Emerging Technologies With P Fertilizers

2007 Fertilizer Outlook and Technology Conference

Terry A. Tindall Ph.D.

J.R. Simplot Company

NEW METHODS FOR INFLUENCING PHOSPHATE AVAILABILITY TO PLANTS

Common Objective…

Treat Microenvironments, Not Entire Soil Mass, to Improve Effectiveness

TECHNOLOGY INCLUDED IN THIS REPORT PROVIDED BY:

Agrium
Simplot
Specialty Fertilizer Products

Phosphate becomes tied-up, or fixed

On low pH soils

- **Aluminum**
- **Iron**

On high pH soils

- **Calcium**
- **Magnesium**

PHOSPHORUS FERTILIZERS THE PROBLEM

- Crop recovery limited to 5 – 25% of applied P fertilizer during the season of application (Mortvedt, 1994).
- At high pH, P is fixed by Ca and Mg.
- At low pH, P is fixed by Fe and Al.

MICROENVIRONMENTAL CONDITIONS HAVE SUBSTANTIAL EFFECTS ON NUTRIENT AVAILABILITY

MODIFICATION OF MICROENVIRONMENTS RELATIVE TO P AVAILABILITY

- Banding of P
- Dual banding of ammonium N and P
- Injection of P fertilizers--fertigation

WE'VE UNDERSTOOD THE VALUE OF PREPLANT BANDING OF N AND P FOR OVER 30 YEARS

NEW POLYMER COATINGS FOR INCREASING PHOSPHORUS USE EFFICIENCY AND INCREASING PROFITABILITY

AGRIUM

Controlled Release Phosphate (CRP)

Polymer-coated, slowed dissolution

- **Diminished effect on crop emergence**
- **Greater flexibility in starter P rates**
- **Extended availability of P…slowed fixation**

AGRIUM'S EXPERIENCE WITH POYMER COATINGS

- Polymer coated urea (ESN)
- Polymer coated P
- Controlled Release w/POLYON—10-48-0—temperature dependent

RESEARCHERS

- Dr. Cynthia Grant, AAFC
- Dr. Jeff Schoenau, Univ. of Saskatchewan

Dr. Jeff Stark and Dr. Terry Tindall—U of ID and JRS

EVALUATING THE IMPACT OF SEED-ROW PLACED CRP ON CROP EMERGENCE

J.J. Schoenau, P. Qian, T. King and C. Fatteicher

Univesity of Saskatchewan

SASKATCHEWAN STUDY

Objective:

Compare impact of controlled release P to conventional MAP on germination and emergence of 5 crops…canola, yellow pea, flax, mustard and alfalfa.

AGRIUM CRP EFFECTS ON CROP EMERGENCE

Rate of P	Emergence Counts 20 days After Planting					
	Canola		Flax		Alfalfa	
kg P_2O_5/ha	MAP	CRP	MAP	CRP	MAP	CRP
0	11.5a	10.8a	13.8a	12.0a	14.3a	12.8a
20	10.8a	11.0a	12.8a	11.3a	13.3a	12.0a
40	8.3c	11.5a	8.8c	12.0a	9.0b	12.5a
60	5.8d	11.0a	4.5d	12.0a	5.3c	10.3a
80	5.5d	11.3a	2.0e	11.8a	2.3d	14.3a

$P < 0.05$, Soil pH = 7.4. Jeff Schoenau et al., U. of Saskatchewan.

AGRIUM CRP EFFECTS ON CROP EMERGENCE

	% Emergence 20 days After Planting					
Rate of P	Canola		Flax		Alfalfa	
kg P_2O_5/ha	MAP	CRP	MAP	CRP	MAP	CRP
0	96a	90a	69a	60a	71a	64a
20	90ab	92a	64ab	56a	66a	60a
40	69c	96a	44c	60a	45b	63a
60	48d	92a	23d	60a	26c	51a
80	46d	94a	10e	50a	11d	71a

$P < 0.05$, Soil pH = 7.4. Jeff Schoenau et al., U. of Saskatchewan.

CONCLUSIONS

- Negative impact of conventional MAP at rates of 30 kg P_2O_5 and above for all crops
- Up to 80 kg P_2O_5 as CRP did not reduce germination and emergence except on yellow pea
- CRP would have advantages with seed contact fertilization

IMPROVING P NUTRITION IN WHEAT

Cynthia Grant et al

AAFC, Brandon, MB

OBJECTIVES

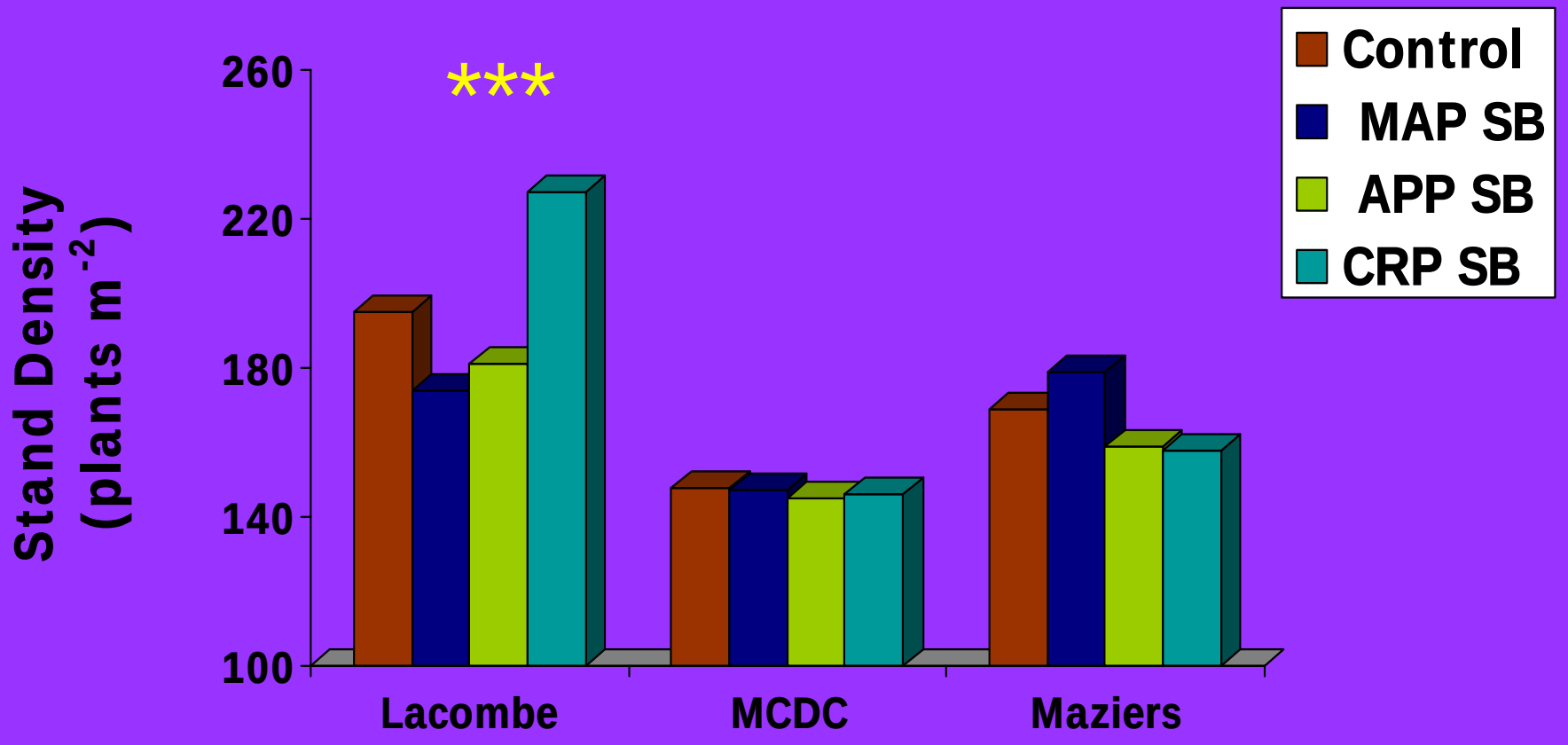
- Compare efficiency of sidebanded MAP to surface or sidebanded fluid P (APP)
- Evaluate the performance of controlled release P (CRP) compared to MAP
- Investigate mycorrhizal inoculant effects on crop responses to applied P

