Phosphorus Fertilization of Corn and Soybeans in Manitoba

AGVISE Soil Fertility Seminar – March 16, 2016

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Phosphorus and Zinc Fertilization Beneficial Management Practices for Corn in Manitoba Preliminary Results

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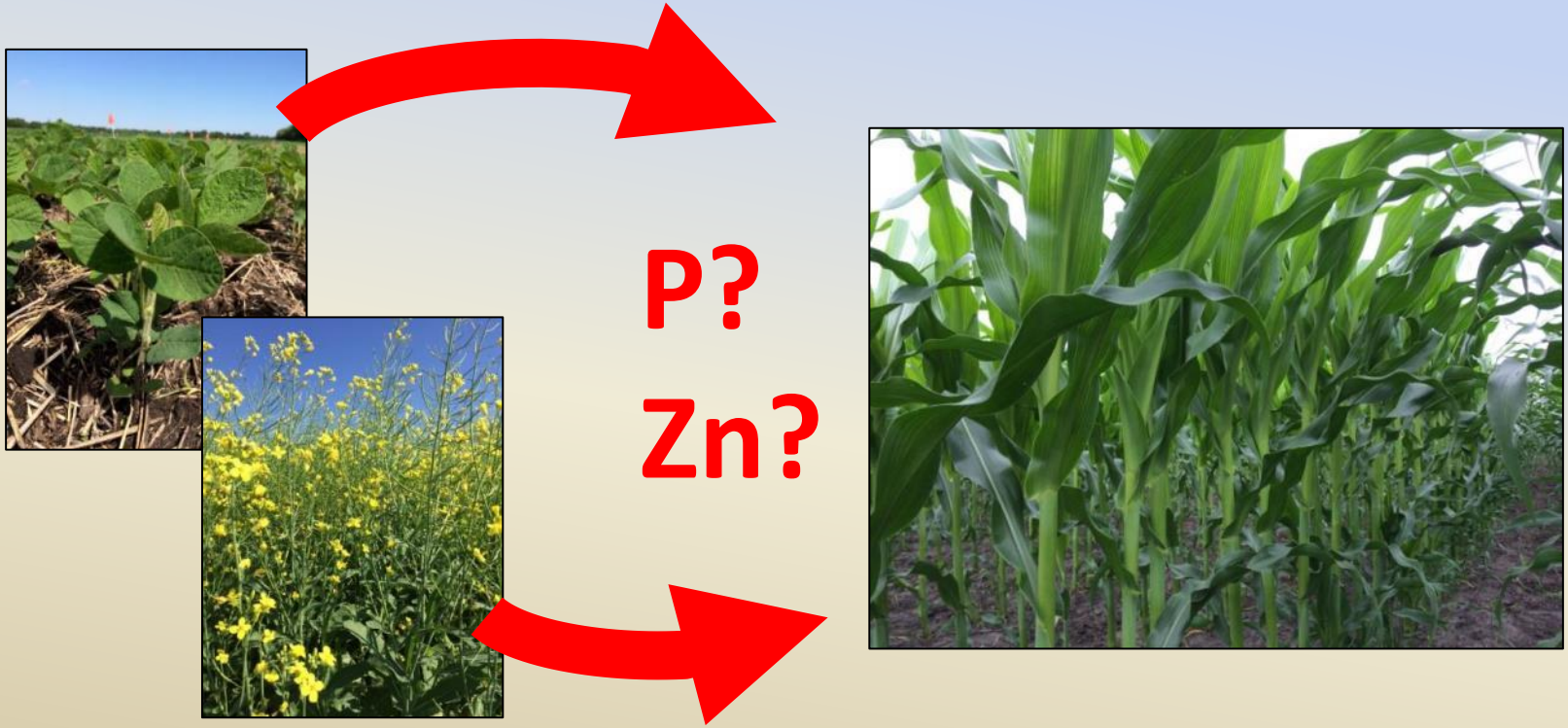
UofM & MCGA's Corn Agronomy Project

Crop Rotation Study

Fertilization strategies for corn grown after canola vs. soybeans



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Rotation Study: Background

- Corn is highly dependent on mycorrhizal fungi (AMF)
- Canola is non-mycorrhizal, so AMF population drops
- Therefore, corn on canola stubble is prone to P perhaps Zn deficiency (Ontario & BC studies)
- Starter fertilizer P and Zn may help to offset this problem

P deficiency symptoms at V3

No P Check

Corn on Canola
MAP 54 lb P_2O_5 ac^{-1}

Rotation Study: Site Information

Location	Carman, MB	Stephenfield, MB
Planting Date	May 25/2015	May 26/2015
Soil Temperature at Planting	19°C at 2” (5cm)	15°C at 2” (5cm)
Harvest Date	October 15/2015	October 14/2015
Olsen-P (ppm)	19	6
DTPA-Zn (ppm)	1.50	0.82

Corn Hybrid: DKC 26-28RIB (2150 CHU)

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2 Previous Crop Treatments

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Rotation Study: 5 Fertilizer Treatments

(lbs/ac, sidebanded 2” by 1” at planting)

CONTROL

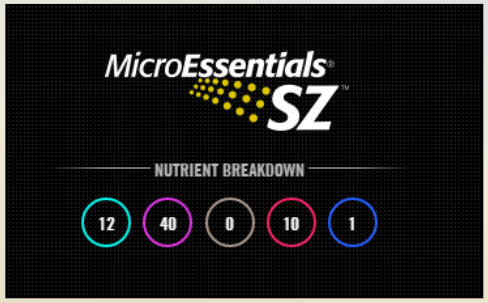
1. No P Check

MAP (11-52-0) + AS (21-0-0-24)

2. 27 P_2O_5 0 Zn 6.8 S
3. 54 P_2O_5 0 Zn 13.5 S

MicroEssentials SZ (12-40-0-10S-1Zn)

4. 27 P_2O_5 0.68 Zn 6.8 S
5. 54 P_2O_5 1.35 Zn 13.5 S



MicroEssentials (December 14, 2015) http://www.microessentials.com/#fusion-process

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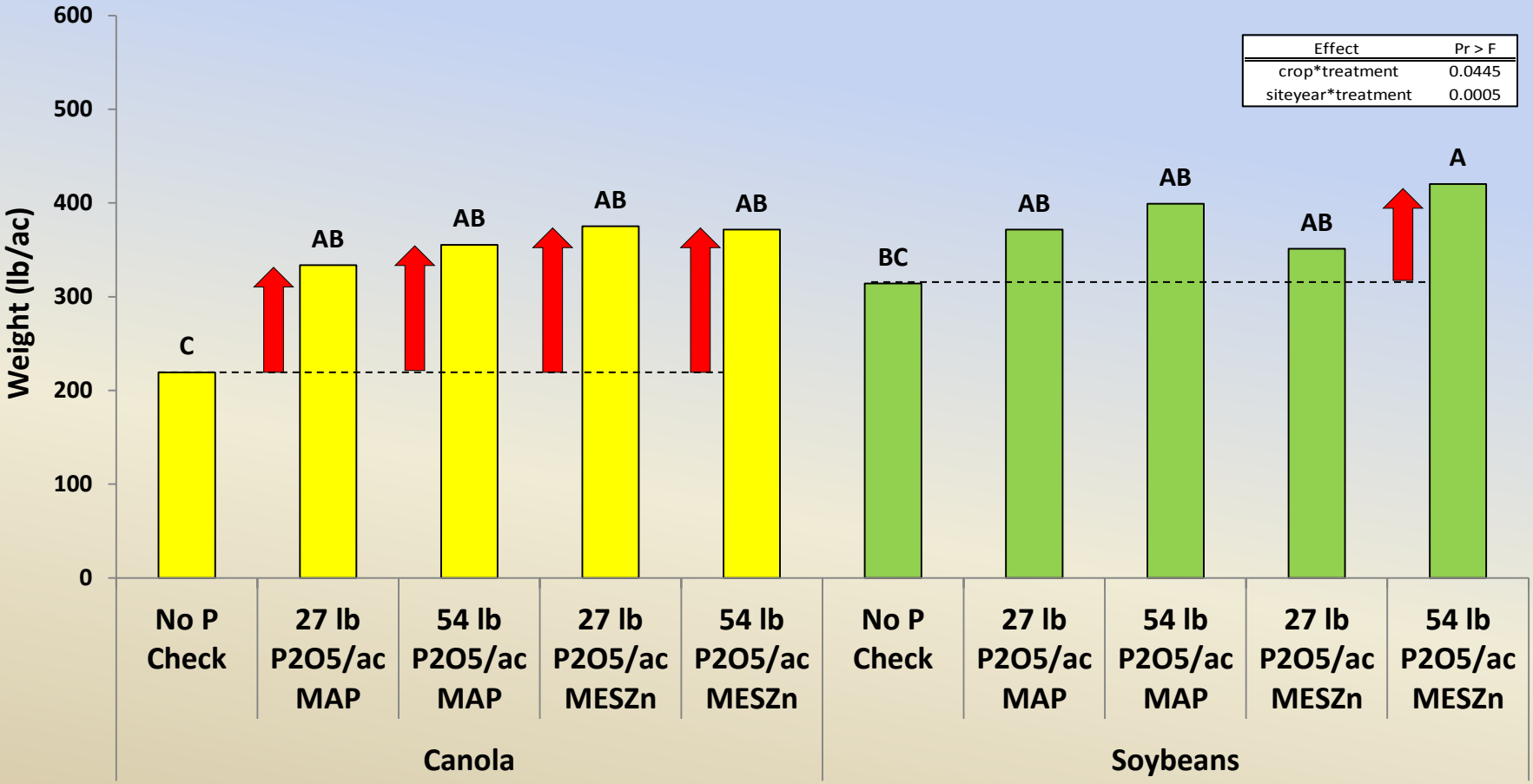
Rotation Study: Preliminary Results

Collected at V4, 10 plants from each plot (P, Zn analysis)

Corn Early Season Biomass (V4)



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Rotation Study: Preliminary Results

Maturity Ratings: Later silking date and delayed maturity (>1 day) in control plots compared to P treatment plots (data not shown).

CORN ON CANOLA

No P check

Sideband
54 lb P_2O_5/ac
MAP

CORN ON SOYBEANS

Sideband
54 lb P_2O_5/ac
MESZn

No P check

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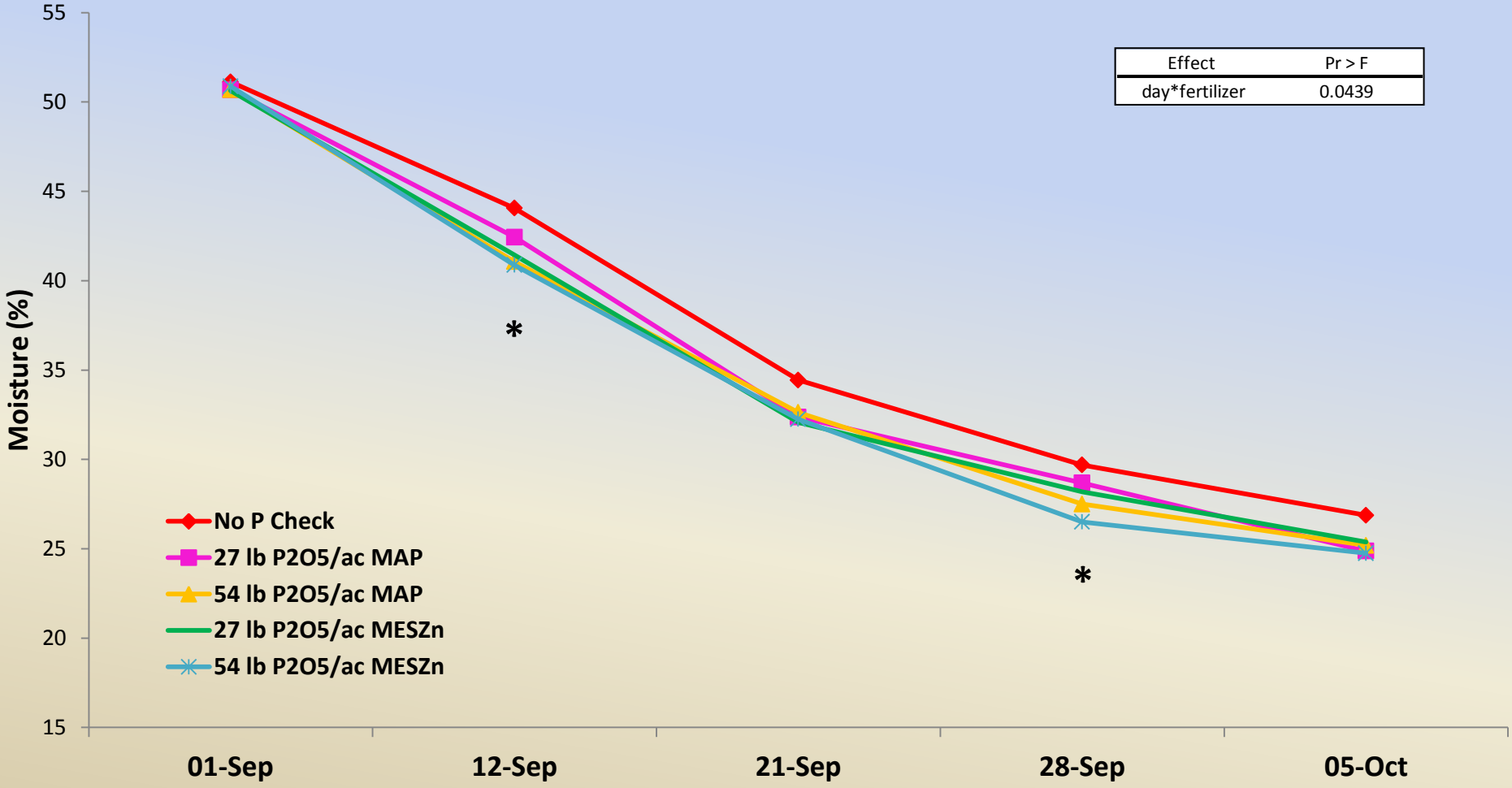
Rotation Study: Preliminary Results

Repeated moisture readings, Milk (R3) until harvest



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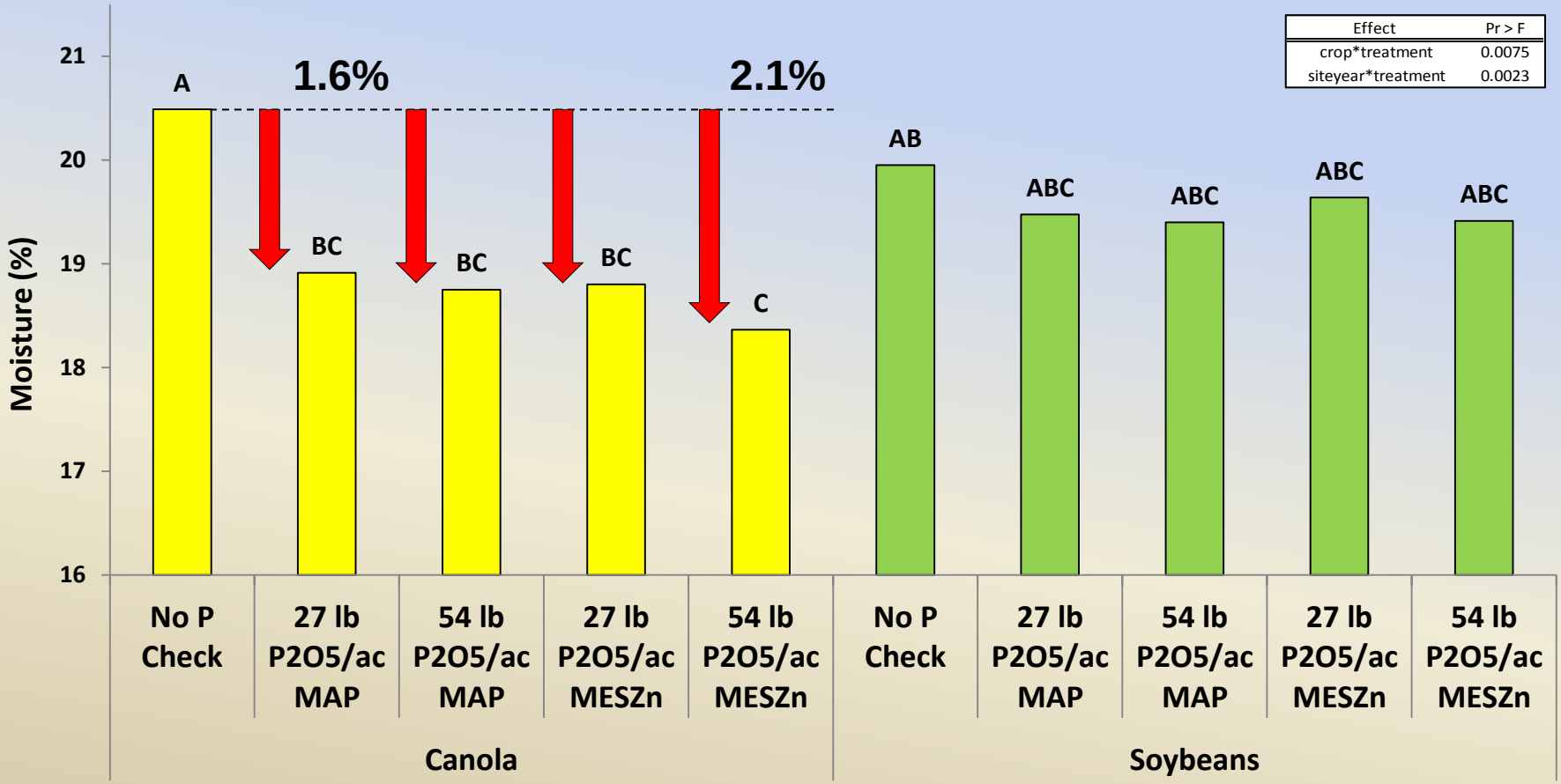
Rotation Study: Preliminary Results

