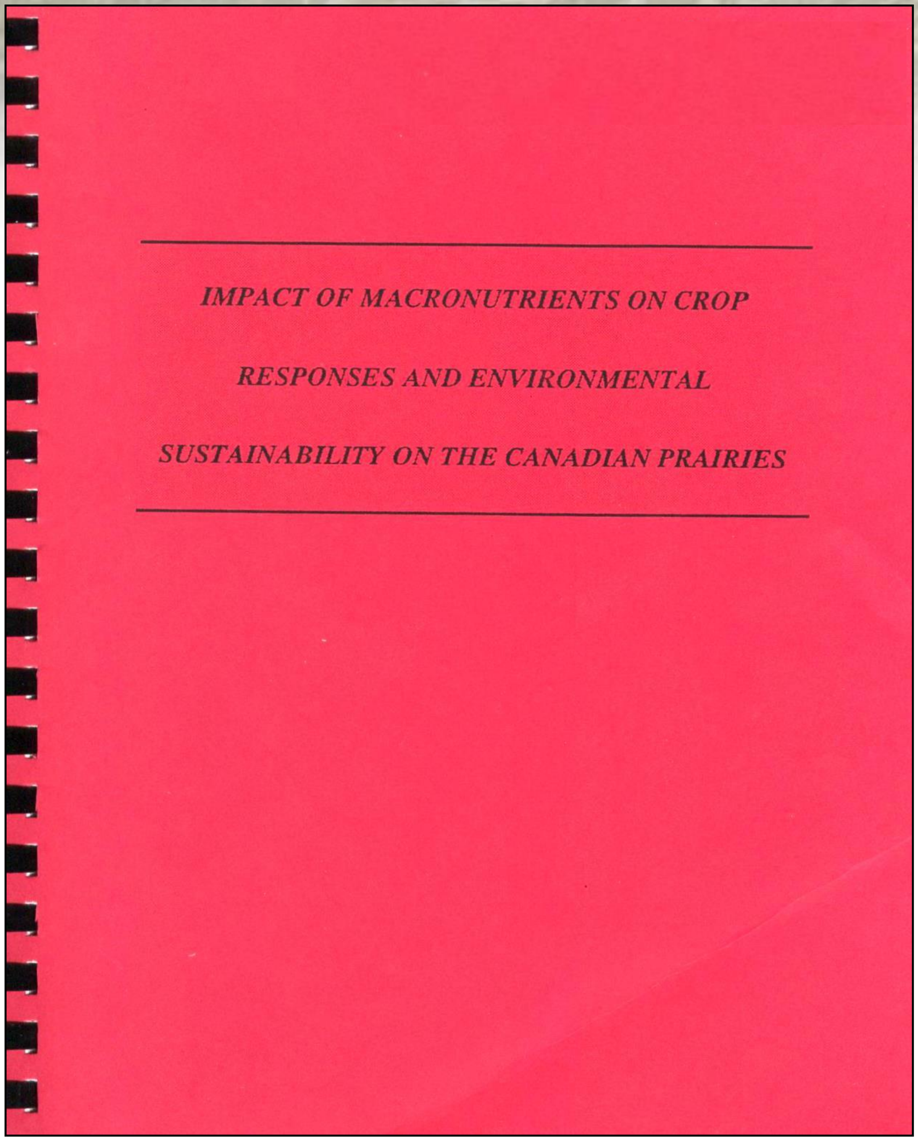
2019 is the 350th anniversary of the discovery of phosphorus by Hennig Brandt in 1669



Joseph Wright © Derby Museum & Art Gallery

Historical Background: The Red Book



A Review of the Impact of Macronutrients on Crop Responses and Environmental Sustainability on the Canadian Prairies. Edited by D.A. Rennie, C.A. Campbell, and T.L. Roberts. 1993. Cdn. Soc. Soil Sci. 527 pages.

Red Book II ... the Sequel? ... only P, so far

4R Phosphorus Fertilizer Management in the Northern Great Plains: A Review of the Scientific Literature

Draft for Technical Advisory Group
January 30, 2019

Don Flaten and Cindy Grant
University of Manitoba

The overall purpose of this review is to assemble and summarize the existing science base for 4R P fertilizer management (“right” source, “right” rate, “right” time and “right” place for fertilizer application) for crop production in the Northern Great Plains region of North America. In addition, this review will identify key gaps in knowledge and priorities for future research on this topic.

Outline of Literature Review

1. Introduction (~1 page, plus references)
   - Reasons behind project … including changes in farming practices

2. Background of 4R Nutrient Stewardship (~5 pages, plus references)
   - History
   - Background and principles
   - Gaps in knowledge

3. Agronomic Value of P for Crop Production (~12 pages, plus references)
   - Functions of P in crops
   - P accumulation in crops
   - Effects of P deficiency
   - Gaps in knowledge

4. P Behaviour in Soil (~22 pages, plus references)
   - The phosphorus cycle
   - What happens when P fertilizer is added to the soil?
   - Residual value of fertilizer P
   - Alternative measurements for assessing P use efficiency
   - Gaps in knowledge

5. Environmental Concerns Related to P Fertilizer (~20 pages, plus references)
   - P loss to surface water and eutrophication
   - P depletion in soils
   - Cadmium loading to soil
   - Gaps in knowledge

6. Phosphorus Fertilizer Sources (~24 pages, plus references)
   - Traditional sources of P fertilizer
   - Fertilizer additives and coatings
   - Reclaimed and by-product sources of phosphorus
   - Microbial products
   - Gaps in knowledge

7. Phosphorus Fertilizer Rates (~34 pages, plus references)
   - Strategies for phosphorus management
   - Use of soil testing as the basis for selecting rates of P
   - Selecting rates of P applications in long-term sustainability strategy
   - Selecting rates of P application in a short-term sufficiency strategy
   - Differences in P response among crops
   - Gaps in knowledge

8. Phosphorus Fertilizer Placement (~16 pages, plus references)
   - Efficiency of band versus broadcast application
   - Effect of band position
   - Seeding toxicity issues related to seed-placed phosphorus
   - Dual banding of N and P fertilizer
   - Gaps in knowledge

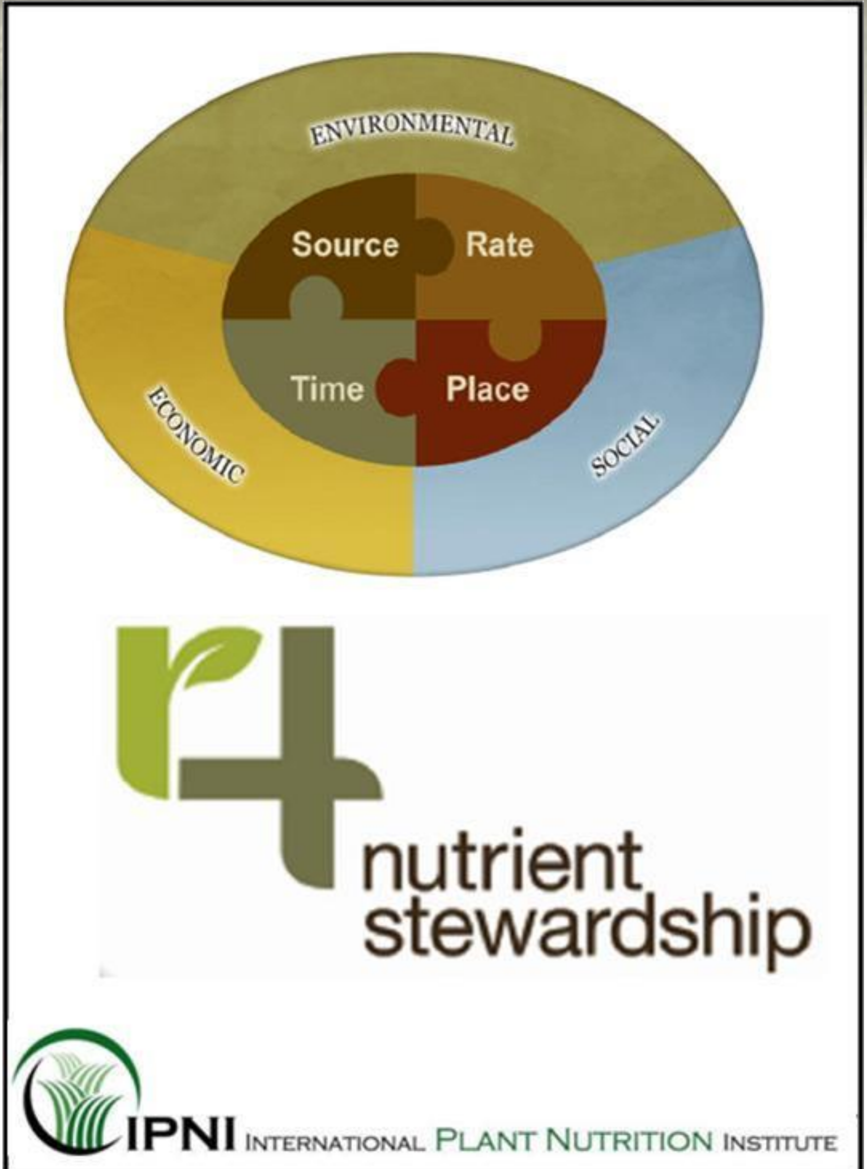
9. Phosphorus Fertilizer Timing (~14 pages, plus references)
   - Importance of early season supply
   - Requirement for P supply during grain fill/flowering
   - Factors affecting early-season supply of P to the plant
   - Implications for P fertilizer management
   - Gaps in knowledge

10. Creating a 4R Phosphorus Fertilization Package (~20 pages, plus references)
    - Agronomic drivers for phosphorus management on the Northern Great Plains
      - Tillage system
      - Cropping sequence and intensity
      - Weed competition
      - Effects of other nutrients
    - The 4R package
    - 4R for the environment
    - Gaps in knowledge

Chapter 2 - 4R Nutrient Stewardship

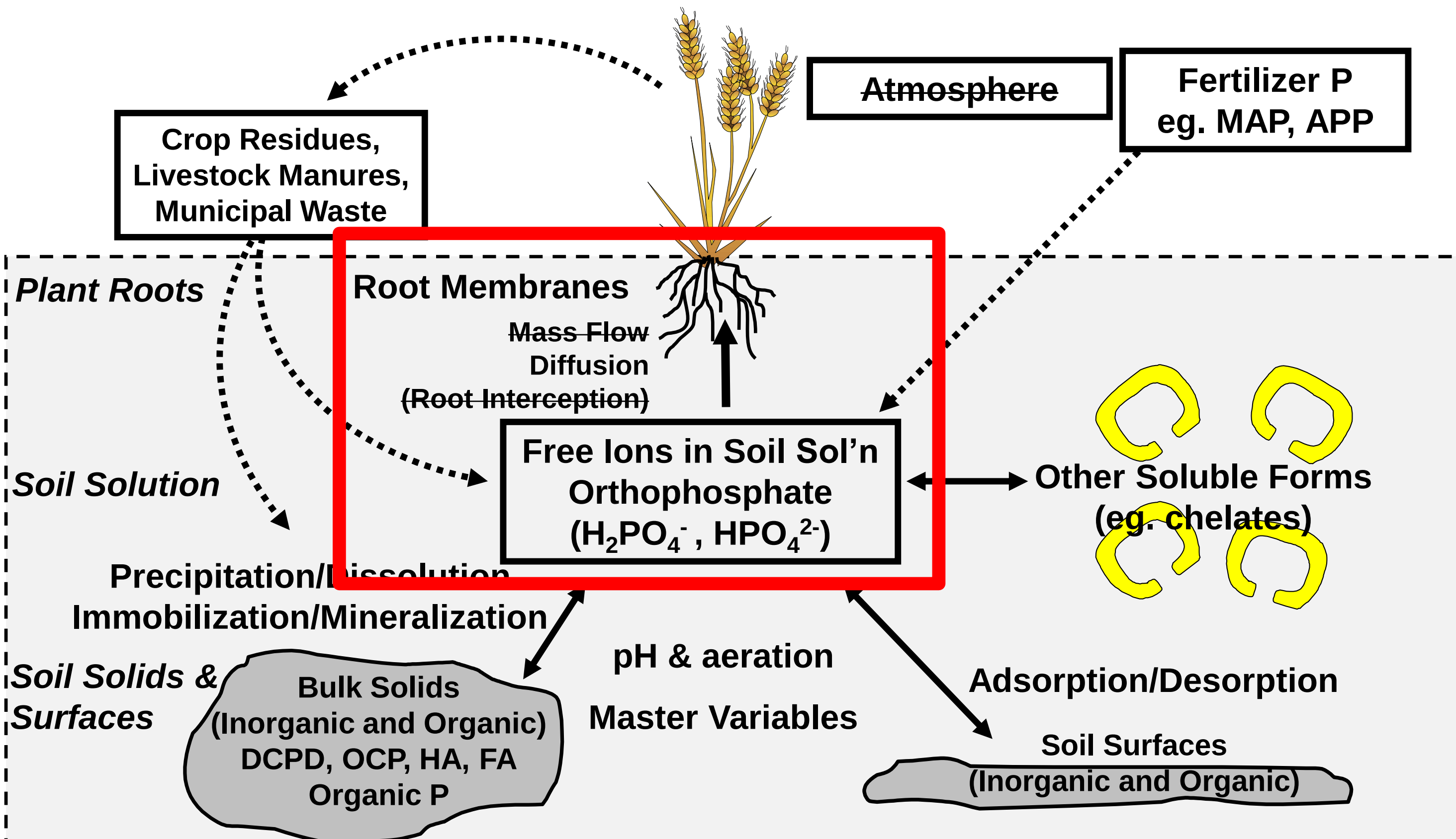
- ✓ Right source
- ✓ Right rate
- ✓ Right placement
- ✓ Right timing

In a coherent combination suited to the crop, economics, and environment



Chapter 3 - Agronomic value of P for Crops

- essential for many plant processes & components, eg. DNA
- taken up only as "ortho-P" ($H_2PO_4^-$ or HPO_4^{2-})
- moves to root mainly by diffusion, over v. short distances
- uptake affected by soil, plant & environmental factors

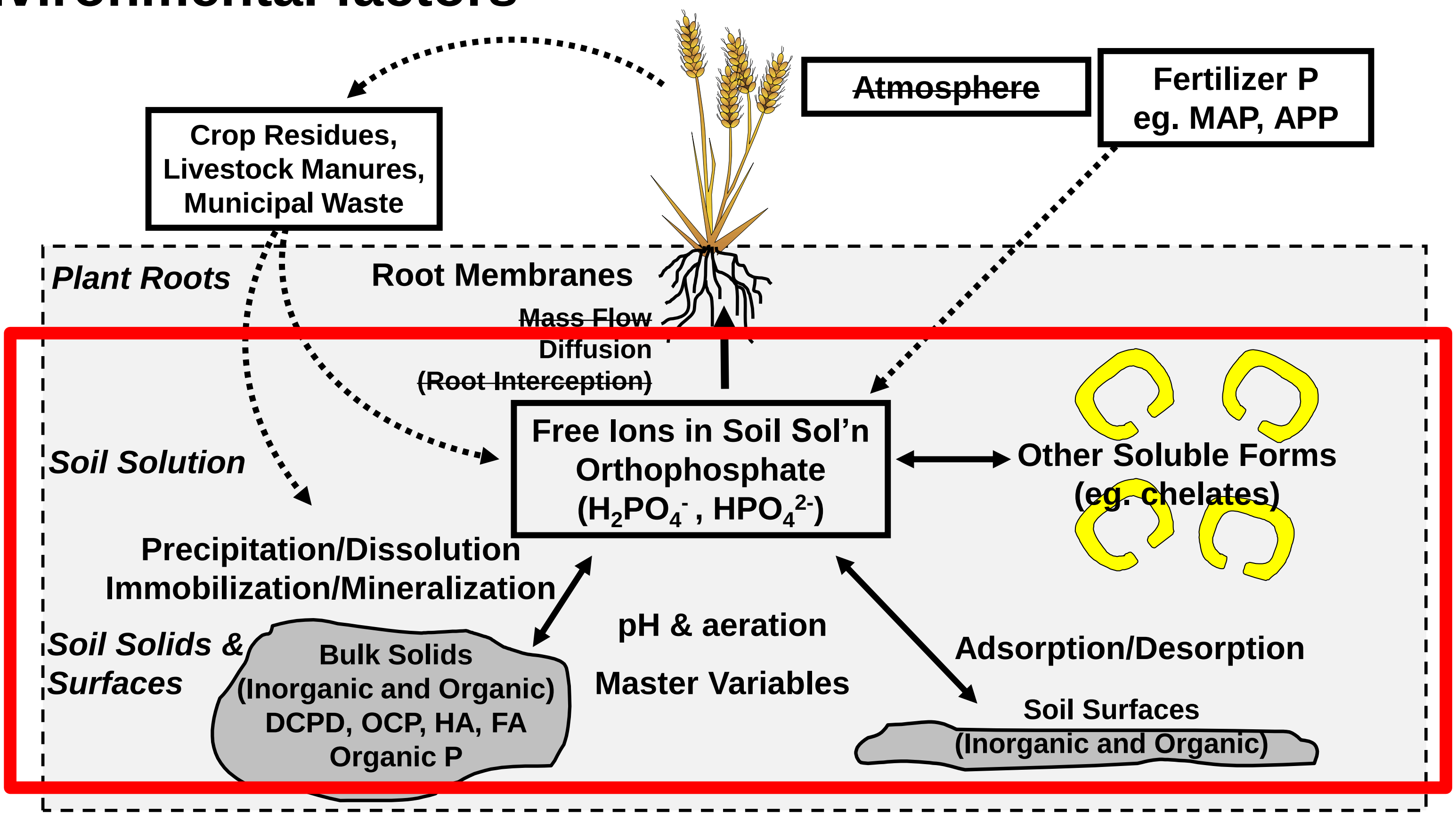


Clayton Harder's canola field, north of Wpg. with and without 40 lbs P_2O_5 + 12 lbs S/acre

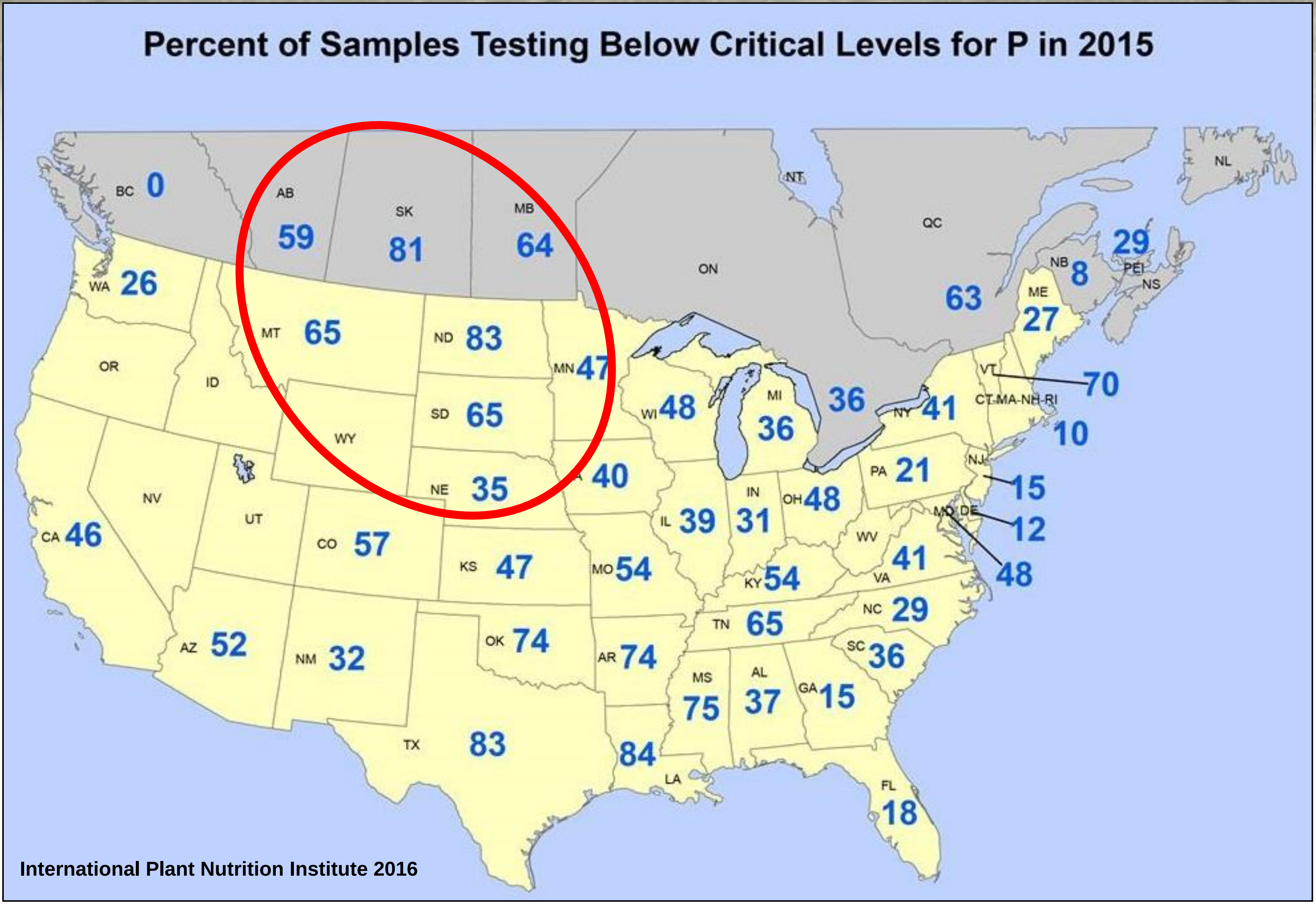
Photo: Clayton Harder

Chapter 4 - P Behaviour in Soil

- very small concentrations of P in solution
- most soil P is retained strongly by precipitation and immobilization in soil solids, and adsorption to soil surfaces
- release for crop uptake is affected by soil, plant & environmental factors



