MINING OR MANAGING PHOSPHORUS

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Introduction

- Limited resource globally
- Phosphorous (P) is usually low in availability in most ecosystems
- Cycles slowly through the environment
- Best managed agronomically in the long-term (>5 yr) rather than yearly

Phosphate Rock Resources

- Phosphate rock resources occur principally as sedimentary marine phosphorites. The largest sedimentary deposits are found in northern Africa (Morocco), China, the Middle East, and the United States.

- Some igneous occurrences are found in Brazil, Canada, Russia, and South Africa.

(U.S. Geological Survey, 2007)

Finite Reserves

- Known reserves could run out in 60 years to 400 years, more easily or less expensive mining, compared to more expensively mined sources.

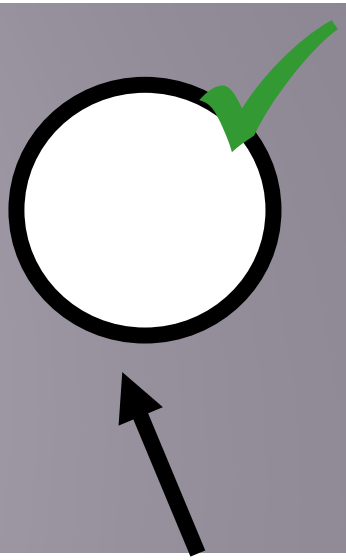
- "Without phosphorous there will be no agriculture, nor biofuels, nor life. Other minerals, like nitrogen, potassium, cobalt, magnesium and molybdenum, are also essential, but their sources are not as limited. "
(Euripedes Malavolta, University of Sao Paulo; Tierramérica 2007)

Saudi Arabian Phosphate Deposits

Saudi Arabia hosts some of the largest, but undeveloped, phosphate rock deposits in the world.

Figure 1. Excavated open trench in the Al Jalamid deposit showing 9.5m thick overburden of bioclasic dolomitic limestone and the top of the Thaniyat phosphorite member containing calcareous compact to semi-friable phosphorite with 25% P_2O_5 (level with figures waist).