LOCATIONS

- 2 in Manitoba
- 1 in Alberta

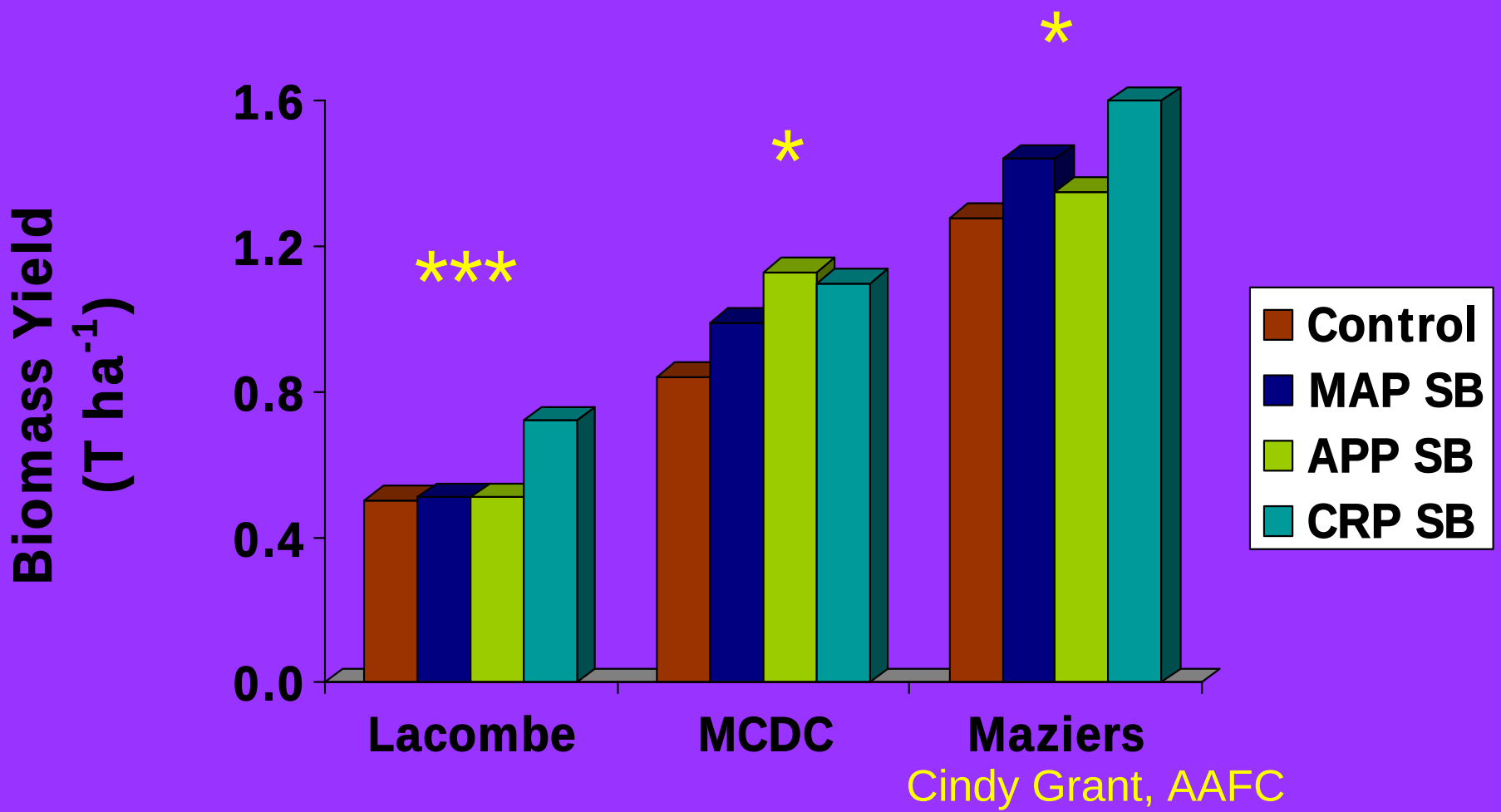
SPRING WHEAT

CRP Enhanced Stand Density at 2 weeks at Lacombe

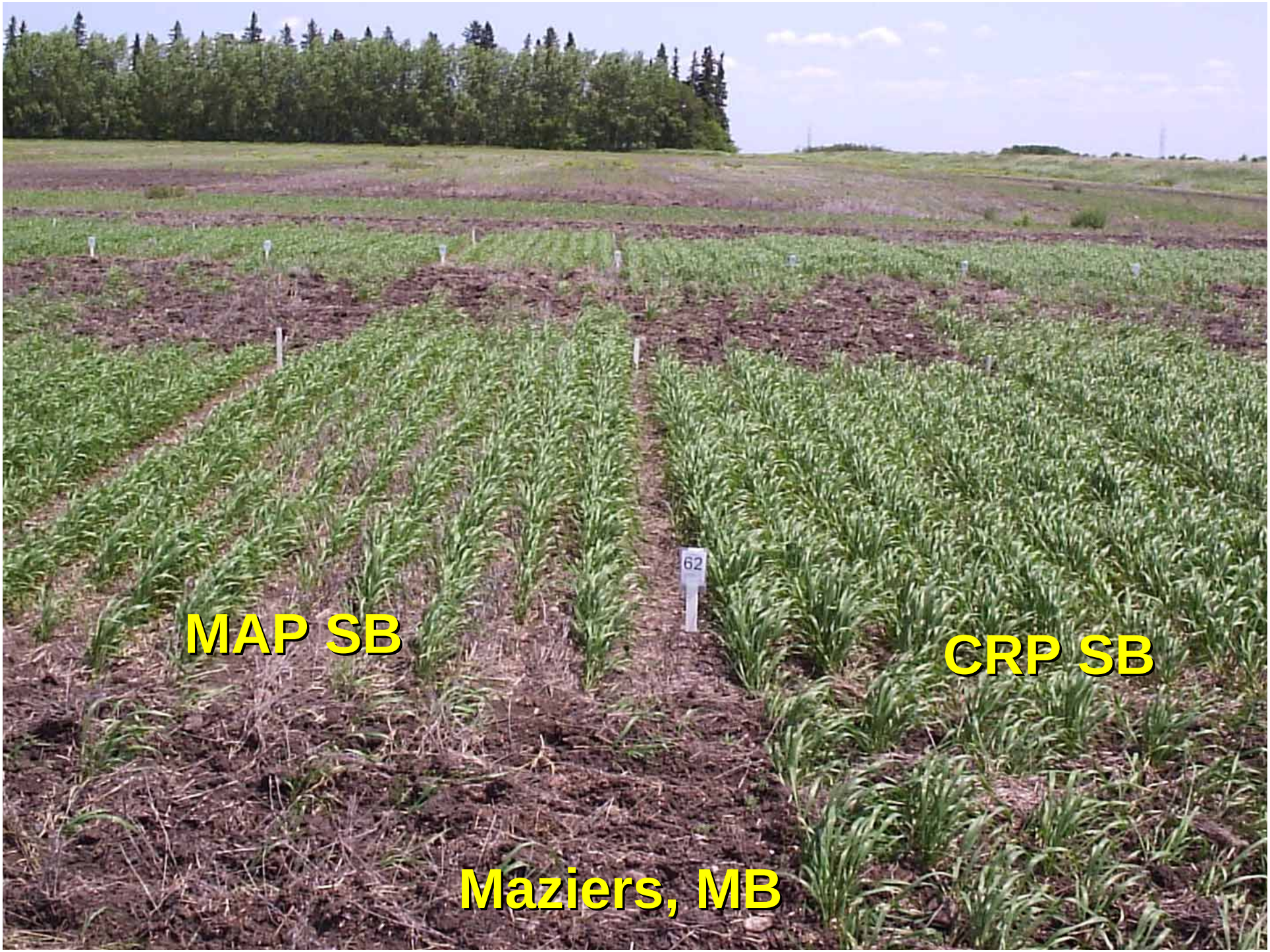


Cindy Grant, AAFC

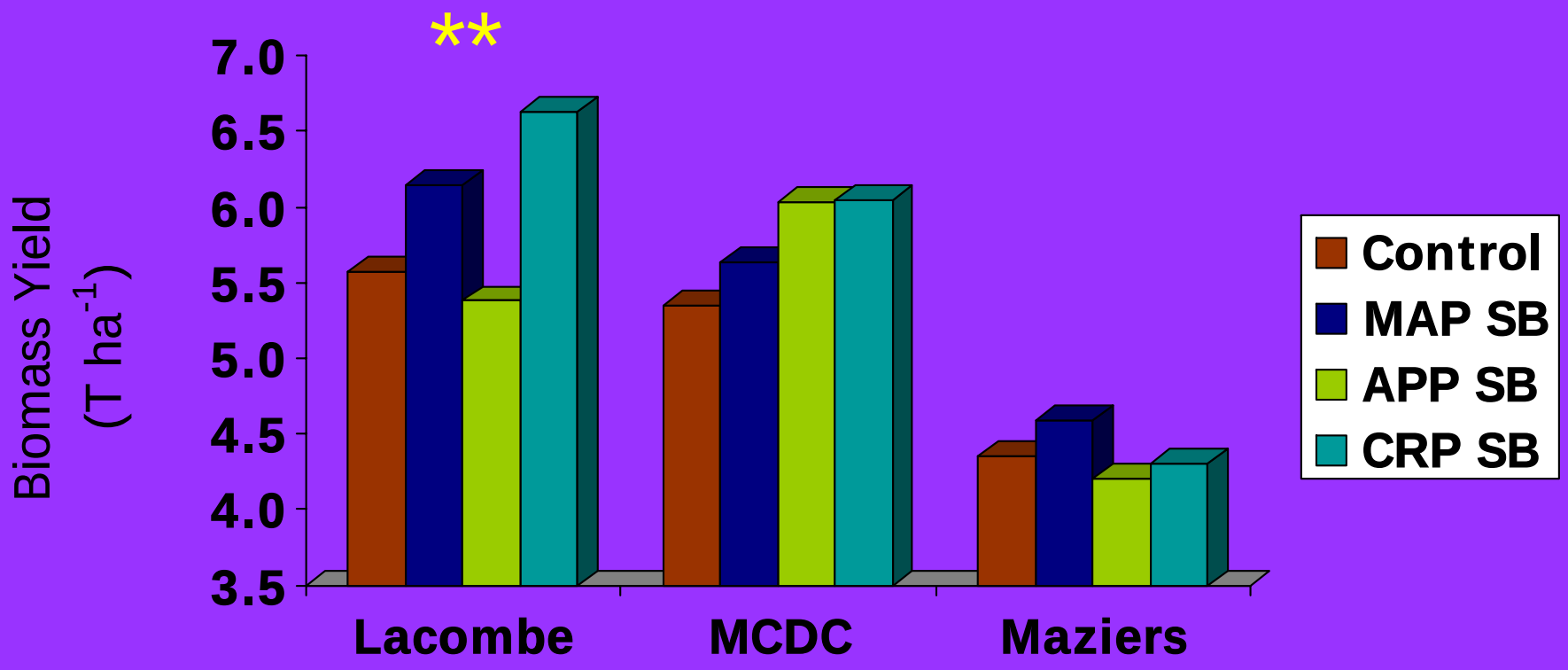
CRP Increased Biomass Production at Six Weeks at Two Sites



Cindy Grant, AAFC

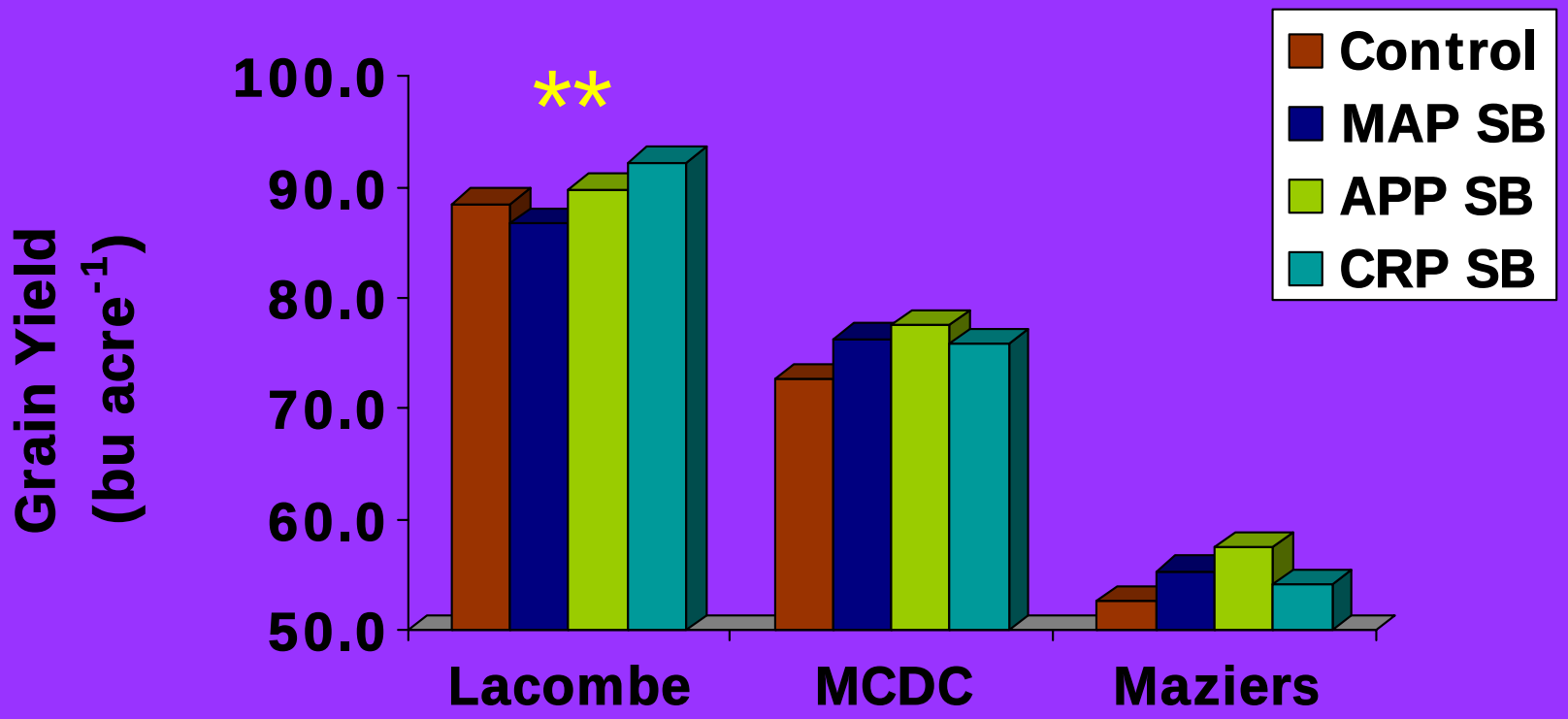

MAP SB
CRP SB
Maziers, MB

Biomass at Heading Was Increased by CRP at Lacombe



Cindy Grant, AAFC

Grain Yield at Lacombe was Higher with Side-banded CRP than MAP



Yield with APP similar or numerically better

Cindy Grant, AAFC

PRODUCT:

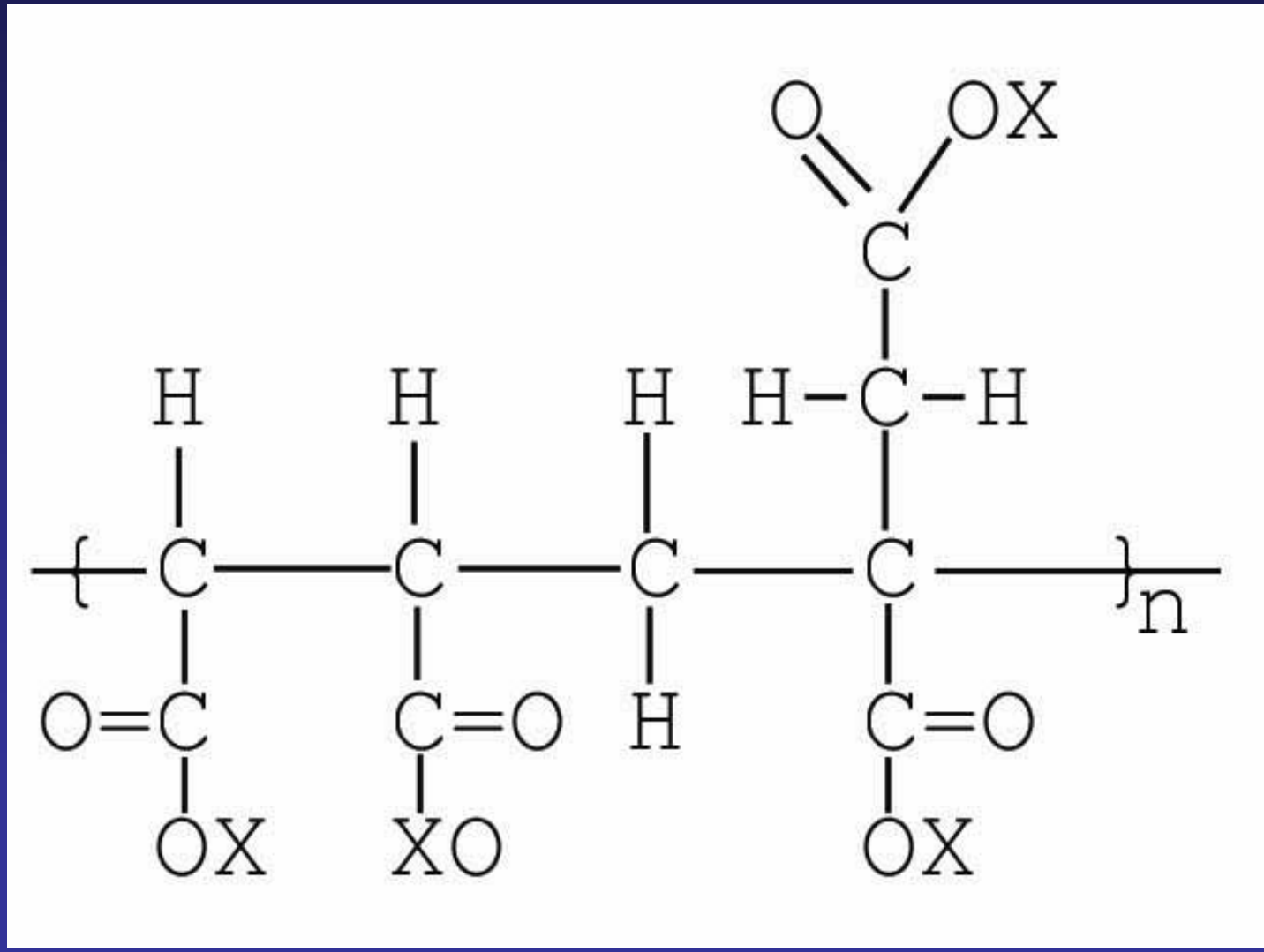
AVAIL

Specialty Fertilizer Products and
J.R. Simplot

WHAT IS AVAIL?

- **One of a patented family of dicarboxylic copolymers.**
- **Used as a coating on granular phosphates or mixed into fluid P fertilizers to enhance P availability.**

AVAIL Polymer Chain

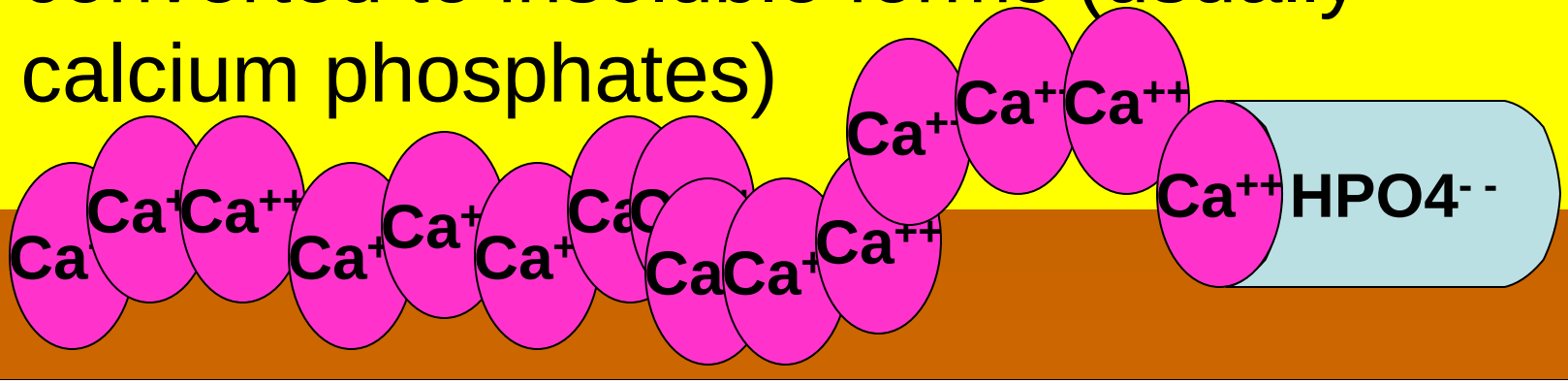


AVAIL CHARACTERISTICS

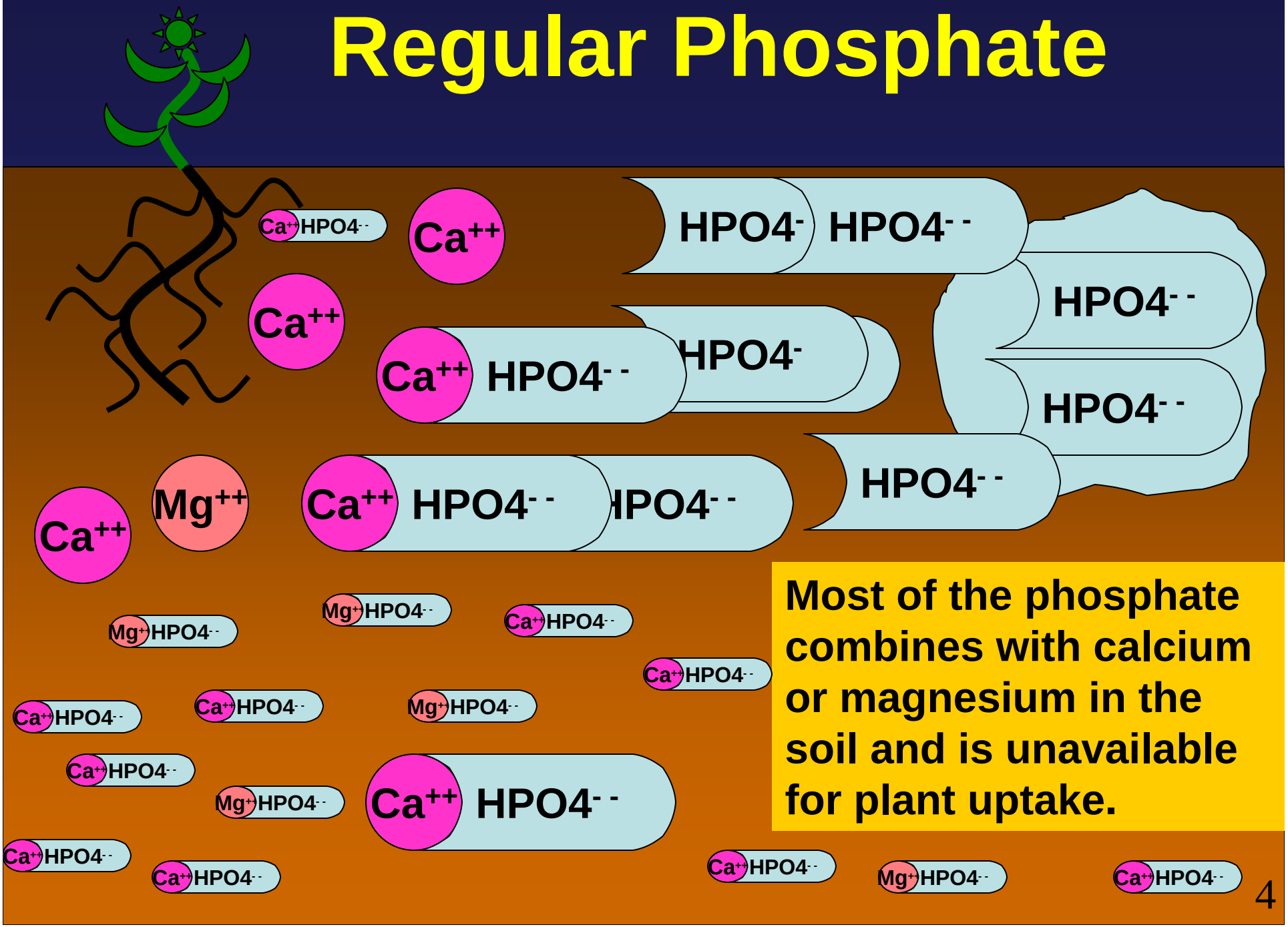
- **An extremely high cation exchange capacity – approximately 1800 milliequivalents /100 gms.**
- **Polymeric structure is very specific to attracting and adsorbing multivalent cations.**
- **Functionality is not affected by pH, temperature ranges.**
- **Biodegradable and water soluble.**

Soil Phosphate

- 95% of the phosphorus in the soil is tied up as insoluble compounds and is unavailable for use by the plant.
- Added fertilizer phosphate is quickly converted to insoluble forms (usually calcium phosphates)