Majority of Soils on Northern Great Plains Are Deficient in P



Environment and cropping system drive P management decisions on Northern Great Plains

- Cold soils in spring
- Short growing season
- Often high pH carbonated soils
- Snow-melt runoff

- Reduced tillage
- Movement towards diversified rotations
- High-yielding cultivars

Photo: Agritruth.ca

Chapter 5 - Environmental Concerns

- Small amounts of P loss cause large problems with water quality
- Most P loss in NGP is dissolved P during snowmelt
- Careful management of P rate, placement and timing is critical for reducing the risk of P loss to surface water
- Cadmium content in P fertilizer is also a concern ... for human health

P Fertilization … the Basics

$$\text{Rec. Fertilizer Rate} = \frac{\text{Crop Requirement - Soil Supply}}{\text{Fertilizer Use Efficiency}}$$

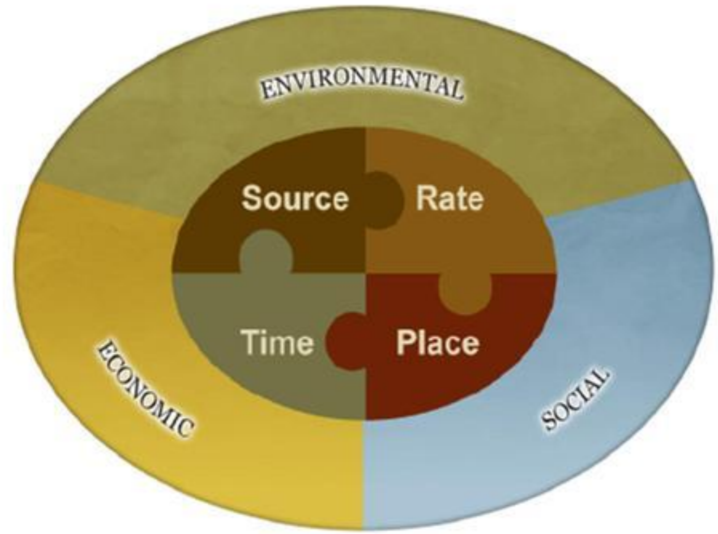
Therefore, field-specific recommendations require detailed knowledge of:

i) crop's nutrient <u>requirements</u>, considering environment, crop species & variety/hybrid, yield potential, quality goals, etc.
ii) soil's power to <u>supply</u> nutrients over growing season
iii) fertilizer use efficiency for different sources, placements, & timings

Chapter 6 - Right Source

- ✓ **Right source**
- ✓ Right rate
- ✓ Right placement
- ✓ Right timing

In a coherent combination suited to the crop, economics, and environment



nutrient stewardship

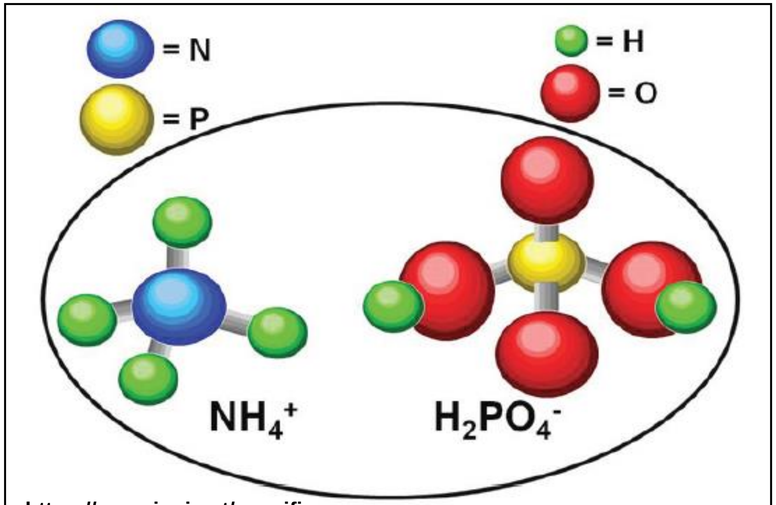
IPNI International Plant Nutrition Institute

Traditional Phosphate Fertilizers

1. Rock phosphate (highly insoluble, but rec. for organic)
2. Monoammonium phosphate or MAP (eg. 11-52-0)
3. Triple super phosphate or TSP (eg. 0-45-0)
4. Ammonium polyphosphate or APP (eg. 10-34-0)

Monoammonium phosphate or MAP (eg. 11-52-0)

- inexpensive to manufacture, easy to handle
- granular form; most popular P fert. in W. Canada (not U.S.)
- low NH_4 content & low pH rx zone = low toxicity for seedrow placement (vs DAP, 18-46-0)
- performs better than calcium phosphate (eg. 0-45-0) in W. Canada: NH_4^+ enhances P uptake, partly due to acidification of rhizosphere during NH_4^+ absorption ("ammonium-ion effect")



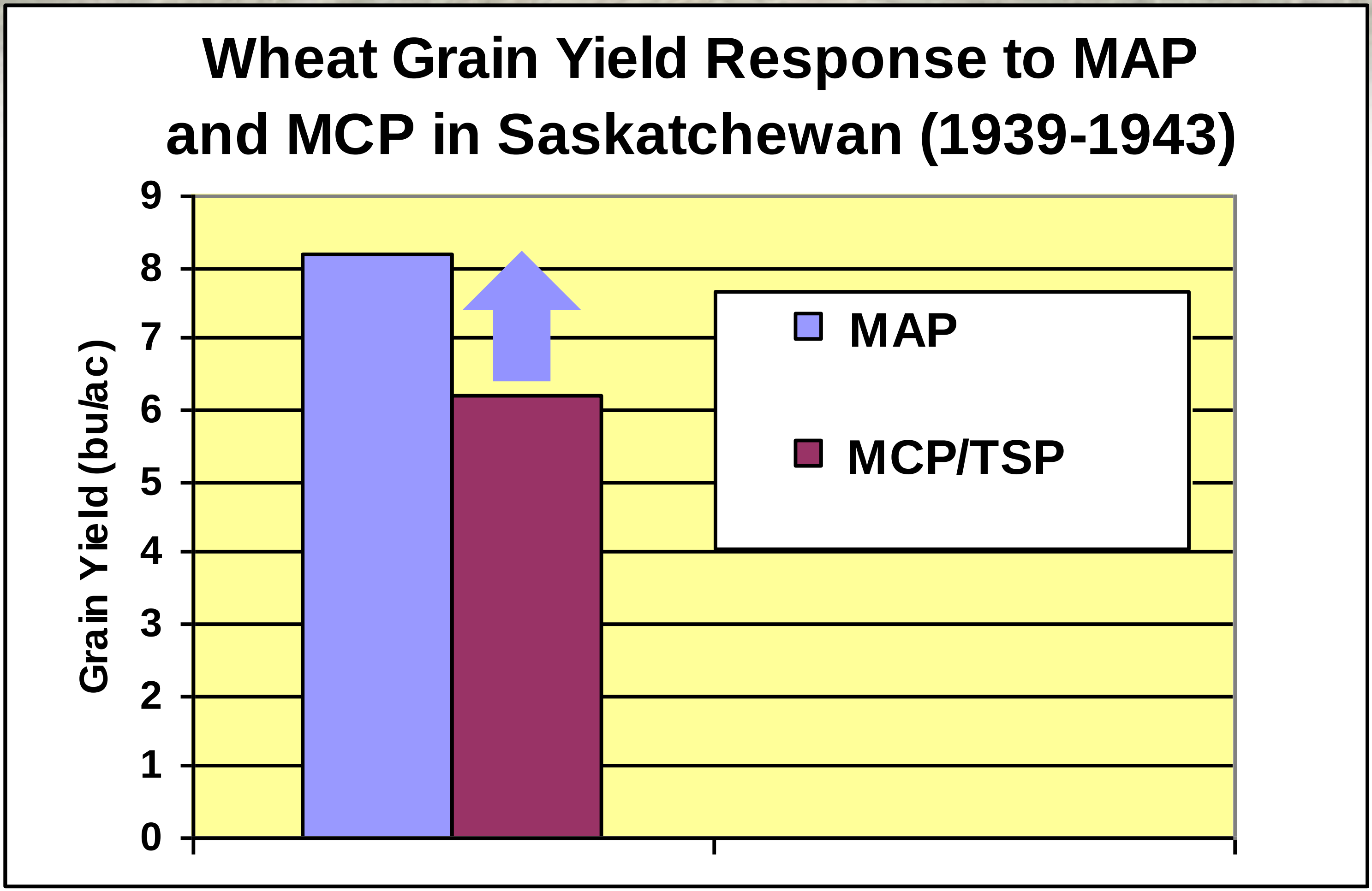
https://www.ipni.net/specifics-en

Triple super phosphate (eg. 0-45-0)

- granular form; not popular in W. Canada, but popular in U.S.
- also called mono<u>calcium</u> phosphate
- not as effective as MAP in W. Canada, but a good source of P, especially in research trials where no N is desired as part of P application

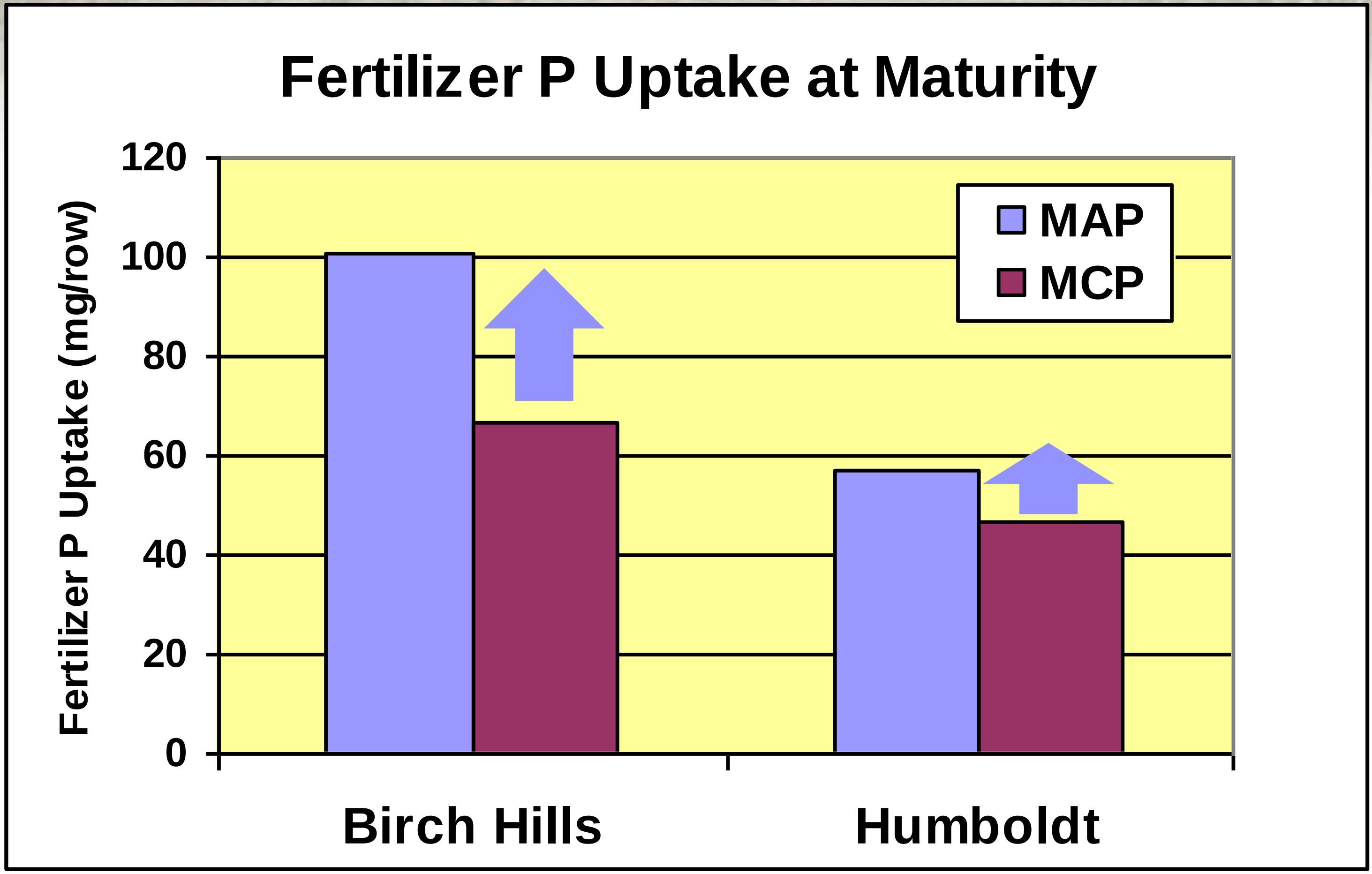
https://www.ipni.net/specifics-en

MAP (eg. 11-48-0) was superior to TSP/MCP (0-43-0) in Saskatchewan field trials



Averages for 12 lb P_2O_5/ac drilled with seed over 75 site years (Mitchell 1946 Scientific Agriculture 26:566-577.

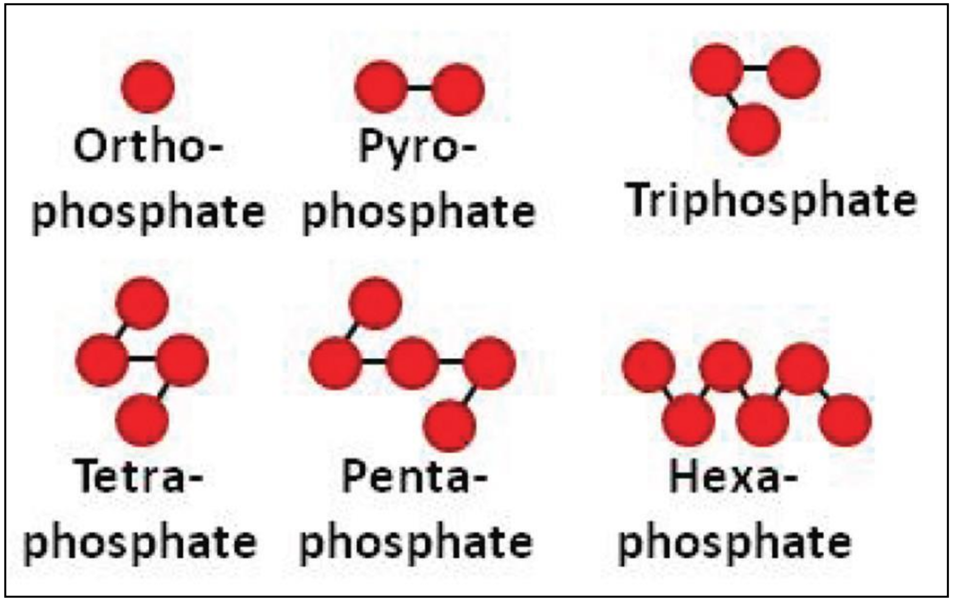
MAP (eg. 11-48-0) was superior to TSP/MCP (0-43-0) in Saskatchewan field trials



Dion, Dehm, and Spinks. 1949

Ammonium polyphosphate or APP (eg. 10-34-0)

- a reasonably popular form of <u>liquid</u> P fertilizer
- poly-P is <u>not</u> immediately available to plants but is quickly split into ortho-P by soil's phosphatase enzymes
- reactions and effectiveness similar to MAP in NGP



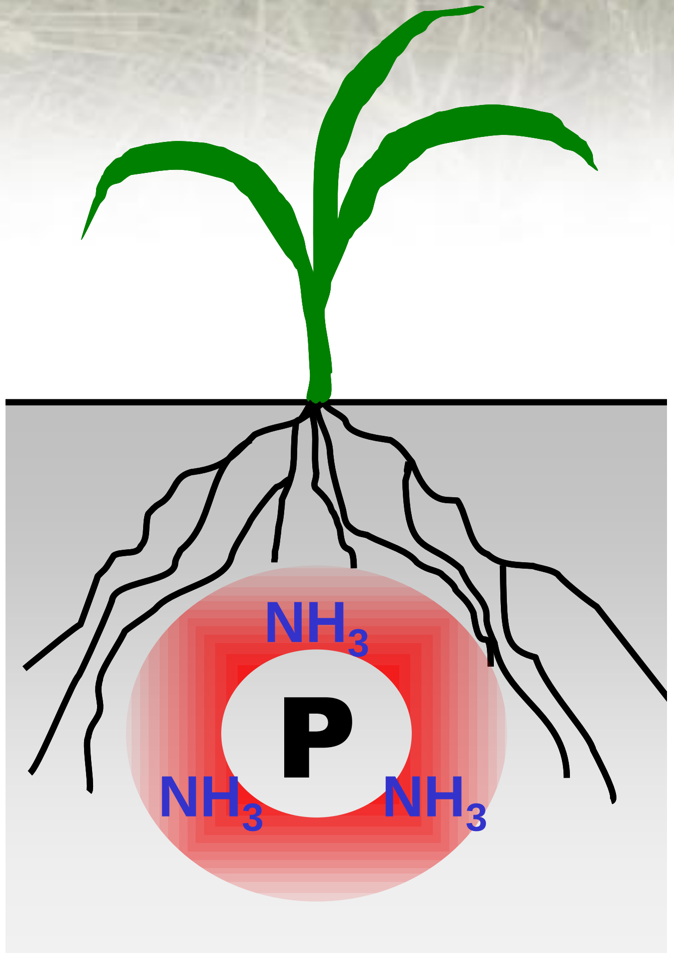
https://www.ipni.net/specifics-en

Products that attempt to improve P use efficiency

- Use of more crop available forms
  - Ammoniated phosphates
  - Dual banding N and P fertilizer together
  - Fluids vs. dry/granular
  - Liquid orthophosphates vs. polyphosphates
- Reduce soil retention
  - Maleic-itaconic acid copolymer additive
- Release P gradually to match plant uptake
  - Polymer coated MAP and struvite
- Fungal inoculants that release P in rhizosphere
  - *Penicillium bilaii*
- Fungal inoculants that improve plant access to P
  - Mycorrhizae

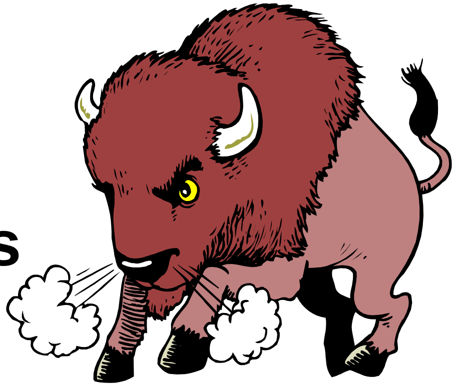
Dual banding N and P fertilizer

- P availability is increased by ammonium in the band
  - Ammoniated P fertilizers (eg. MAP, APP) outperform other P fertilizers
  - Adding urea or ammonia to MAP bands (dual banding) increases fertilizer P uptake when fertilizer is banded away from seed
- P availability is delayed when banded with high rates of N
  - Typical rates of N will delay P uptake for several weeks due to band toxicity
- Some starter P should be placed in seed row when “dual banding” N & P
  - Enables early season access to P