Recorded at harvest

Corn Grain Moisture (Harvest)



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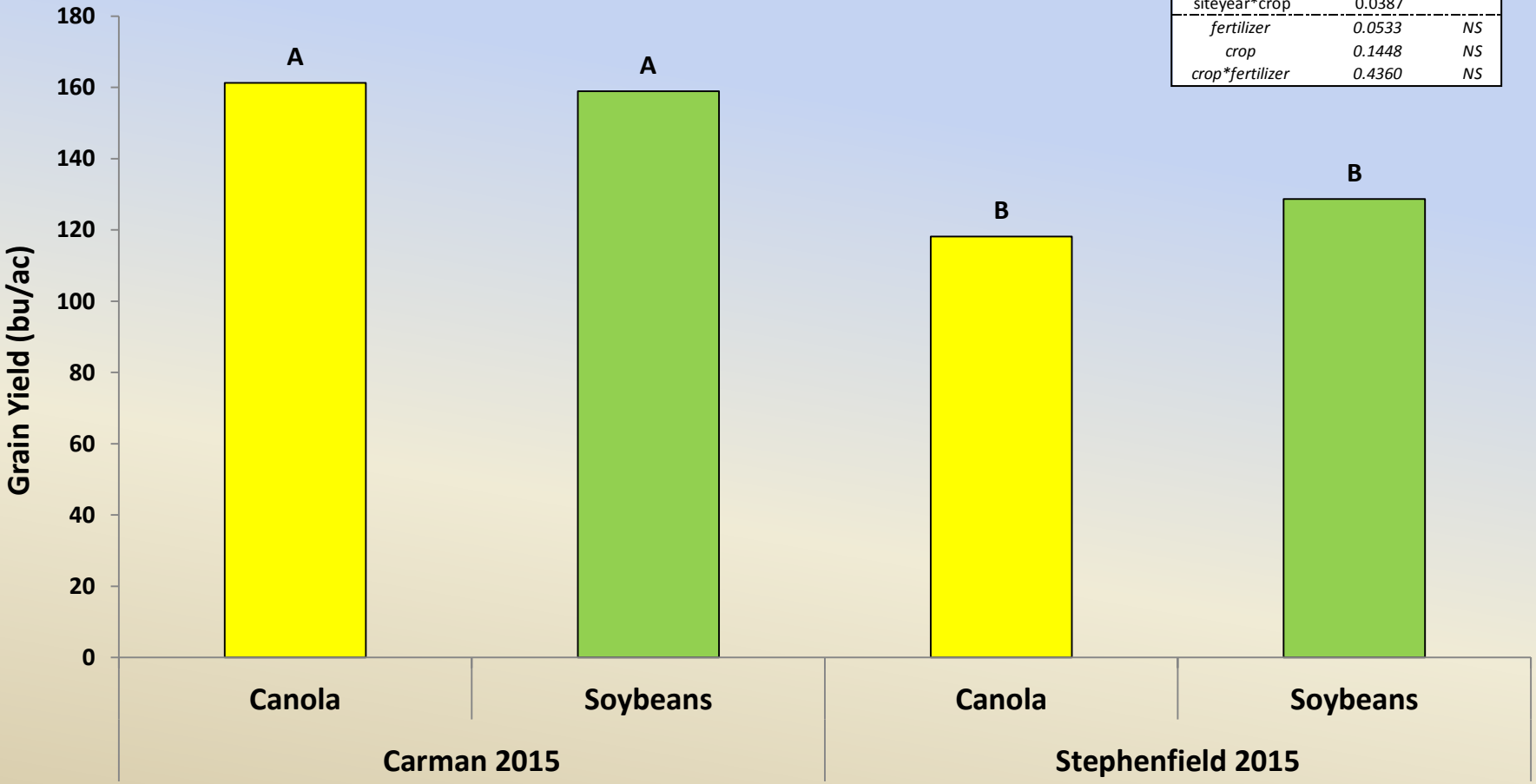
Rotation Study: Preliminary Results

Recorded at harvest, adjusted to 15.5%

Corn Grain Yield

Effect	Pr > F	
siteyear*crop	0.0387	
fertilizer	*0.0533*	*NS*
crop	*0.1448*	*NS*
*crop*fertilizer*	*0.4360*	*NS*



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Rotation Study: Summary

- **All fertilizer P treatments significantly increased early season biomass in corn following canola and advanced maturity, regardless of the crop.**
- **Grain yields not affected this year**
  - **Preceding crop and/or P fertilization**
- **1.6 – 2.1% decrease in grain moisture at harvest with addition of starter MAP and MESZn in corn on canola**

http://cliparts.co/cliparts/dc9/Xon/dc9XonoKi.jpg

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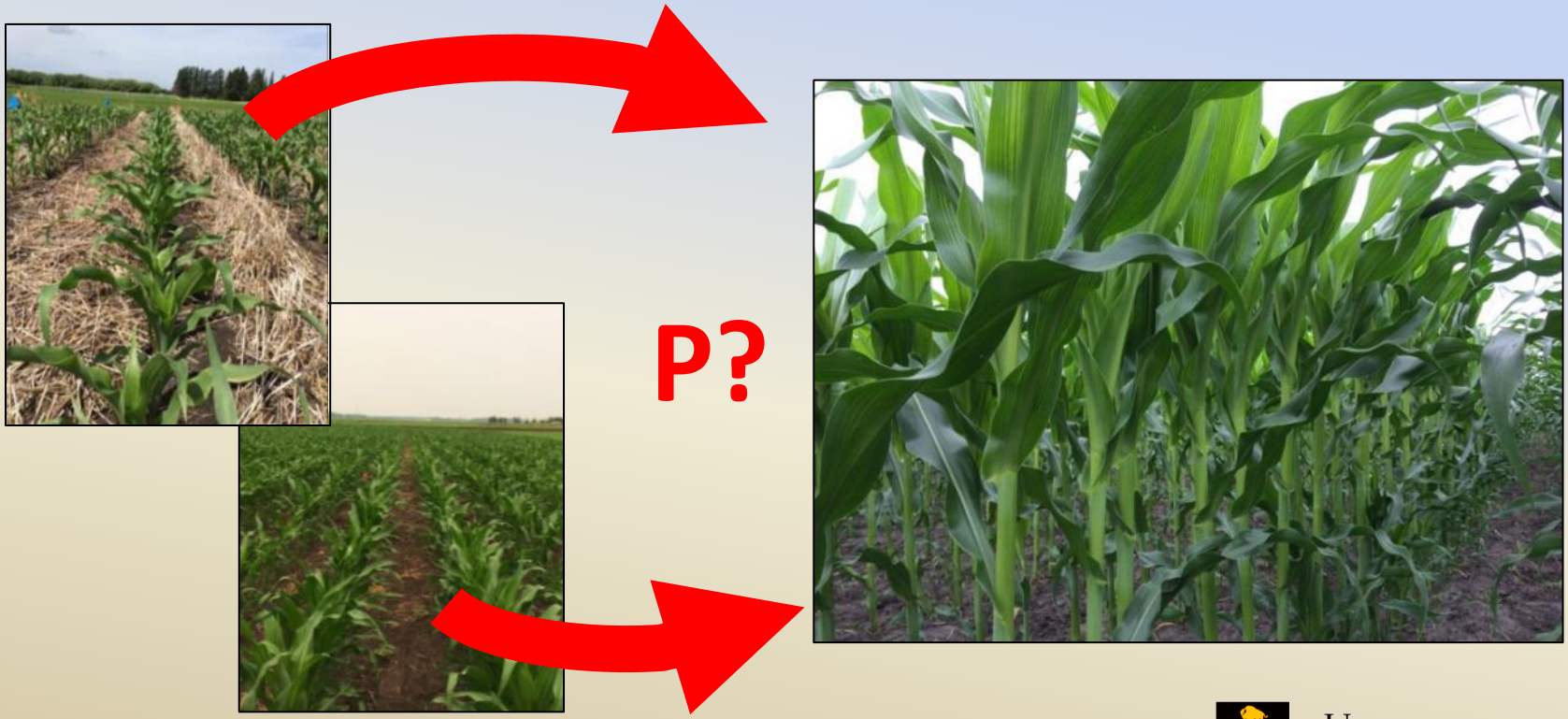
Tillage Study

Fertilization strategies for corn planted in strip tillage vs. conventional tillage



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Tillage Study: Background

Strip till:

- reduces risk of erosion
- provides opportunity to preplant band P
- may provide a warmer or cooler seed bed zone vs. conventional tillage
- cool soil may aggravate P deficiencies

Application of starter P may:

- accelerate early-season crop development
- decrease grain moisture
- increase grain yield

P deficiency symptoms at V3 in striptill

Spring sideband
MAP 54 lb P_2O_5 ac^{-1}

No P Check

Tillage Study: Site Information

Location	Carman, MB	Portage la Praire, MB
Planting Date	May 25/2015	May 26/2015
Soil Temperature at Planting	19°C at 2” (5cm)	14°C at 2” (5cm)
Harvest Date	October 16/2015	October 19/2015
Olsen-P (ppm)	8	11
Crop Residue	Wheat	Barley

Corn Hybrid: DKC 26-28RIB (2150 CHU)

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2 Previous Tillage Treatments

Tillage Study: 5 Fertilizer Treatments

(lbs/ac, spring (2” by 1”) and fall application (4-5”))

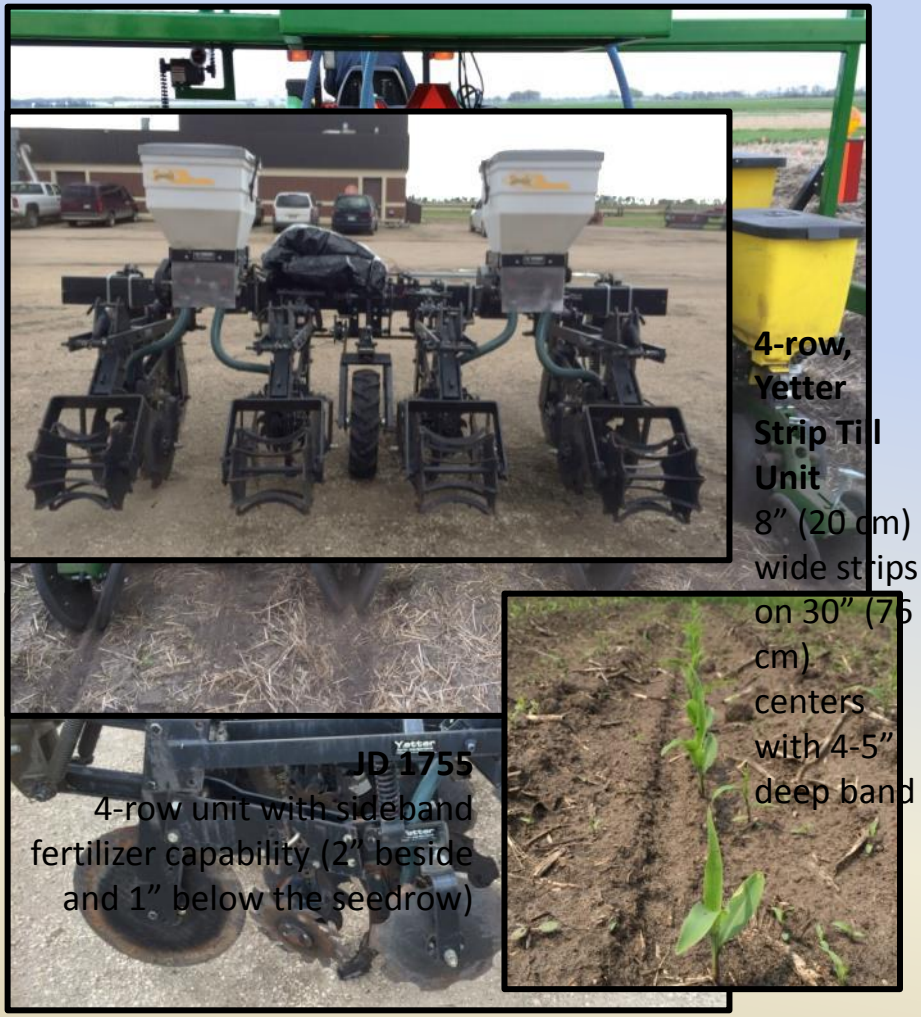
CONTROL

1. No P Check

MAP (11-52-0) *Only*

2. 27 P_2O_5 SPRING SB
3. 54 P_2O_5 SPRING SB

4. 27 P_2O_5 FALL DB
5. 54 P_2O_5 FALL DB



4-row, Yetter Strip Till Unit
8” (20 cm) wide strips on 30” (76 cm) centers with 4-5” deep band

JD 1755
4-row unit with sideband fertilizer capability (2” beside and 1” below the seedrow)

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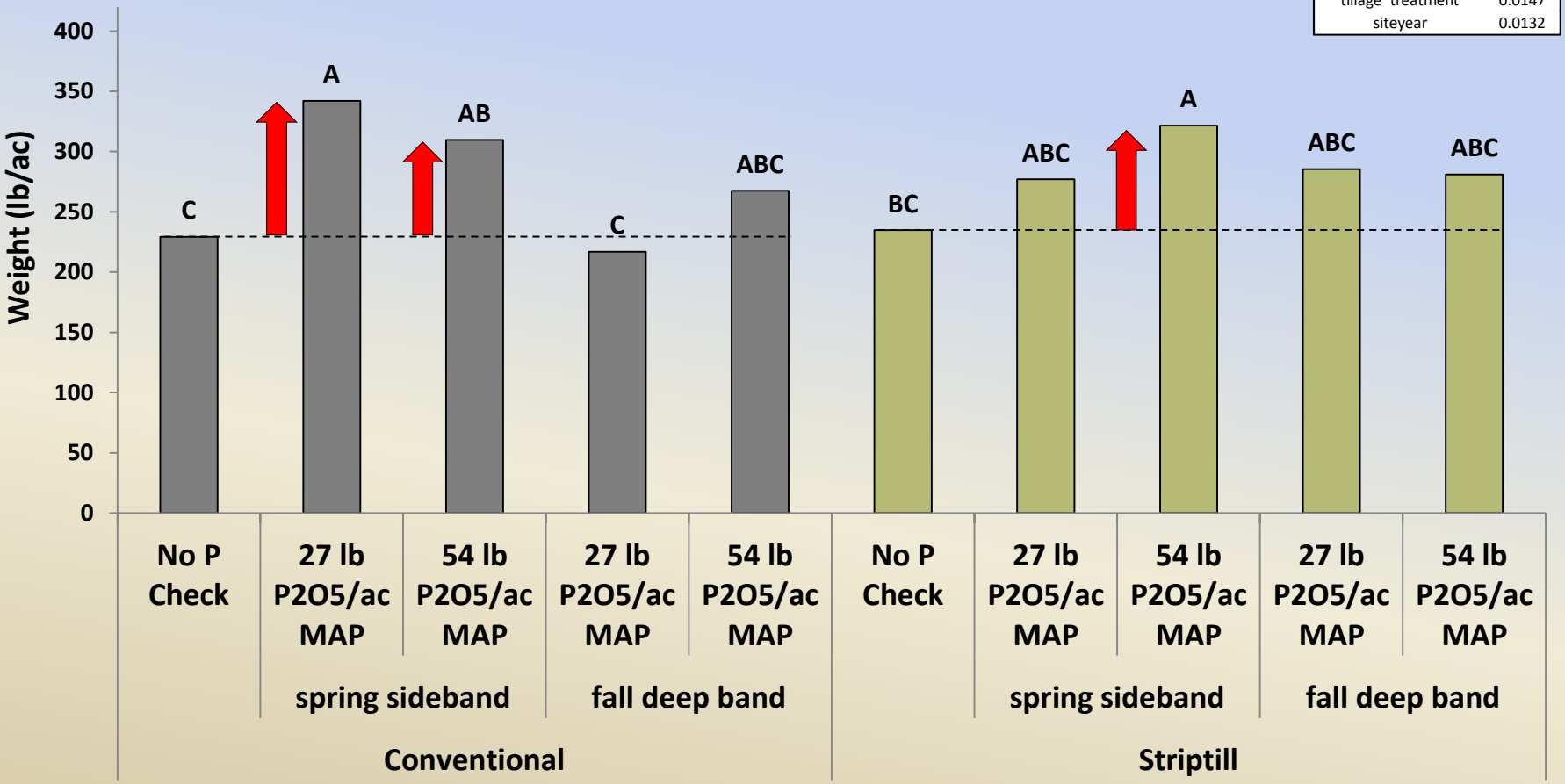
Tillage Study: Preliminary Results