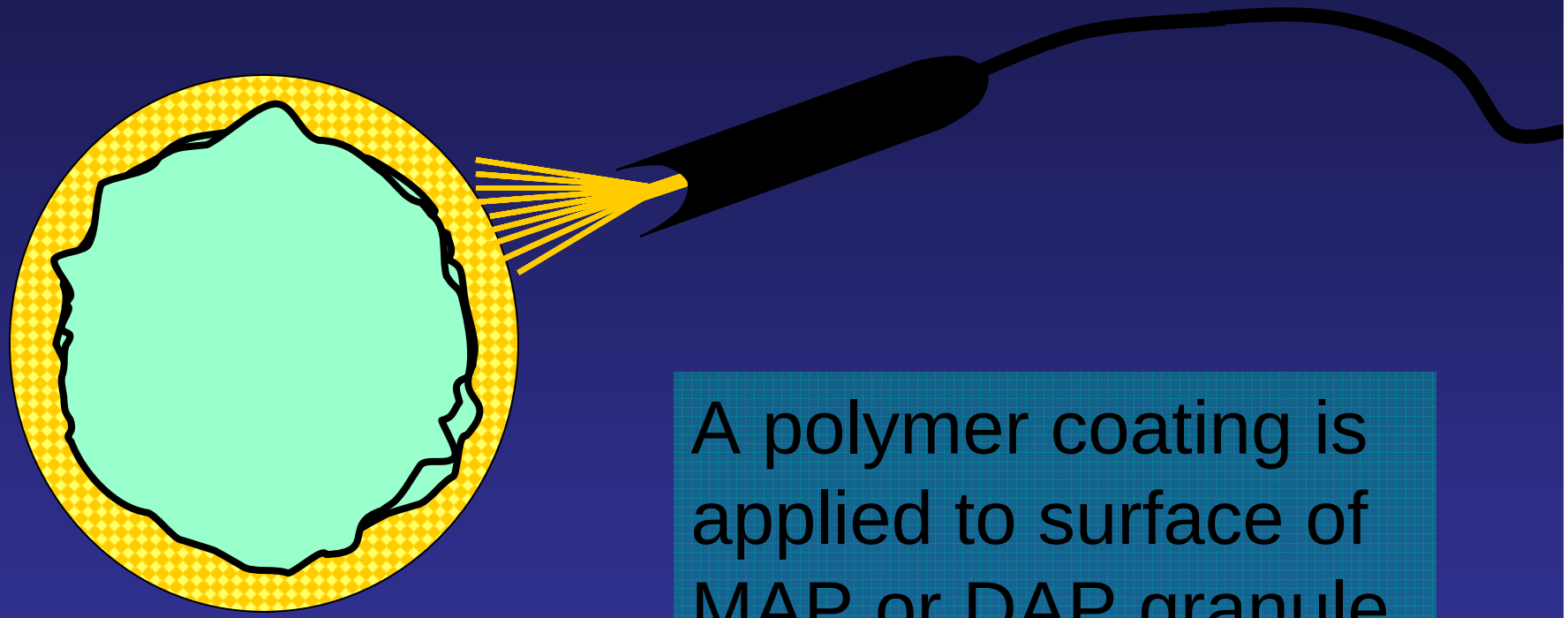


Regular Phosphate



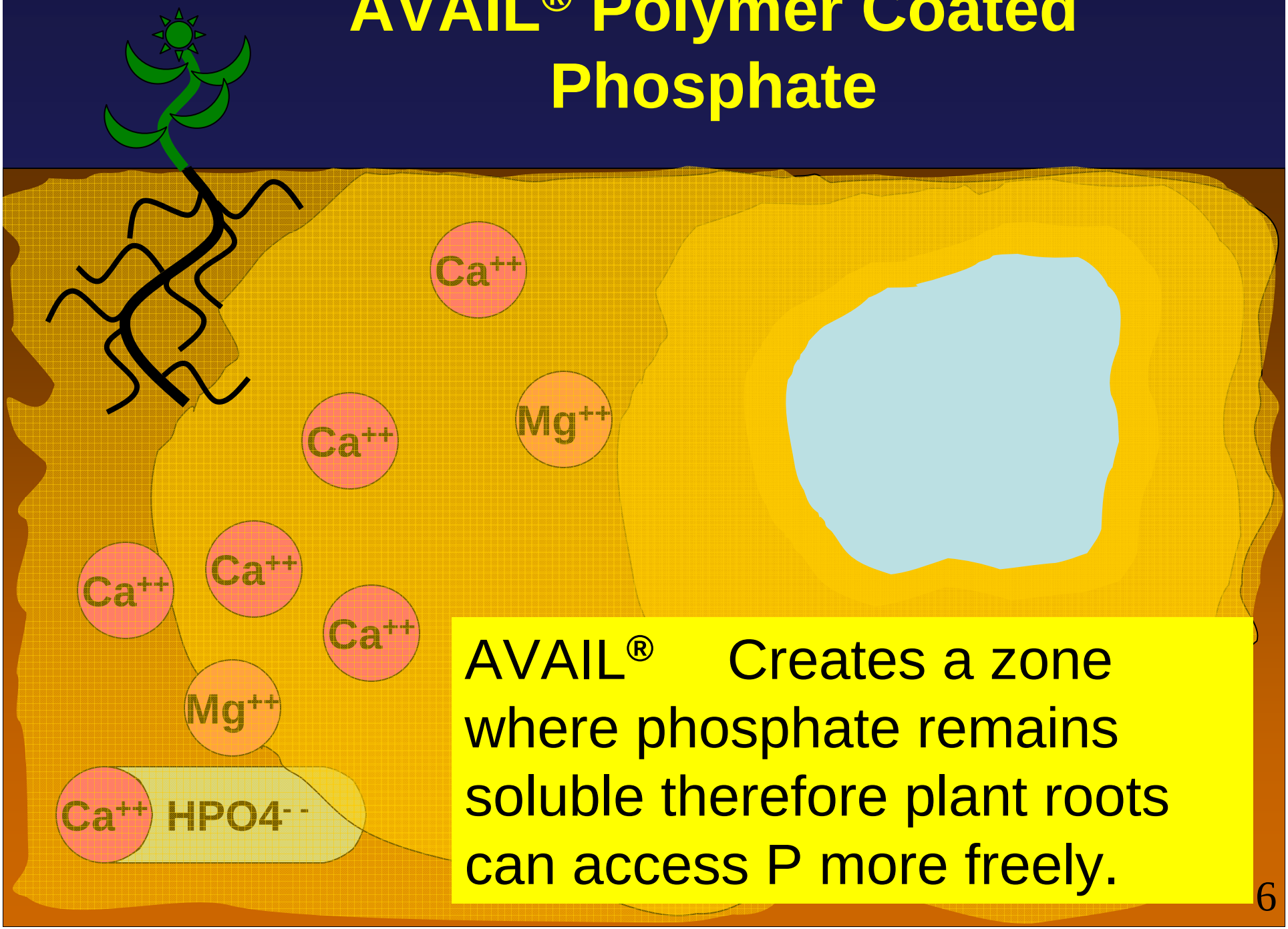
Most of the phosphate combines with calcium or magnesium in the soil and is unavailable for plant uptake.

AVAIL® Phosphate Enhancer



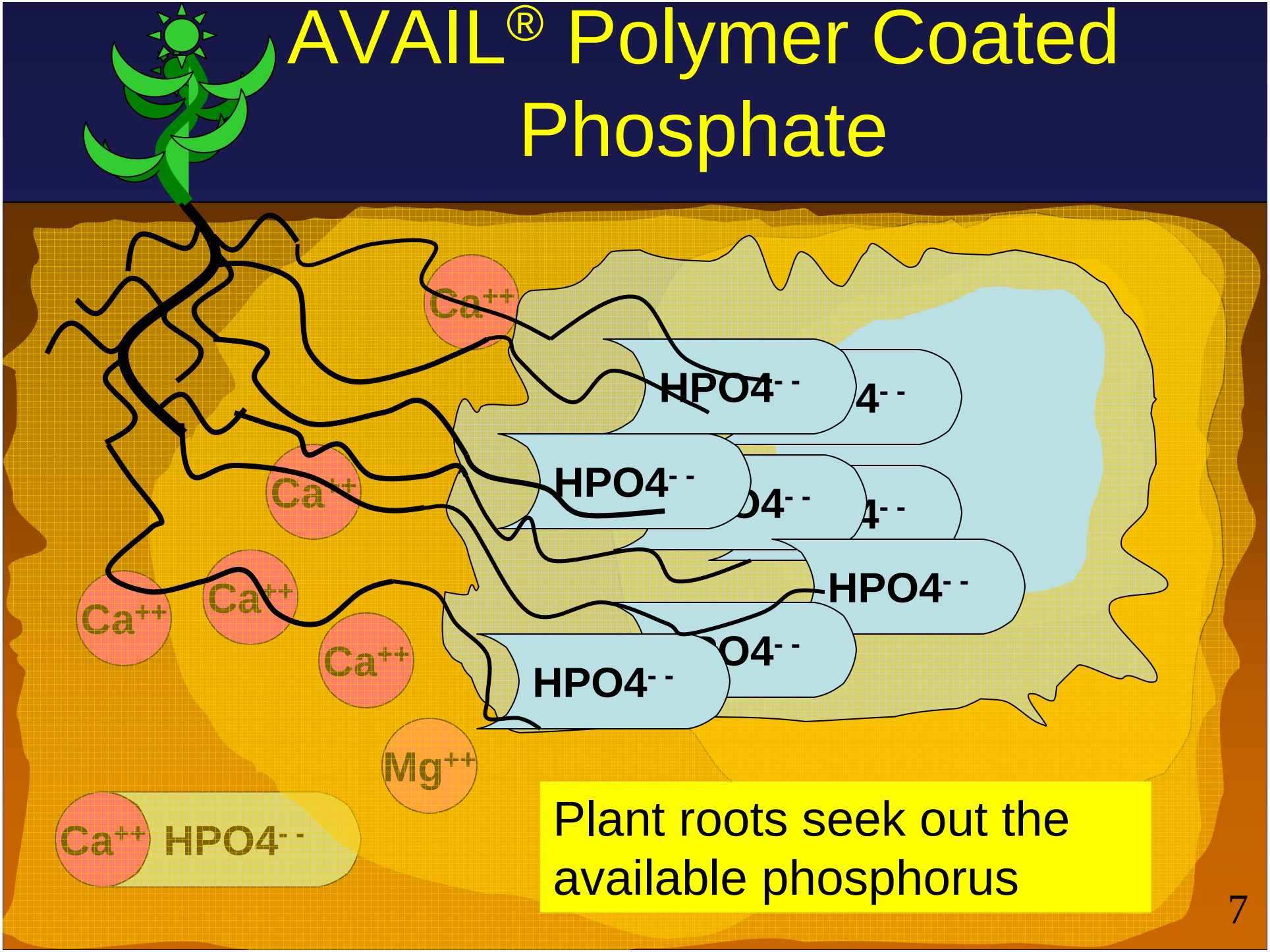
A polymer coating is applied to surface of MAP or DAP granule

AVAIL® Polymer Coated Phosphate



AVAIL® Creates a zone where phosphate remains soluble therefore plant roots can access P more freely.