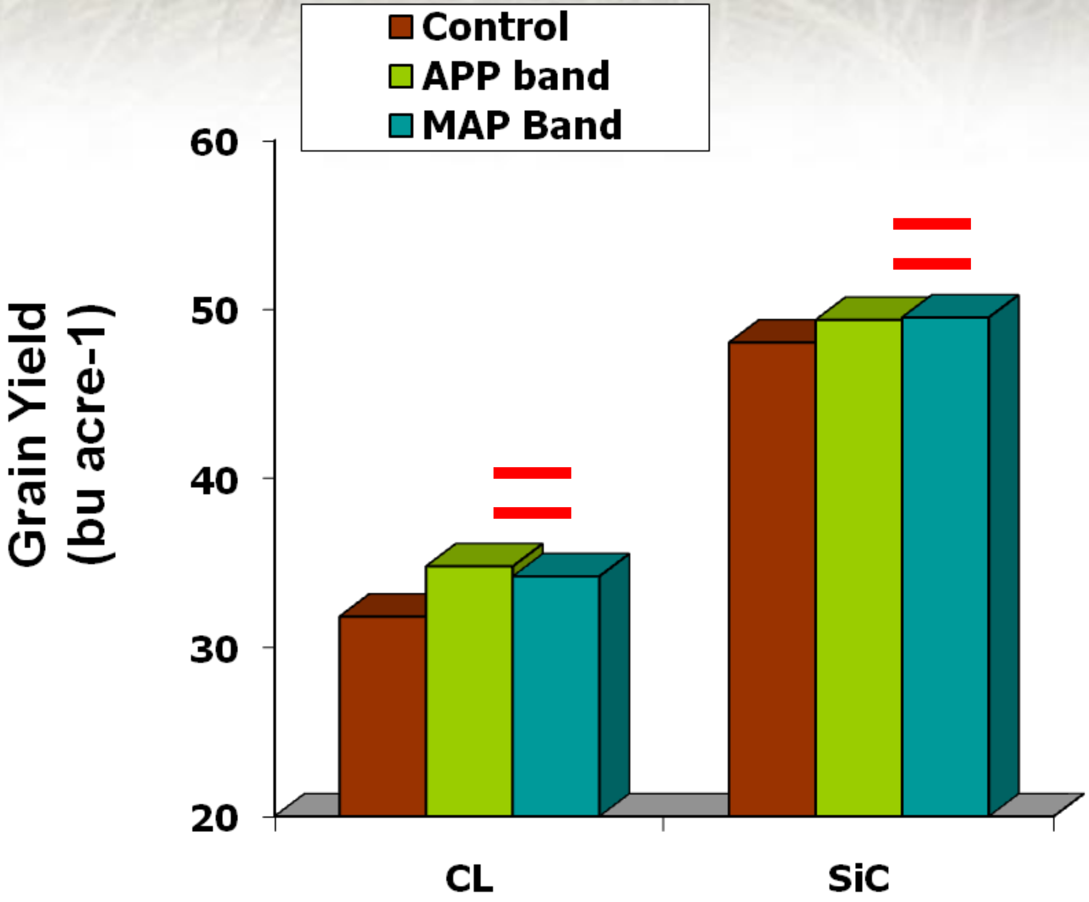
Fluid vs. Dry Fertilizers

- Under arid, highly calcareous conditions in Australia, fluid forms of P are more available than dry
  - water moving toward dissolving granule carries Ca to the fertilizer
  - Ca precipitates P and leads to small reaction zone
  - fluid forms increase reaction zone and allow greater root uptake
- Similar benefit has not shown up in tests in Manitoba and is unlikely in humid areas



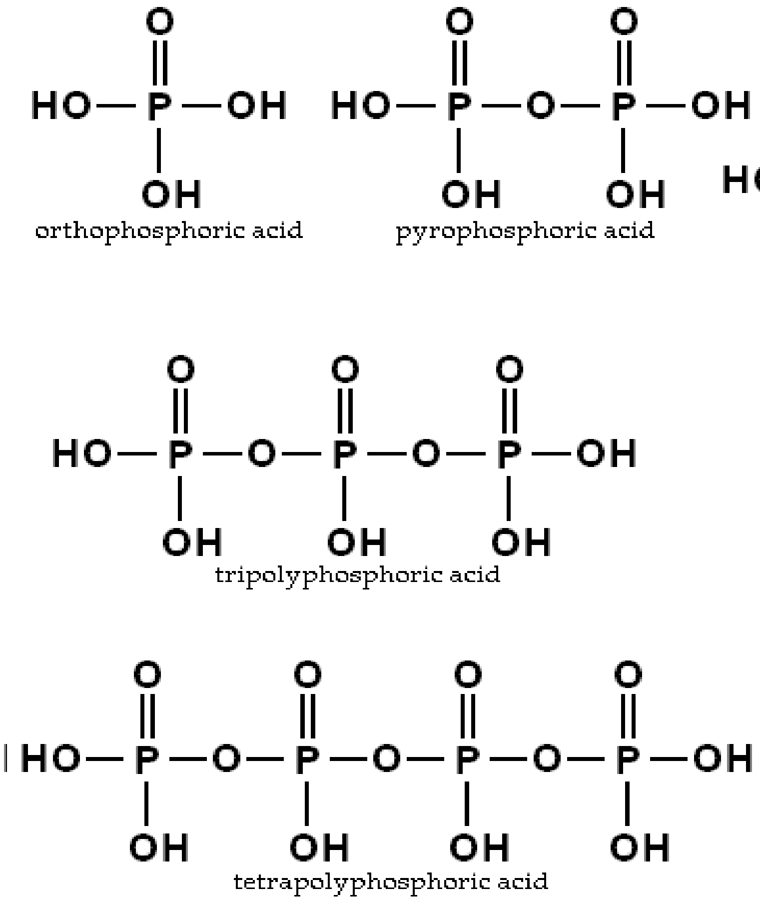
No difference between dry MAP & fluid APP in wheat yield over three years at two sites near Brandon

- **Similar results in previous studies by Racz and in later studies on canola**
- **Soils in MB trials were much less calcareous than the 70% calcium carbonate in the Australian trials**



Orthophosphates vs. Polyphosphates

- **Polyphosphates are chains of orthophosphates**
- **Most "polyphosphate" fertilizers (eg. 10-34-0) still have 40-60% of the phosphate in the orthophosphate form**
- **Polyphosphate converts to orthophosphate in soils rapidly**
  - **Half usually is converted within a week,**
  - **Conversion may be slower if soils are cool and dry**
- **Generally no difference in effectiveness under field conditions**



http://www.extension.umn.edu/distribution/cropsystems/DC6288.html

Orthophosphates vs. Polyphosphates

Communications in Soil Science and Plant Analysis, 44:136–144, 2013

ISSN: 0010-3624 print / 1532-2416 online
DOI: 10.1080/00103624.2013.736162

Taylor & Francis
Taylor & Francis Group

Effects of Phosphorus Form on Short-Term Solubility and Availability in Soils

T. B. GOH,[1] R. E. KARAMANOS,[2] AND J. LEE[3]

[1]Department of Soil Science, University of Manitoba, Winnipeg, Canada
[2]Viterra Inc., Calgary, Canada
[3]AGVISE Laboratories, Northwood, North Dakota, USA

A laboratory ex
phosphate fertili
pH levels. Three
one calcareous,
samples treated
(9–18–9 and 6–2
(11–52–0) at rat
incubated for a
used to assess w
cated four times.
all four products
2 to 4 d of incubation, suggesting that there was no difference in P availability among these products soon after their application at the time of seeding.

"Wide differences in soluble and bicarbonate-extractable P levels from all four products in all three soils at the onset of incubation became insignificant after 2 to 4 d of incubation, suggesting that there was no difference in P availability among these products soon after their application at the time of seeding."

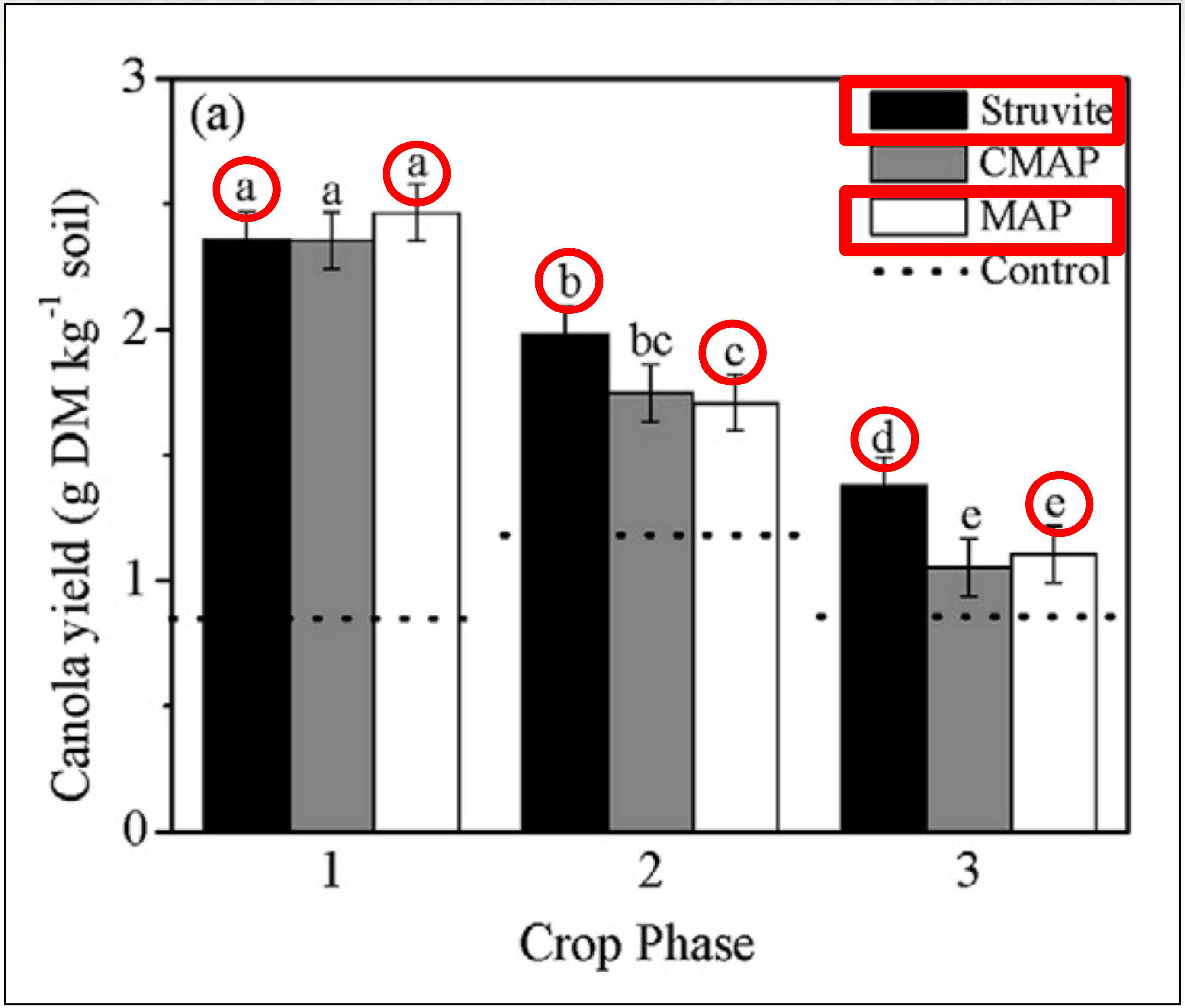
Keywords Availability, bicarbonate, emergence, water soluble

Struvite

- **Commercial struvite is recovered from wastewater**
- **Represents a vital step towards sustainable use of recycled P**

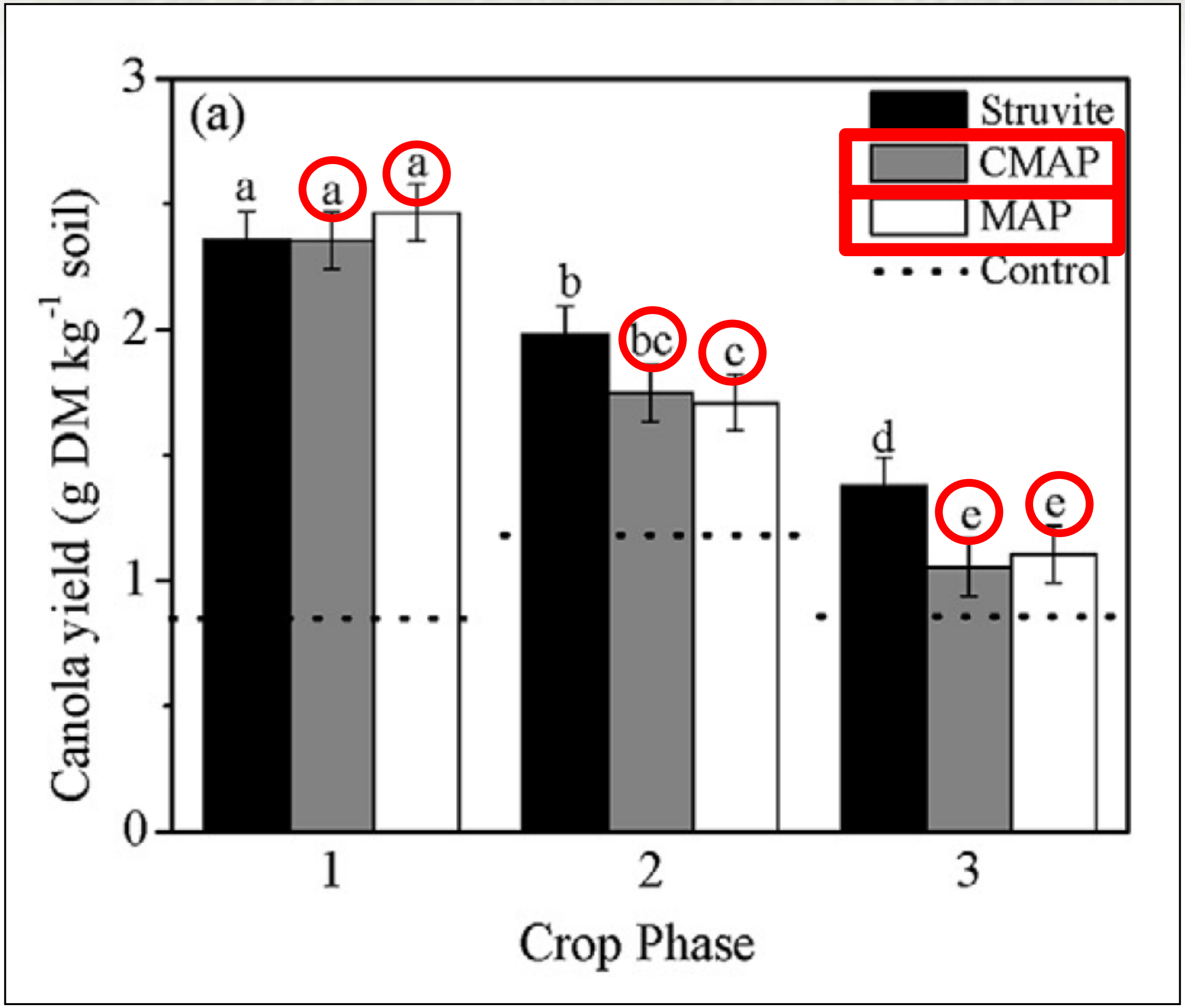
Struvite and Polymer Coated MAP

- Greenhouse trials to measure vegetative growth & P uptake
- Canola dry matter response to struvite from pig manure was equal to that for MAP (11-52-0) in the 1st crop and superior to MAP in the 2nd and 3rd crops.



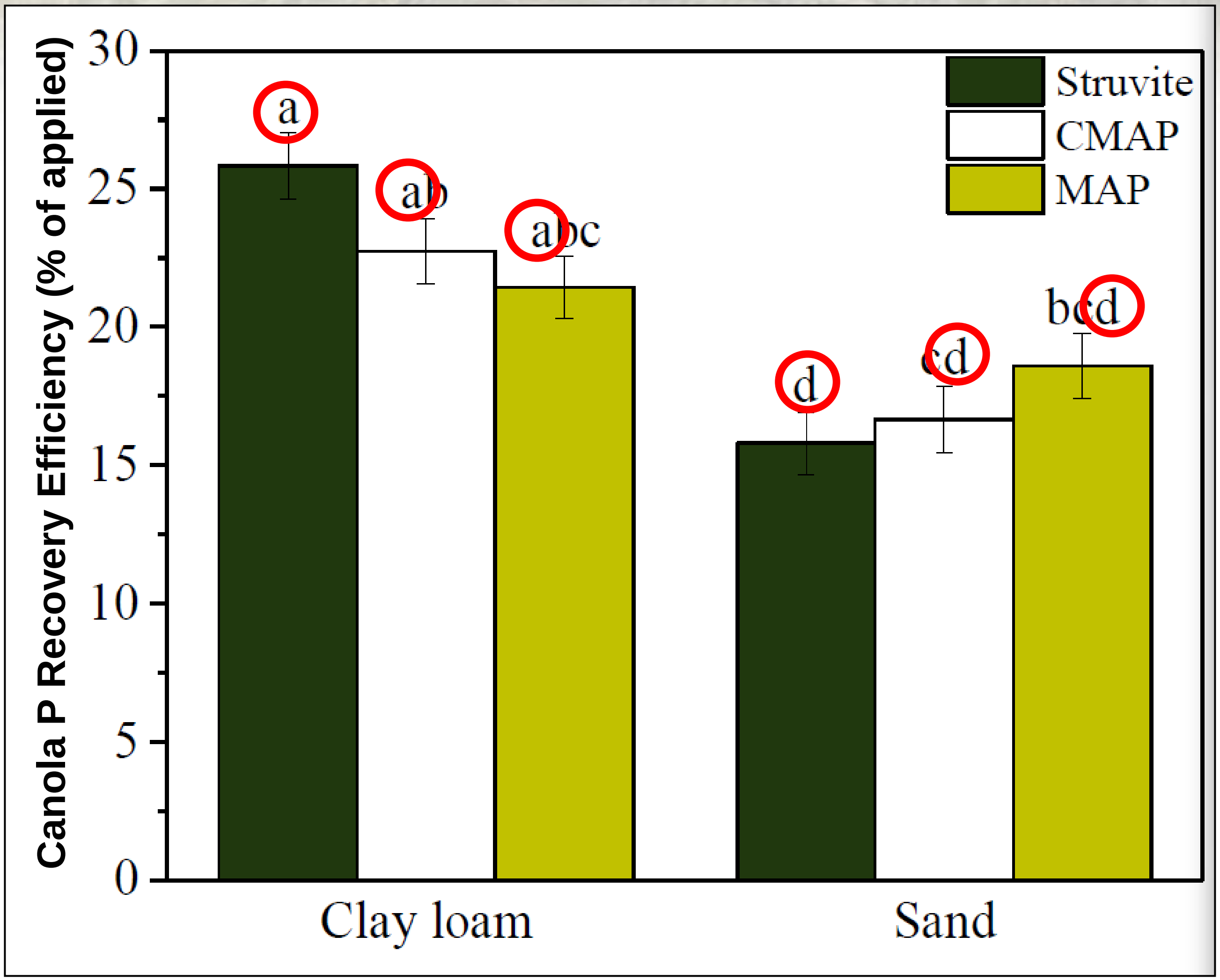
Struvite and Polymer Coated MAP

Canola dry matter response to polymer coated MAP was equal to that for uncoated MAP (11-52-0) in all three crops.

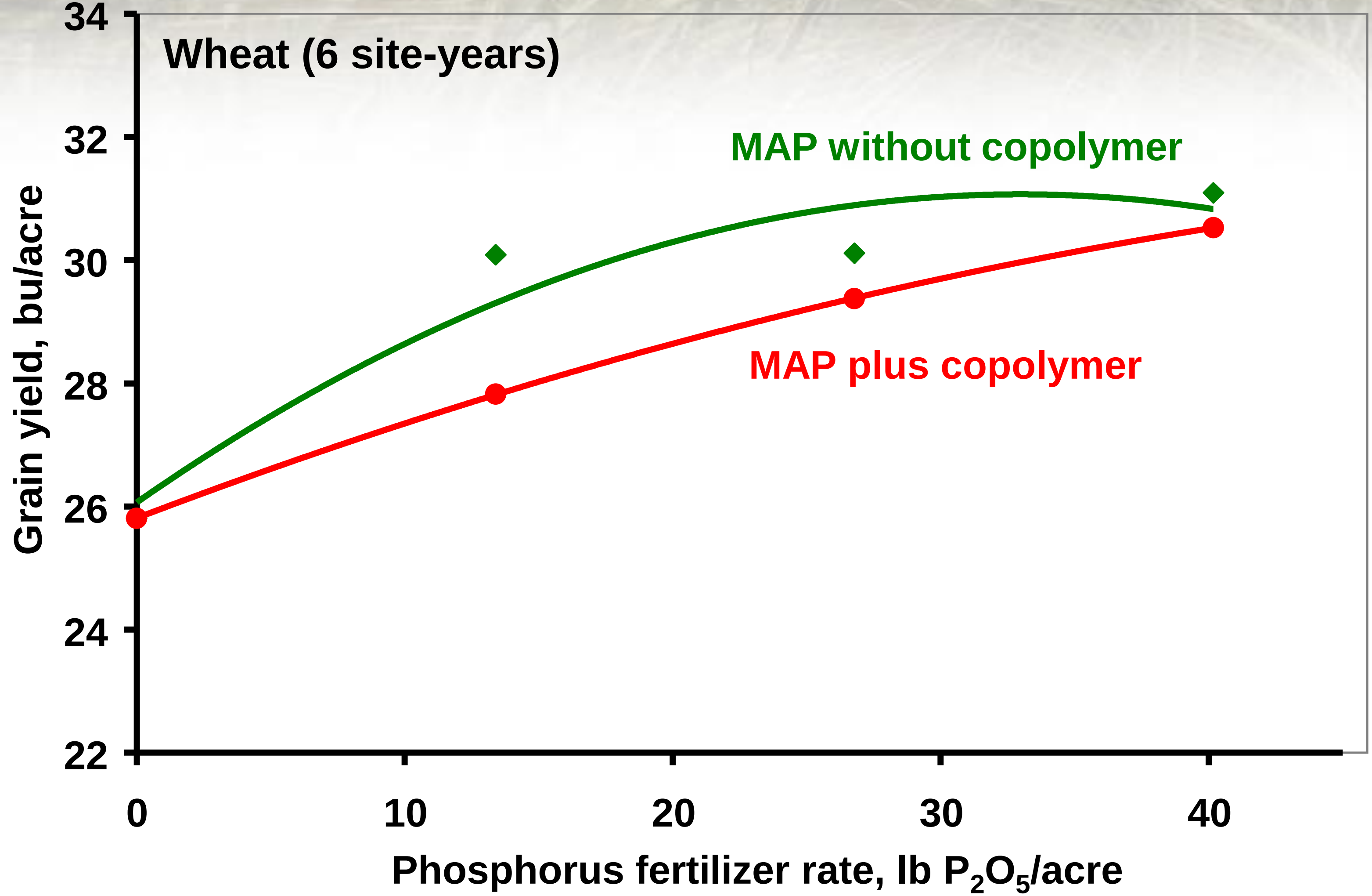


Struvite and Polymer Coated MAP

When all crops of wheat and canola were analyzed, overall recovery of P from struvite and coated MAP in wheat and canola was similar to uncoated MAP (11-52-0) in clay loam and sand



Yield of wheat on the prairies was similar if MAP was applied with or without maleic-itaconic acid copolymer



R. Karamanos

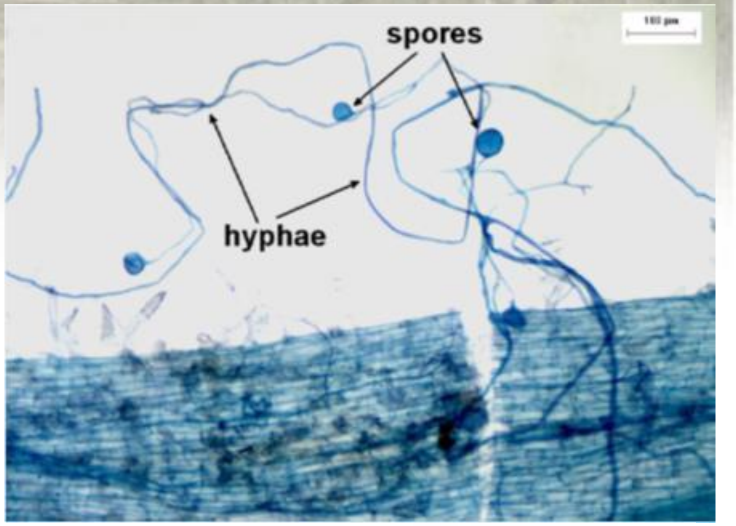
What about microbial products?