Collected at V4, 10 plants from each plot (P, Zn analysis)

Corn Early Season Biomass (V4)

Effect	Pr > F
tillage*treatment	0.0147
siteyear	0.0132



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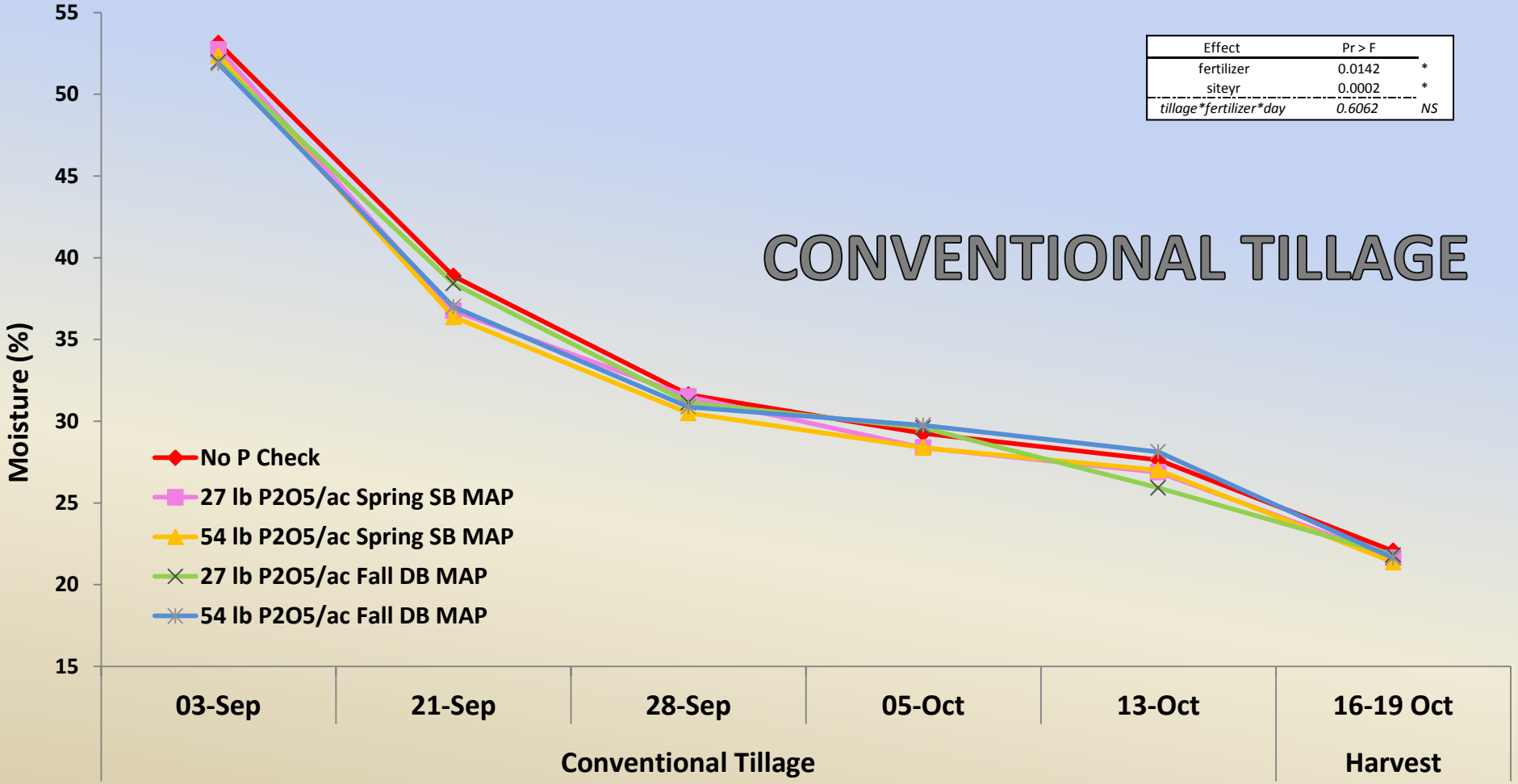
Tillage Study: Preliminary Results

Maturity Ratings: Later silking date and delayed maturity (>1 day) in control plots compared to 3 of 4 P treatment plots (data not shown).

Tillage Study: Preliminary Results

Repeated moisture readings, Milk (R3) until harvest



Effect	Pr > F	
fertilizer	0.0142	*
siteyr	0.0002	*
*tillage*fertilizer*day*	*0.6062*	*NS*

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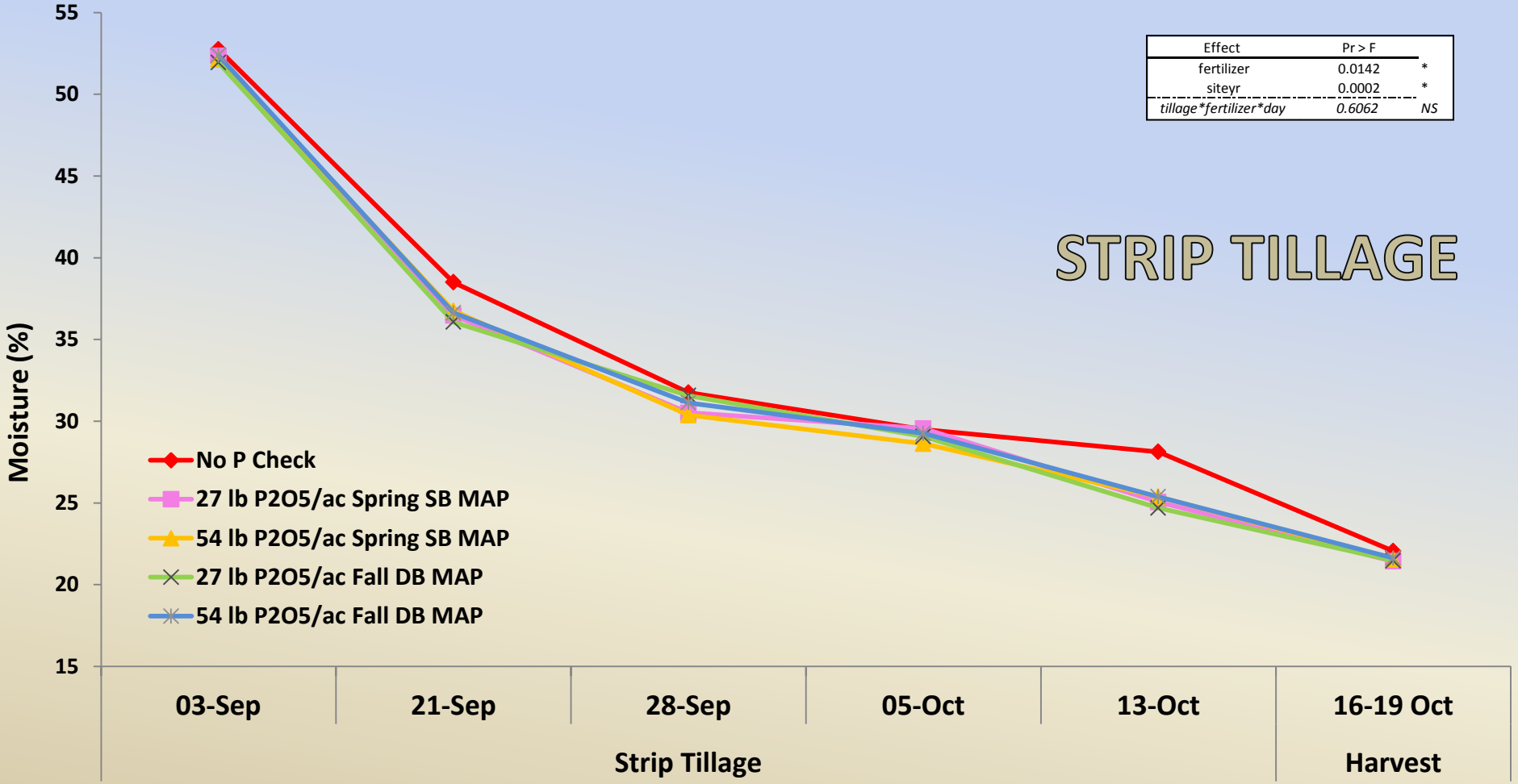
Tillage Study: Preliminary Results

Repeated moisture readings, Milk (R3) until harvest



Effect	Pr > F	
fertilizer	0.0142	*
siteyr	0.0002	*
*tillage*fertilizer*day*	*0.6062*	*NS*

STRIP TILLAGE

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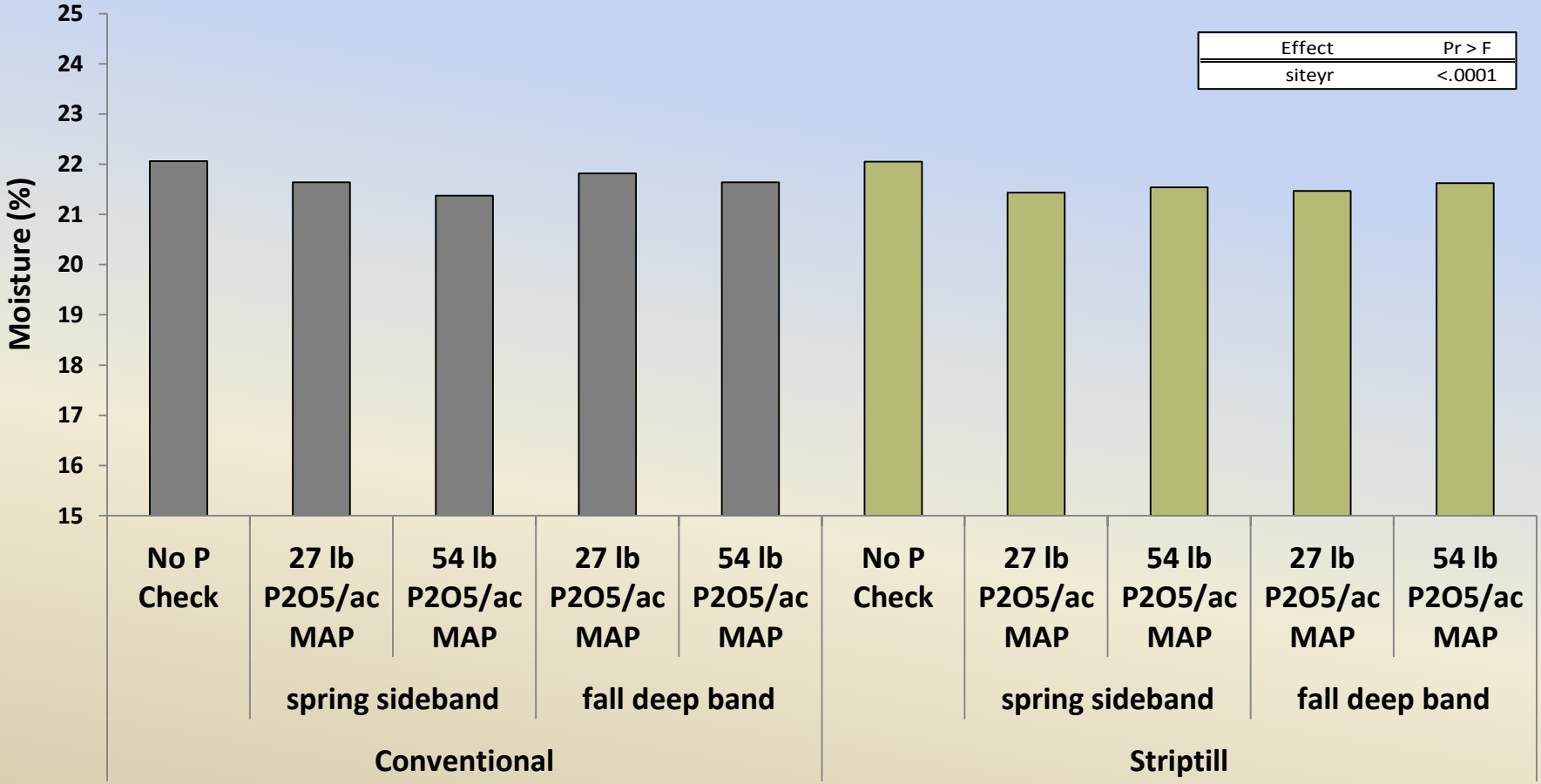
Tillage Study: Preliminary Results

Recorded at harvest

Corn Grain Moisture (Harvest)



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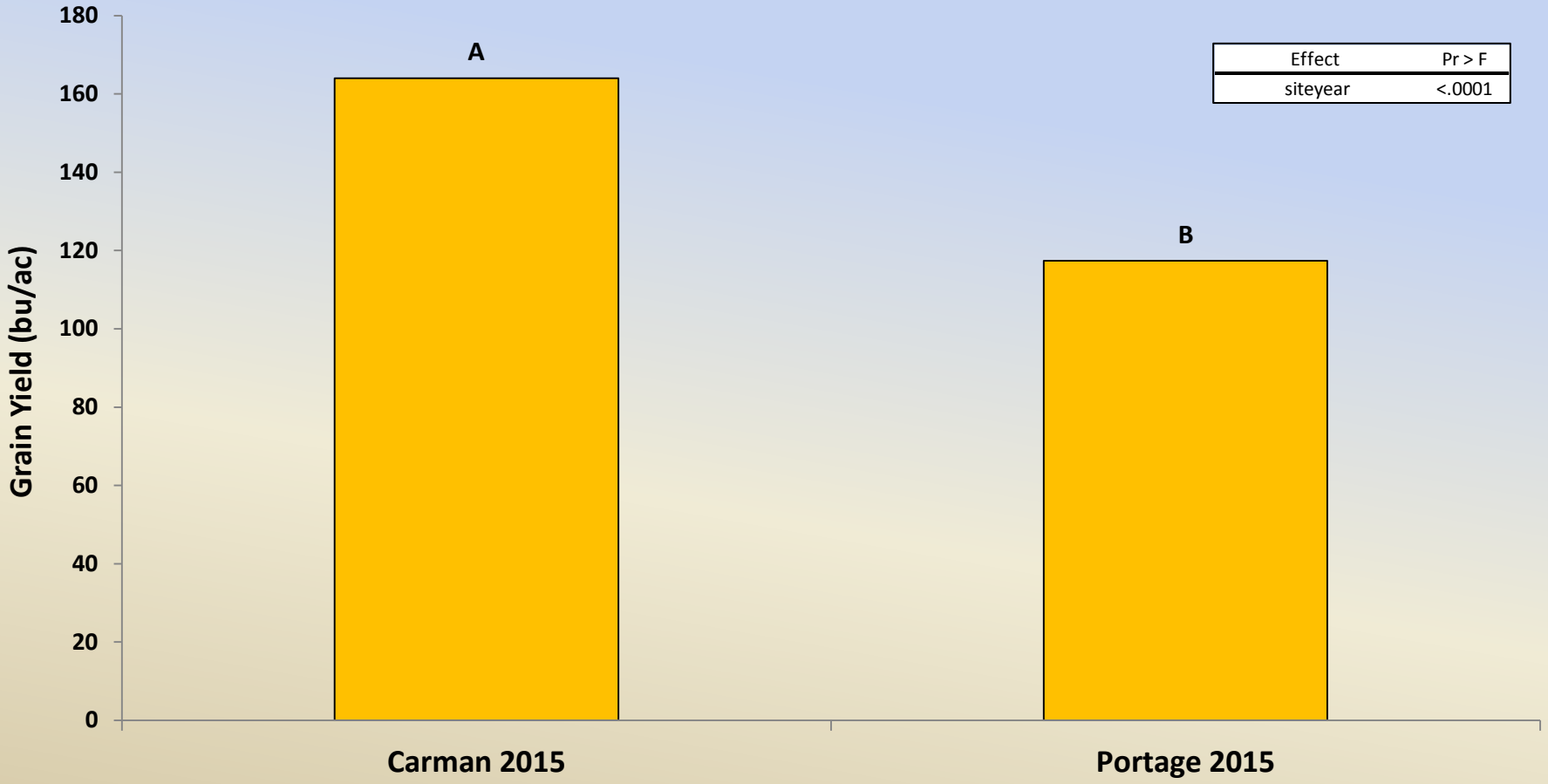
Tillage Study: Preliminary Results

Recorded at harvest, adjusted to 15.5%

Corn Grain Yield



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Tillage Study: Summary

- **Fertilizer P increased early and midseason growth and advanced maturity, especially if sidebanded in spring on conventionally tilled land**
- **Grain yields and grain moisture not affected this year by tillage and/or P fertilization**

Good News…

Corn planted in strip till yielded as well as corn planted in conventional till and had similar grain moisture

https://cdn.vectorstock.com/i/composite/43,88/cartoon-happy-corn-giving-thumb-up-vector-5824388.jpg

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Amended Crop Rotation Study

Mosaic Microessentials SZ fertilization for corn grown after canola vs. soybeans

P? Zn?