TOTAL PHOSPHORUS
400 to 2,000 lb, P_2O_5/acre



LABILE PHOSPHORUS 10 to 200 lb P_2O_5/acre

SOLUBLE P
0.034 lb P_2O_5/acre

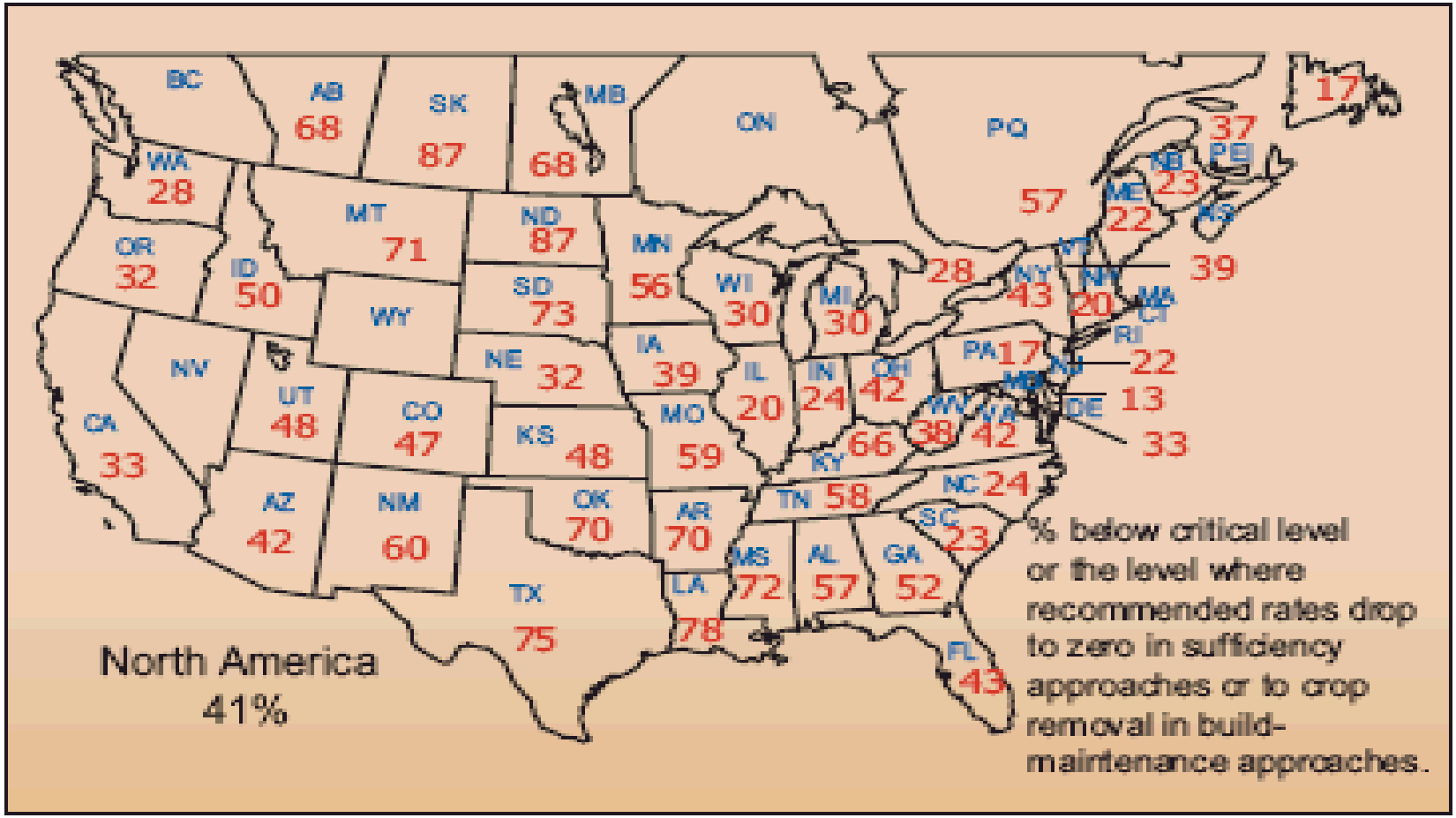
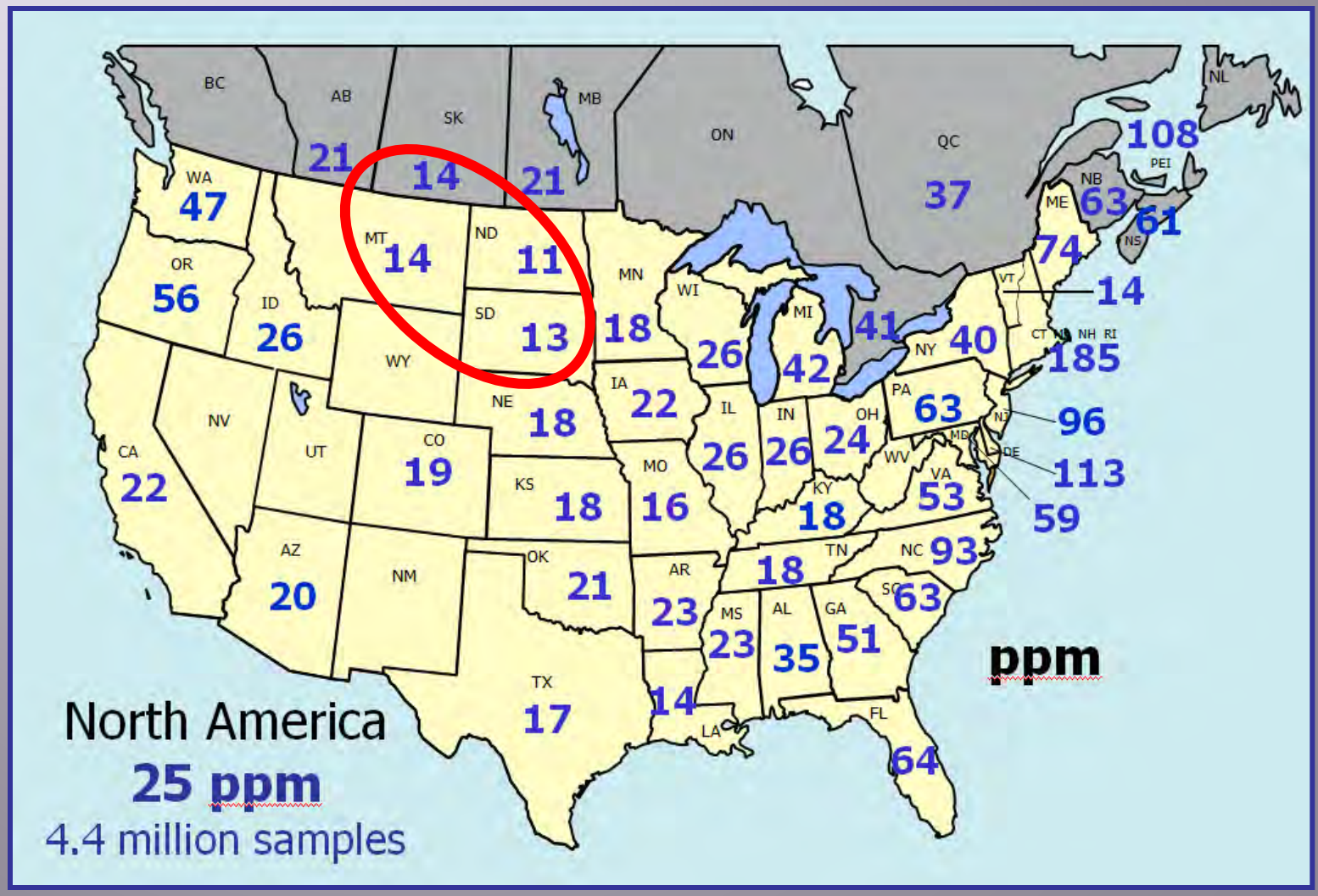