Two major products sold in western Canada

- *Penicillium bilaii*
- Mycorrhizal inoculants

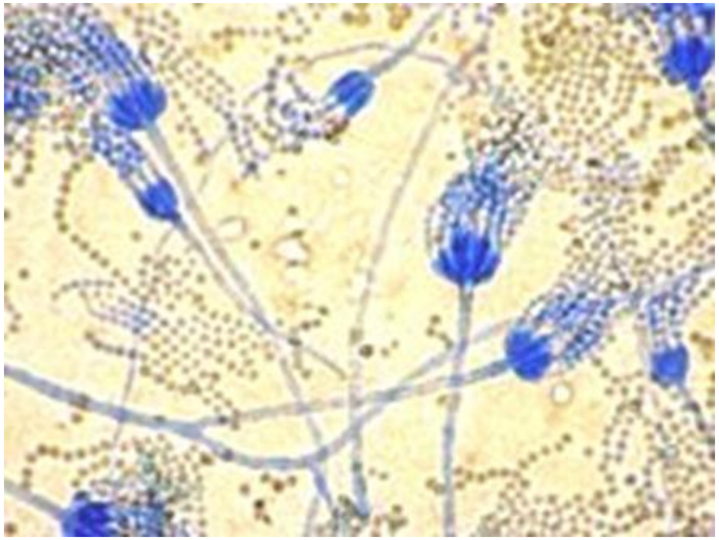
Low or no P application rates based on claims of enhanced P availability

If application rates are reduced to below crop removal when these products are used, it will increase the P deficit ... the imbalance between crop removal and P applied

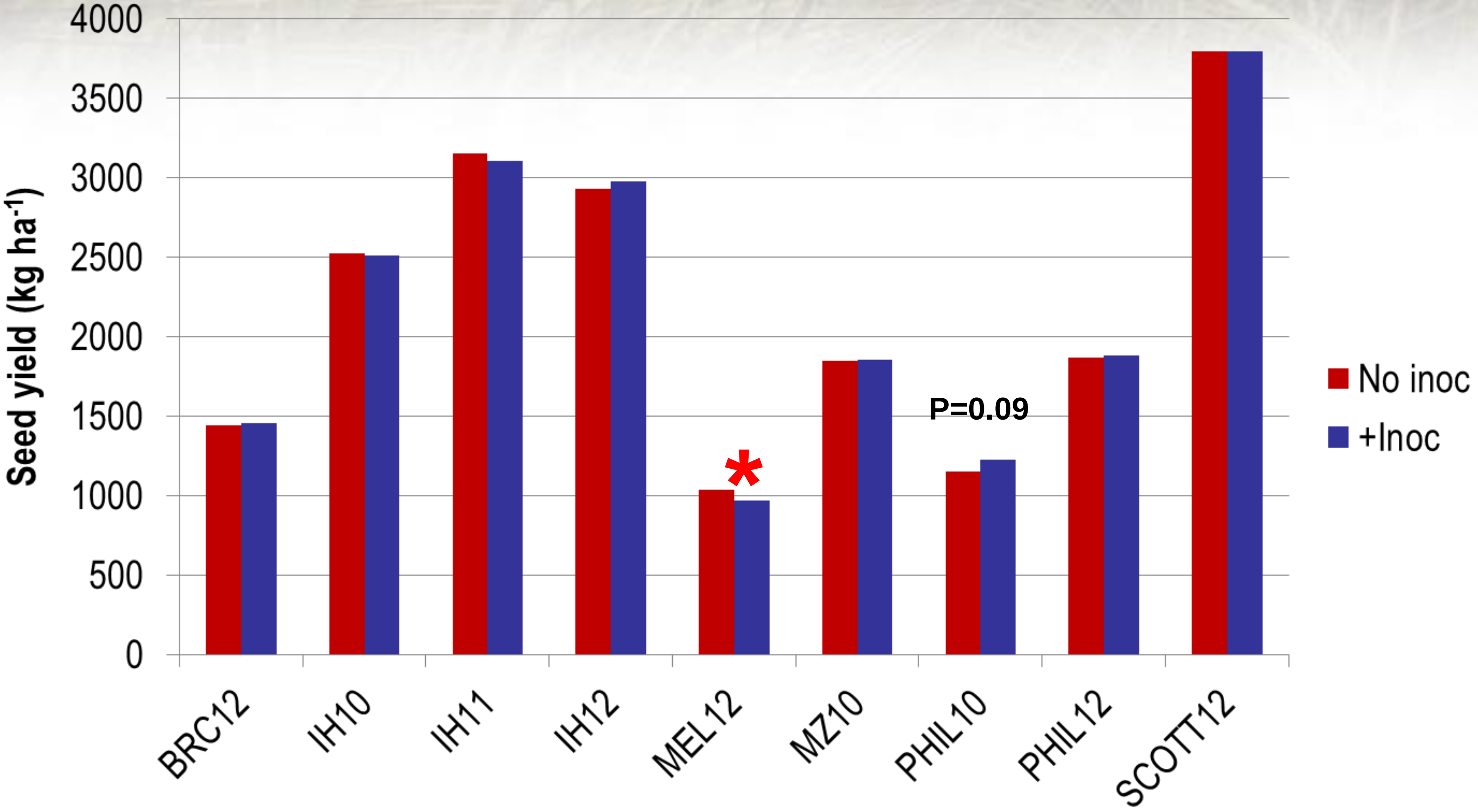


Provide is a fungal inoculant

- ***Penicillium bilaii*** **(also classified as P. bilaji and P. bilaiae) is a fungus that colonizes the rhizosphere**
- **Effective in solubilizing phosphorus (P) under laboratory conditions**
- **Under field conditions, results have not been consistent**



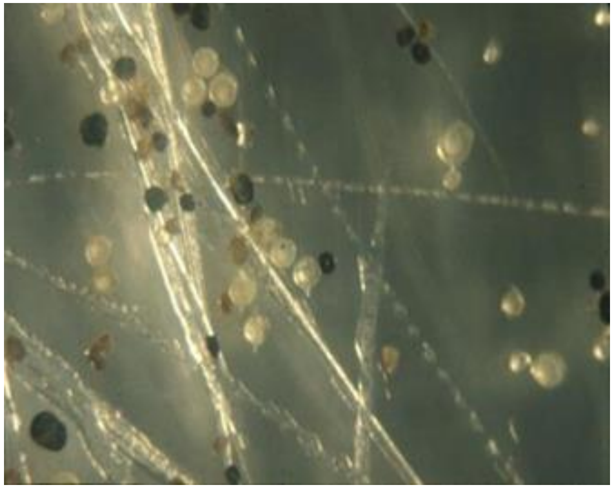
Penicillium bilaii did not benefit canola yield in recent studies in Manitoba and Saskatchewan

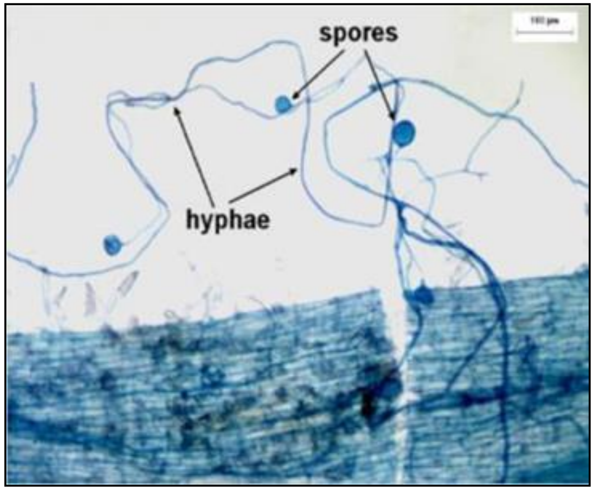


Ramona Mohr

Mycorrhizal fungi inoculants

- very important organisms that help crops such as corn and flax take up nutrients
- inoculants not generally used in field crops
- not for use with canola since canola does not form mycorrhizal associations
- watch for P problems in mycorrhizal-dependent crops such as corn or flax grown after canola





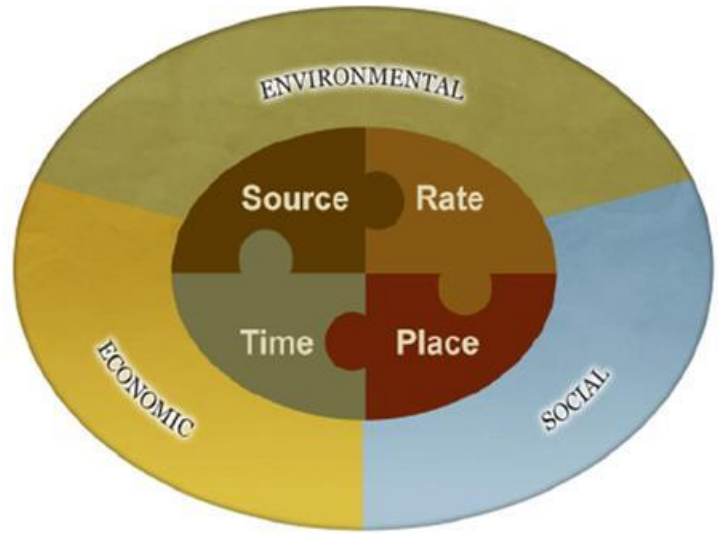
Key Messages for Selecting the Right Source of P

- MAP (eg. 11-52-0) and APP (eg. 10-34-0) are the standard fertilizer sources for the Northern Great Plains; ammonium in formulation enhances efficiency on high pH, calcareous soils
- No evidence of significant agronomic difference between orthophosphate and polyphosphate
- Fluids and dry formulations perform similarly on the Northern Great Plains
- Novel P fertilizer formulations or use of microbial products have generally not shown increased effectiveness over MAP and APP under field conditions on the Northern Great Plains
- Recycled P products such as struvite offer improvements in long term sustainability

Chapter 7 - Right Rate

- ✓ Right source
- ✓ **Right rate**
- ✓ Right placement
- ✓ Right timing

In a coherent combination suited to the crop, economics, and environment



nutrient stewardship

IPNI INTERNATIONAL PLANT NUTRITION INSTITUTE

Soil tests as the basis for recommending P rates

Appendix Table 17. Phosphorus recommendations for field crops based on soil test levels and placement[76].

Soil Phosphorus (sodium bicarbonate or Olsen P test)			Cereal	Corn Sunflower	Canola Mustard Flax		Buckwheat Fababeans		Potatoes		Peas Lentils Field beans[1] Soybeans[1]		Legume forages		Perennial grass forages	
ppm	lb/ac	Rating	S[1]	Sb[2]	B[3]	S[1]	B[3]	S[1]	B[3]	PPI[4]	B[3]	S[1]	seeding PPI[5]	Est. stand BT[6]	seeding PPI[5]	Est. stand BT[6]
0	0	VL	40	40	40	20	40	20	55	110	40	20	75	55	45	30
	5	VL	40	40	40	20	40	20	55	110	40	20	75	55	45	30
5	10	L	40	40	40	20	40	20	50	100	40	15	75	55	45	30
	15	L	35	35	35	20	35	20	45	90	35	15	65	50	35	20
10	20	M	30	30	30	20	30	20	45	90	30	10	60	40	30	20
	25	M	20	20	20	20	20	20	40	80	20	10	50	35	20	15
15	30	H	15	15	15	0	15	20	35	70	15	0	45	30	15	10
	35	H	10	10	10	0	10	20	30	60	10	0	30	20	0	0
20	40	VH	10	10	10	0	10	20	30	60	10	0	30	20	0	0
20+	40+	VH+	10	10	10	0	10	20	30	60	10	0	25	20	0	0

FERTILIZER PHOSPHATE (P_2O_5) RECOMMENDED (lb/ac)

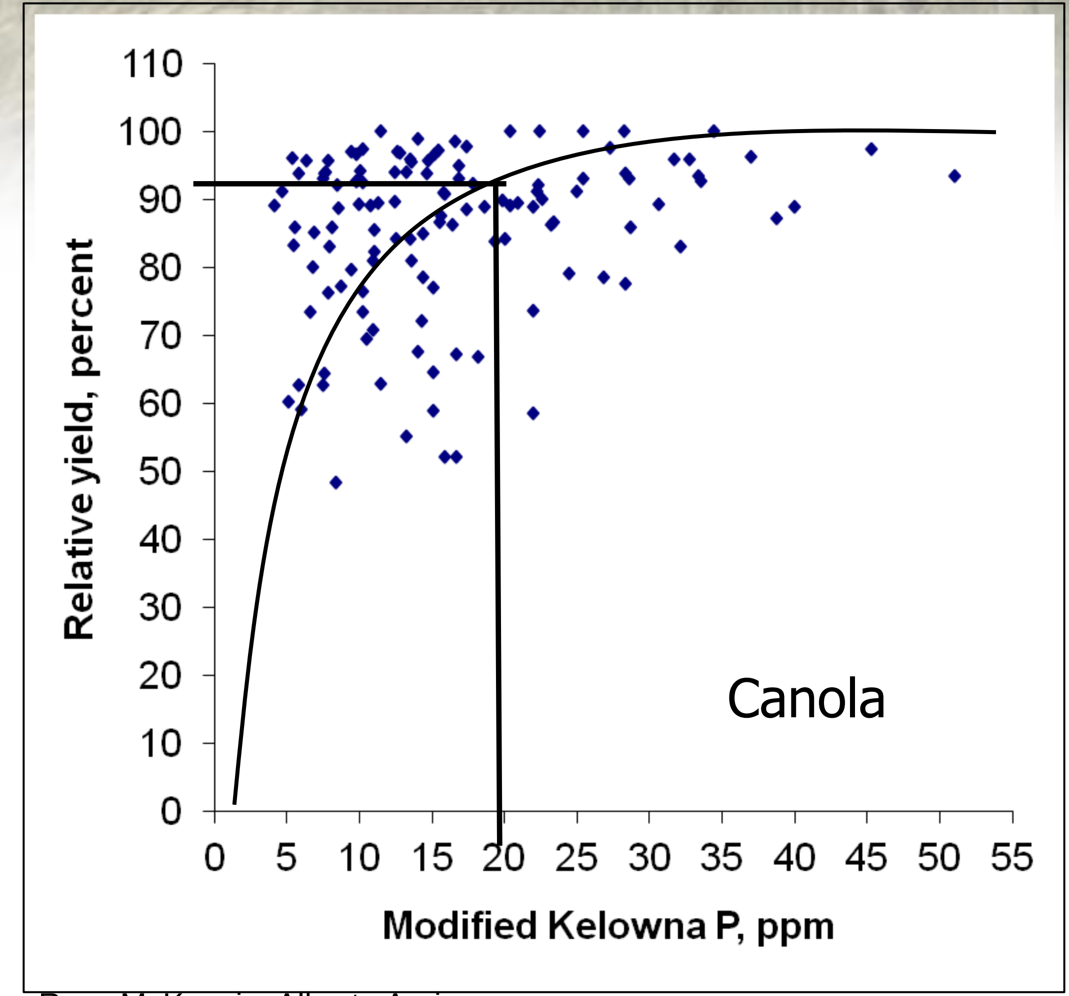
REVISED 2007

Covering New Ground

Manitoba

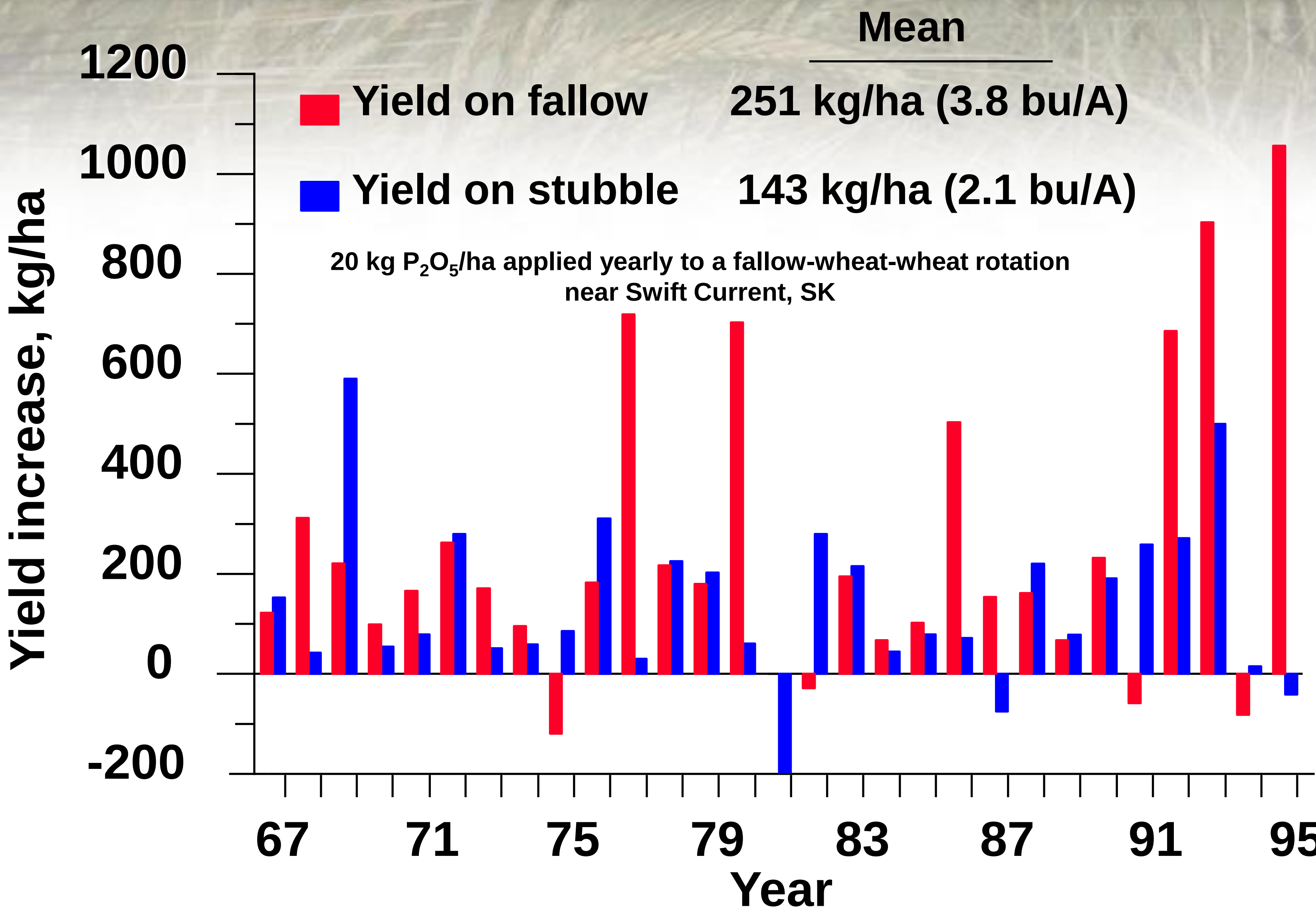
Critical soil test P thresholds are not exact

- **Alberta data show a critical level of 20-25 ppm for <u>average</u> of 10% response**
- **Above this level, only maintenance (crop removal) application would be required**
- **… but the variability is high**



Ross McKenzie, Alberta Agric.