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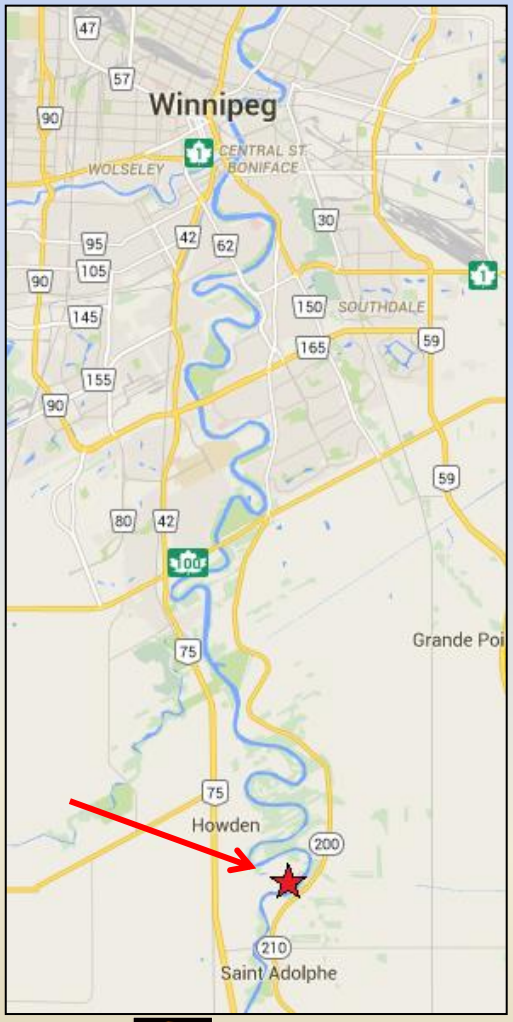
MESZn Study: Site Information

Location	Kelburn Farm
Planting Date	June 1, 2015
Soil Temperature at Planting	13°C at 2” (5cm)
Harvest Date	October 26/2015
Olsen-P (ppm)	41 (avg.)
DTPA-Zn (ppm)	2.3 (avg.)
Olsen-P (ppm)	24 – 63 (range)
DTPA-Zn (ppm)	1.7 – 3.9 (range)



Corn Hybrid: DKC 26-28RIB (2150 CHU)

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2 Previous Crop Treatments

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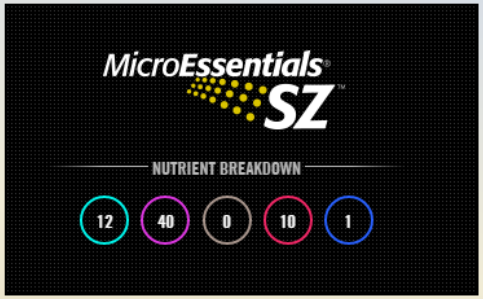
MESZn Study: 3 Fertilizer Treatments
(lbs/ac, sidebanded 2” by 2” at planting)

CONTROL

1. No P Check

MicroEssentials SZ (12-40-0-10S-1Zn)

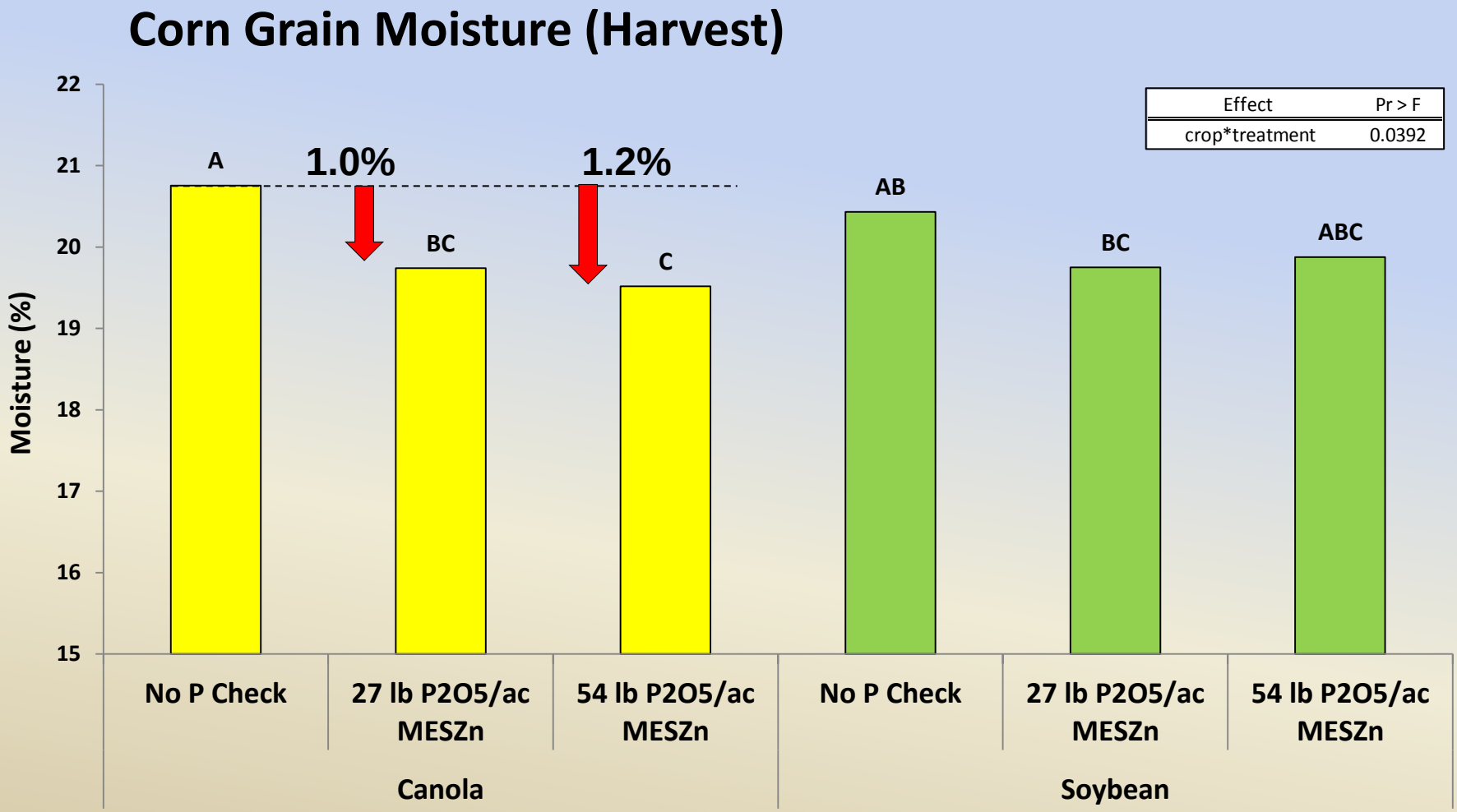
2. 27 P_2O_5 0.68 Zn 6.8 S
3. 54 P_2O_5 1.35 Zn 13.5 S



MicroEssentials (December 14, 2015) http://www.microessentials.com/#fusion-process

MESZn Study: Preliminary Results

Recorded at harvest



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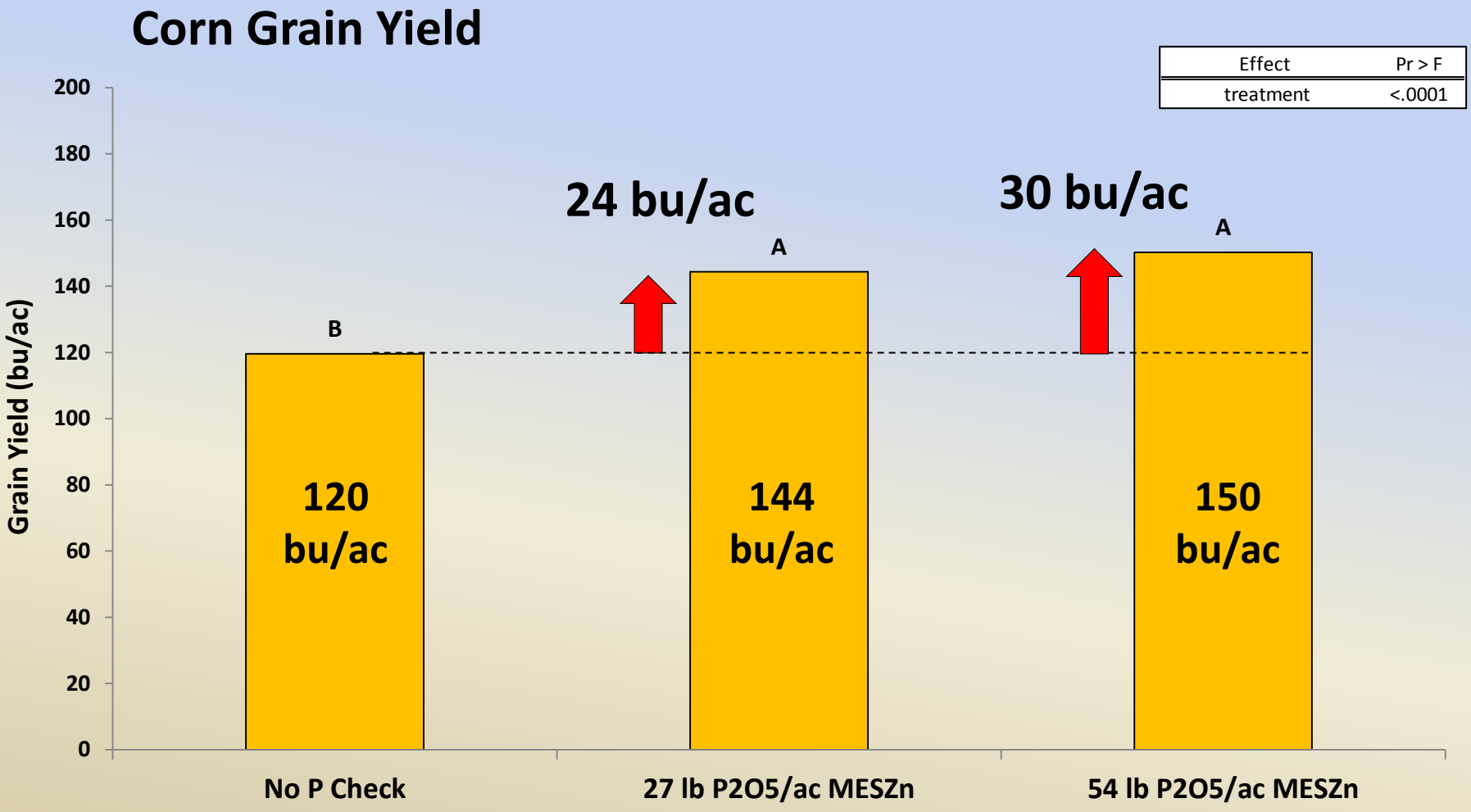
MESZn Study: Preliminary Results

Recorded at harvest, adjusted to 15.5%



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MESZn Study: Summary

In spite of the high concentrations of Olsen P at this site, the corn grain yields for the MESZn treatments were 24 – 30 bu/ac greater than those in the control, regardless of previous crop.

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Plans for the 2016 season of corn fertilization studies:

- **Crop Rotation Study**: 2 sites with corn test crop
  - Carman, MB and Portage la Prairie, MB
- **Tillage Study**: 2 sites with corn test crop
  - Carman, MB and Portage la Prairie, MB
- **Mosaic MESZn Study**: 1 site with corn test crop
  - Kelburn Farm (near St. Adolphe, MB)

Acknowledgments

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Richardson Pioneer (B.Hellegards)
Western Economic Diversification Canada

Thank you!

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Phosphorus Management for Soybeans – Final Results

Gustavo Bardella, Don Flaten, and John Heard

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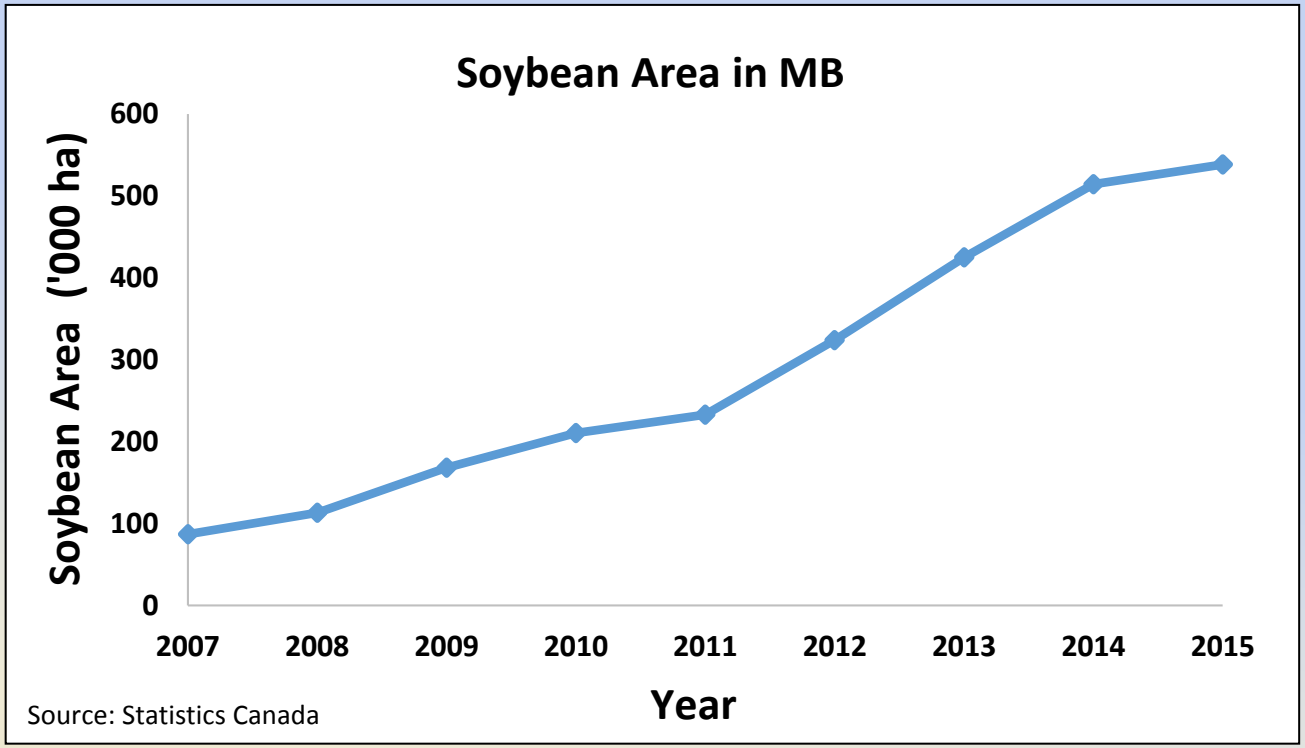
Background



- Soybeans remove large amounts of P (≥ 0.85 lb P_2O_5/bu)
- Wide row spacings and narrow seed/fertilizer spread increase risk of fertilizer toxicity in seed row (current guidelines recommend a maximum of 10 lb P_2O_5/ac)
- Questions remain about P fertility, P fertilization and P placement in soybeans

Two Soybean Fertilization Studies 2013-2015

Study #1 – Short term effects of P fertilizer rate & placement

- **Assess risk of reduced stand and yield from seed–placed P**
- **Assess dry matter and seed yield response to P fertilizer placements and rates**

Study #2 – Long term effects of soil P fertility

- **Assess soybean response to starter P fertilizer and soil P fertility from historic fertilization practices**

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Manitoba Soybean P Project #1: Effects of P Fertilizer Rate & Placement on Plant Stand and Seed Yield

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Materials and Methods

- 8 sites in 2013
- 10 sites in 2014
- 10 sites in 2015
- 28 site years in total

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Materials and Methods, cont'd.