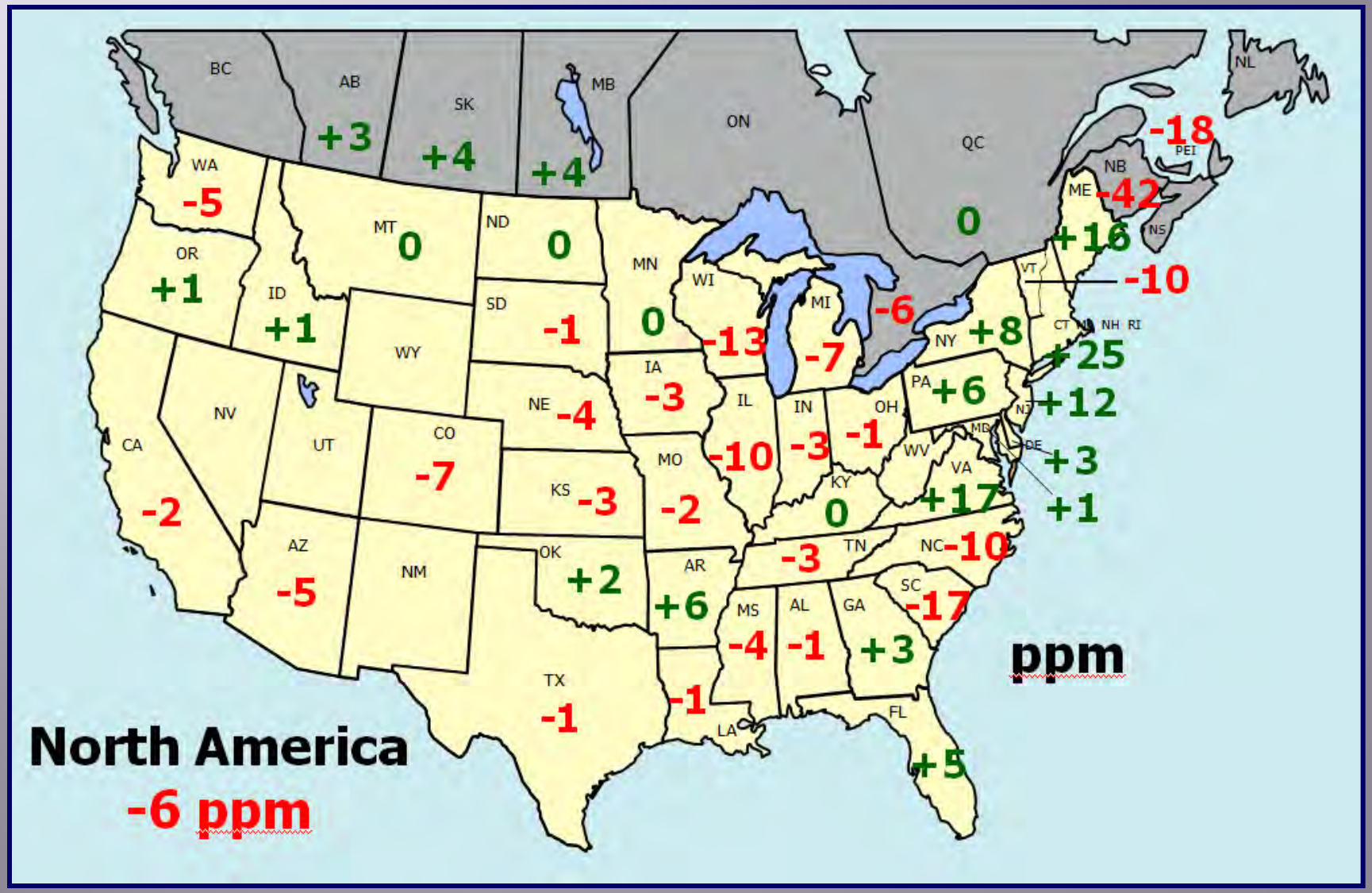
Figure 3. Percent of soil samples requiring annual P fertilization to avoid profit loss in most major crops in 2005.