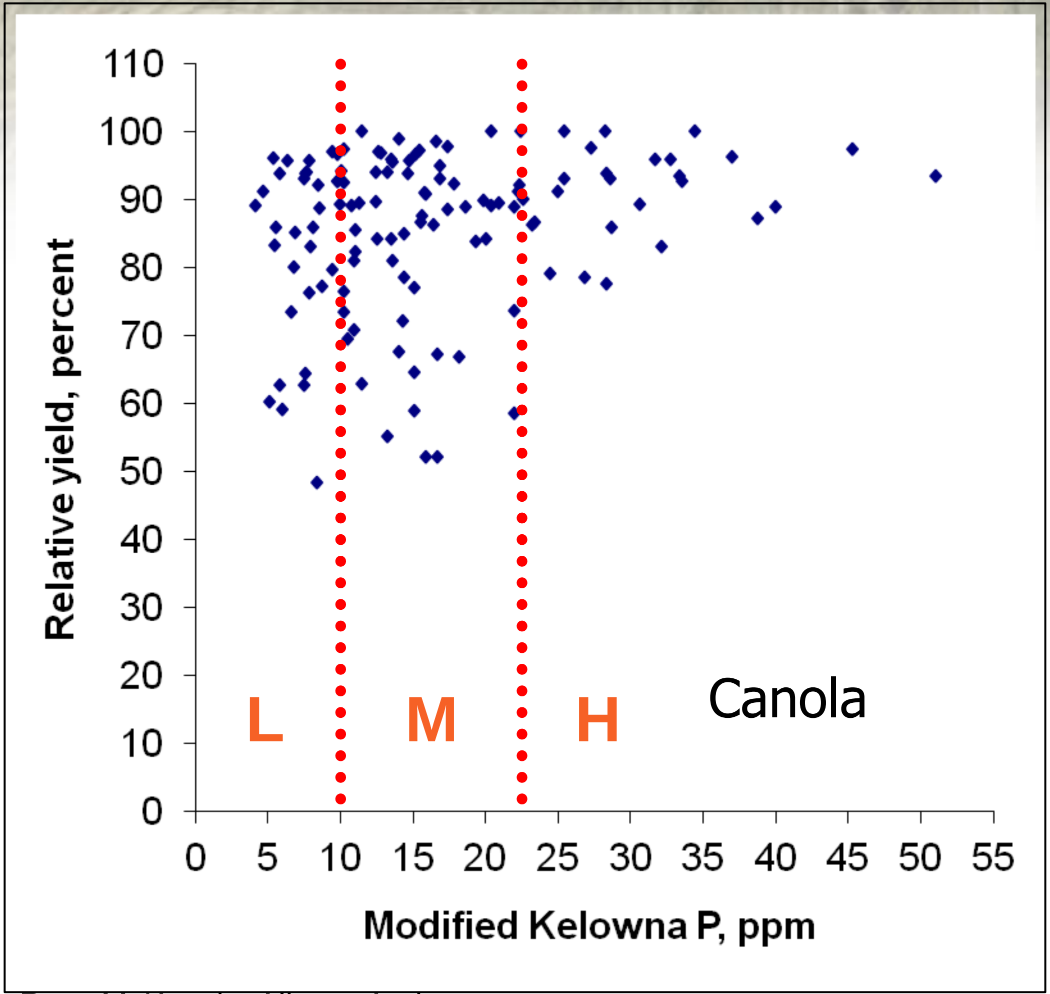
Yield Response to P is Highly Variable from Year to Year ... and from One Crop Phase to Another



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.

Critical soil test P thresholds are not exact

- **Given the high variability, a probability approach may be more realistic than a "response curve"**



Ross McKenzie, Alberta Agric.

Manitoba P Response Probabilities

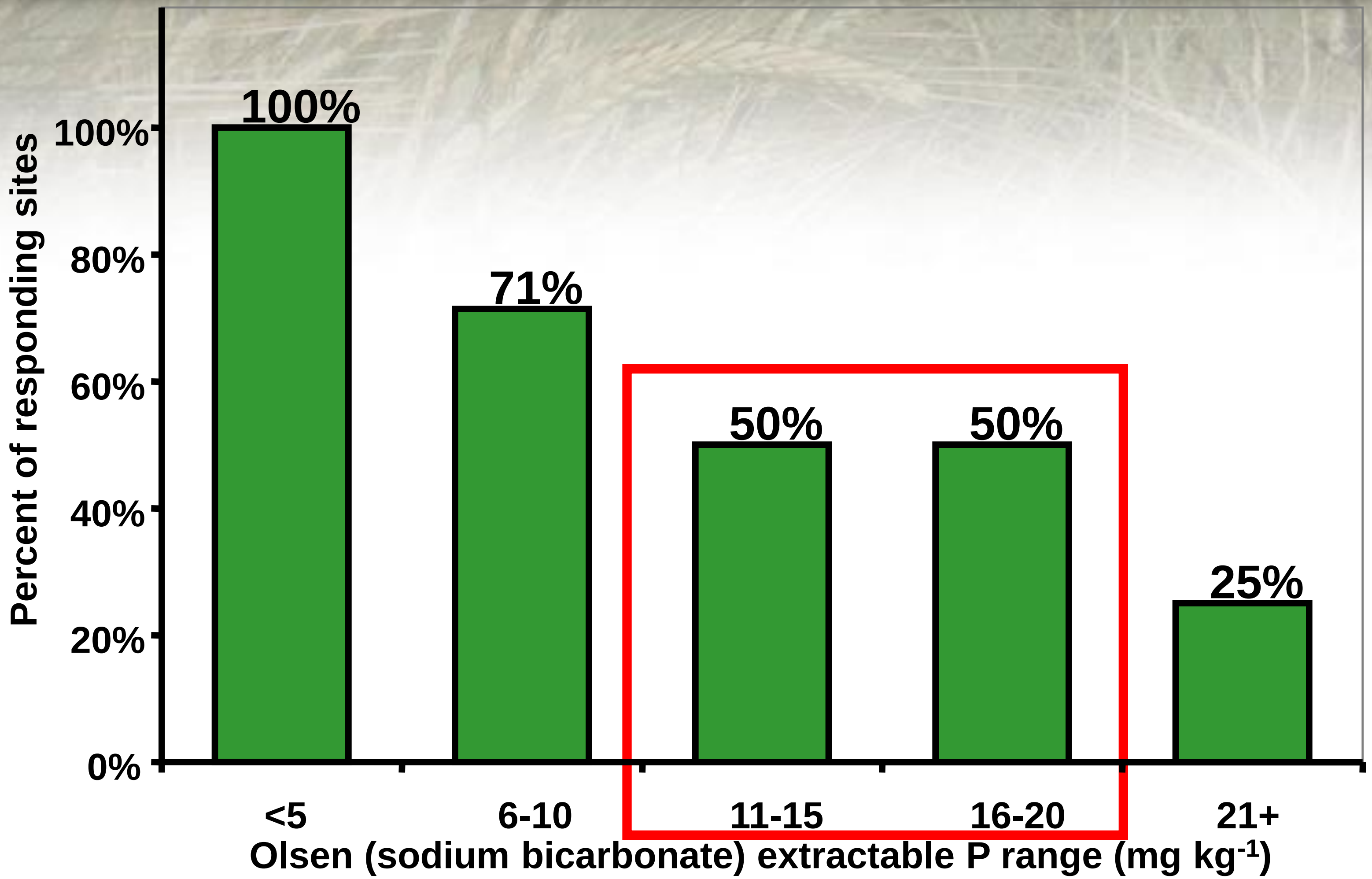
Available P (ppm Olsen)	Number of Experiments	% Responding to Fertilizer P
0-5 V. Low	15	100
5-12 Low-Med	50	62
12-18 Med-High	16	56
>18 High-VH	14	29
Overall	95	63

Hedlin, U of M, 1962

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

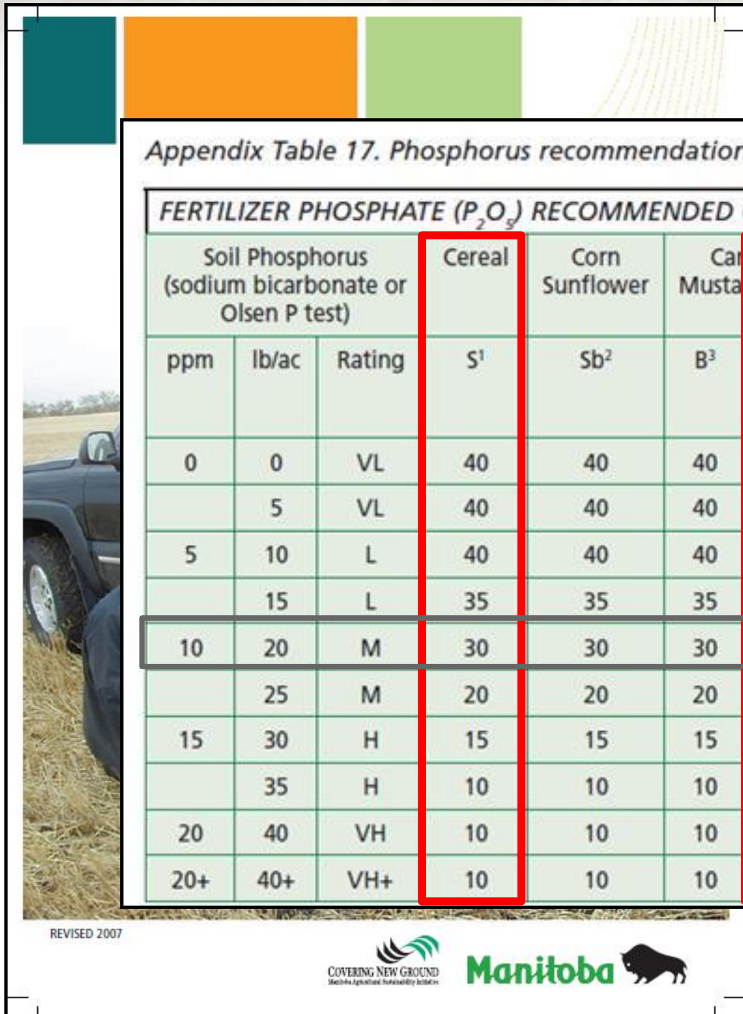
P Response Probabilities for Westco Studies with Spring Wheat in AB, SK and MB 1988-1995



Karamanos, 33 site years in AB, SK, MB 1988-1995

Short-term P sufficiency strategy often depletes long-term P fertility, especially for seedrow placed P

eg. MB Soil Fertility Guide recommendations for 10 ppm Olsen P



Appendix Table 17. Phosphorus recommendations for field crops based on soil test levels and placement[76].

FERTILIZER PHOSPHATE (P_2O_5) RECOMMENDED (lb/ac)																
Soil Phosphorus (sodium bicarbonate or Olsen P test)			Cereal	Corn Sunflower	Canola Mustard Flax		Buckwheat Fababeans		Potatoes		Peas Lentils Field beans[1] Soybeans[1]		Legume forages		Perennial grass forages	
ppm	lb/ac	Rating	S[1]	Sb[2]	B[3]	S[1]	B[3]	S[1]	B[3]	PPI[4]	B[3]	S[1]	seeding PPI[5]	Est. stand BT[6]	seeding PPI[5]	Est. stand BT[6]
0	0	VL	40	40	40	20	40	20	55	110	40	20	75	55	45	30
	5	VL	40	40	40	20	40	20	55	110	40	20	75	55	45	30
5	10	L	40	40	40	20	40	20	50	100	40	15	75	55	45	30
	15	L	35	35	35	20	35	20	45	90	35	15	65	50	35	20
10	20	M	30	30	30	20	30	20	45	90	30	10	60	40	30	20
	25	M	20	20	20	20	20	20	40	80	20	10	50	35	20	15
15	30	H	15	15	15	0	15	20	35	70	15	0	45	30	15	10
	35	H	10	10	10	0	10	20	30	60	10	0	30	20	0	0
20	40	VH	10	10	10	0	10	20	30	60	10	0	30	20	0	0
20+	40+	VH+	10	10	10	0	10	20	30	60	10	0	25	20	0	0

Short-term P sufficiency strategy often depletes long-term P fertility, especially for seedrow placed P

P balance for 4 year rotation: Following MB Soil Fertility Guide Rec. for 10 ppm Olsen P				
Crop	Yield (bu/ac)	P Applied	P Removed*	Annual Balance
		----------	(lb P_2O_5/ac)	----------
GP spring wheat	60	30	35	-5
Canola	40	20	40	-20
Winter wheat	75	30	38	-8
Soybeans	35	10	30	-20
4 Year Total		90	143	-53

* Using 0.59, 1.0, 0.51, 0.85 lb P_2O_5/bu respectively for grain only

P Rate can be Managed for Short-Term Sufficiency or Long-term Sustainability

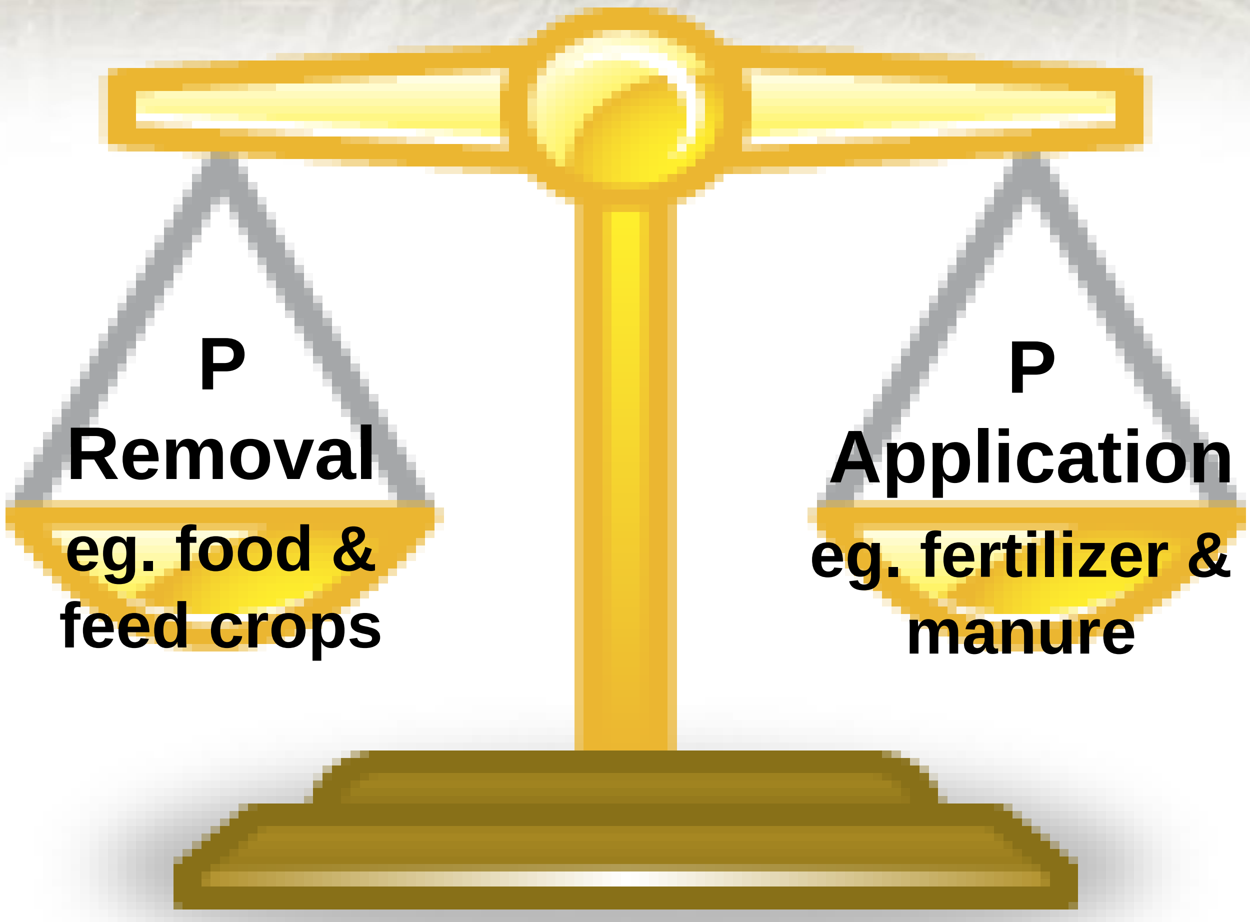
Short-term sufficiency

- Rate chosen based on economic yield response in the year of application
  - Often seed-place a low rate of P
- Suitable for short-term land tenure and when P costs are high relative to crop prices

Long-term sustainability

- Target applications to reach and maintain soil test P target range:
  - Build on low-P soils
  - Deplete on high-P soils
- Long-term economics considers residual P value
- Suitable for long-term land tenure and when P costs are low relative to crop prices

Balancing P application with crop removal is essential to avoid excessive accumulation or depletion of P in soil

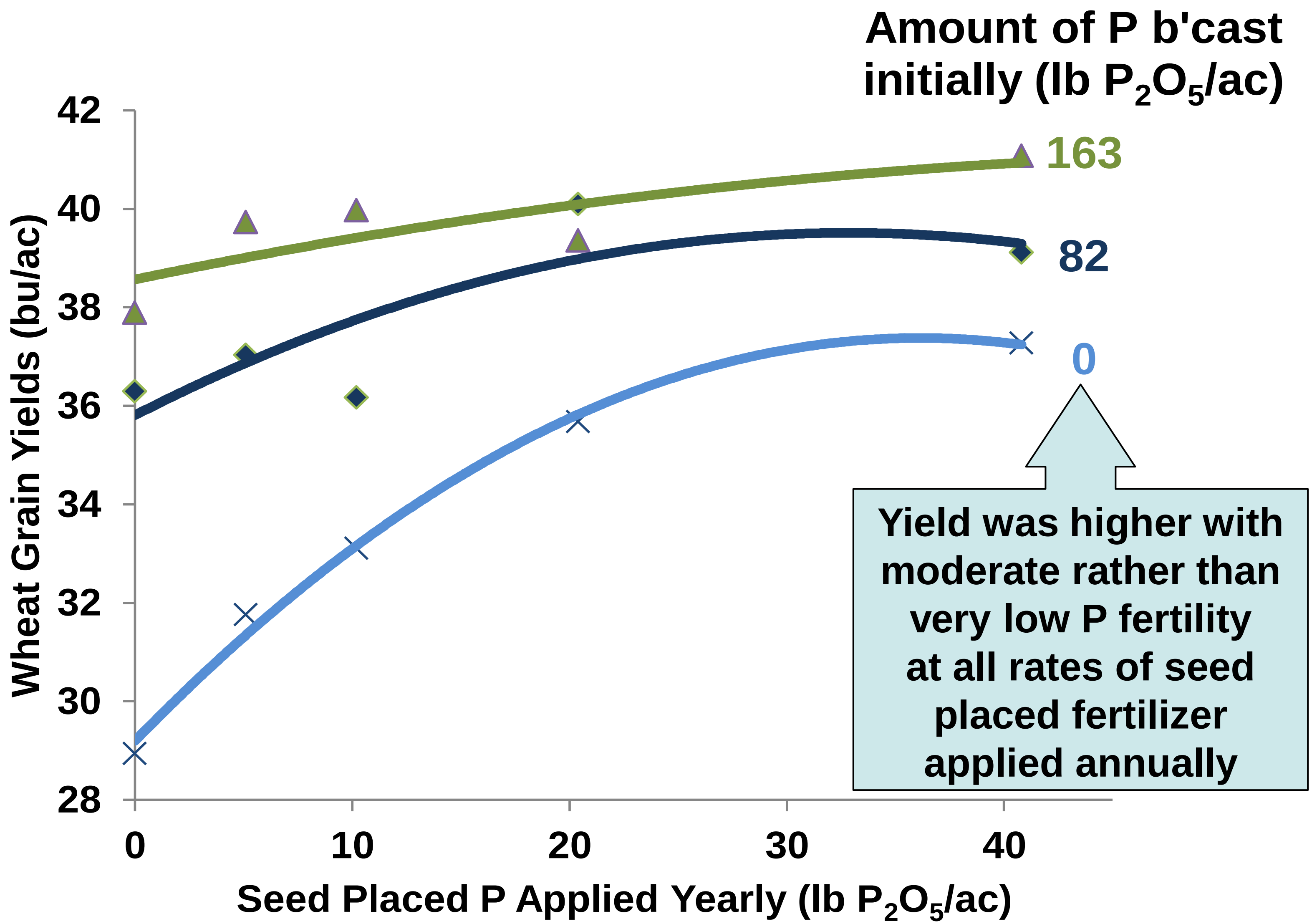


Dr. Martin Entz's long term organic rotation demonstrates the importance of P replacement

Alfalfa no compost (P)