- Row spacing varied from 7 to 12"
- Opener type: knife or disc … low seed bed utilization

Site	Olsen P (ppm)			Soil Texture	Row Spacing	Seeder Opener
---	2013	2014	2015	----	Inches	Type
Roseisle	N/A	4 (VL)	4 (VL)	Sandy Loam	8	Knife
Melita	3 (VL)	5 (L)	7 (L)	Sandy Clay Loam	9.5	Knife
Brandon	5 (L)	6 (L)	5 (L)	Clay Loam	8	Knife
Carman	N/A	15 (H)	7 (L)	Sandy Clay Loam	8	Knife
Roblin	7 (L)	22 (VH)	8 (L)	Clay Loam	9	Knife
Beausejour	8 (L)	13 (M)	7 (L)	Heavy Clay	9	Disc
Arborg	14 (M)	22 (VH)	14 (M)	Silty Clay	9	Disc
St Adolphe	23 (VH)	25 (VH)	71 (VH)	Heavy Clay	7.3	Knife
Portage	34 (VH)	18 (H)	10 (L)	Clay Loam	12	Disc
Carberry	44 (VH)	11 (M)	15 (H)	Clay Loam	12	Disc

Materials and Methods, cont'd.

- Monoammonium phosphate (MAP, 11-52-0) was applied in spring, at the rates of 20, 40 and 80 lb P_2O_5/ac … in the seed row, side banded or broadcast
- Dekalb 24-10 RY seeded for a target of 210,000 plants/ac
- Treatments replicated 3 or 4 times
- Plant stand assessed with 2, 3 and 4 weeks after planting
- Midseason biomass collected at R3
- Seed yield and quality
- Data analysed using SAS Proc Glimmix

Results

Effect of P rate and placement on soybean stand four weeks after planting

	Year		
	2013	2014	2015
# Sites	8	10	10
Plant Stand for Control ('000 plants/ac)	84 - 263	116 - 258	70 - 301
# Sites with Plant Stand Reduction			
@ 20 lb SP	0	1[a]	0
@ 40 lb SP	0	2[a,b]	1[c]
@ 80 lb SP	2[d]	2[a,b]	1[d]
% Stand Reduction*	39 - 71	36 - 51	23 - 41

[a] At Portage in 2014, seed row P reduced emergence for all rates of P, compared to the control, at 5% level of probability.
[b] At Carberry in 2014, seed row P reduced seedling emergence at 40 and 80 lb P_2O_5 per acre.
[c] At Roseisle in 2015, seed row P reduced seedling emergence at a rate of 40 lb P_2O_5 per acre, but not at 80 lb per acre. Therefore, this reduced emergence may have been random error.
[d] At Melita & Carberry in 2013, & Roblin in 2015 seedling emergence was reduced only by seed row P at 80 lb P_2O_5 per acre.

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Why was seedling damage from seedrow P so rare?

- Soybeans are less sensitive to seedrow P applied as MAP (11-52-0) than previously thought
- However, seedling damage from seedrow P was still a risk ... especially in medium to coarse textured soils and/or when wide row spacing and low seed bed utilization increased fertilizer concentration in the seed row
- Weather conditions should also be considered, especially rainfall and soil moisture

Effect of P rate and placement on midseason dry matter biomass (DM at R3)

	Year		
	2013	2014	2015
# Sites Sampled	6	7	8
Biomass Yield for Control ('000 lb/ac)	4.41 - 6.37	2.11 - 3.77	2.10 - 4.33
# Sites with DM Increase	0	0	0
# Sites with DM Decrease	2*	0	0
% DM Decrease*	39 - 59	0	0

* Sites were affected by the 80 lb P_2O_5/ac seed-placed and/or 40 lb P_2O_5/ac broadcast treatments with significant reductions, compared to the control, at 5% level of probability.

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Effect of P rate and placement on soybean seed yield for 28 site years in Manitoba

	Year		
	2013	2014	2015
# Sites	8	10	10
Mean Seed Yield (bu/ac)	46	42	51
Seed Yield for Control (bu/ac)	23 - 66	18 - 60	37 - 65
# Sites with Yield Increase	0	0	0
# Sites with Yield Decrease	2*	0	0
% Yield Decrease*	29 - 36	0	0

* Sites were affected only by the 80 SP treatment (80 lb P_2O_5/ac seed-placed) with significant reductions, compared to the control, at 5% level of probability.

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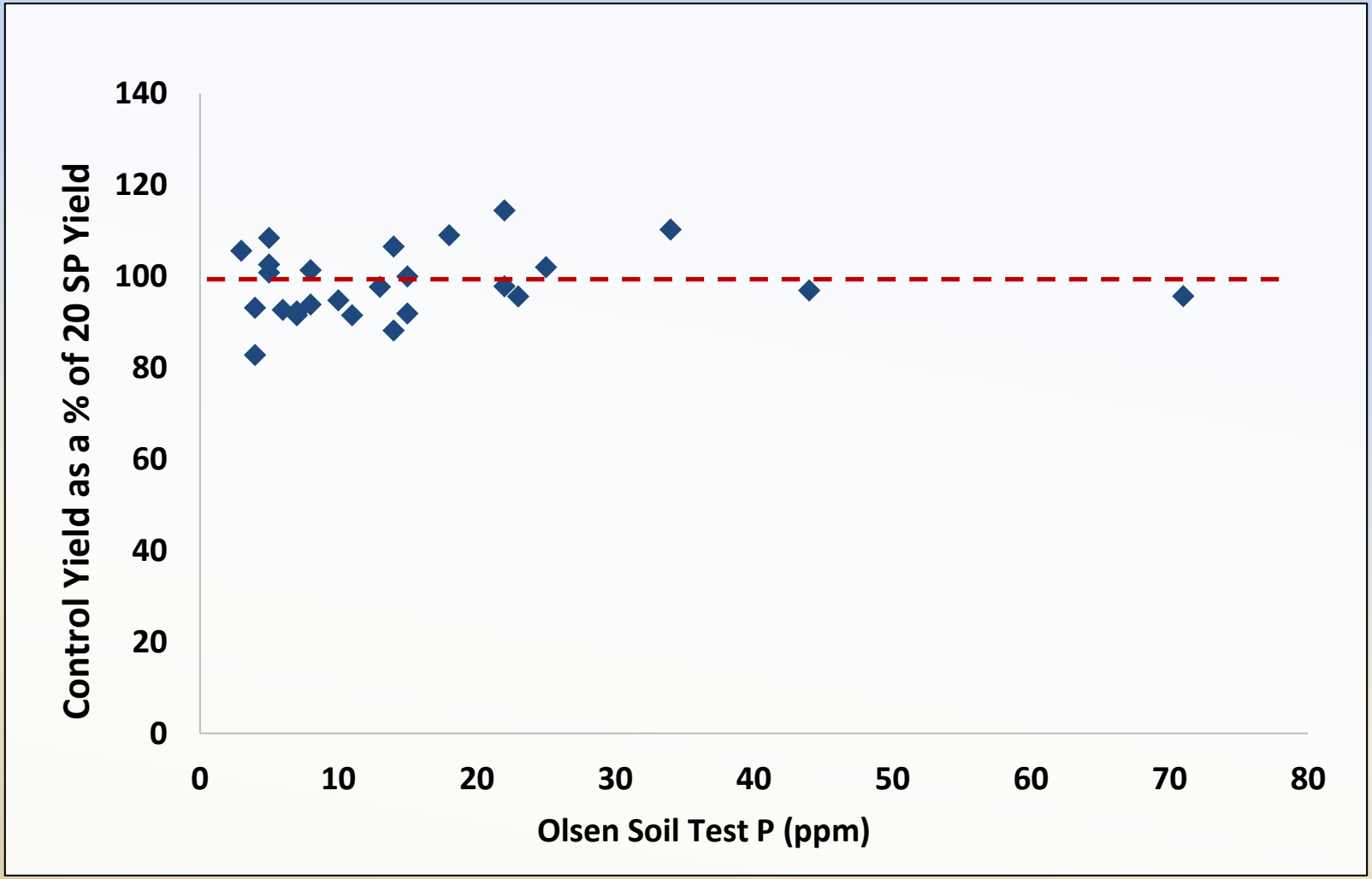
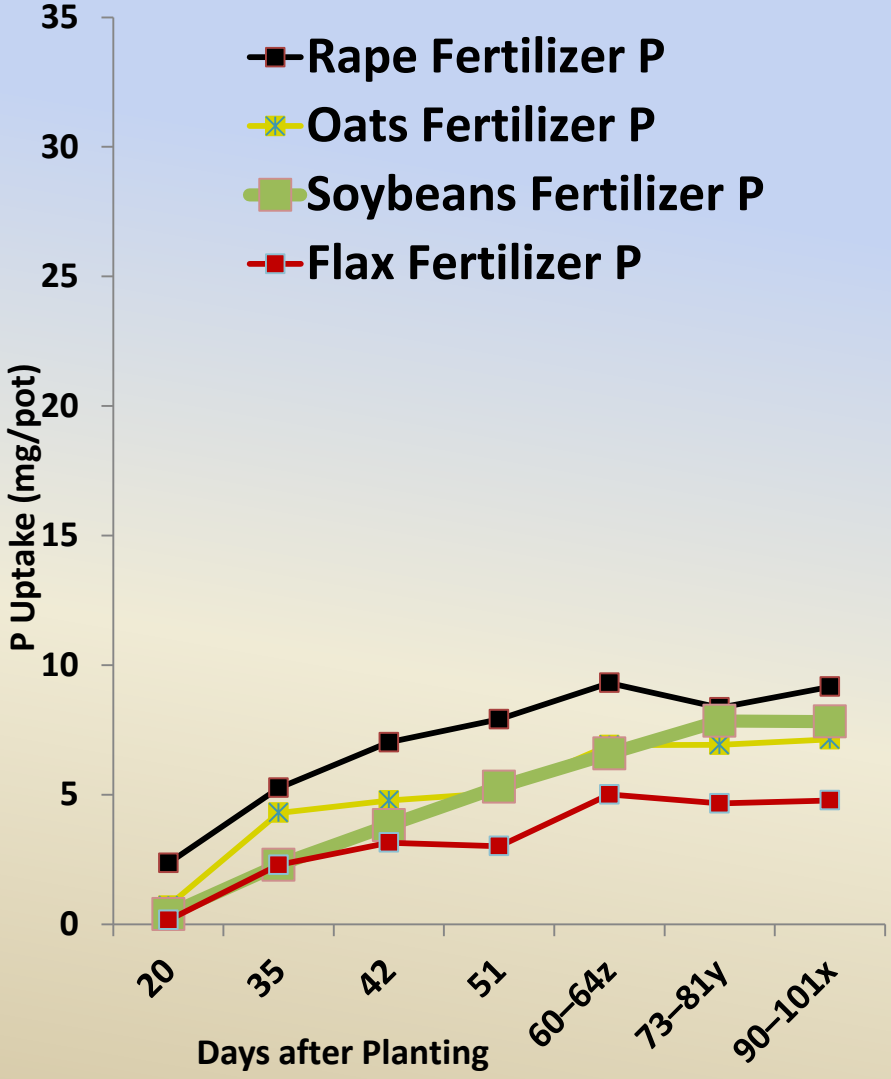
Relationship between soil P fertility and relative yield of control treatments (no P added) vs. seed placed 20 lb P_2O_5/ac in P rate and placement study

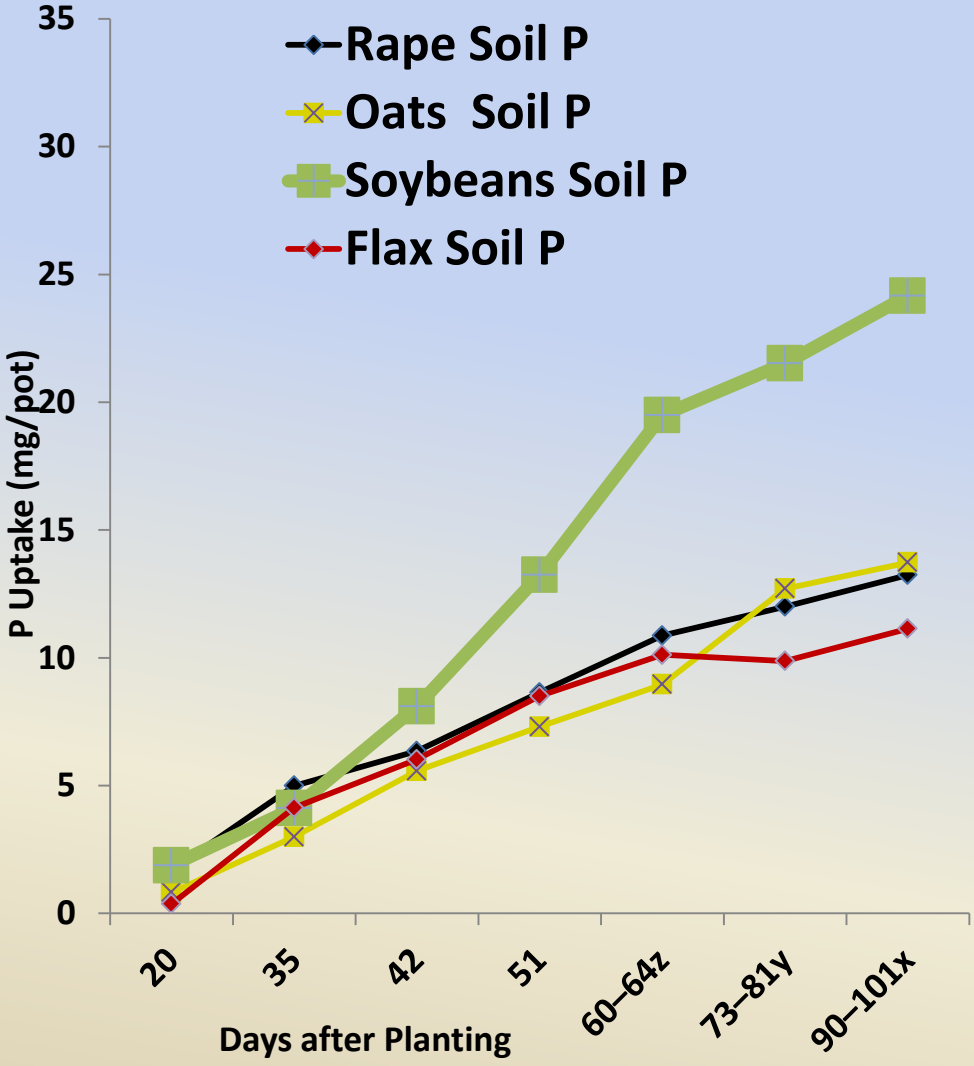


Why no yield response to P?