AVAIL® Polymer Coated Phosphate

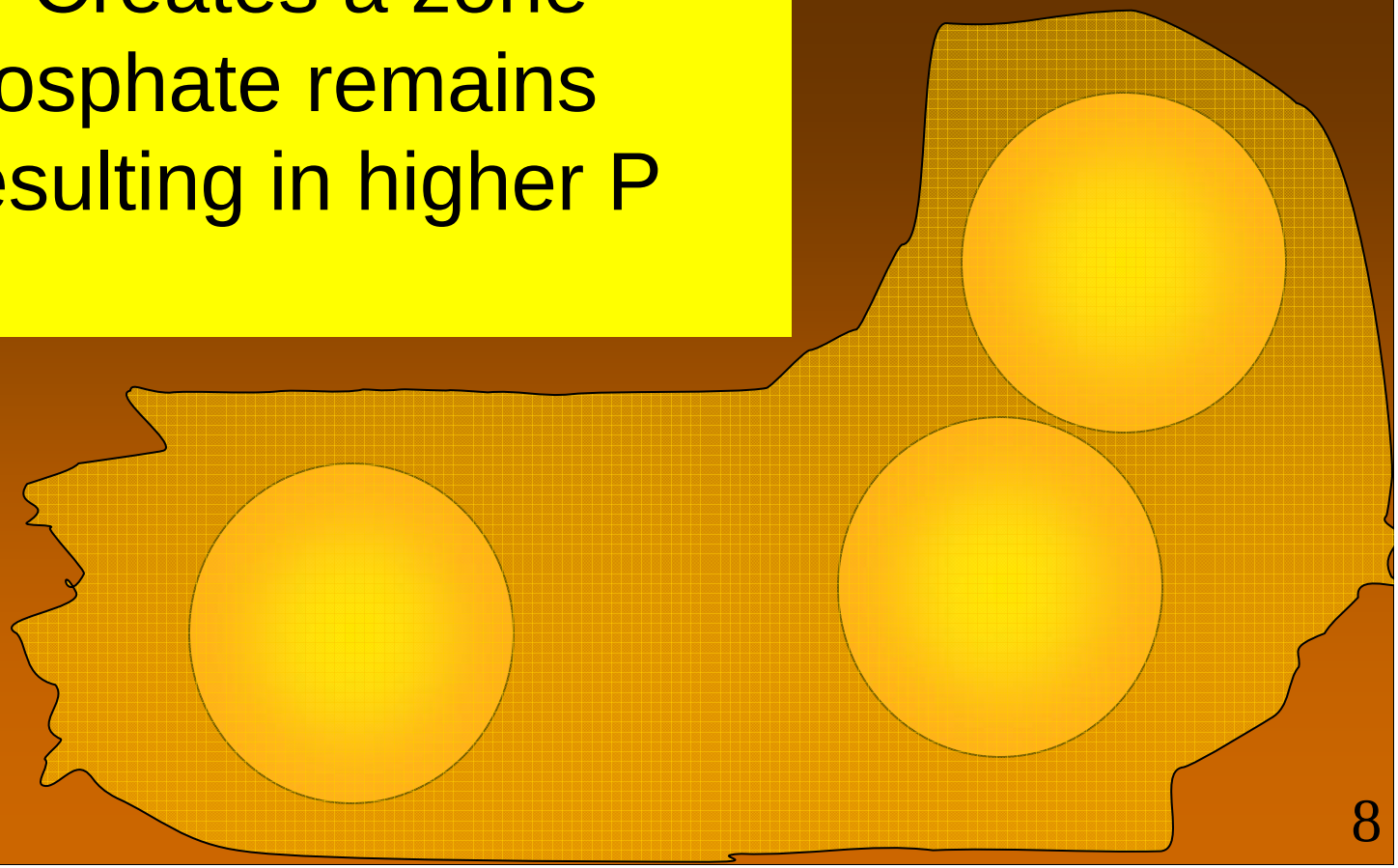


Plant roots seek out the available phosphorus

AVAIL® Phosphate Enhancer

Phosphate for the 21st Century

AVAIL® Creates a zone where phosphate remains soluble resulting in higher P uptake!



WHAT IS THE MODE OF ACTION?

Mode of Action Theory

- **Polymer sequesters antagonistic cations out of soil solution around P fertilizer granule.**
- **P remains unfixed and available for plant uptake.**
- **Results in highly concentrated zones of available P for the plants (microenvironments).**

INITIAL GREENHOUSE STUDY AT KANSAS STATE UNIVERSITY

- Acidic (pH 4.7), high P soil
- 1% polymer coating on MAP
- P banded beside seed
- Essentially doubled corn dry matter

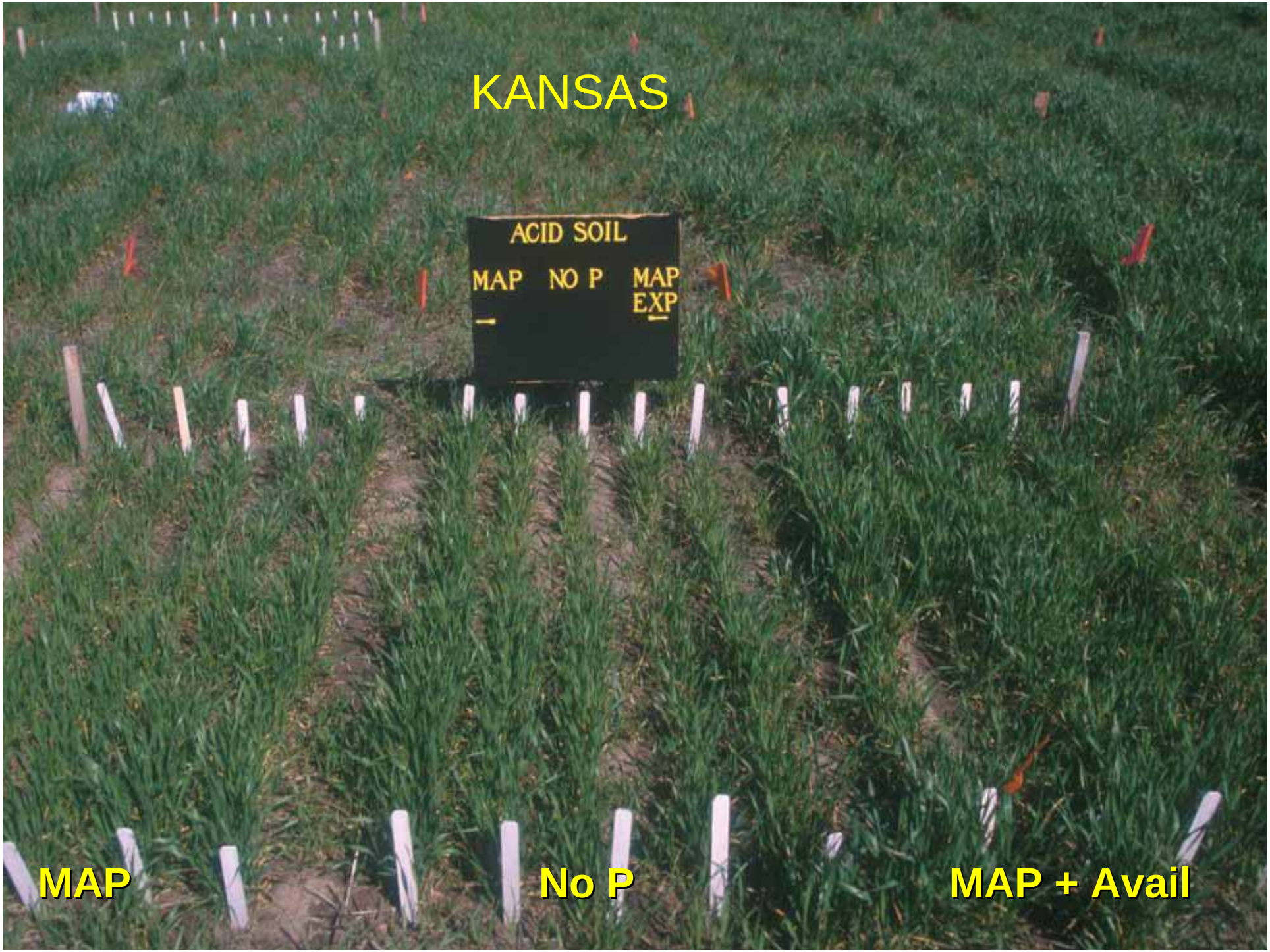
Initial Testing of SFP Experimental Materials at Kansas State University.

INITIAL AVAIL EVALUATION
Corn - Greenhouse

Material	Dry Wt.	P Conc.	P Uptake
	grams	%	mgm
Control	5.18	0.827	43.2
P1X	8.90	0.996	88.7
P2X	9.55	1.043	99.6
$LSD_{.05}$	2.47	0.177	31.8

Lamond, Kansas State Univ.

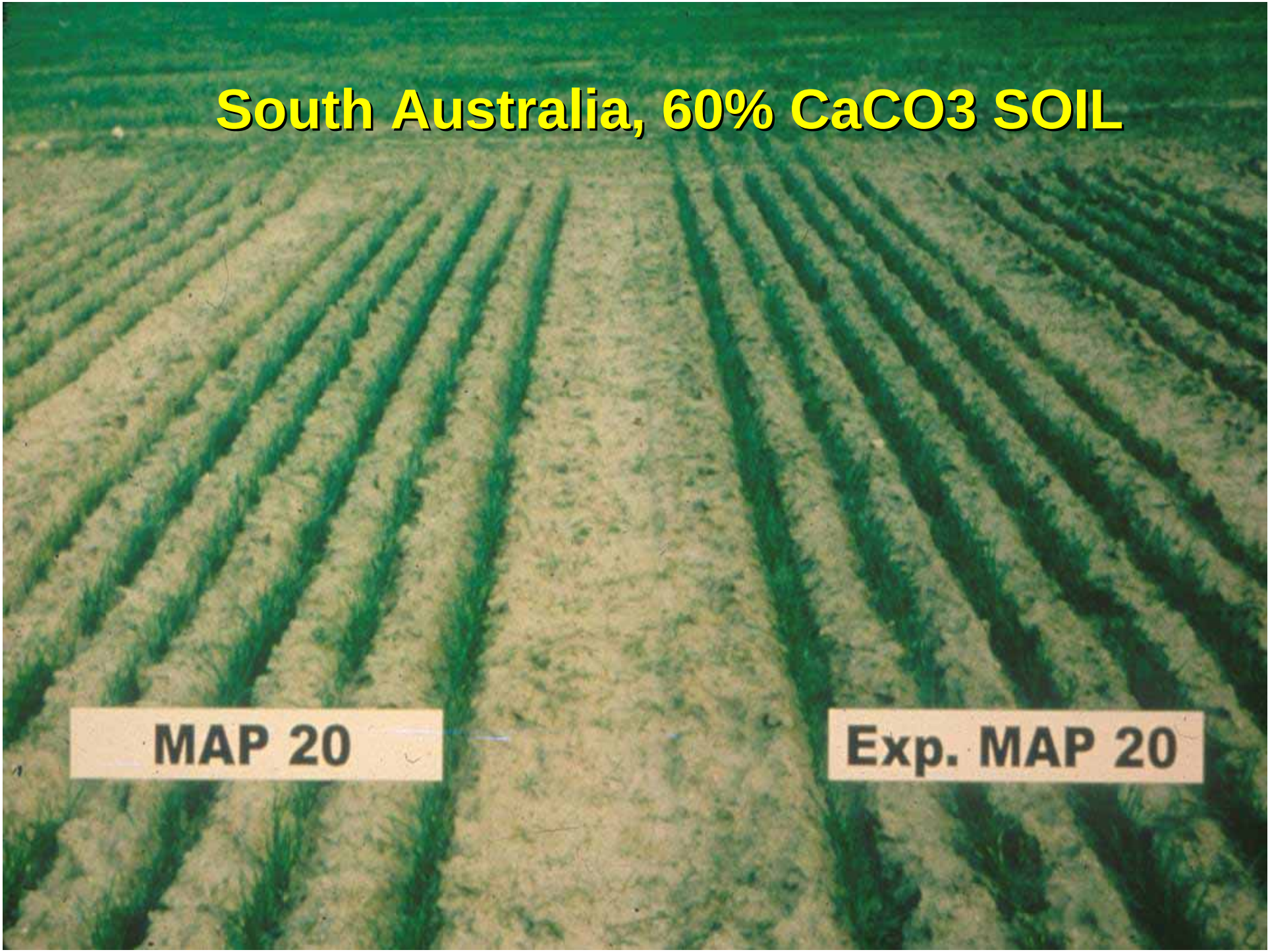
Soil pH=4.7; Soil test P=74 ppm Bray-1. 40 lb/A (20 ppm) P_2O_5 banded on basis of 30" row.