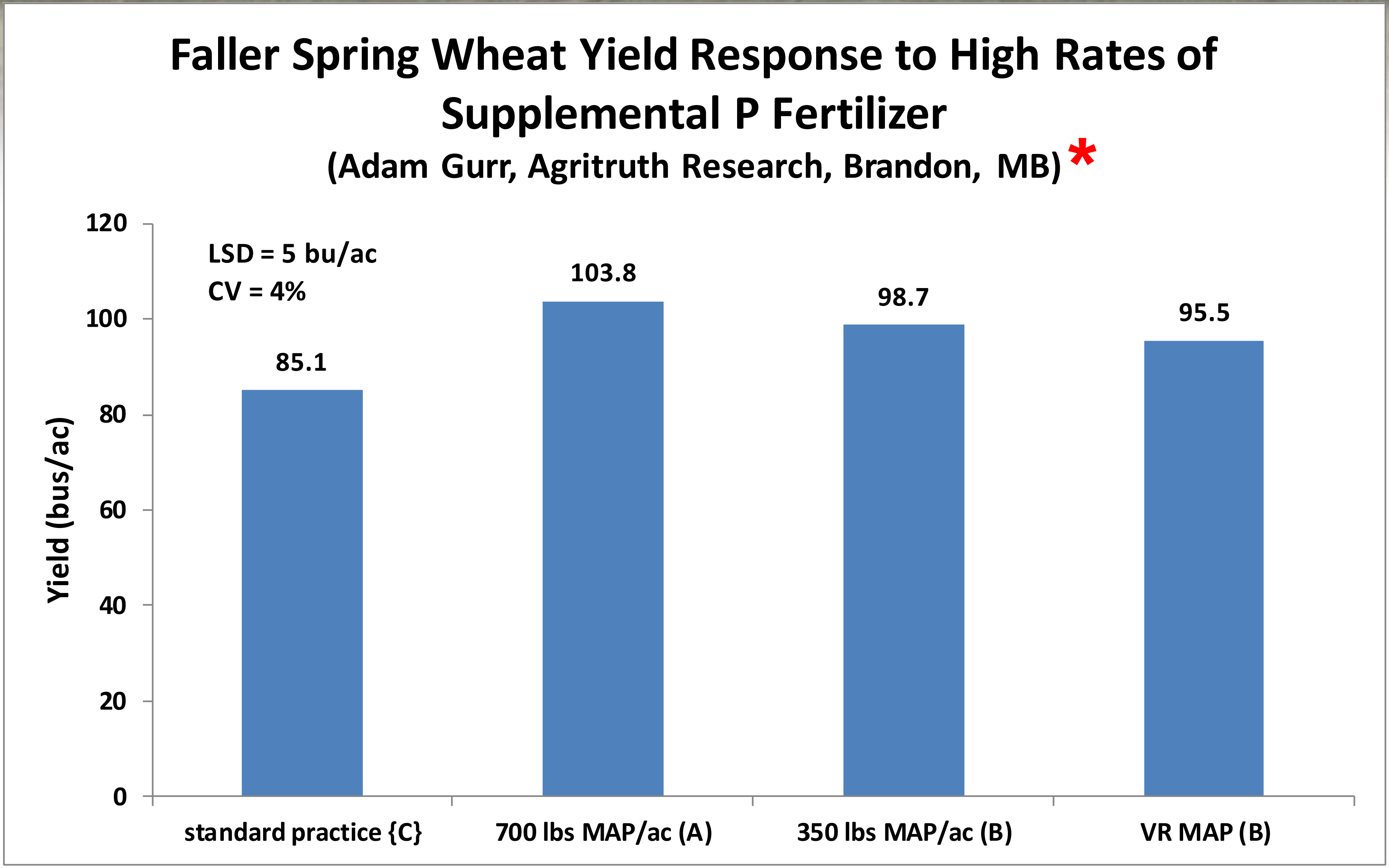
Alfalfa + compost (P)

Crops respond to P fertilizer and soil P fertility, so depleted soil P can decrease crop yield potential



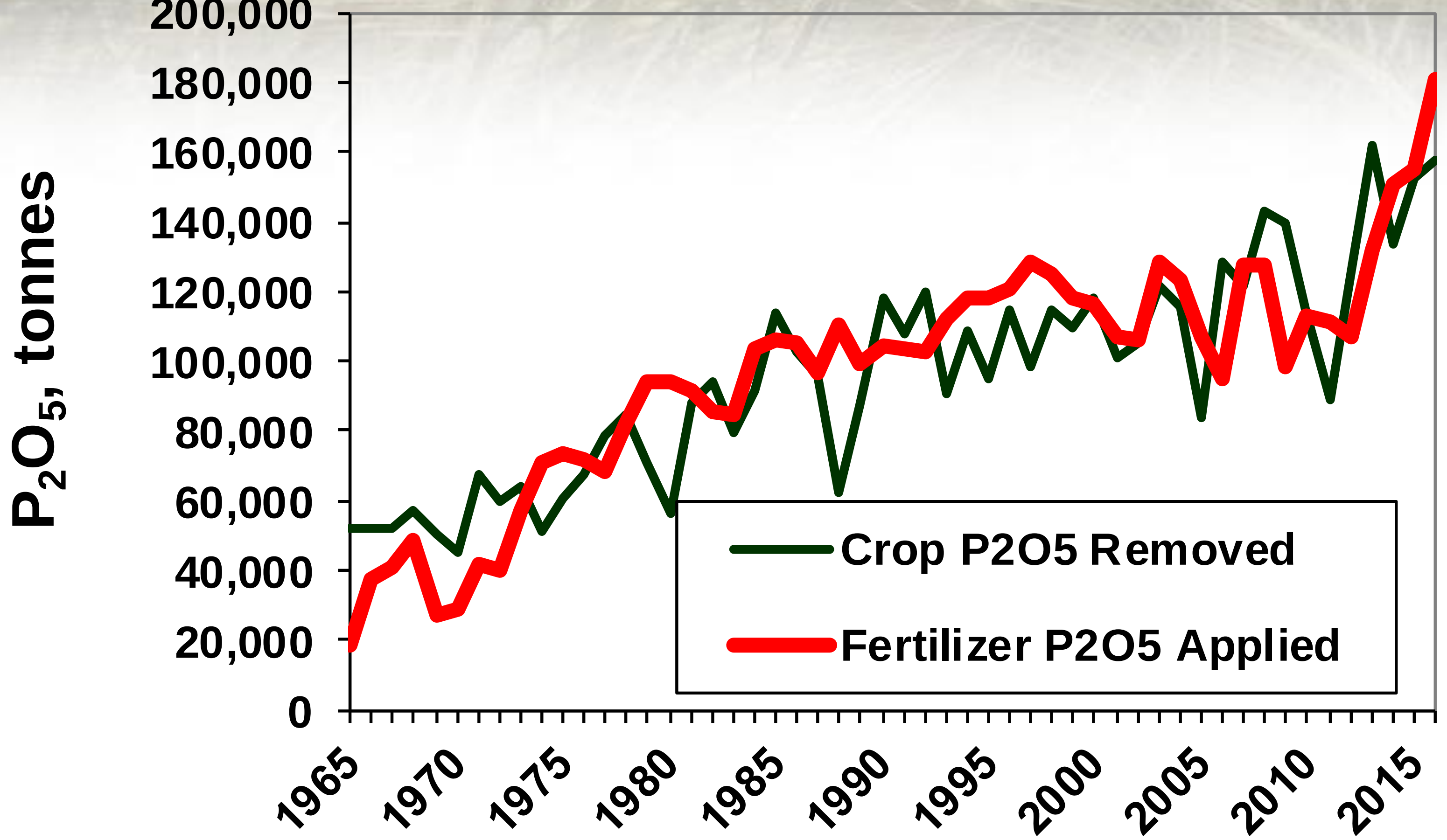
Six year study in SK by Wagar et al. 1986

Crops respond to P fertilizer and soil P fertility, so supplemental P can increase crop yield



* data are for only the first site-year of study (2018)

Crop Removal and Replacement of P in Manitoba (1965-2016)*

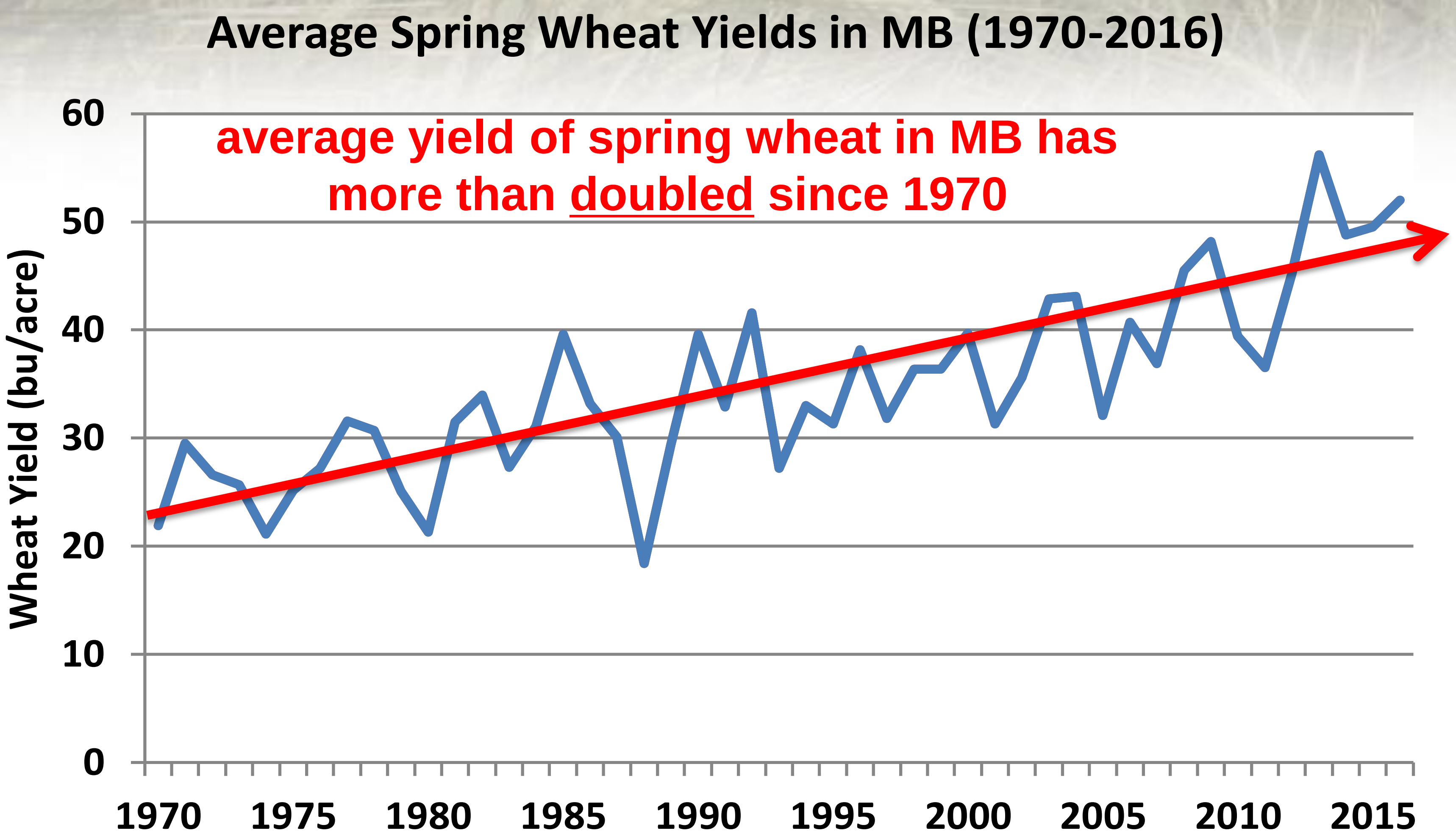


*John Heard (Manitoba Agriculture) with data from Statistics Canada data, does not include additions of manure or removal of straw P

P fertility is declining in many Prairie soils

- **Short term P sufficiency strategies often deplete P fertility (already discussed)**
- **Yields of all crops have increased, increasing P removal in grain**
- **Increased acres of canola, soybeans and corn,**
  - **high rates of P removal**
  - **low rates of P can be placed in the seed row, without risk of toxicity**
- **Decreased barley and wheat acres**
  - **less opportunity to place high rates of P with seed**

Increased crop yields = more P removal



Statistics Canada - Estimated areas, yield, production, average farm price and total farm value of principal field crops, in imperial units annual

More canola + soybeans = more P removal

Crop	Seed Yield bu/acre	Uptake/Removal* lb P_2O_5/ac	lb/bu
Wheat	60 bu	54 (36)	0.59
Canola	40 bu	67 (40)	1.0
Soybeans	35 bu	38 (30)	0.85
Barley	80 bu	45 (34)	0.43
Peas	50 bu	43 (34)	0.68
Oats	100 bu	41 (26)	0.26
Corn	100 bu	63 (44)	0.44

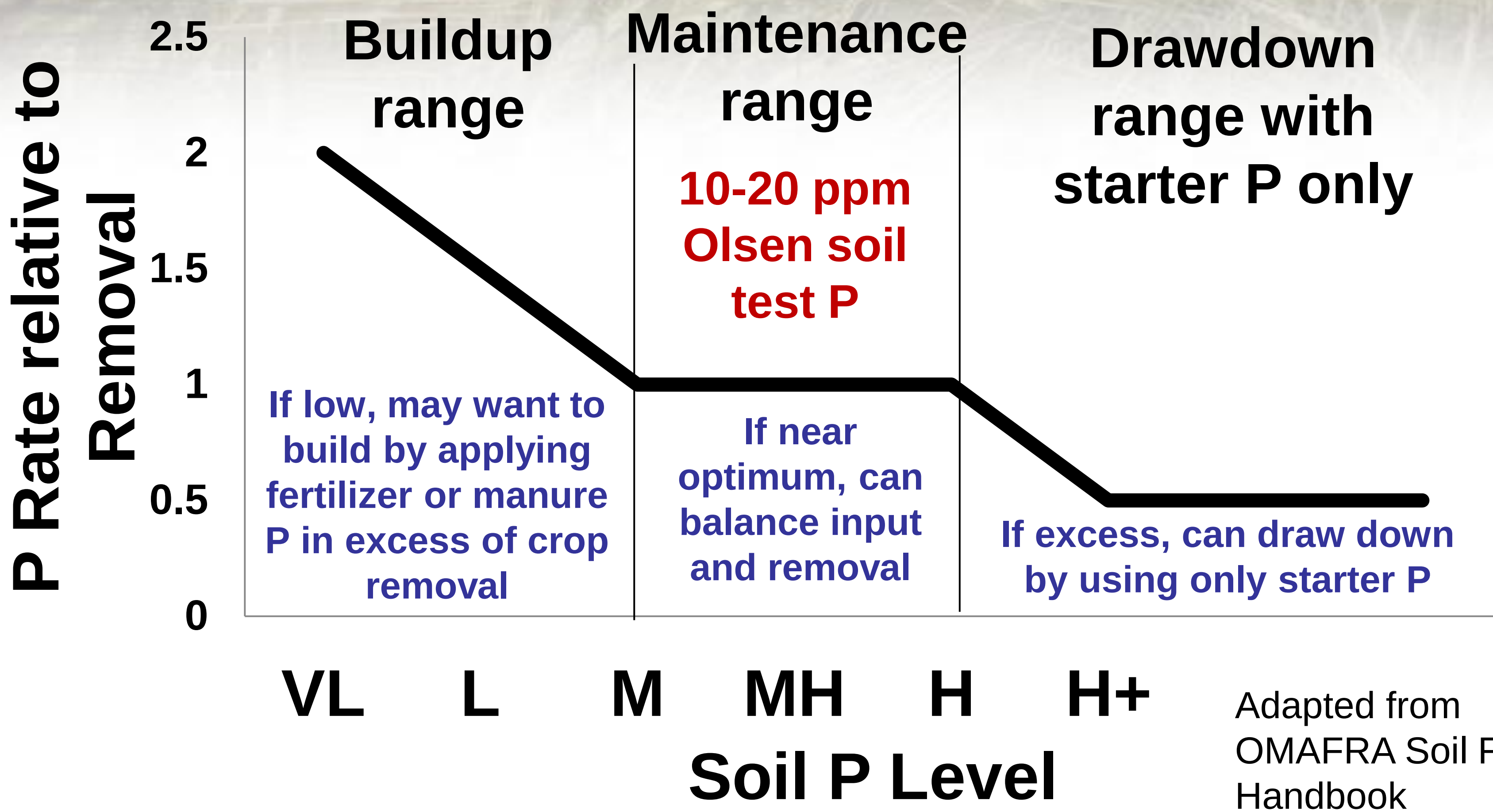
*Removed in grain

Safe rates of seed-placed P will not replace P removal for many crops ... especially for soybeans and canola

Crop	Yield	P Removal	Seed Limit	Balance
	(bu/ac)	----------- lb P_2O_5/acre -----------		
Wheat	60	36	50	+14
Canola	40	40	20	-20
Soybeans	35	28	10	-18
Barley	80	38	50	+12
Flax	32	20	20	0
Peas	50	38	20	- 18
Oats	100	29	50	+21

*Rates are based on solid seeding with disk or knife openers with a 1 in. spread, 6 to 7 in. row spacing and good to excellent soil moisture

A fertilization concept to move soil P levels into an optimum range over time



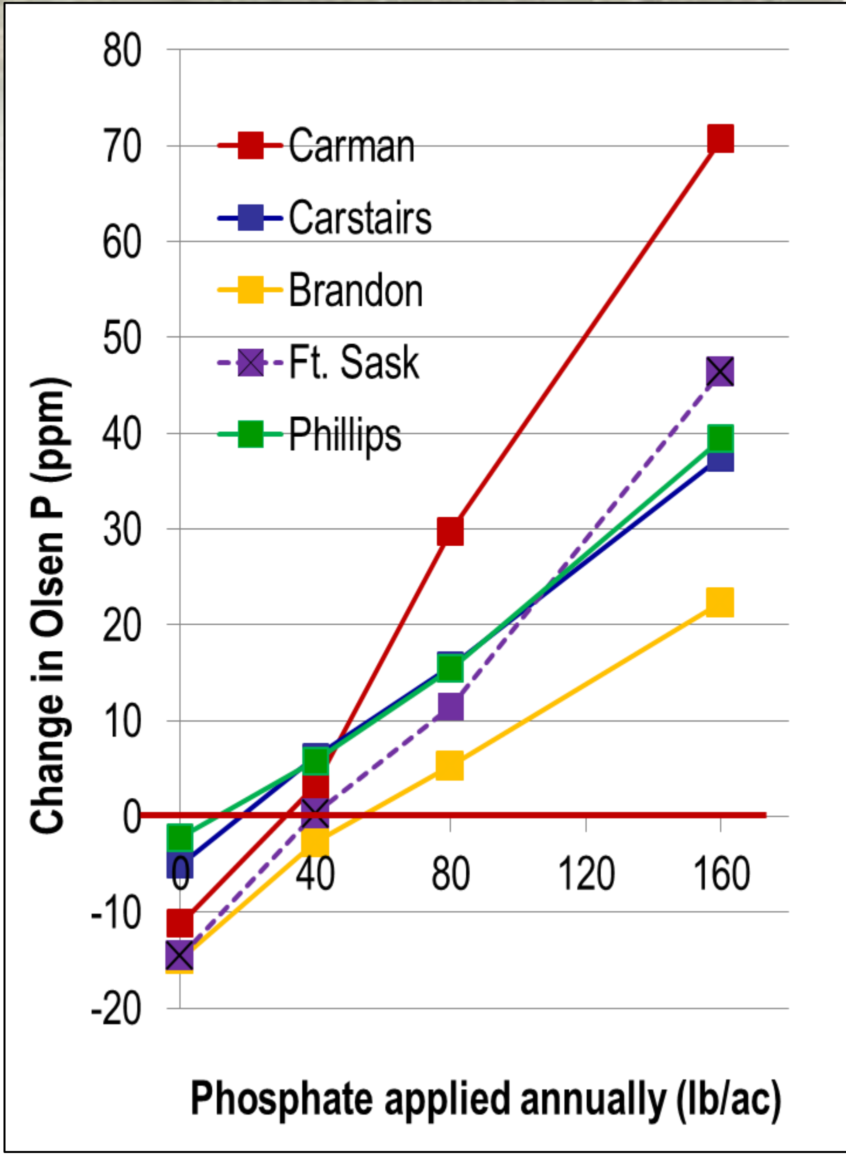
Adapted from OMAFRA Soil Fertility Handbook

Effect of P balance on soil test P buildup and drawdown varies with soil type

eg. 8 year study in AB & MB in a durum-flax rotation

- **Olsen P increased with high P rates**
- **Olsen P declined when no P applied**
- **At 40 lb phosphate/acre/year, Olsen P was maintained at most sites**
- **Surplus P to raise Olsen P by 1 ppm:**
  - **16-23 lb P_2O_5/ac at Carman**
  - **29-32 lb P_2O_5/ac at Carstairs**
  - **27-35 lb P_2O_5/ac at Brandon**
  - **21-25 lb P_2O_5/ac at Ft. Sask.**
  - **32-41 lb P_2O_5/ac at Phillips**
- **Most rapid change in light-textured, poorly buffered soils**

Grant et al. unpublished



Recommended Strategies for Maintaining P Fertility

- Apply sufficient P in side- or midrow bands to match crop removal on annual basis
- Use a rotational fertilization strategy over several years :
  - Add extra P to crops in rotation that tolerate high rates of seed-placed P (eg. cereals)
  - Periodically band P fertilizer into soil during fall tillage ... eg. MAP with AS prior to canola, which responds to fert. P, N and S
  - Apply manure periodically to meet crop N requirements