Median Bray P-1 Equivalent Soil Test Levels, 2010

Some of the Lowest levels in the Great Plains



Change in median Bray P equivalent soil test levels from 2005 to 2010.



Efficiency of P Fertilizers

- In the year of application uptake of P from P fertilizer is usually 25% or less (e.g. 10% to 15%) using the "direct labeled" method.
  - Calculated as the amount of labeled P (^{32}P-labelled fertilizer) taken up in the crop as a percentage of labeled P fertilizer applied.
- However when measured a number of years and crops in a rotation using the "balance method", the efficiency is often up to 90%.
  - Calculated as the total P in the crop divided by P applied, expressed as a percentage

(Syers et al 2008)

Ideal P Management

1. Build up P availability to a critical soil-test level
   - This critical soil test level is soil specific, but near the sufficiency range, but not excess
2. Continue to apply P at rates close to crop removal
   - This approach is based on research described by A.E. (Johnny) Johnston a researcher at Rothamsted Research Station in England.
   - It can result in as efficient uptake of P as can be achieved and results in as high of yields of crop possible as long as other nutrients and agronomic practices are optimized.

(Syers et al 2008)

Critical P Availability Level Approach

(Syers et al 2008)

FIGURE 5

The theoretical realtionship between crop yield and the level of readily-plant-available P and K in soil

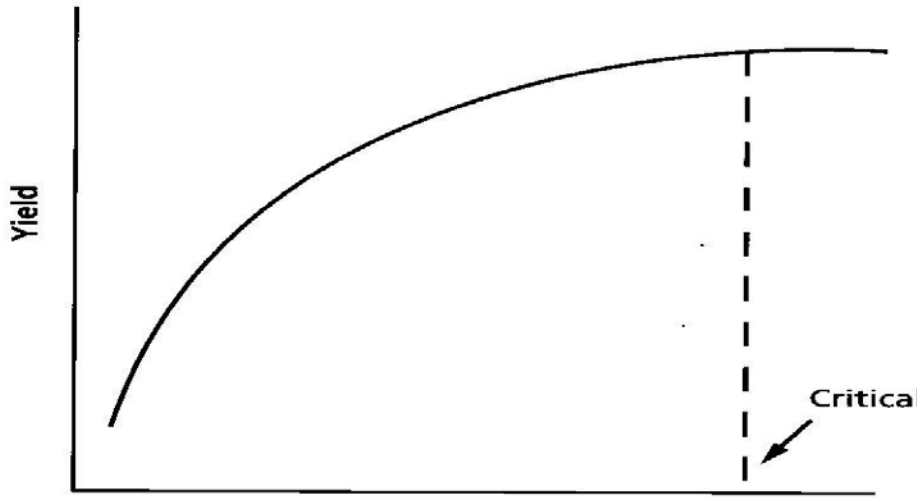
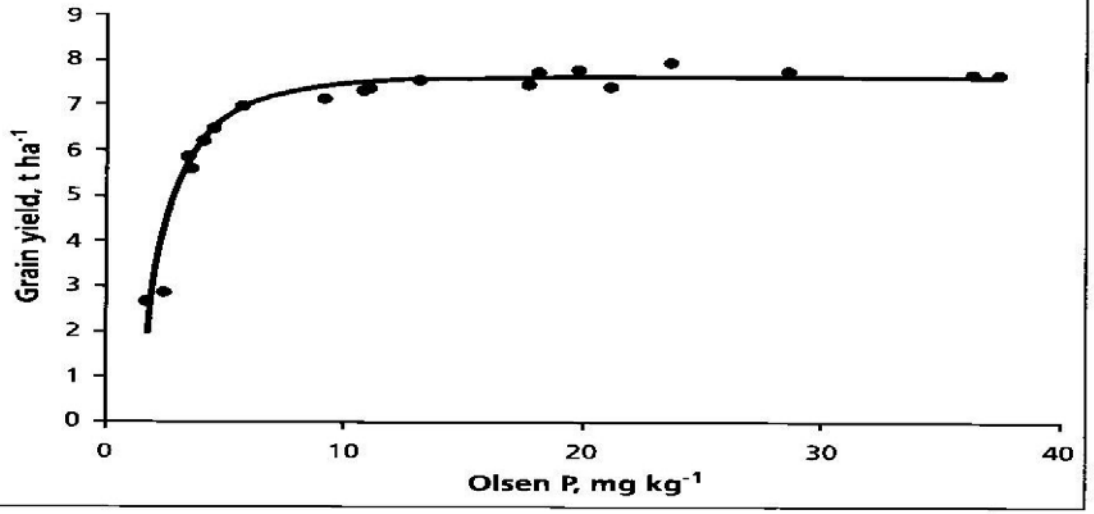