KANSAS
ACID SOIL
MAP NO P MAP EXP
MAP
No P
MAP + Avail

WHEAT RESPONSE TO ENHANCED P AVAILABILITY
Kansas

Treatment Applied	Grain Yield bu/A
Control	31.6
MAP	34.2
MAP + polymer	39.5

1% polymer Murphy Agro – Kansas State Univ.
20 lb P_2O_5/A banded at planting. Soil pH 4.7


South Australia, 60% CaCO3 SOIL
MAP 20
Exp. MAP 20

POLYMER AND P APPLICATION METHOD EFFECTS ON WHEAT
Arkansas

Treatment	Yield bu/A
Control	46.7
MAP banded	54.7
MAP + polymer, banded	76.9
MAP broadcast	58.2
MAP + polymer, broadcast	65.6
MAP + seed, broadcast	55.1
Map + polymer + seed, broadcast	68.3
LSD (0.10)	7.5

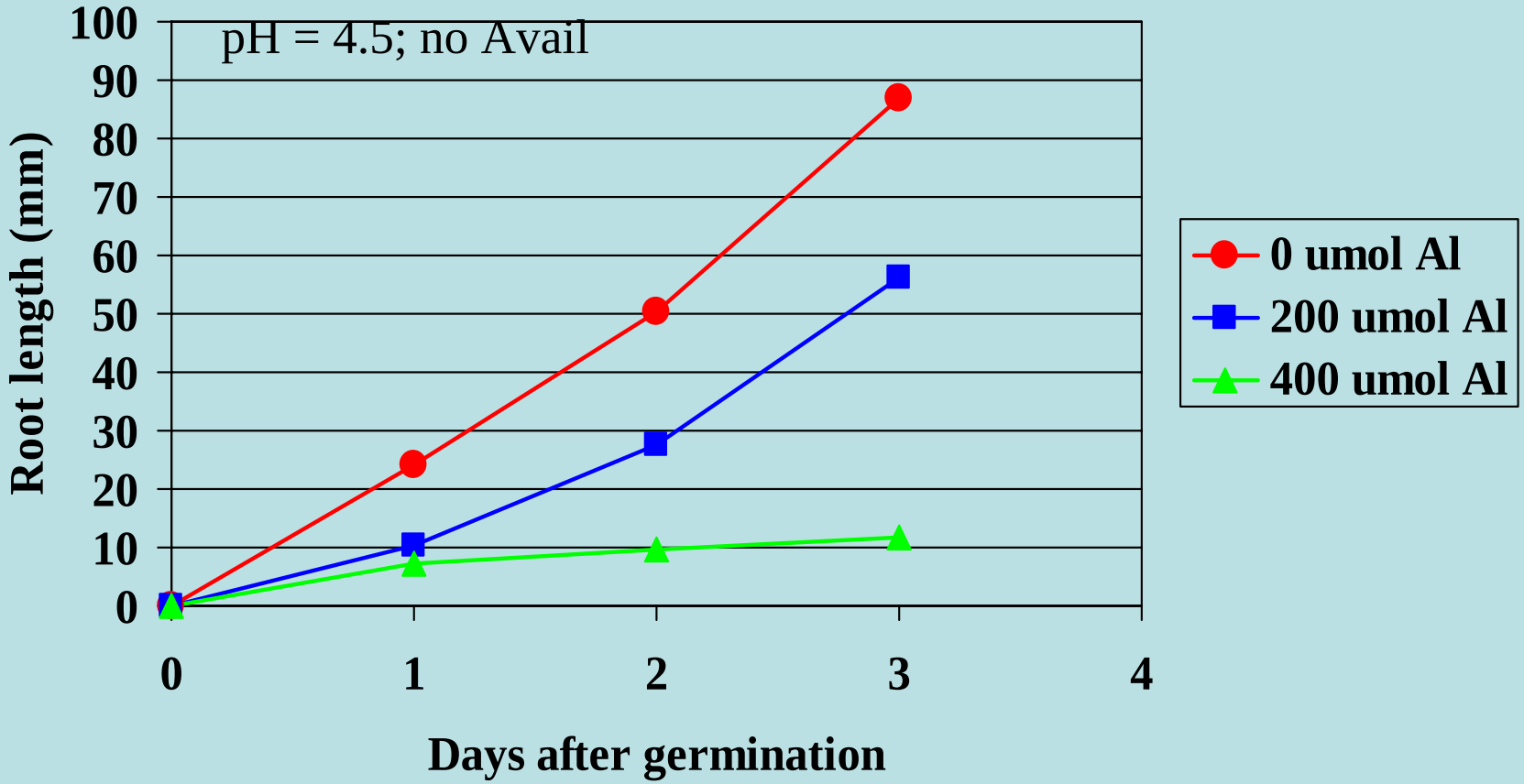
30 lb P_2O_5/A. Soil P test low. Soil pH=7.6. Palmer, Univ. of Arkansas

AVAIL EFFECTS ON ALUMINUM TOXICITY TO WHEAT SEEDLINGS

Dr. Rich Koenig, Washington State Univ.

* Screening test for wheat varieties
* Various concentrations of Al
* Included Avail polymer as a variable