Key Messages for Selecting the Right Rate of P

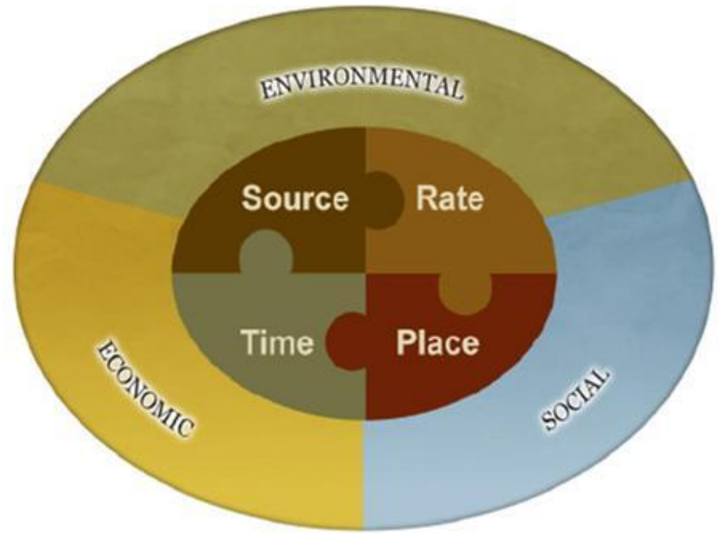
Avoid excess P depletion or accumulation

- **Deficits can reduce P fertility & long term productivity**
- **Surpluses can increase risk of P loss and eutrophication**
- **Target Olsen P levels of around 15 ppm**
  - **build levels in cereal years, with side- or mid-row band applications, or with manure**
  - **Consider a maintenance strategy when target soil levels are attained**

Chapter 8, 9 - Right Placement and Timing

- ✓ Right source
- ✓ Right rate
- ✓ **Right placement**
- ✓ **Right timing**

In a coherent combination suited to the crop, economics, and environment

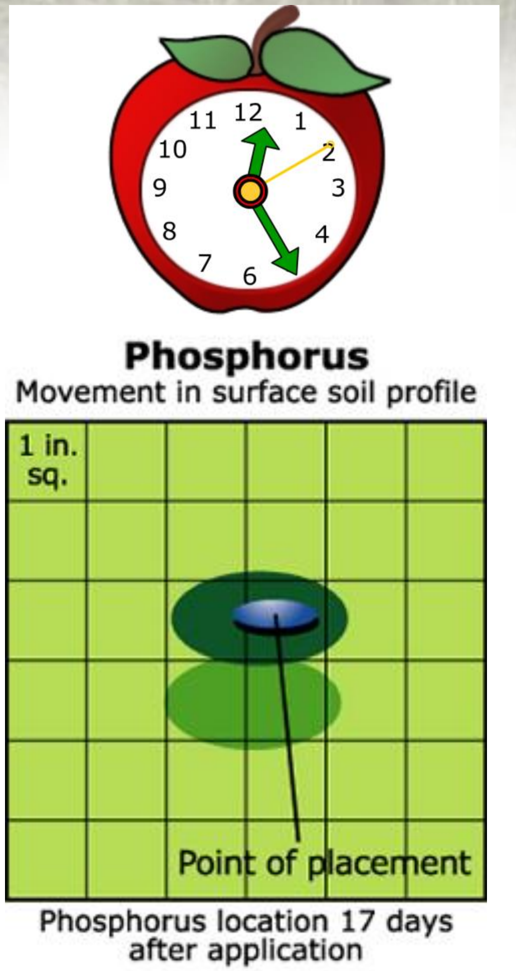


nutrient stewardship

IPNI INTERNATIONAL PLANT NUTRITION INSTITUTE

Principles of Phosphorus Nutrition that Affect P Placement and Timing

- **P is needed early in growth**
  - **Plants must have adequate supply in first 3-6 weeks**
- **Phosphorus will not move far through the soil**
  - **Movement is limited to a few mm**
- **Adequate P needs to be near the seed-row so the plants can access it early in the season ... especially in cold soils where P movement and root growth are slow**

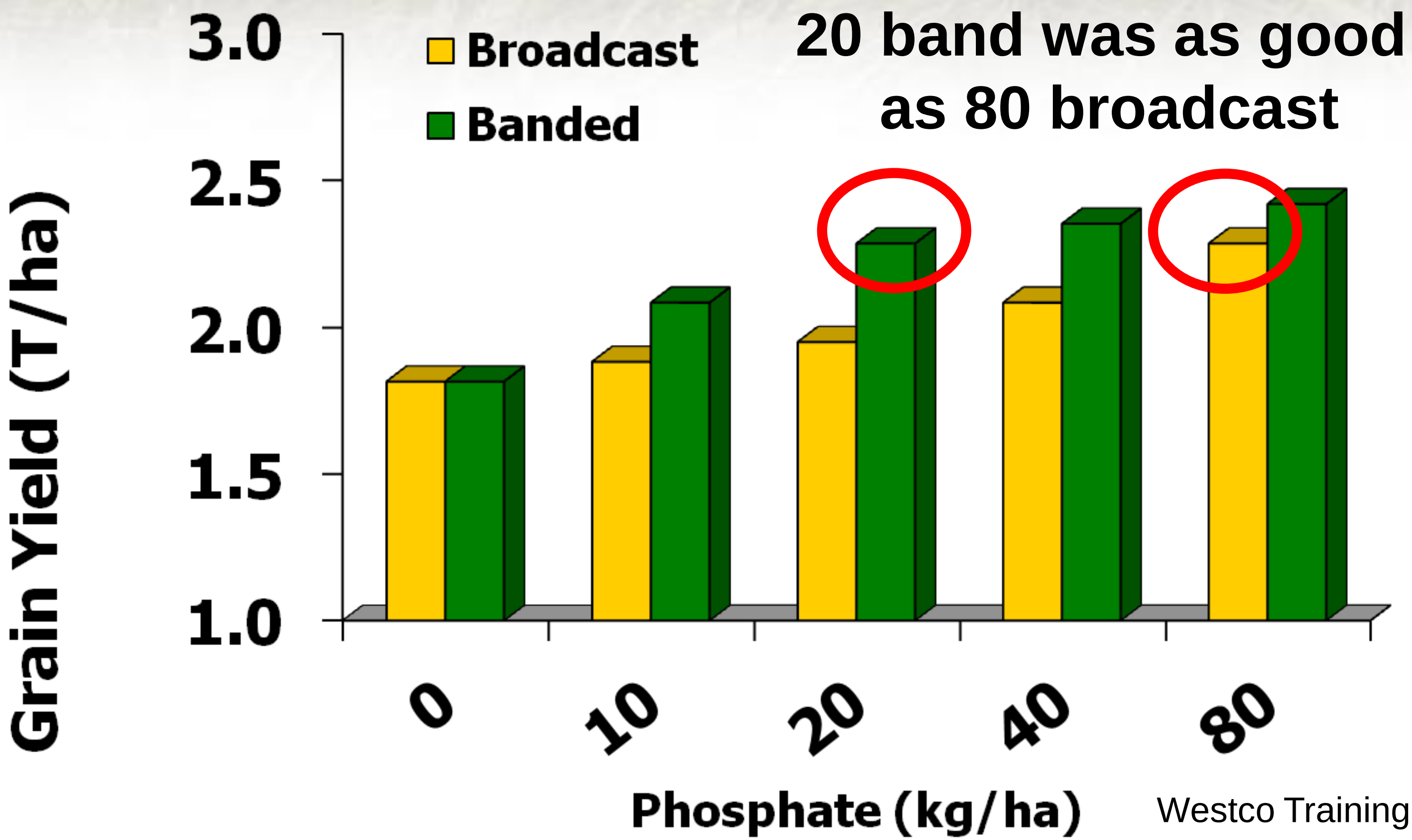


Banding P near seed is most important with

- Low soil P levels
- Restricted rooting
  - Compaction
  - Tillage pans
- Cool soil conditions
  - Solubility, mobility, rooting
  - Early seeding

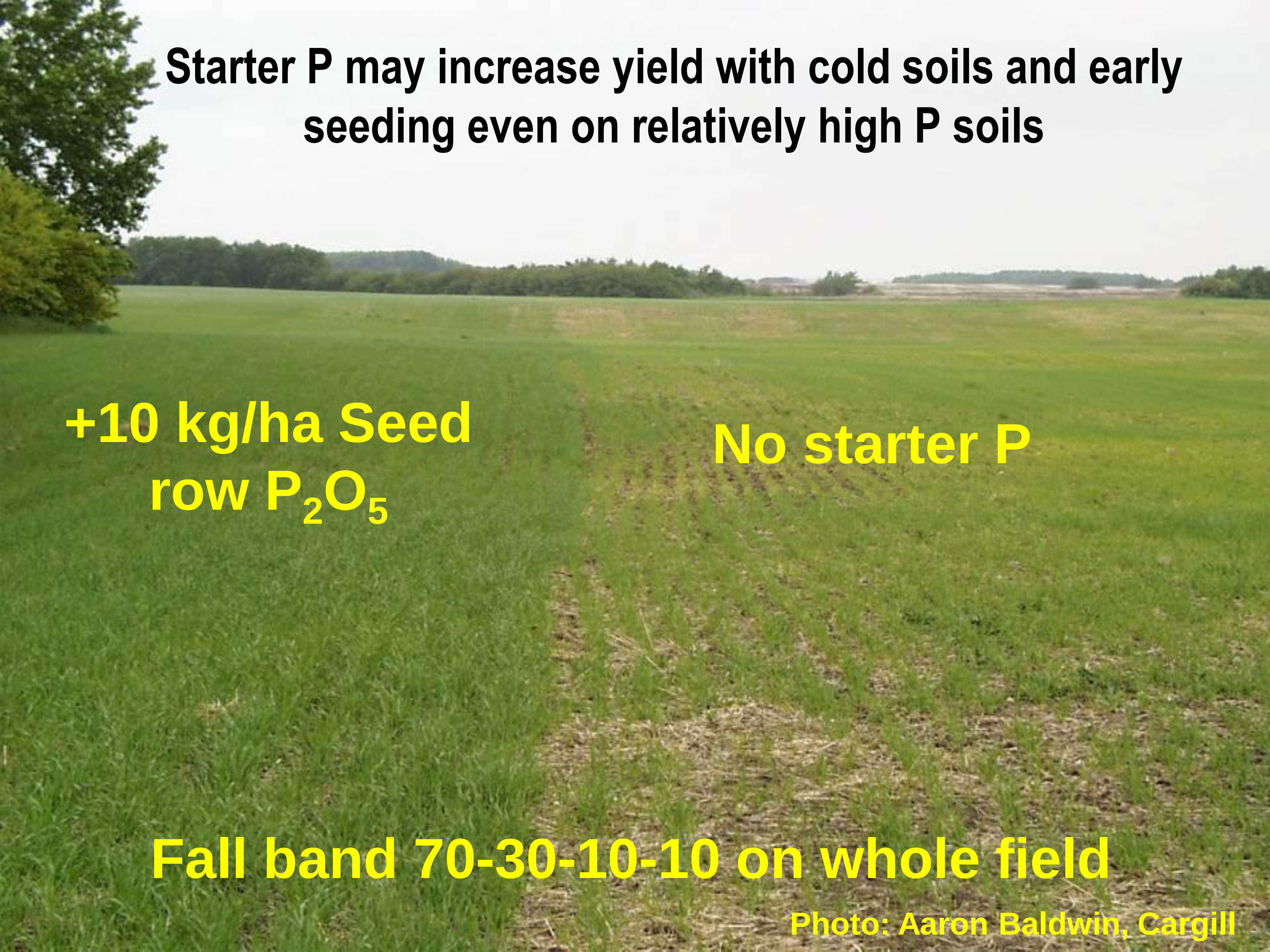
Factors that impede the ability of the crop to access P early in the season will increase the need for starter P

Wheat yield is higher with banded than broadcast P fertilizer

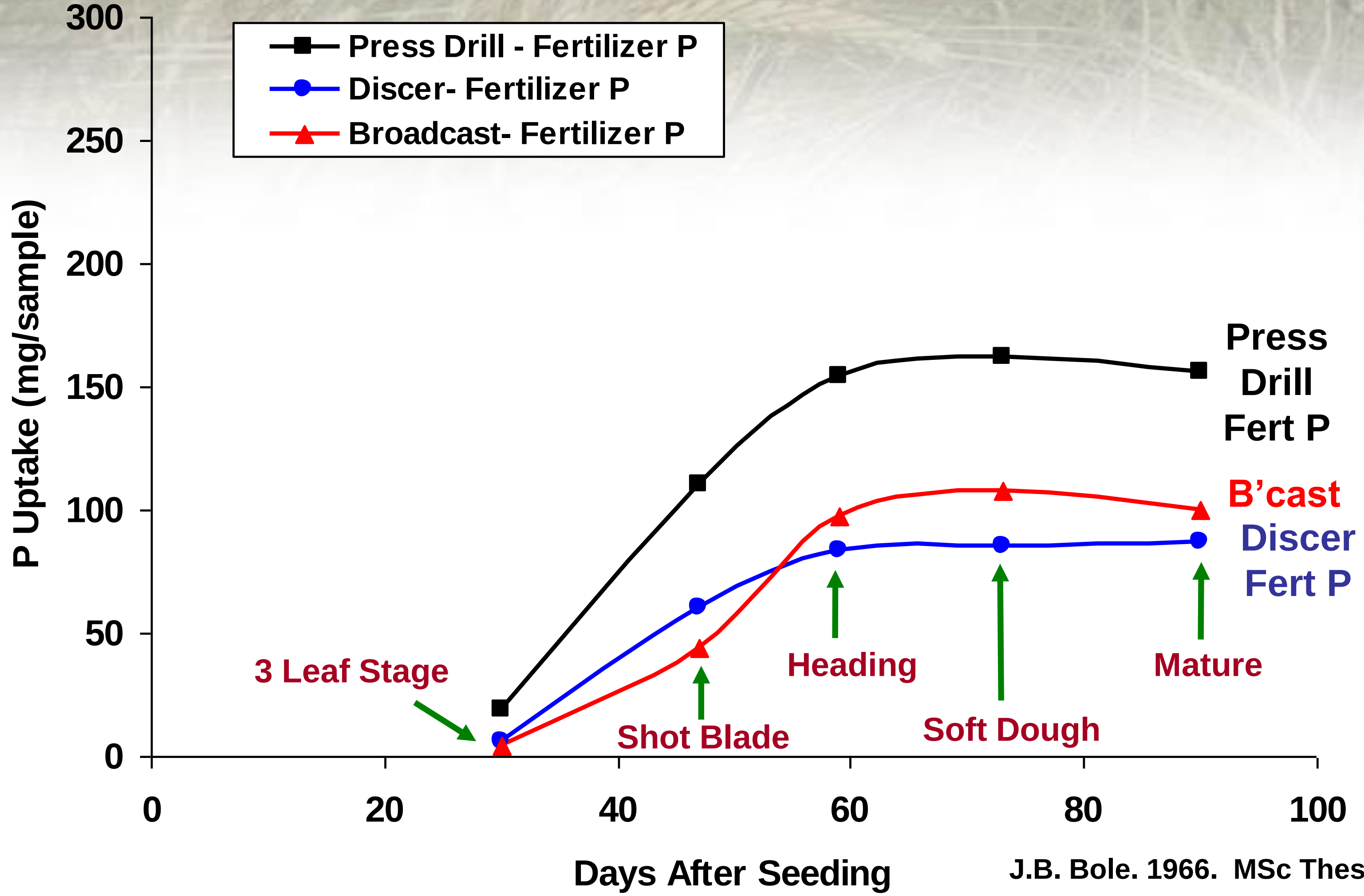


Westco Training Manual

Starter P may increase yield with cold soils and early seeding even on relatively high P soils



Effect of “Seed Row” Fertilizer Placement on Wheat Varies with Implement and SBU



J.B. Bole. 1966. MSc Thesis

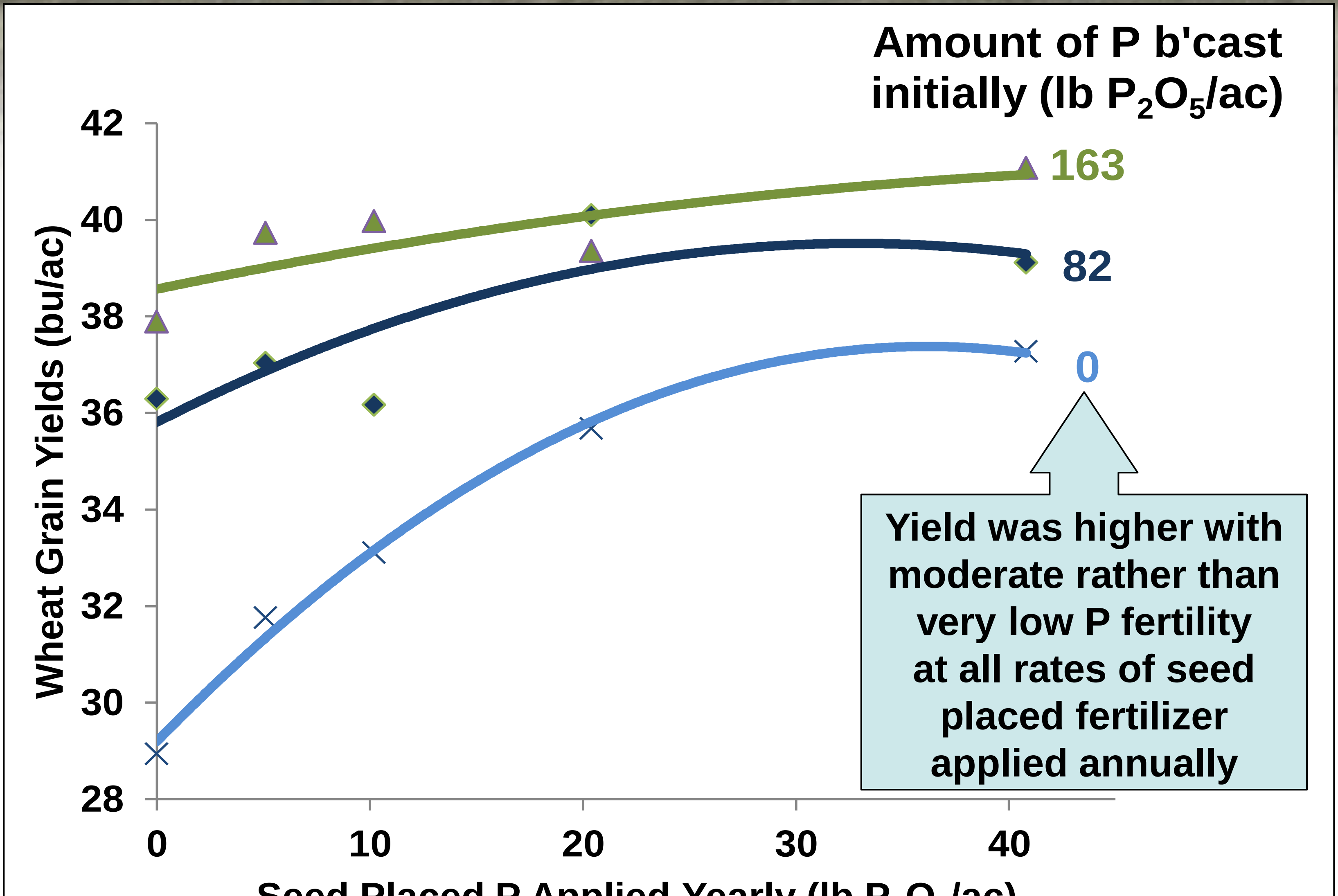
Crops differ in response to fertilizer P

(Flax Council of Canada)

(Canola Council of Canada)