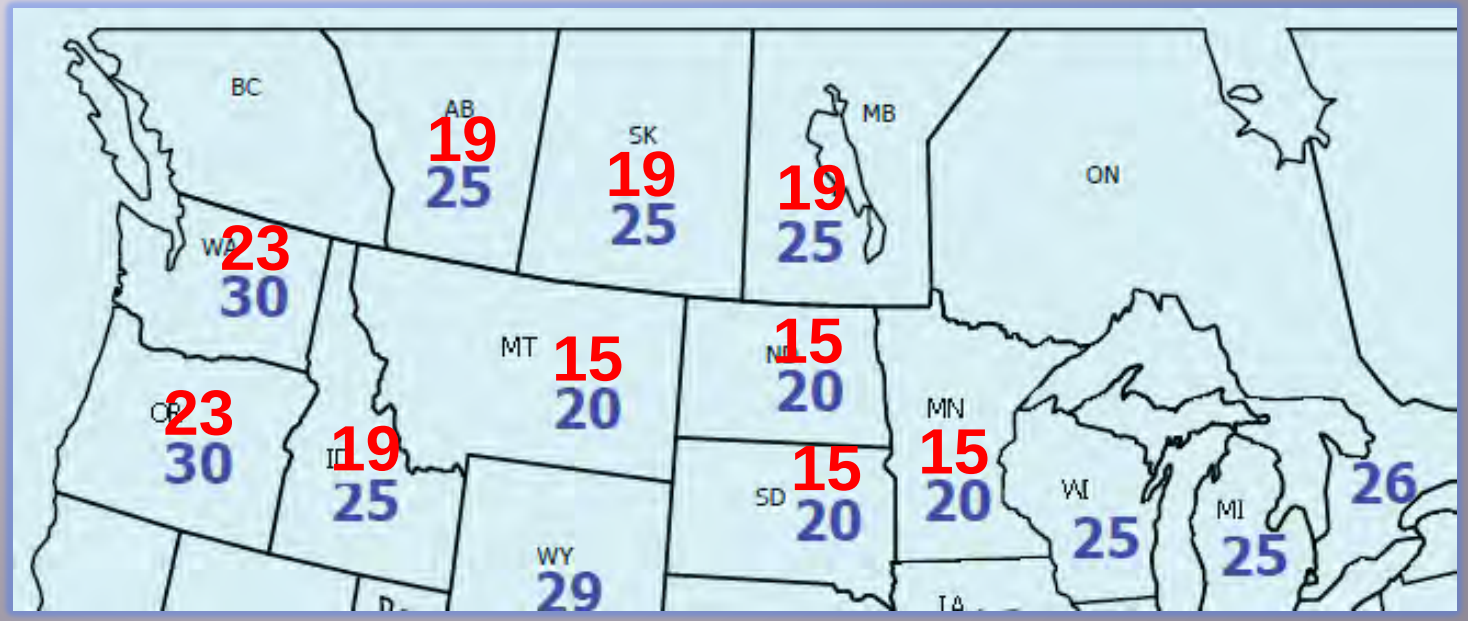
FIGURE 6

The relationship between Olsen P and the yield of wheat grain on a silty clay loam soil