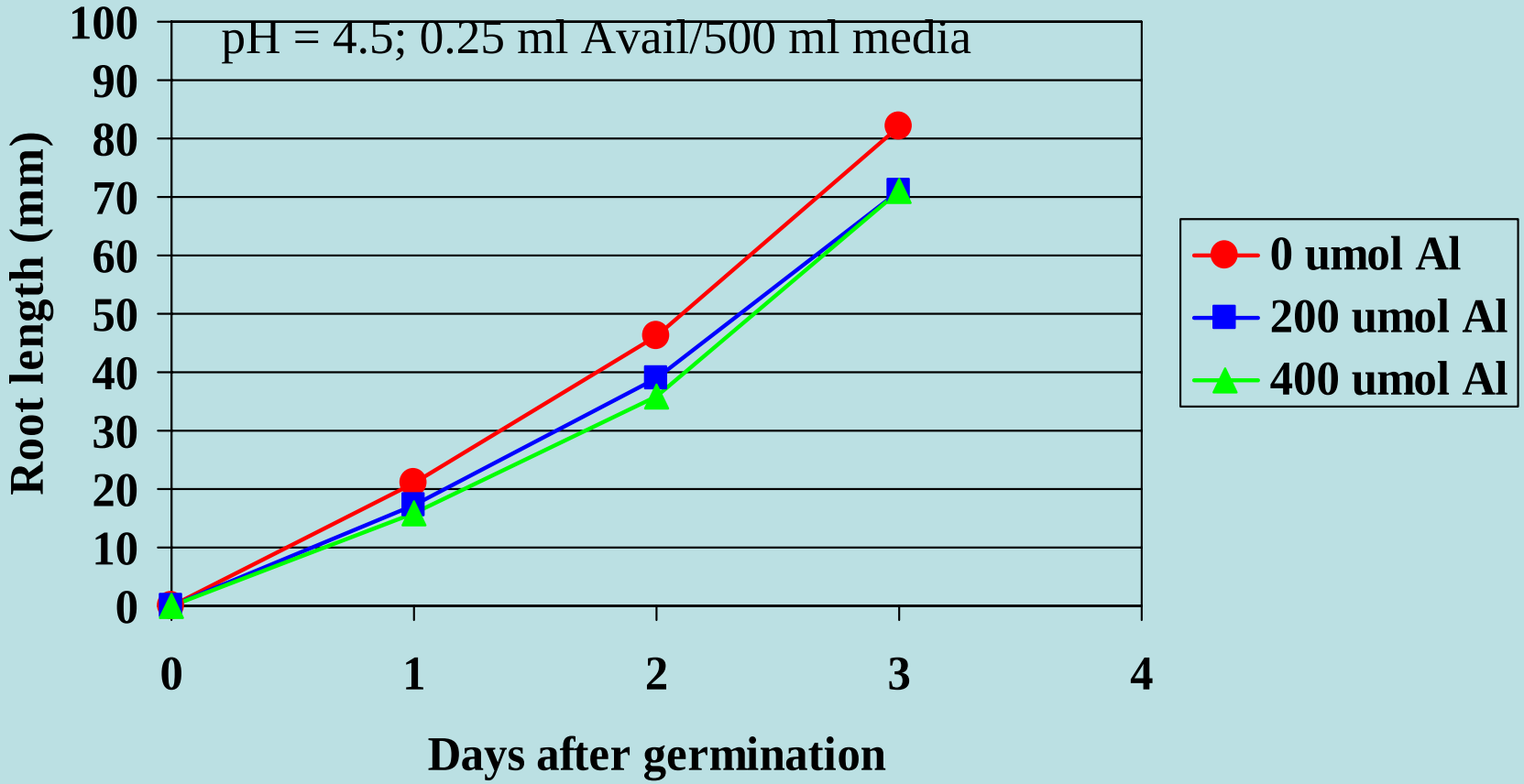
ALUMINUM EFFECTS ON WHEAT GROWTH
Low pH



Rich Koenig, WSU

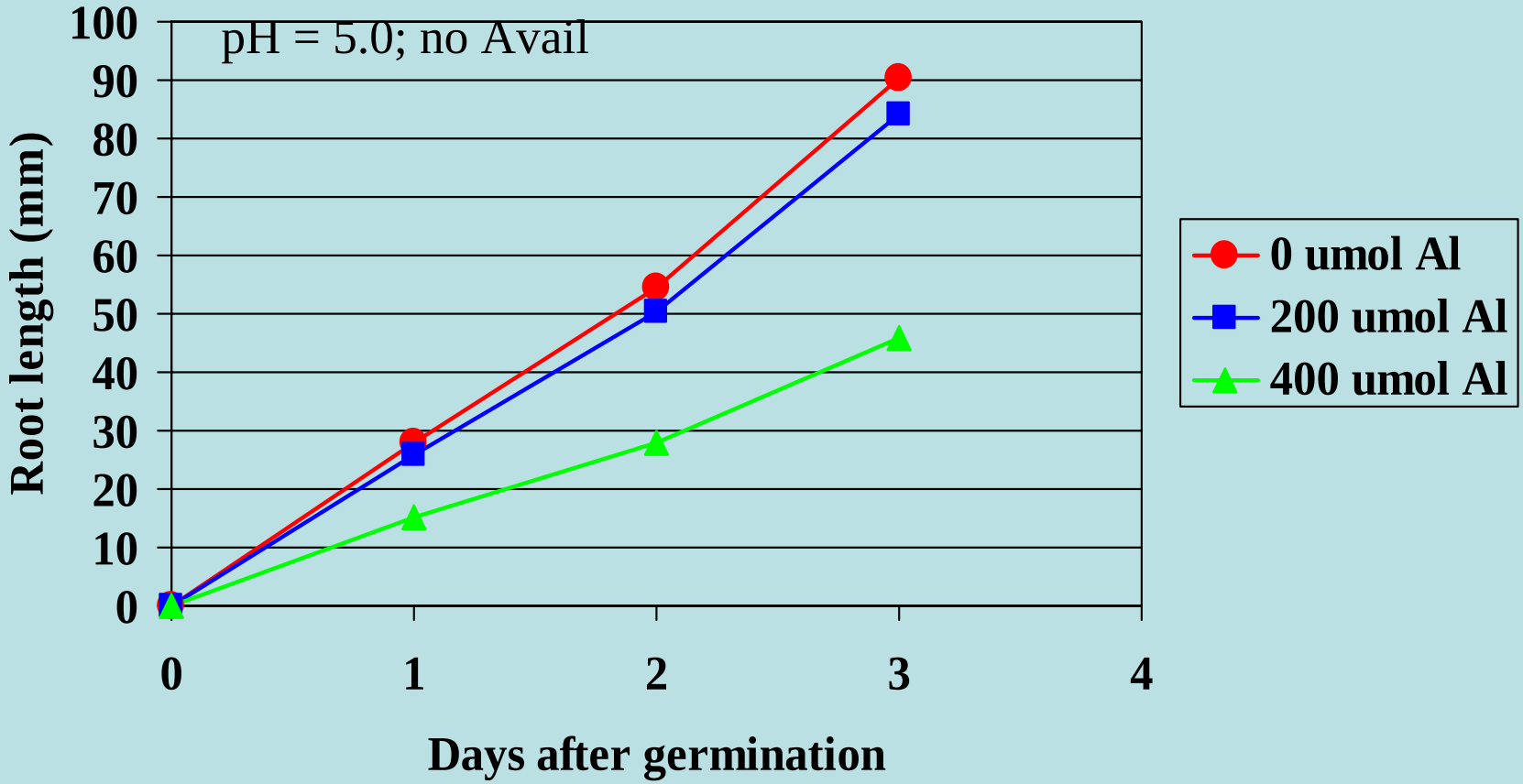
ALUMINUM EFFECTS ON WHEAT IN PRESENCE OF AVAIL POLYMER

Low pH



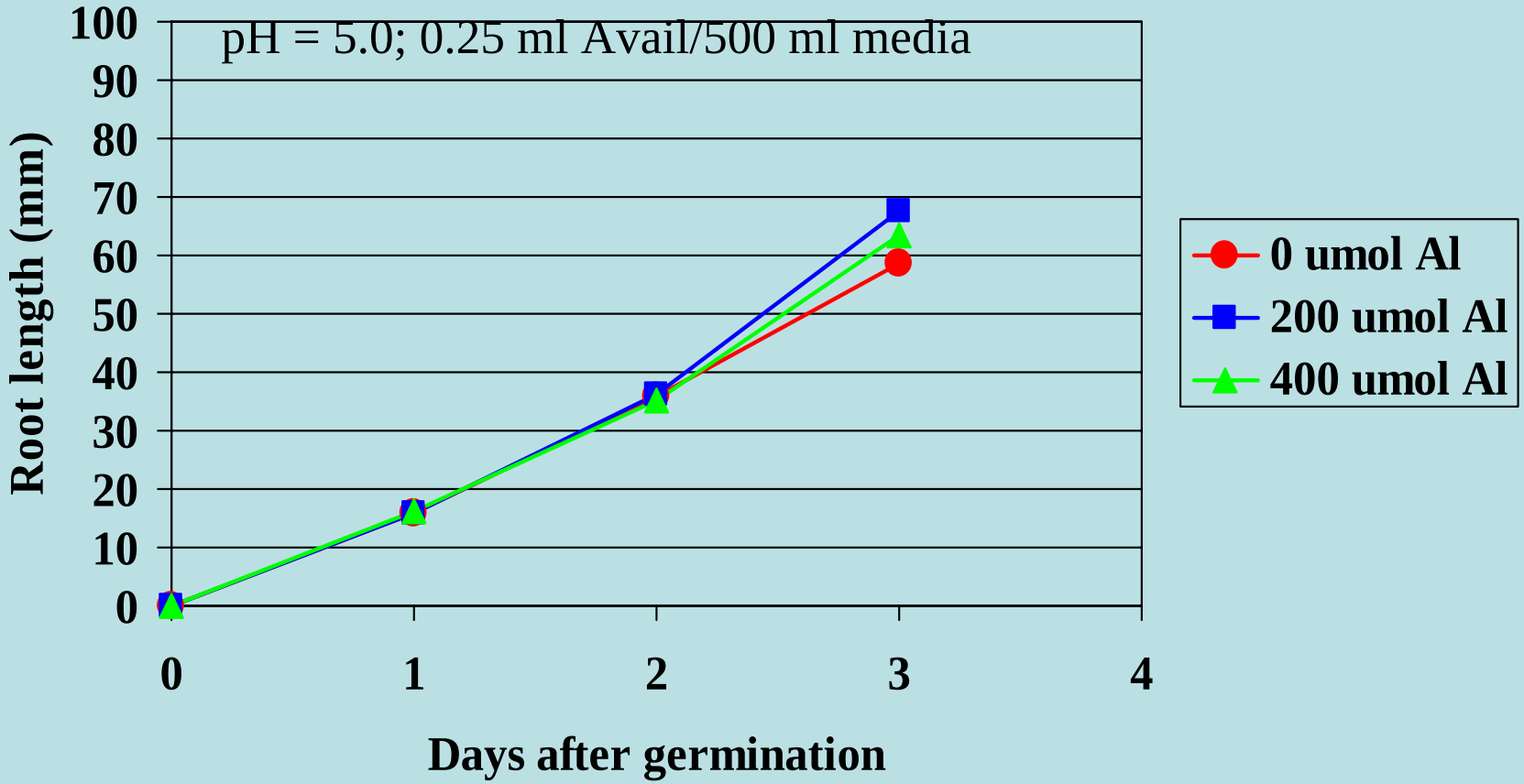
Rich Koenig, WSU

ALUMINUM EFFECTS ON WHEAT GROWTH
pH 5.0



Rich Koenig, WSU

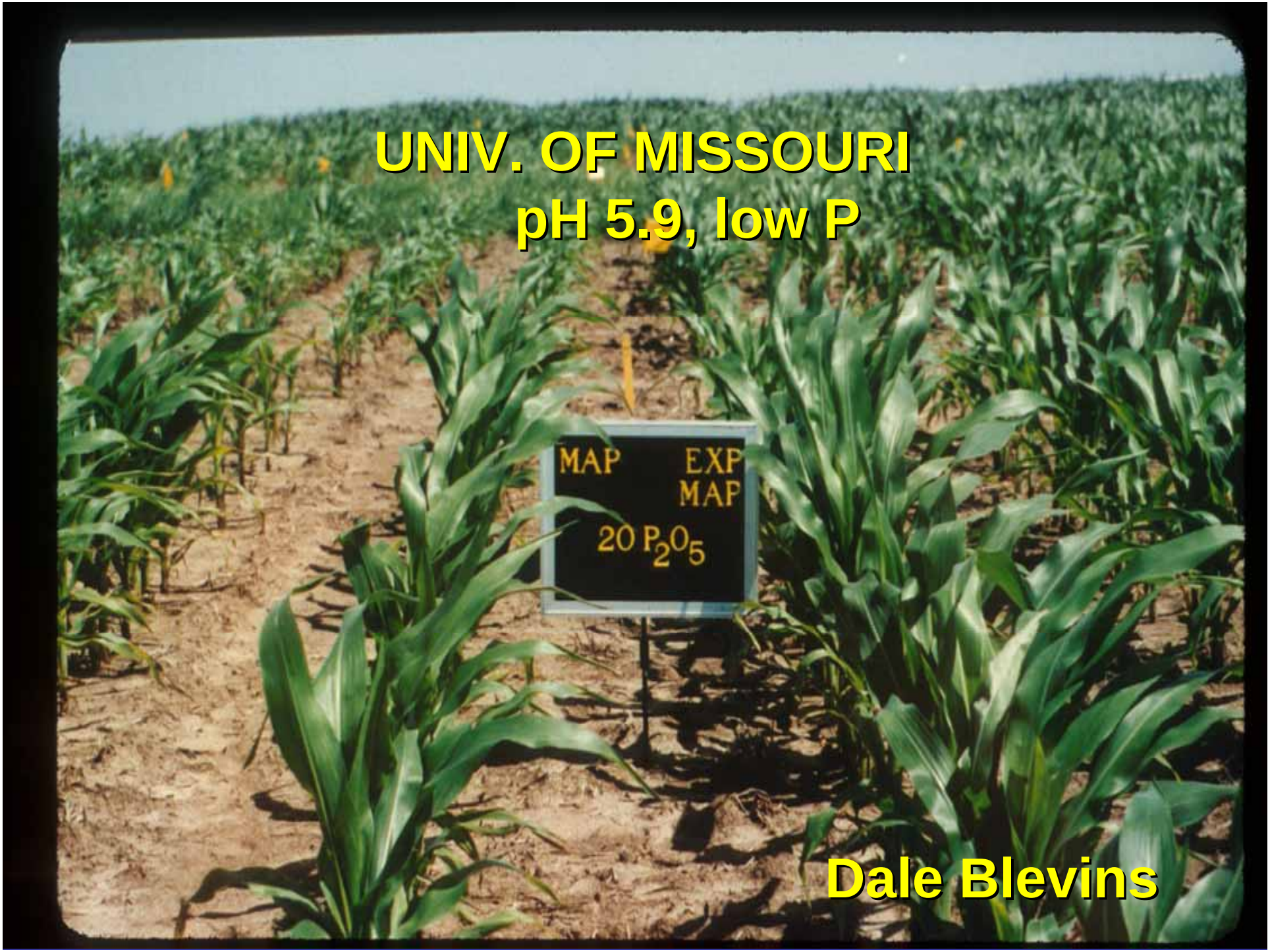
ALUMINUM EFFECTS ON WHEAT GROWTH IN PRESENCE OF AVAIL POLYMER
pH 5.0



Rich Koenig, WSU

WSU WORK HELPS CONFIRM THEORY OF AVAIL EFFECTS ON P FIXING CATIONS

- ***Polymer lowers the activity of multivalent cations in solution*.**


UNIV. OF MISSOURI
pH 5.9, low P
MAP
EXP MAP
20 P_2O_5
Dale Blevins

CORN RESPONSE TO ENHANCED P AVAILABILITY
Missouri

Treatment	Grain Yield bu/A
Control, no P	135
MAP broadcast	132
MAP + polymer broadcast	151
MAP banded	132
MAP + polymer banded	157
LSD (0.10)	13

1% polymer coating — Dale Blevins, Univ. of Missouri

20 lb P_2O_5/A Soil test Bray P-1: 7 ppm pH: 5.9

AVAIL RATE EFFECTS ON CORN

Kansas

Treatments	V-6 Dry wt lb/A	V-6 P Uptake lb/A	Grain yield bu/A
No P control	380	0.91	103
MAP	501	1.34	121
MAP + 1% Avail	592	1.61	138
MAP + 0.75% Avail	585	1.58	136
MAP + 0.50% Avail	620	1.73	140
MAP + 0.25% Avail	601	1.65	137
LSD .10	32	0.21	13

All P banded, 30 lb P_2O_5/A. Soil pH = 7.4; Bray P-1 P = 9 ppm

Location: Osage county, KS. Dr. Ray Lamond, Kansas State University

WHAT ABOUT RESIDUAL EFFECTS OF AVAIL?

AVAIL HAS NO RESIDUAL EFFECT
Soybeans - Kansas

Year 1 Treatment lb P_2O_5/A	Year 2 Bean Yield bu/A
0	58
30 MAP	59
30 MAP + Avail	58
60 MAP	59
60 MAP + Avail	60
$LSD_{.10}$	NS

Avail coated at 0.5%. Soil pH = 6.8.
Bray 1-P = 25 ppm.