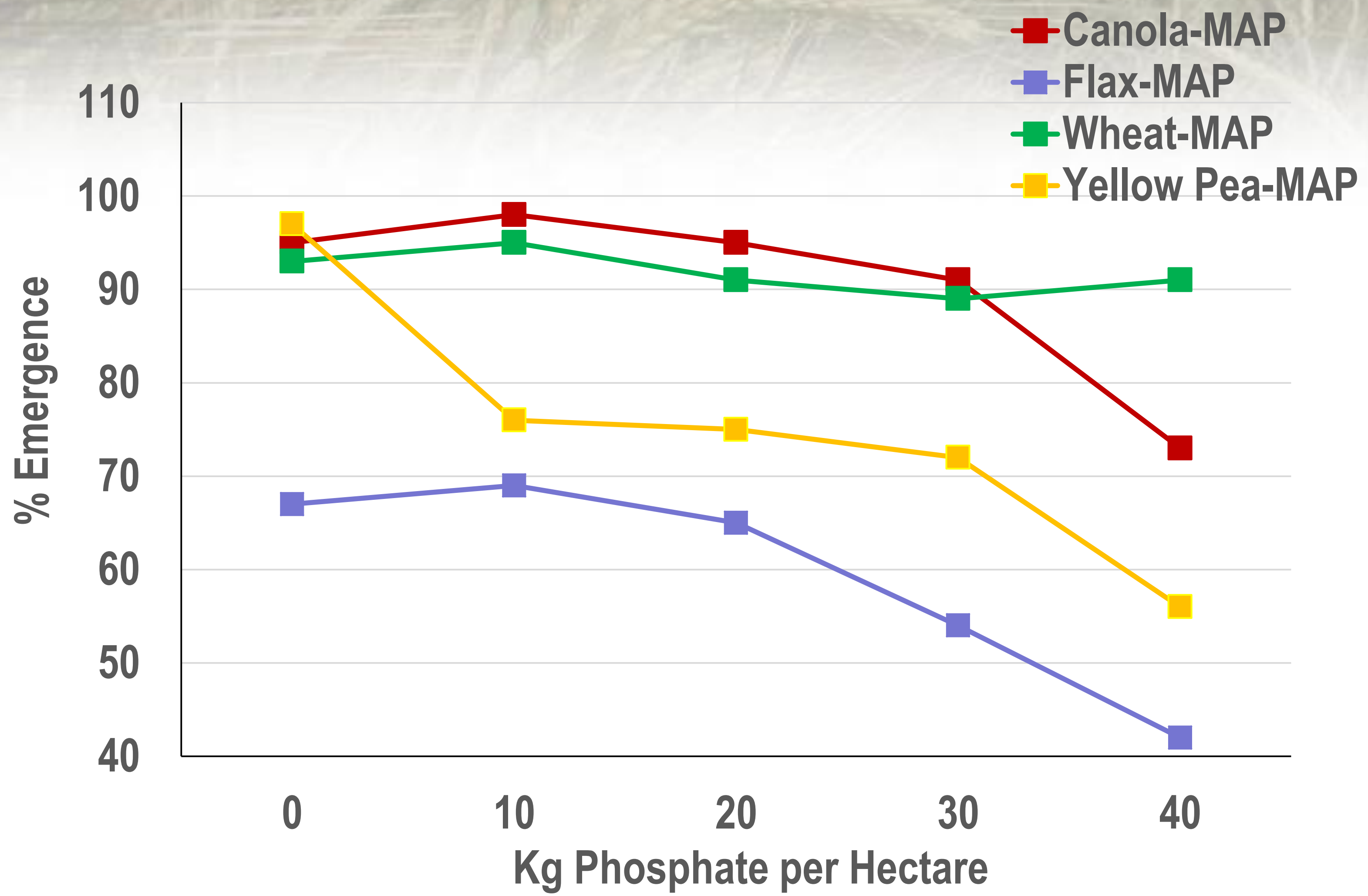
- **Cereals moderate in their ability to use soil and fertilizer P**
- **Canola effective at feeding from both fertilizer and soil P**
  - **Modification of rhizosphere**
  - **Proliferation of roots in fertilizer reaction zone**
- **Flax has poor ability to take up fertilizer P**
  - **Relies more strongly on soil P**
  - **Poor response to fertilizer P**
- **Sensitivity to seed-placed P is also important**

Seed-placed P fertilizer cannot fully compensate for very low P fertility in the soil



Six year study in SK by Wagar et al. 1986

Seed-placed MAP can lead to seedling damage in sensitive crops



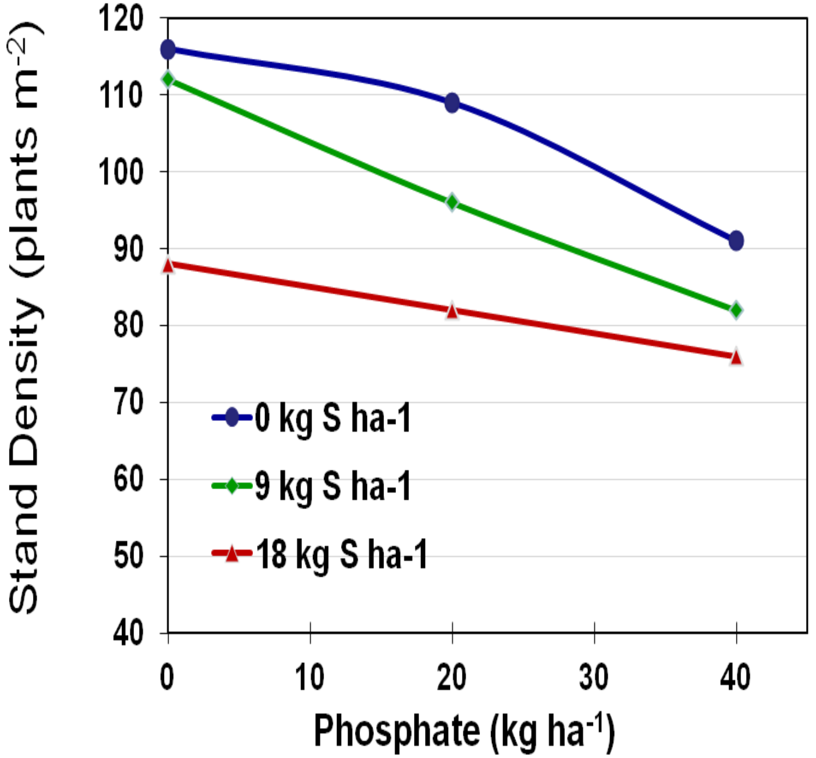
J. Schoenau

Seed-placed MAP can lead to seedling damage in sensitive crops

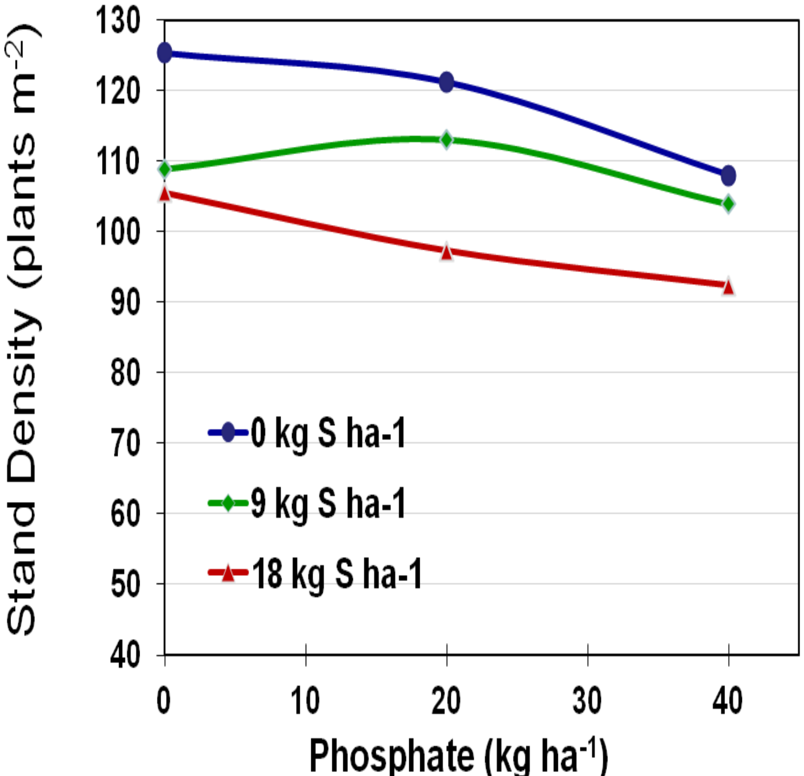
Seedling damage will be affected by other nutrients in band

- **Stand density decreased with increasing rates of seed-placed MAP**
- **Most damage occurred with highest rates of MAP and ammonium sulphate**

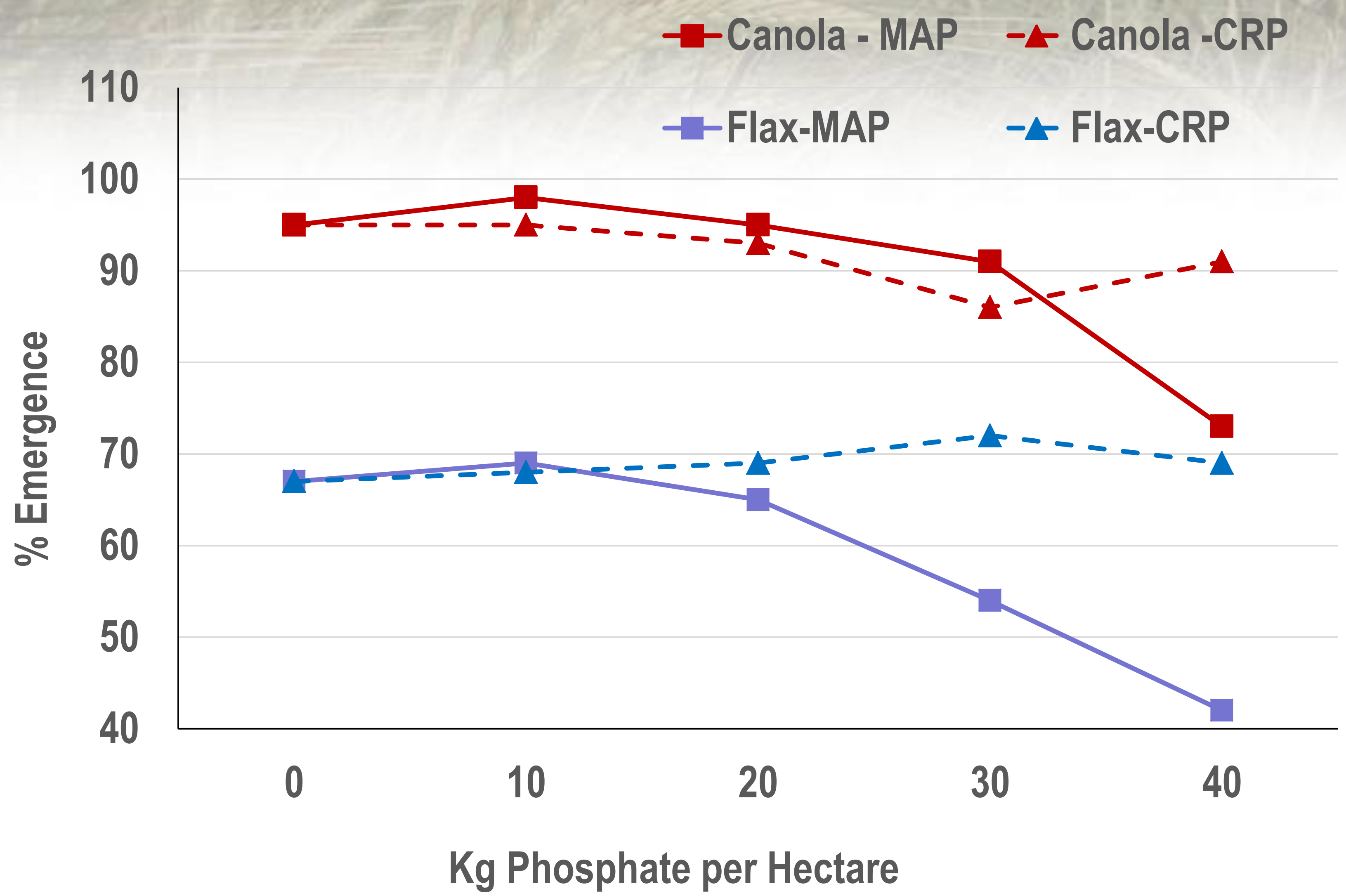
Quebec 2010



Thunder Bay 2011

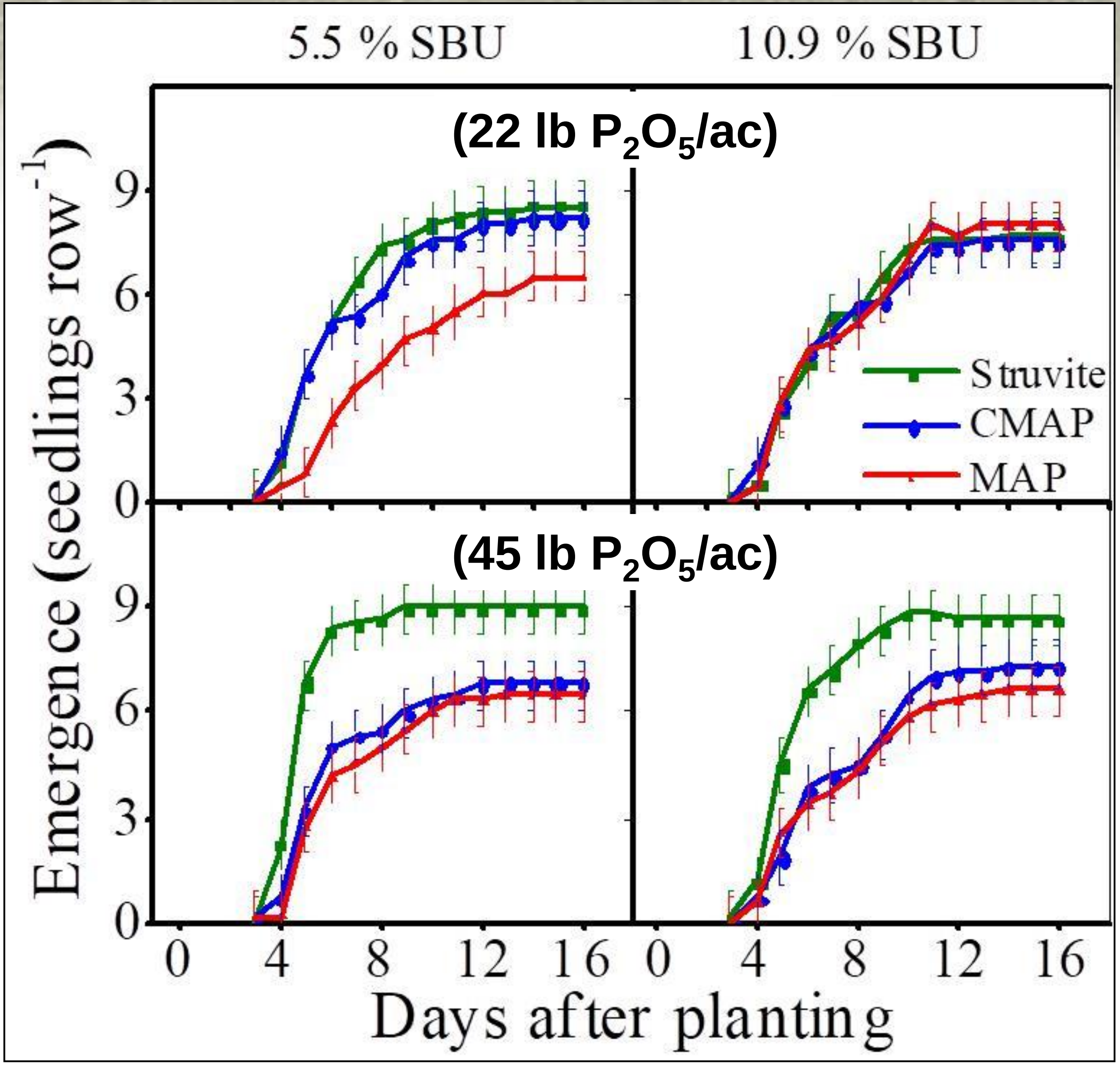


Seedling damage was reduced by use of controlled release phosphate



Seedling damage was reduced by use of struvite and controlled release phosphate

Struvite and coated MAP reduce the risk of seedling toxicity



Katanda et al. 2019
Agron. J. 111:390–396

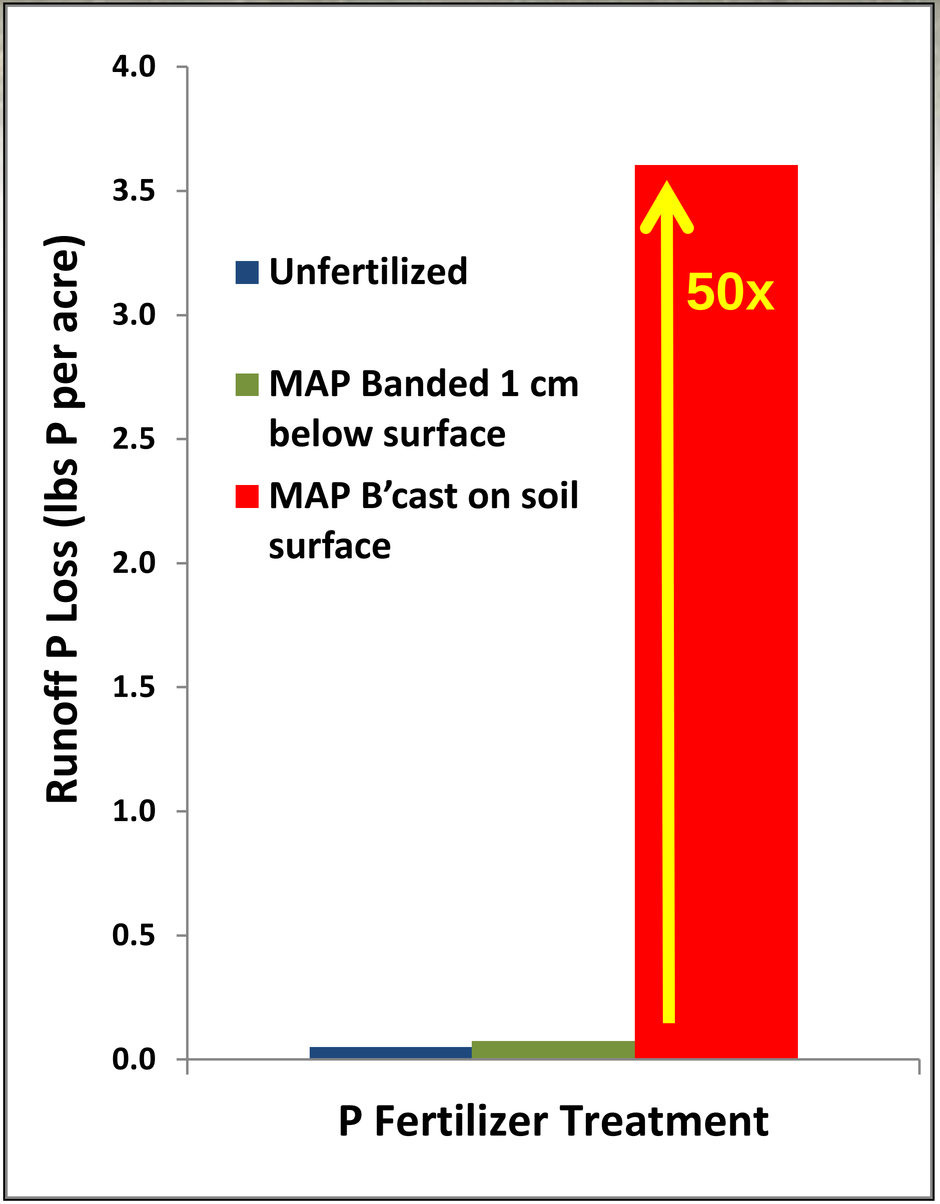
Broadcasting P decreases agronomic efficiency and increases environmental risk

- Broadcasting P fertilizer, especially in conservation tillage systems, is agronomically inefficient and leaves water soluble P on the soil surface ... prone to runoff ... especially if applied in fall

Broadcasting P decreases agronomic efficiency and increases environmental risk

Runoff losses for banded vs. broadcast P applied at 100 lbs MAP (11-52-0) per acre in laboratory studies were 50 times greater for broadcast P than for P banded 1 cm below the soil surface

(Smith et al. 2016)

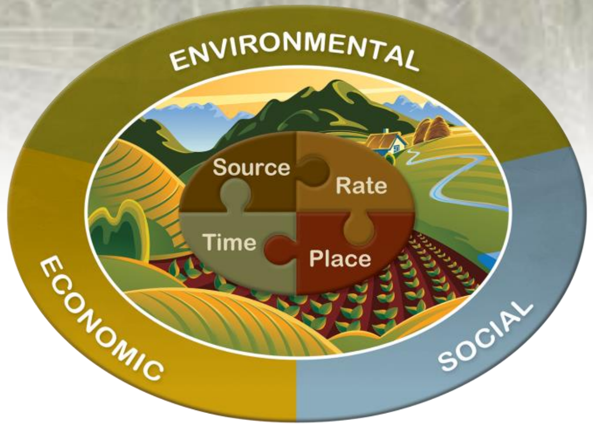


Key Messages for Selecting the Right Placement and Timing for P Fertilizer

- Plants need P from their earliest growth stages
  - P fertilizer should be applied when and where the crop can access it early in the season.
- Cold soils in the early spring can restrict root growth and P availability, limiting early season P supply to crops
- Band application near the seed-row can improve P efficiency
  - Banding slows soil reactions that reduce P availability
  - Place P bands where plant roots will intercept them in early growth
- Broadcast P at the soil surface is agronomically less efficient than in-soil bands and increases the risk of P runoff
- In-soil banding is agronomically and environmentally beneficial for P applications on the Northern Great Plains

Key Overall Messages for 4R P Fertilization in the Northern Great Plains

- **Employing the <u>science</u>-based principles of 4R P fertilizer stewardship is vital for sustainable crop production**
- **The most efficient sources of P fertilizer for this region are ammonium phosphates**
- **Long term sustainable crop production requires P fertilizer rates that match crop removal**
- **Banding P fertilizer in or near the seed-row is agronomically and environmentally beneficial**



✓ **Right source**
✓ **Right rate**
✓ **Right placement**
✓ **Right timing**

Thank you for your attention

Thank you to the project supporters

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