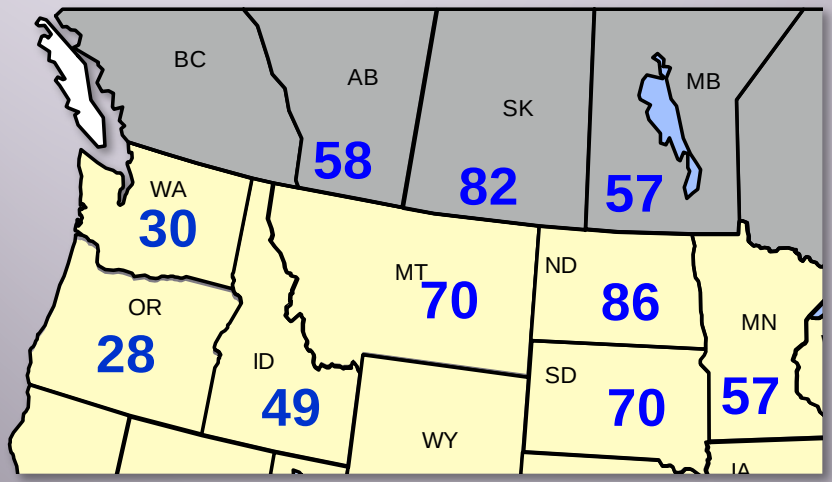
Critical Bray P1 or Olsen soil test levels

Critical level: where recommended rates drop to zero in sufficiency approaches or to crop removal in build – maintenance approaches.



SSSA Symposium
2011 Annual Meeting

Percent of samples testing below critical levels for P for major crops in 2010



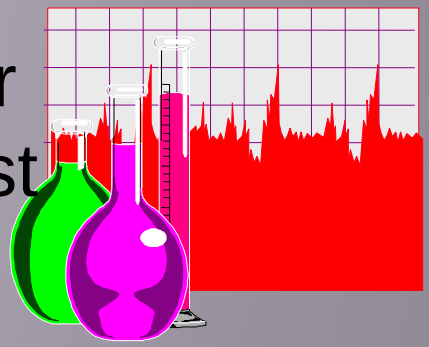
Samples testing below given level, %

	Olsen P, ppm		
(no of samples)	<19	<15	<7
AB (27,000)	58	49	21
SK (24,000)	82	72	35
MB (42,000)	57	47	18
MT (13,000)	81	70	32
ND (75,000)	92	86	44
SD (81,000)	79	70	36

Environmental Issues and Solutions

Little environmental threat from P …

- when application rates of fertilizer and manure are based on soil test recommendations