- P fertilization regardless of soil test P, P rate and P placement did not increase seed yield for soybean
- Even in soils with very low soil P levels such as 3 ppm Olsen P, soybeans were able to take up enough P from the soil to produce high yields without responding to any P fertilizer rate and placement

Soybeans are efficient feeders for soil P





(Kalra and Soper 1968)

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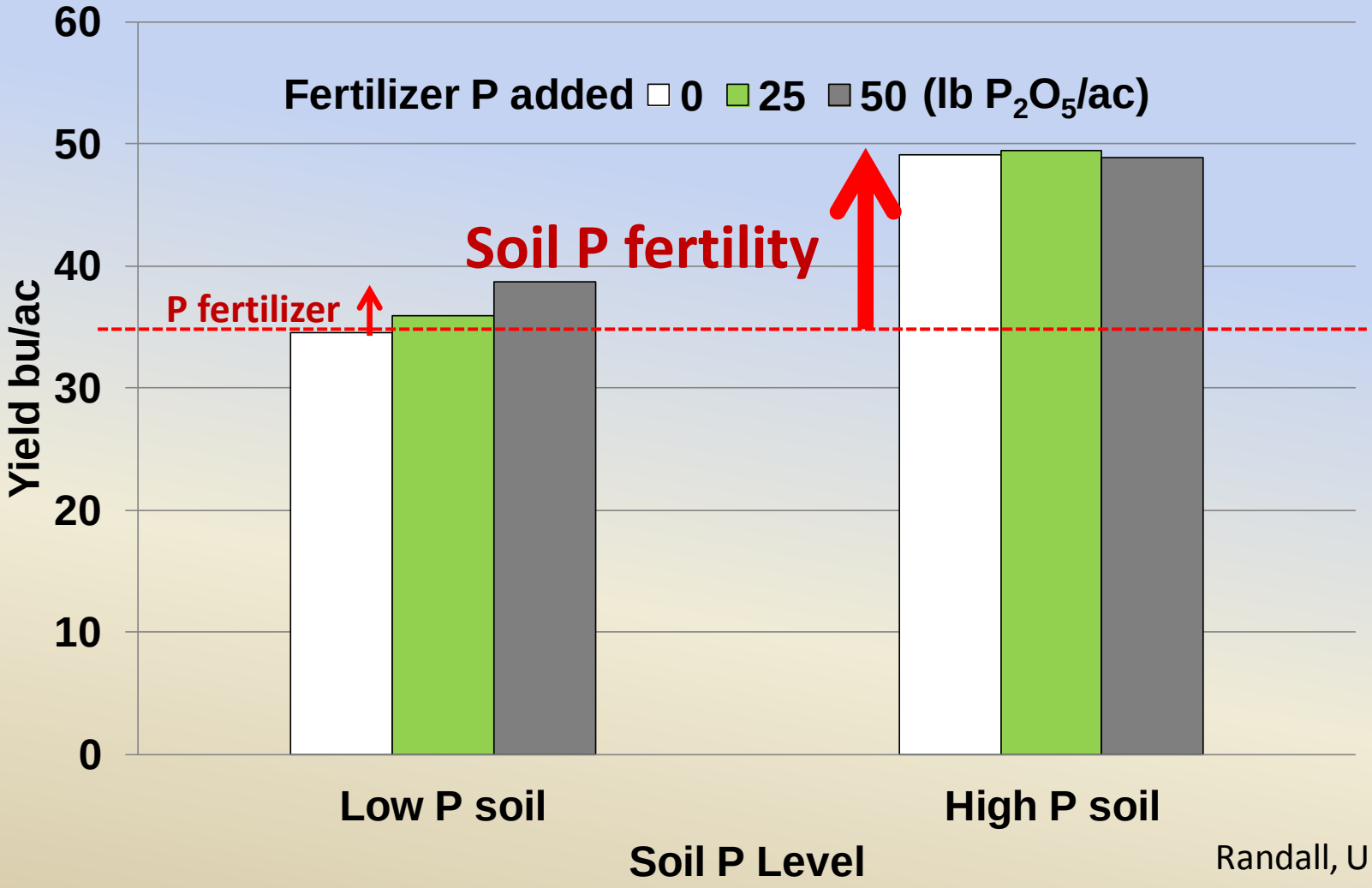
Why so little yield loss from reduced plant stands?

- Soybean plants have a compensatory growth ability that ensures biomass and seed yield stability when there is modest reduction in plant stand
- Other studies show satisfactory yield recovery when the plant stand does not get lower than 100,000 plants/acre (replant threshold)
- The probability of reduced stand from typical agronomic rates of seed-placed P fertilizer is small and the risk of reduced seed yields is even smaller ... so, seedrow placement of P for soybeans is a small risk, with little, if any reward

In Minnesota research, soybean response to soil P fertility was greater than to P fertilizer



Randall, U of Mn

Manitoba Soybean P Project #2:

Long term effects of soil P fertility ... Soybean response to starter P fertilizer and soil P fertility from historic fertilization practices

MATERIALS AND METHODS

➢ **Located on previous long term P fertilization trial**

Soil Test Olsen P (ppm)			
Historical P (lb/ac)	Brandon	Carman	Forrest
0	9	20	6
143	22	31	15
285	33	53	22
570	54	91	40

- **3 sites (Brandon, Forrest & Carman) selected from a trial established in 2002 to investigate crop Cd uptake from P fertilizer as human food safety concern**
- **3 rates of MAP fertilizers varying in Cd concentration were applied annually for 8 years, until 2009, with cumulative rates of 143, 285 and 570 lb P/ac over the 8 year period (~325, 650, and 1300 lb P_2O_5/ac total)**
- **No fertilizer P added from 2010-2012**

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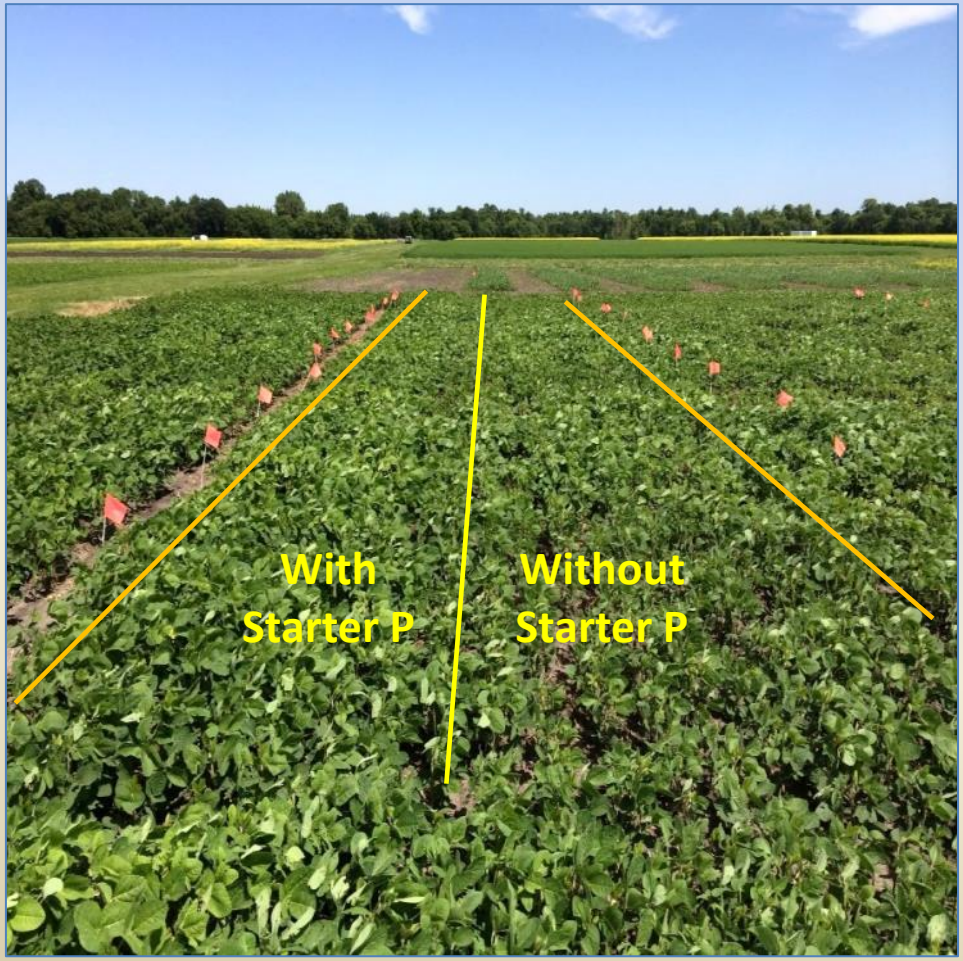
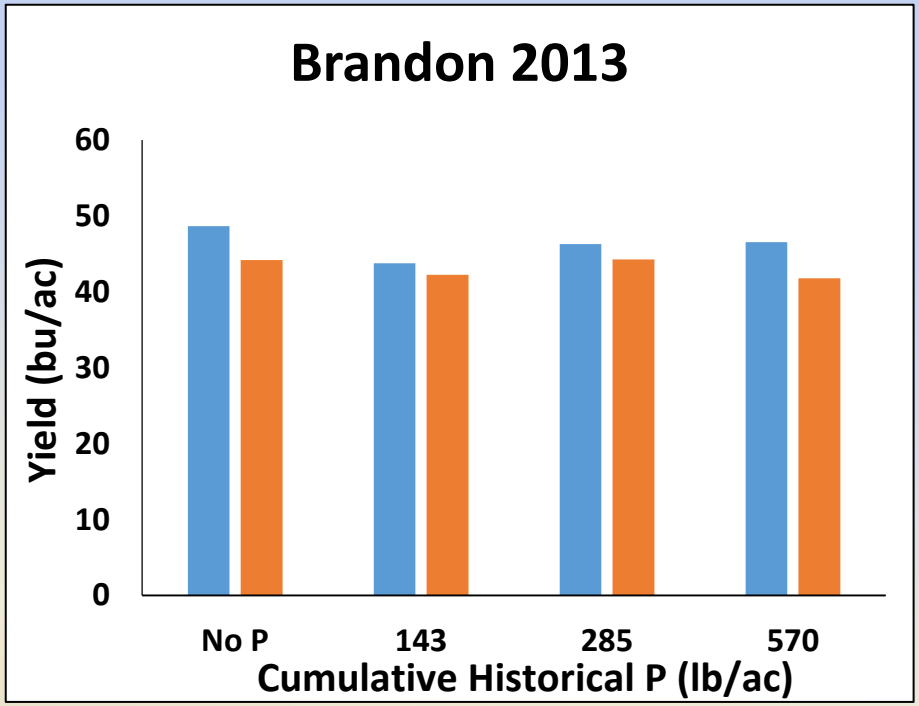
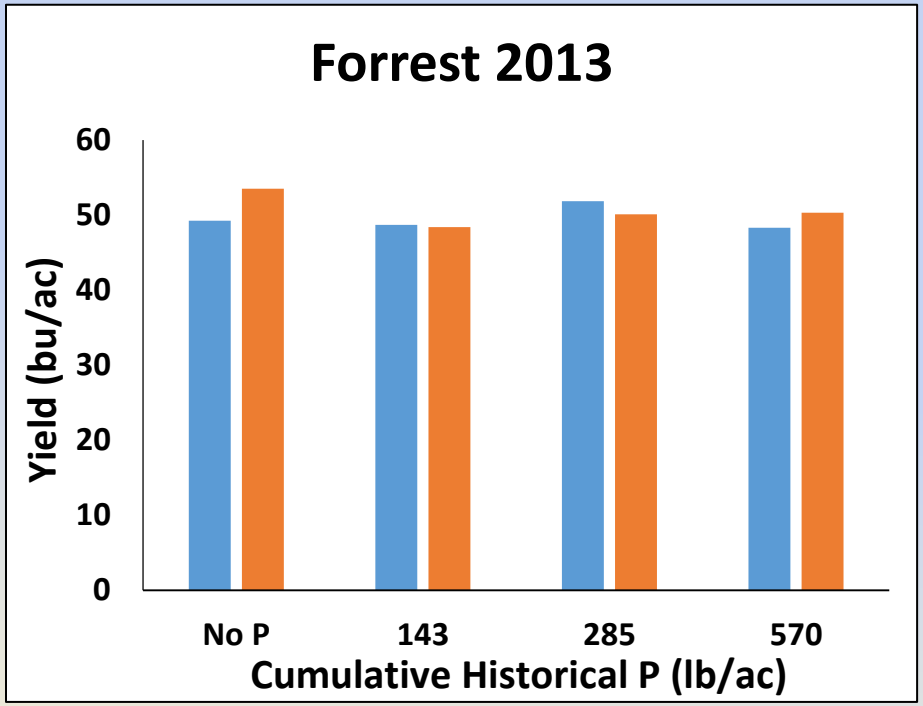
MATERIALS AND METHODS



- Starter P side-banded in half of each plot at planting in 2013 and 2014 (20 kg P/ha or ~ 40 lb P_2O_5/acre)

Soybean Seed Yield 2013





With side-banded starter P (18 lb/ac)

Without starter P

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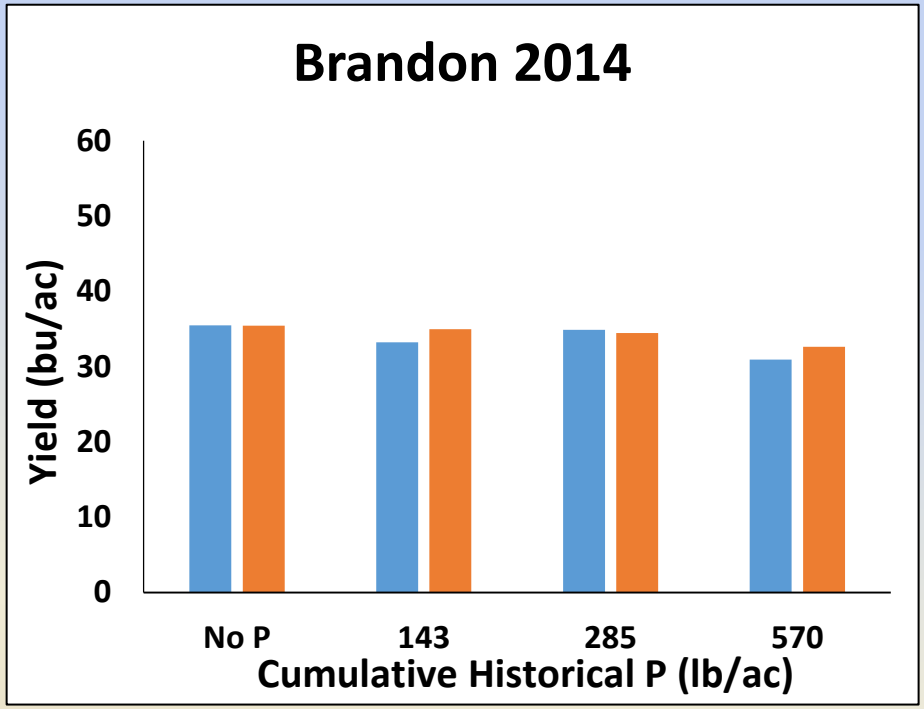
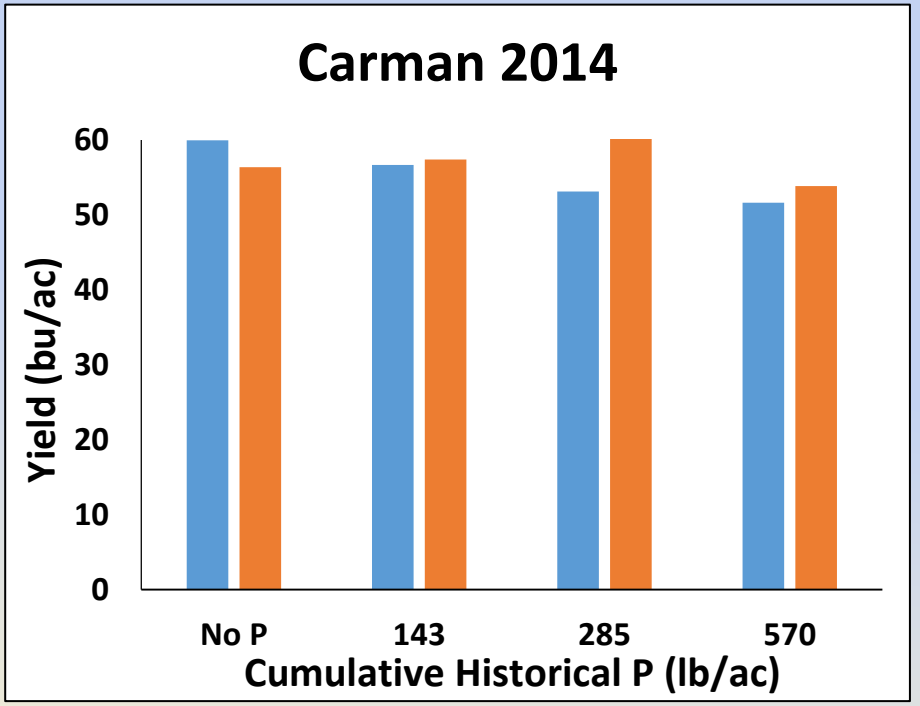
Soybean Seed Yield 2014





With side-banded starter P (18 lb/ac, for 2nd year)