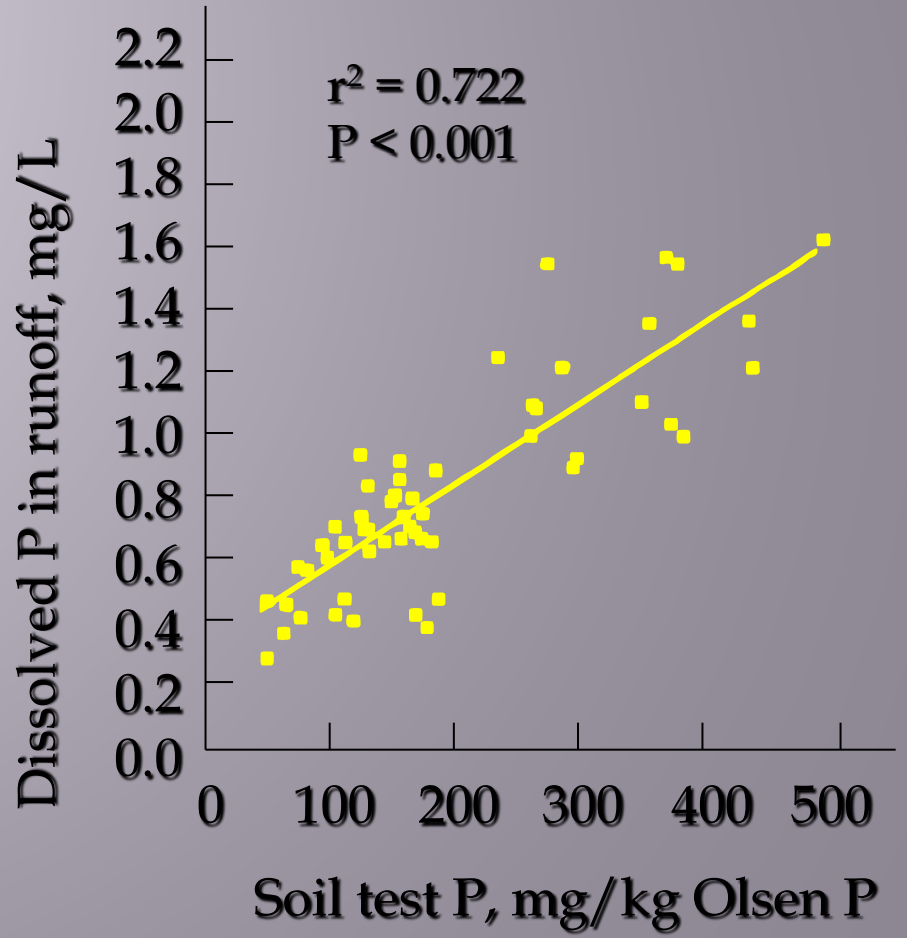


- rates do not greatly exceed crop removal

- good agronomic practices are employed

Soil Test Levels

- Soil tests … good indicators of dissolved P in runoff



(Daniel et al. 1996)

Challenge with Reduced Phosphorous Rate Strategies

1. Designer P-based liquid starter applied at about one-third the normal rate of P.
   - E.g. 6-24-6 seed-row solution at 3 US gal/acre (8 lb P2O5/acre) that costs less than a 46 lb 11-52-0/acre granular seed-row application (24 lb P2O5/acre rate).
     - Yes the application is convenient, it costs less per acre, there is less volume of fertilizer to apply, but
     - You pay more per unit of P2O5, and even though your crop yields may not decrease in the short-term (i.e. 2 to 3 years), your mining the more easily available P out of your soil, and in the longer-term lower crop yields will result.

Four years of low rate liquid P-based starters, P2O5 levels 6 to 12 mg kg-1, All 20 quarter section fields

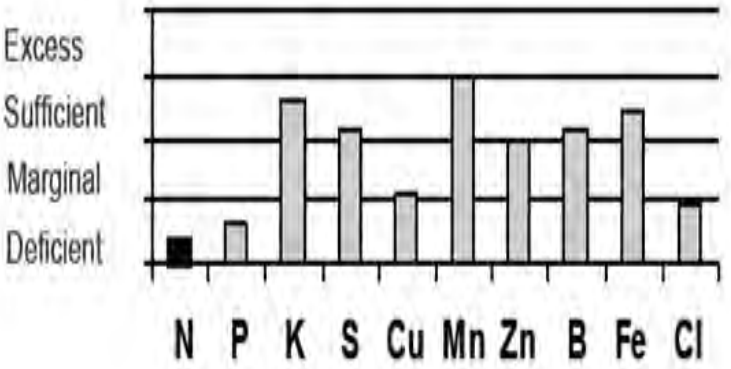
Sample ID 1209145 Date Sampled 26-SEP-12