Without starter P

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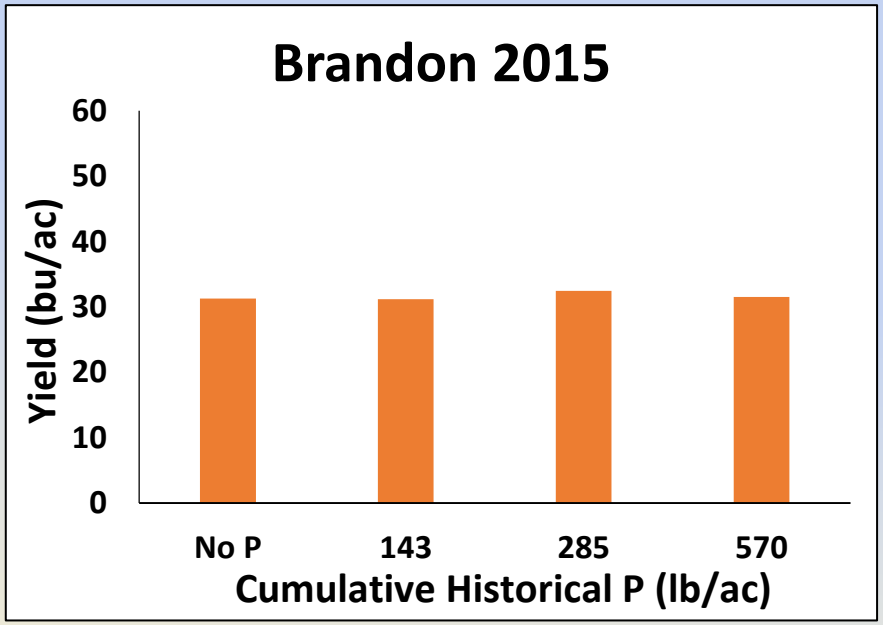
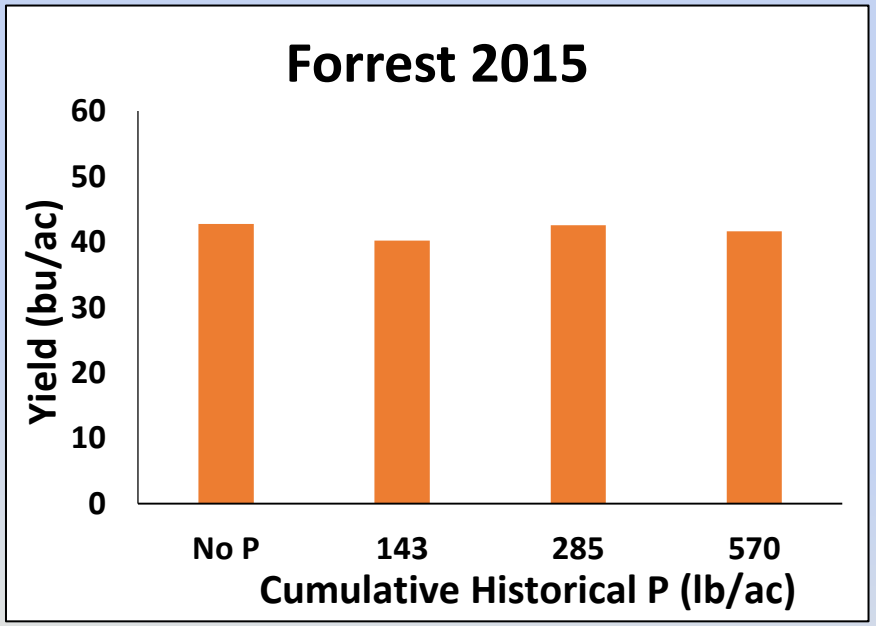
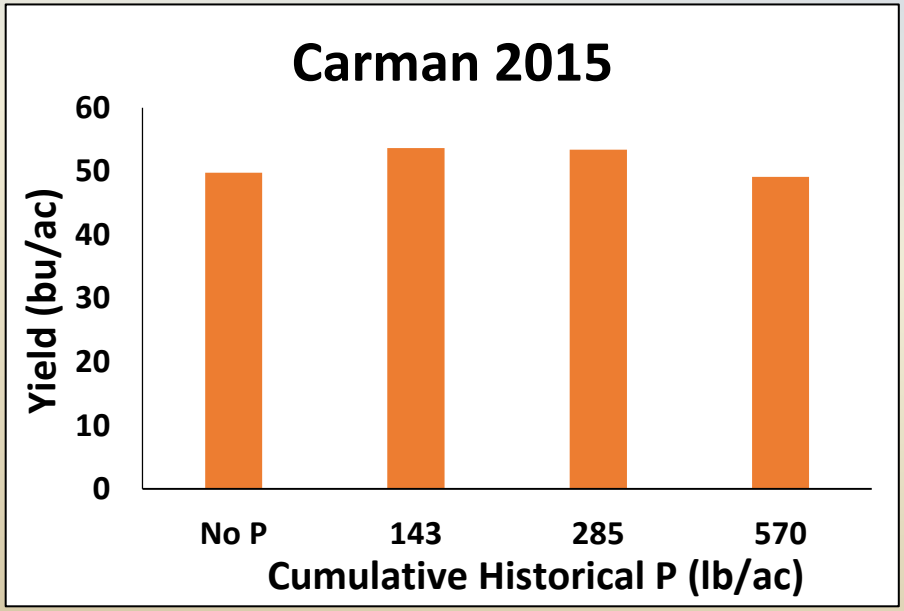
Soybean Seed Yield 2015







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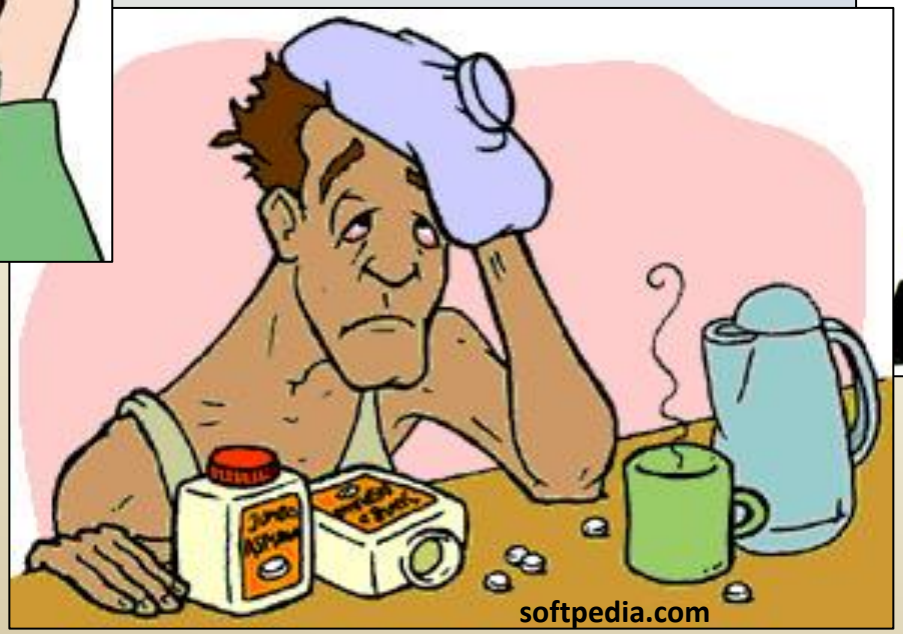
Summary and Conclusions for Soybean P Fertilization Project #2

- No seed yield response to soil P fertility or starter P fertilizer in any year at any site, including two sites with low Olsen soil test P levels (< 10 ppm)
- The threshold for soybean yield responses to soil P fertility and/or P fertilizer appear to be very low in Manitoba soils, lower than those in the soils tested so far
- Observations of higher soybean yields on Manitoba soils with higher P fertility may be due to other factors

Soybeans may not “care” about P fertilizer, but what about the crop after soybeans?

The phosphorus deficit hangover …



www.deviantart.com

P Removal by Annual Crops

Crop	Yield Level/Acre	P_2O_5 Removed by Crop lb/ac	lb/bu
Wheat	45 bu	36 (26)*	0.59
Canola	45 bu	75 (46)	1.0
Soybeans	40 bu	43 (34)	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, only

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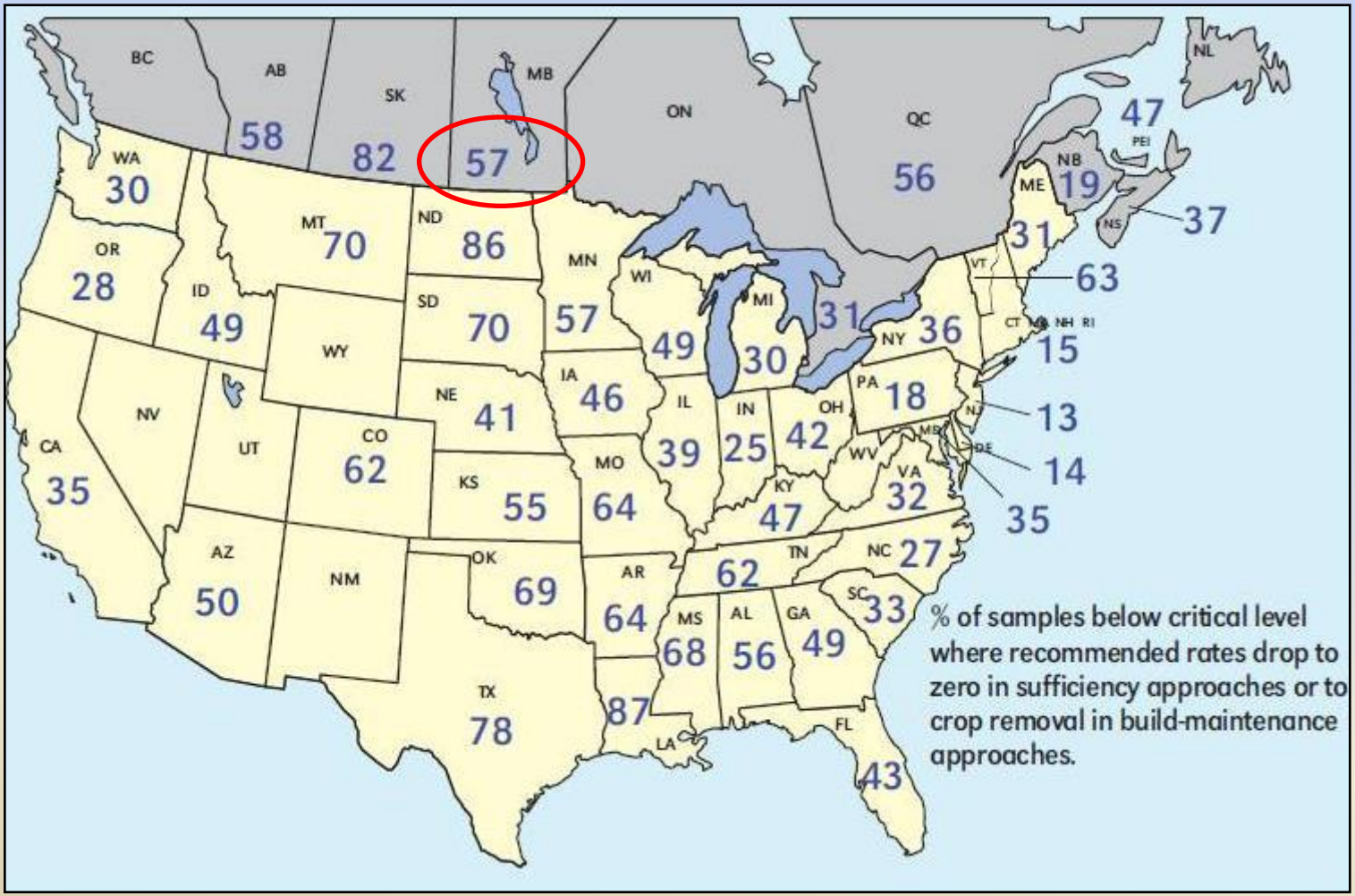
Majority of Manitoba Soils Are Deficient in P According to % Less Than Critical Level



Fixen et al. Better Crops 2010

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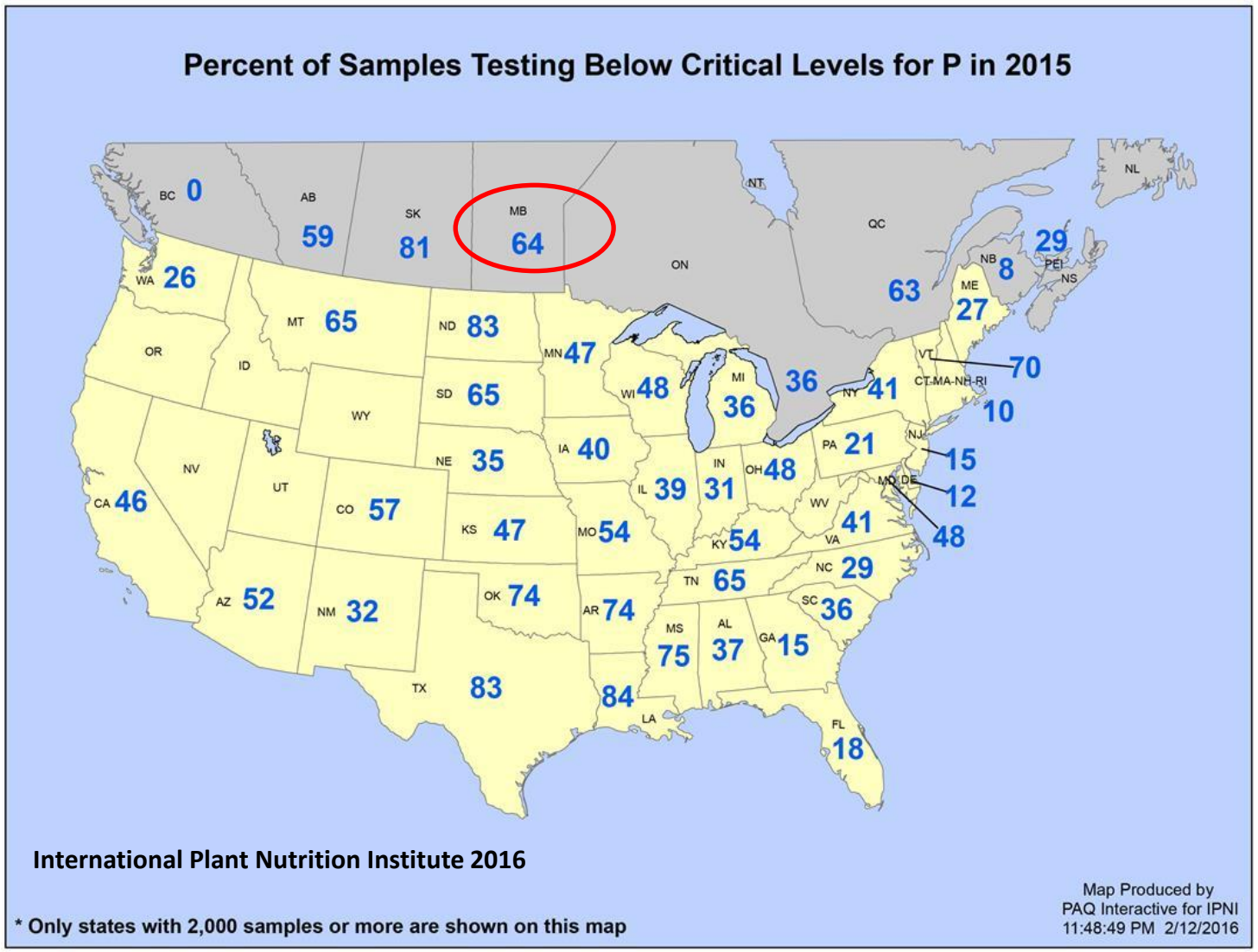
Majority of Manitoba Soils Are Deficient in P According to % Less Than Critical Level