SOIL TEST CHARACTERISTICS

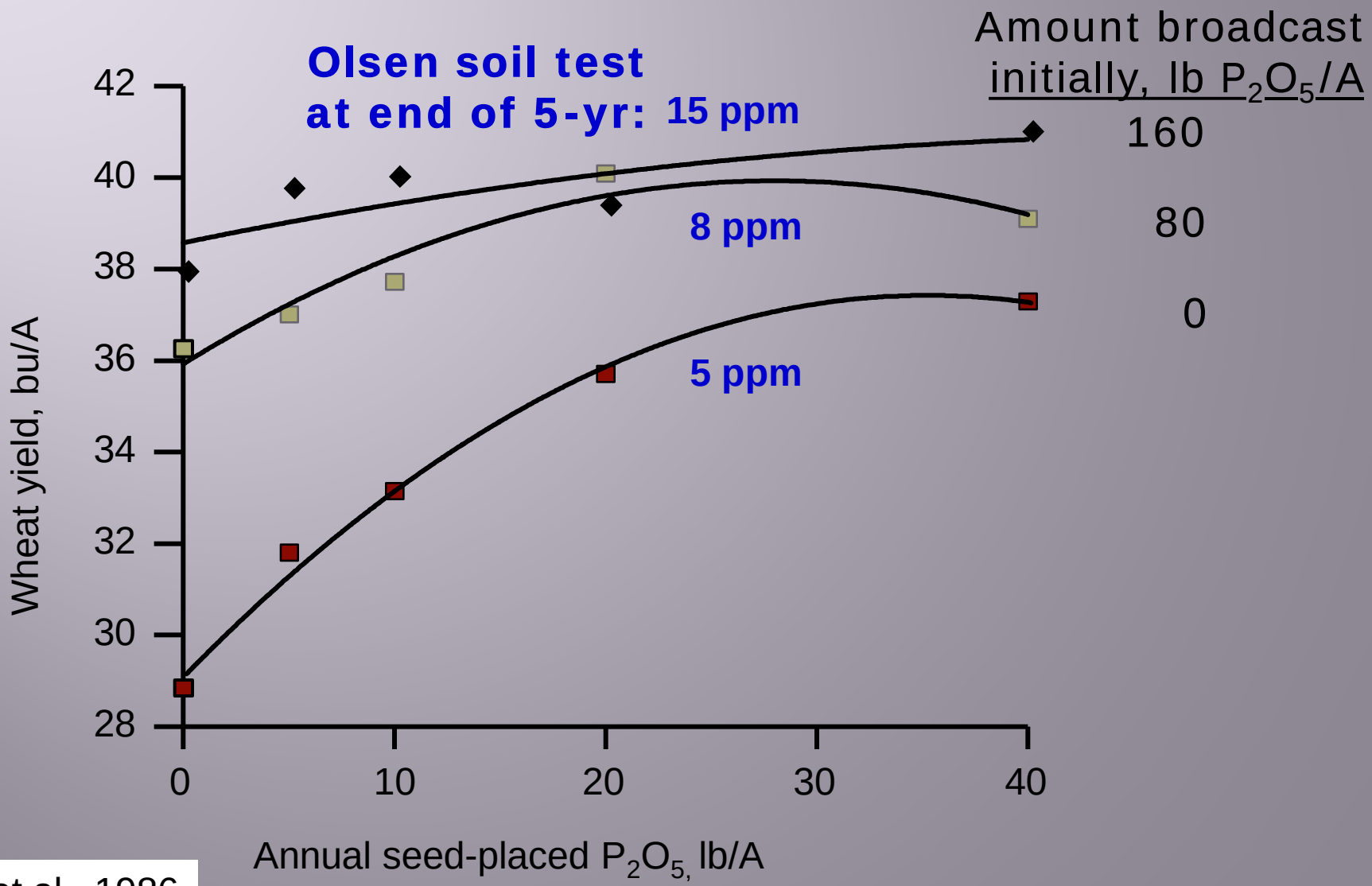
Depth (inches)	Texture	pH 1S:2W	E.C. 1S:2W (mS/cm)	E.C. Calc.Sat.Extr. (mS/cm)	Salinity Rating	Organic Matter %	NH_4-N (lb/ac)	Calculated CEC meq/100g	Ca (ppm)	Mg (ppm)	K (ppm)	Na (ppm)	Base Saturation Ca (% of CEC)	Mg (% of CEC)	K (% of CEC)	Na (% of CEC)
0-6	Loam	6.5	0.2	0.5	Non Saline	3.7										

SOIL TEST NUTRIENT LEVELS lb/acre, P2O5

Depth (inches)	NO_3-N (lb/ac)	P (lb/ac)	K (lb/ac)	SO_4-S (lb/ac)	Cu (lb/ac)	Mn (lb/ac)	Zn (lb/ac)	B (lb/ac)	Fe (lb/ac)	Cl (lb/ac)
0-6	12	12	446	33	1.3	36.5	1.2	1.4	131	7



Attaining a target soil test level is part of preparing for intensification



Wager et al., 1986

Long-Term P Solutions

- Match P additions to crop removals
- Better recycling of P from crop residues, and animal and human wastes
  - P is gathered from large areas
  - Returned to small areas
  - Improve redistribution
- Improved animal and human utilization of P in food

Plant and Ecosystem Solutions

- Genetic modification to develop varieties that need less P fertiliser
  - "No magic of genetic engineering will produce a species that doesn't need phosphate," but it can hopefully produce one that consumes less
- Crop species and varieties that are more adaptable to soils poor in phosphorous (Tierramerica 2007)
- Improved crop rotations, fungal and bacterial species, e.g. AAFC Swift Current research, Hammel et. al

(Malavolta 2007)

Questions