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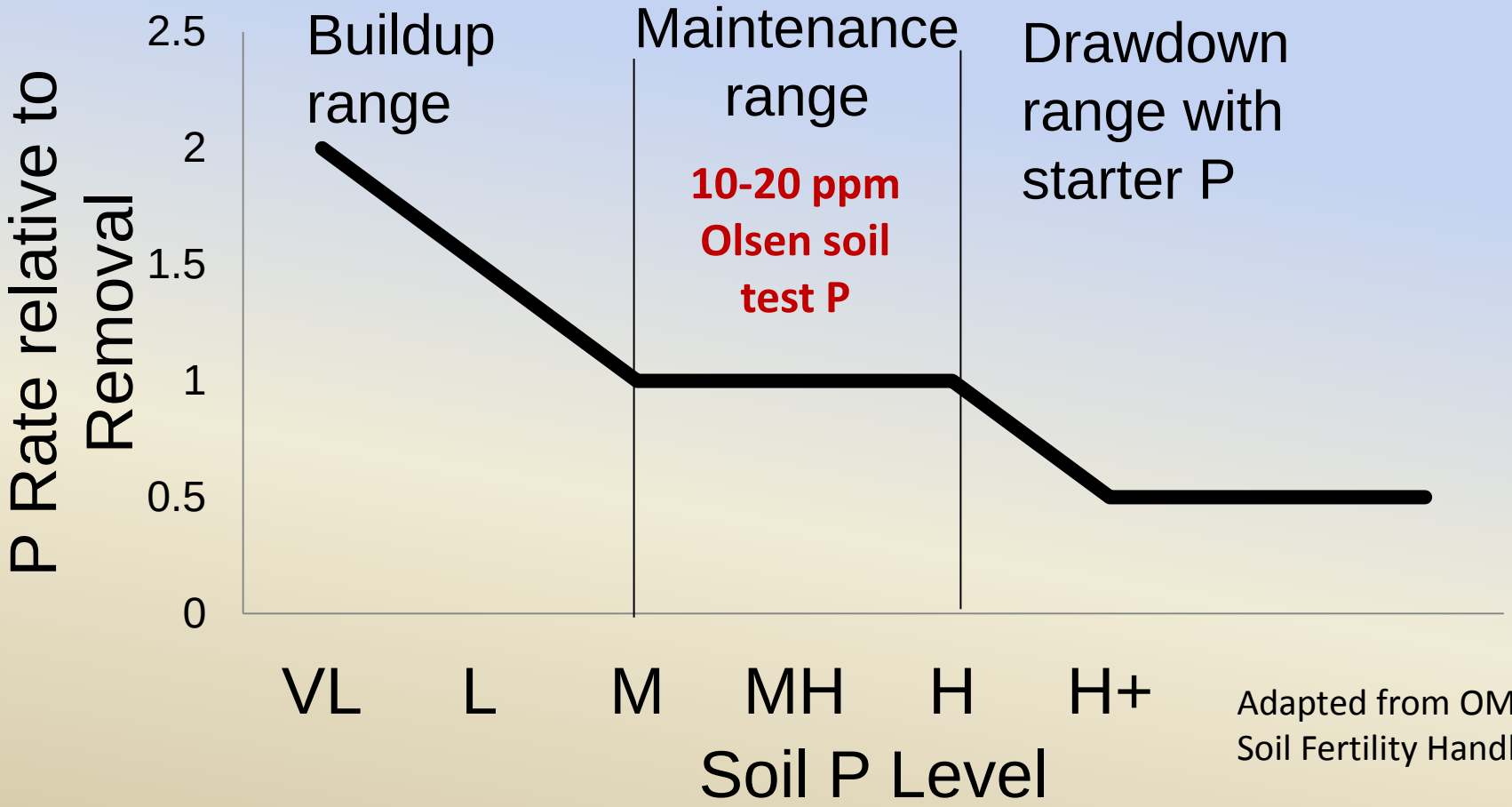
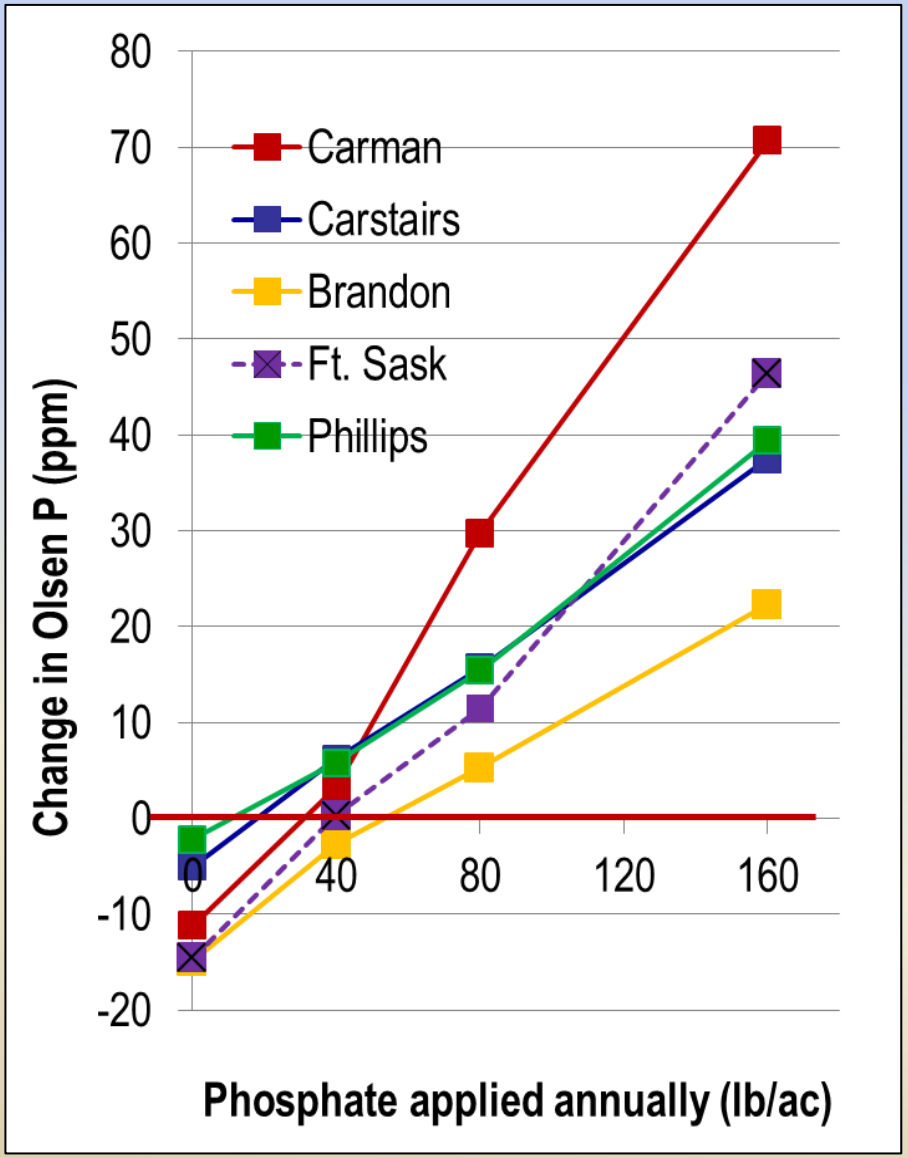
A fertilization concept to move soil P levels into an optimum range over time



Adapted from OMAFRA Soil Fertility Handbook

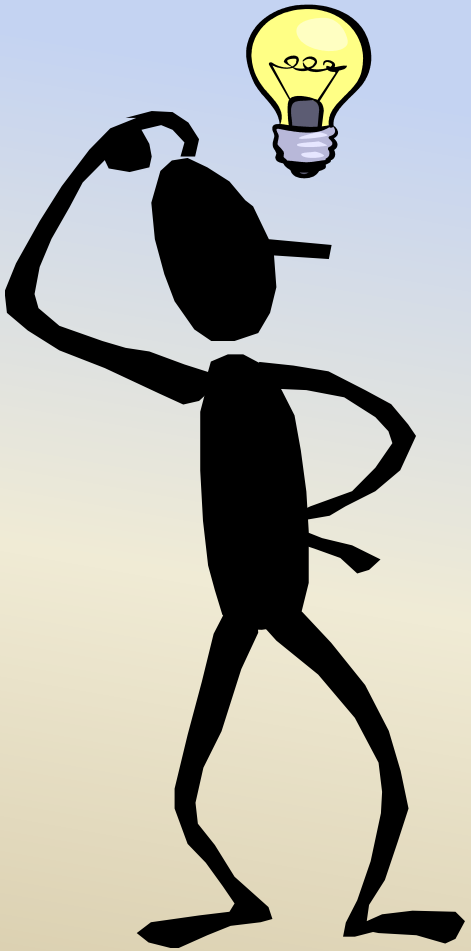
Olsen P also followed P balance in Alberta and Manitoba soils after 8 years of P applications in a durum-flax rotation

- Large increases in Olsen P occurred with high P rates
- Olsen P declined when no P applied
- At 40 lb phosphate/acre/year, Olsen P was maintained at most sites (but flax P removal is low)
- 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



Grant et al. unpublished

Recommended Strategies for Maintaining P Fertility in Soybean Fields



- **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**
  - **Periodically band P into soil during fall tillage ... eg. MAP with AS prior to canola, which responds to fert. P & N**
  - **Build soil P to target level, but avoid excess accumulation, eg. manure applied at rate to meet crop N requirements will provide P benefit for several years**

Phosphorus Fertiliza

www.manitobapulse.ca/production-resources/phosphorus-fertilization-strategies/

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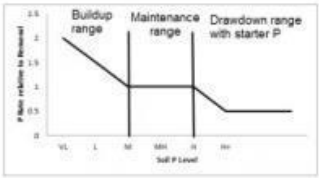
MANITOBA Pulse Soybean GROWERS

Phosphorus Fertilization Strategies



Did you know? Soybeans remove 0.84 lbs P per bushel, which means a 40 bu/ac soybean crop removes 34 lbs P/ac. Attention must be paid to ensure a proper fertilization strategy is adopted to ensure application rates are meeting removal rates through the entire crop rotation – learn more below.

Manitoba fertilizer phosphorus (P) guidelines have not been updated since 1992 and some troubling trends have been identified:

- In several of the past years the crop removal of P has surpassed the application rate of fertilizer P
- More soil test values are declining into the LOW range in some areas of Manitoba

This decline in soil test P levels (STP) may arise for a number of reasons:

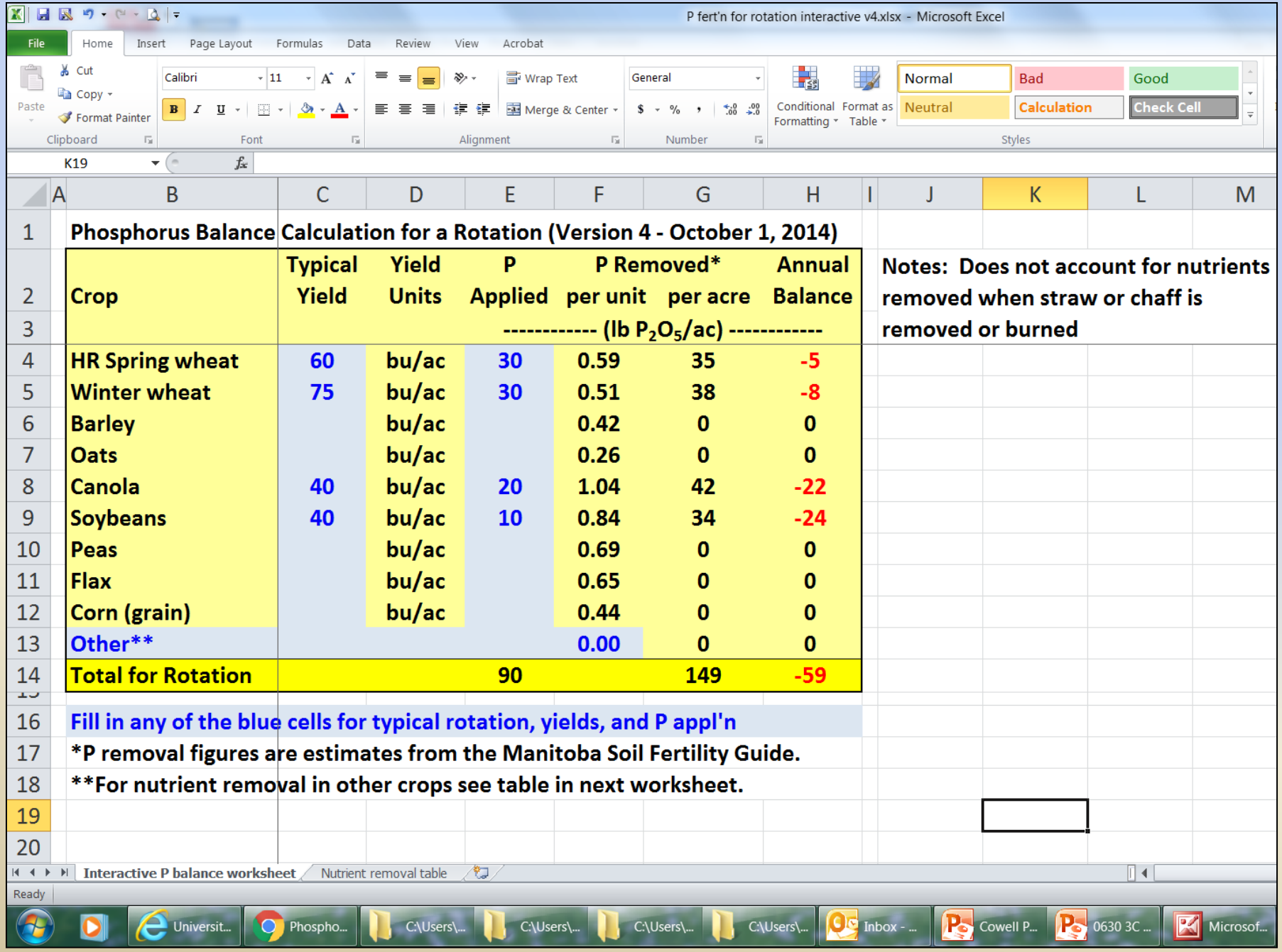
- Changing crop acreages– from relatively low P removal crops of cereals and flax to canola, soybeans and corn
- Move to low disturbance seeders and planters with narrow openers and wide row spacings (low seedbed utilization) which limit the safe rate of seed row applied fertilizer, especially with sensitive crops such as canola and soybeans
- Promotion and adoption of low P rate starter fertilizers that do not replace P that is removed by crops
- Increase in grain yields since development of original MAFRD recommendations in the early 1990s due to breeding (ie introduction of hybrid canola, general purpose spring wheats etc.) and technology (ie fungicide use)
- Provincial recommendation tables do not include yield adjustment factors, so rates have been inadequate to meet current yield levels, let alone match rates of P removal

Thinking about your cropping system, or that your client, does P applied equal P removed? Or are crop removal rates exceeding P applied, leading to a negative soil P balance? Use the Interactive Phosphorus Balance Calculator to determine your annual P balance:

Interactive Phosphorus Fertilization Calculator

Phosphorus Recommendation Strategies for Manitoba

Manitoba Soil Fertility experts have collaborated to develop "Phosphorus Fertilization Strategies for Long Term Agronomic and Environmental Sustainability" which outlines


P fert'n for rotation interactive v4.xlsx - Microsoft Excel
File
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Formulas
Data
Review
View
Acrobat
Cut
Copy
Format Painter
Paste
Calibri
11
Wrap Text
Merge & Center
General
Conditional Formatting
Format as Table
Normal
Bad
Good
Neutral
Calculation
Check Cell
Clipboard
Font
Alignment
Number
Styles
K19
Phosphorus Balance Calculation for a Rotation (Version 4 - October 1, 2014)
Crop
Typical Yield
Yield Units
P Applied
P Removed* per unit
P Removed* per acre
Annual Balance
---------- (lb P2O5/ac) ----------
HR Spring wheat 60 bu/ac 30 0.59 35 -5
Winter wheat 75 bu/ac 30 0.51 38 -8
Barley bu/ac 0.42 0 0
Oats bu/ac 0.26 0 0
Canola 40 bu/ac 20 1.04 42 -22
Soybeans 40 bu/ac 10 0.84 34 -24
Peas bu/ac 0.69 0 0
Flax bu/ac 0.65 0 0
Corn (grain) bu/ac 0.44 0 0
Other** 0.00 0 0
Total for Rotation 90 149 -59
Notes: Does not account for nutrients removed when straw or chaff is removed or burned
Fill in any of the blue cells for typical rotation, yields, and P appl'n
*P removal figures are estimates from the Manitoba Soil Fertility Guide.
**For nutrient removal in other crops see table in next worksheet.
Interactive P balance worksheet
Nutrient removal table
Ready

Overall Summary and Conclusions

- **Fertilizer P appears to have a low probability of increasing yield, regardless of rate or placement**
- **The probability of reduced stand or yield from typical agronomic rates of seed-placed P is small ... but wide row spacings and sandy soils may pose a risk in some years**
- **Soil P fertility appears to have little effect on soybean yield**

Worrying about P fertilization for soybeans may be a distraction … instead, focus on maintaining soil P fertility for the rest of your crop rotation:

- **Consider subsurface banding fertilizer away from seed, rotational P fertilization, or manure app'n at N based rates**
- **Avoid fall broadcast P fertilizer … agronomically & environmentally unsound**

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Acknowledgements

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- R. Burak and J. Pawluk (Prairies East Sustainable Ag Inst.)
- S. Chalmers (Westman Ag Diversification Organization)
- C. Autsema
- Manitoba Pulse and Soybean Growers Association
- Western Grains Research Foundation
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Thank You!

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