Gordon, KSU

ENHANCING P AVAILABILITY FOR CORN
Minnesota

P Source lb P_2O_5/A	P Uptake V-6 g/12 plants	Yield bu/A
0	1.85	136
25 DAP	1.77	151
25 DAP + polymer	2.72	172
50 DAP	2.17	155
50 DAP + polymer	2.47	175
LSD (0.10)	0.71	18

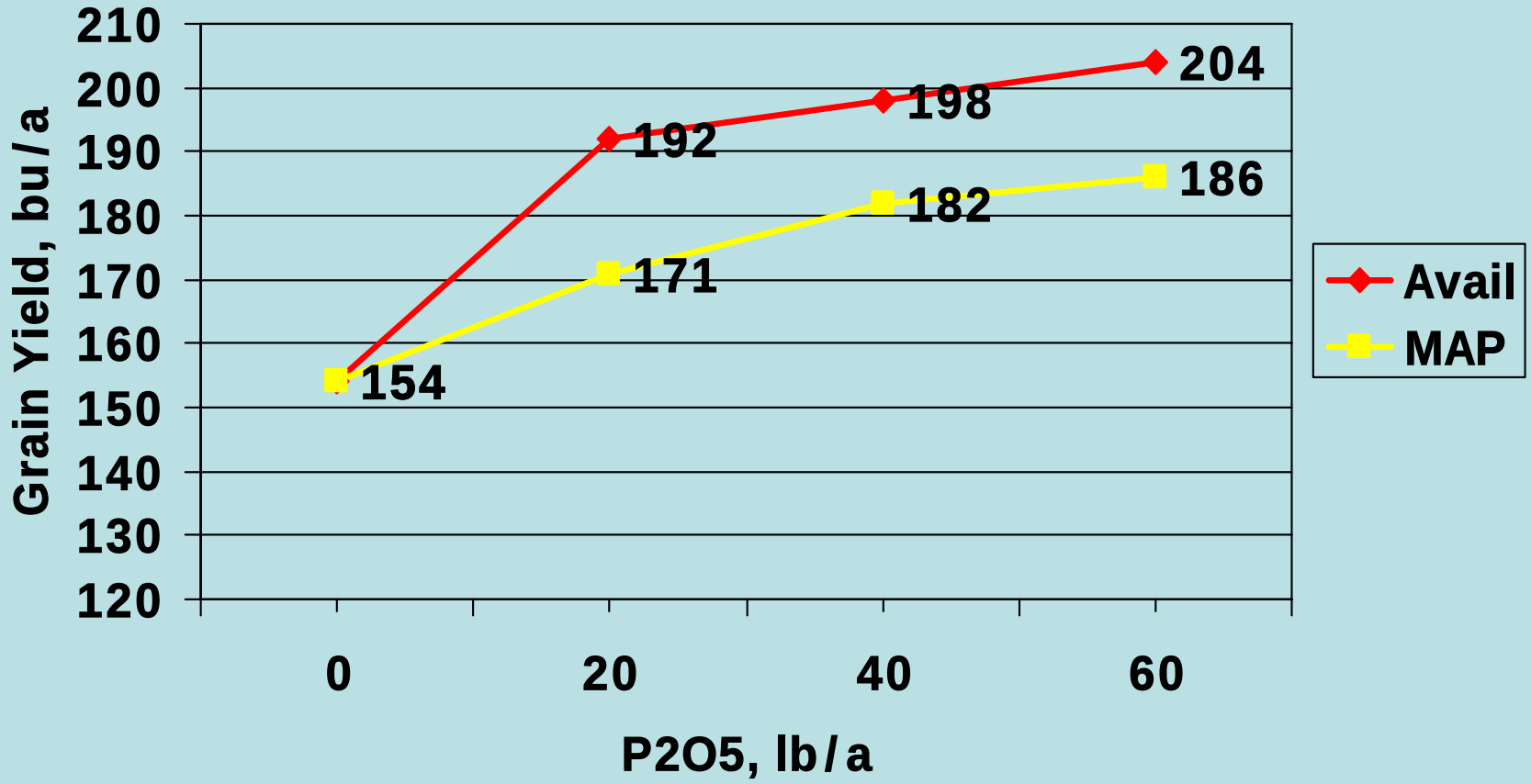
P broadcast, 0.25 % polymer coating. Randall, Univ. of Minnesota
Soil pH: 7.3 Soil test P: 7 ppm Olsen.

Tom Haigh—JRS Kansas and Dr. Barney Gordon KSU


KSU, North Central Exp. Field
MAP
STARTER
60 P_2O_5
CK
SFP
NO POLYMER
POLYMER

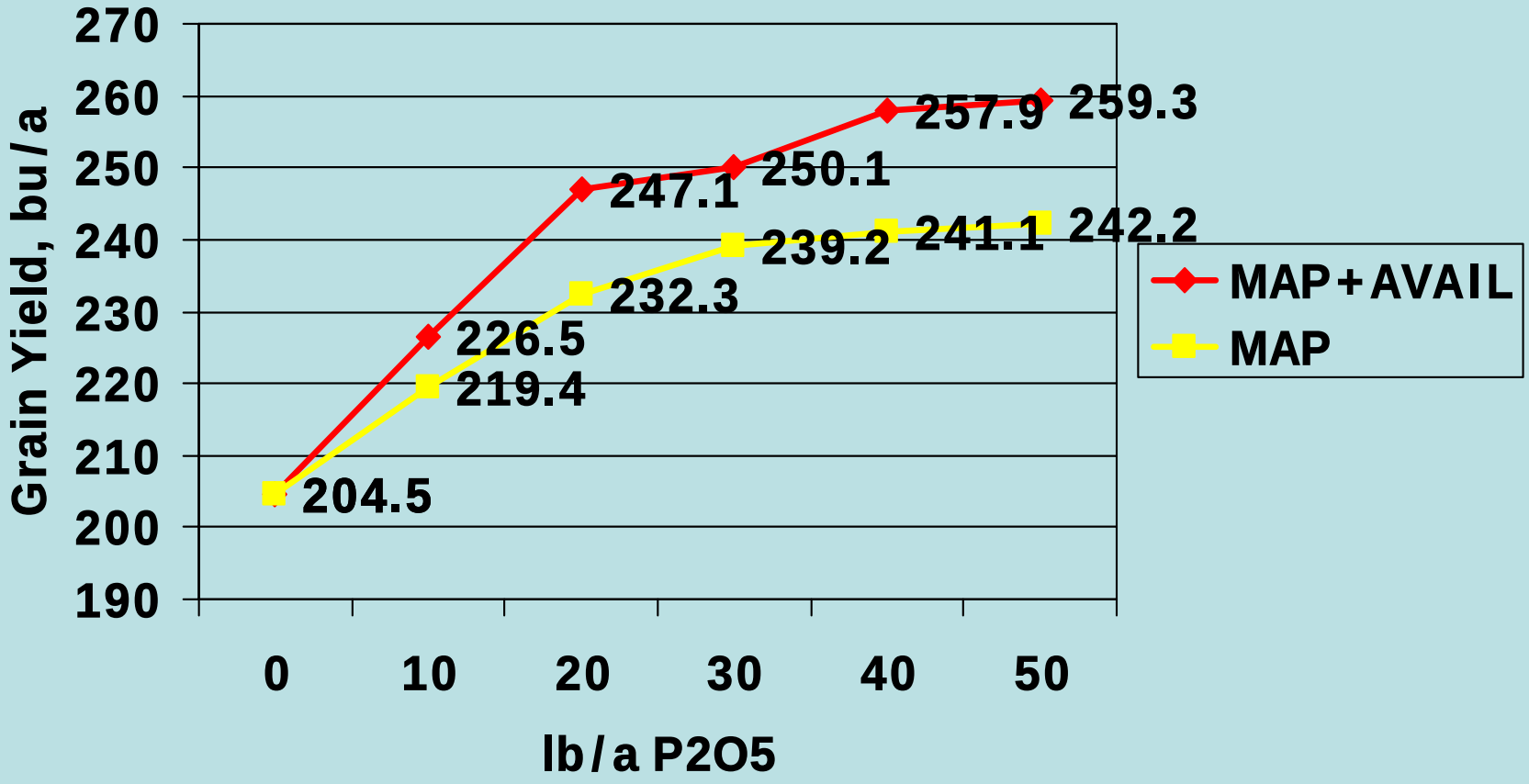

AVAIL
NO AVAIL
MAP
MAP
EXP
60 P
KANSAS

Avail Effects on Corn Grain Yield 2001-2003 Kansas



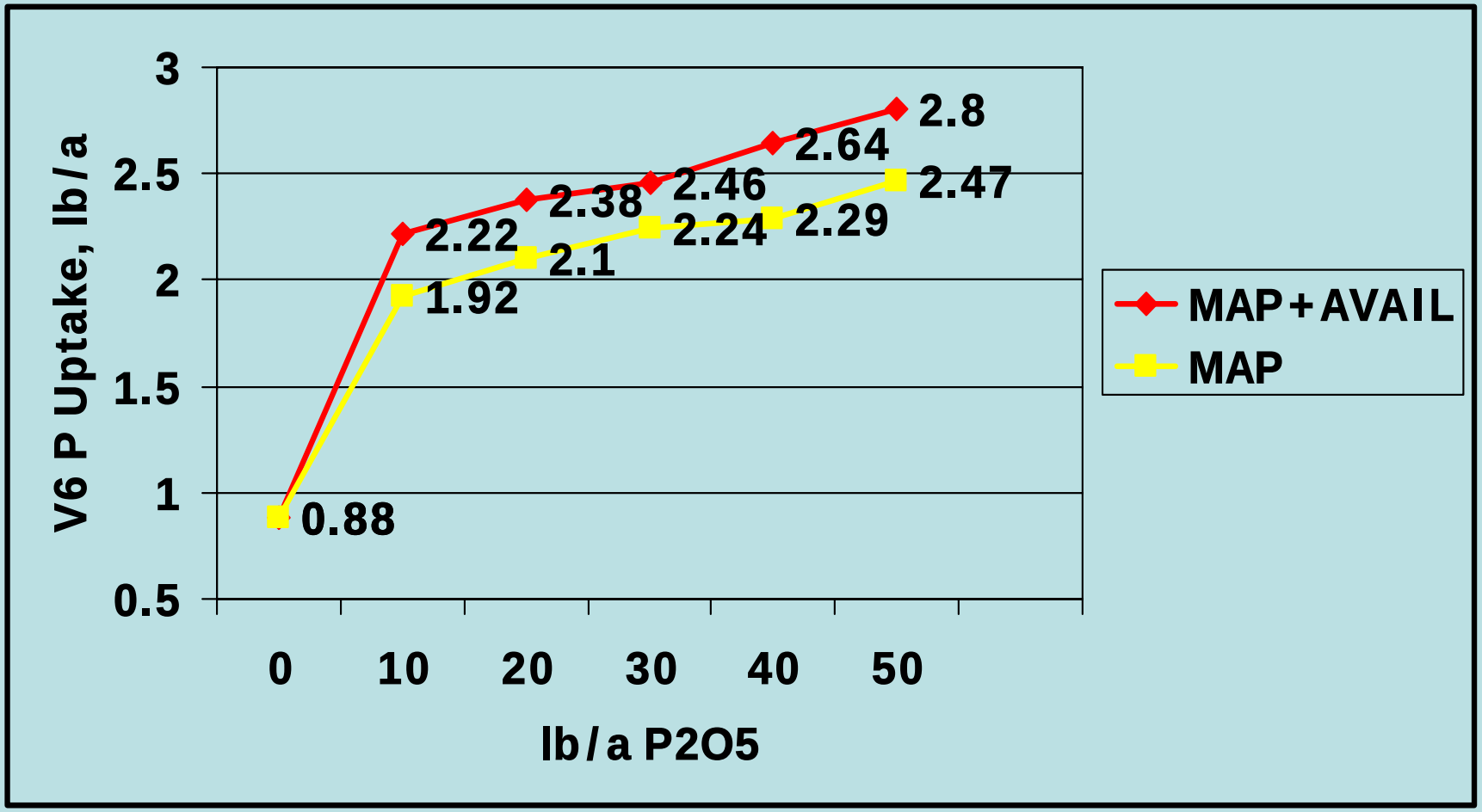
Barney Gordon, KSU

Corn Grain Yield, 2004 Scandia,KS



Barney Gordon, KSU

V6 Whole Plant P Uptake, 2004
Scandia, KS



Barney Gordon, KSU

Kansas State University NorthCentral R&D Center--2006

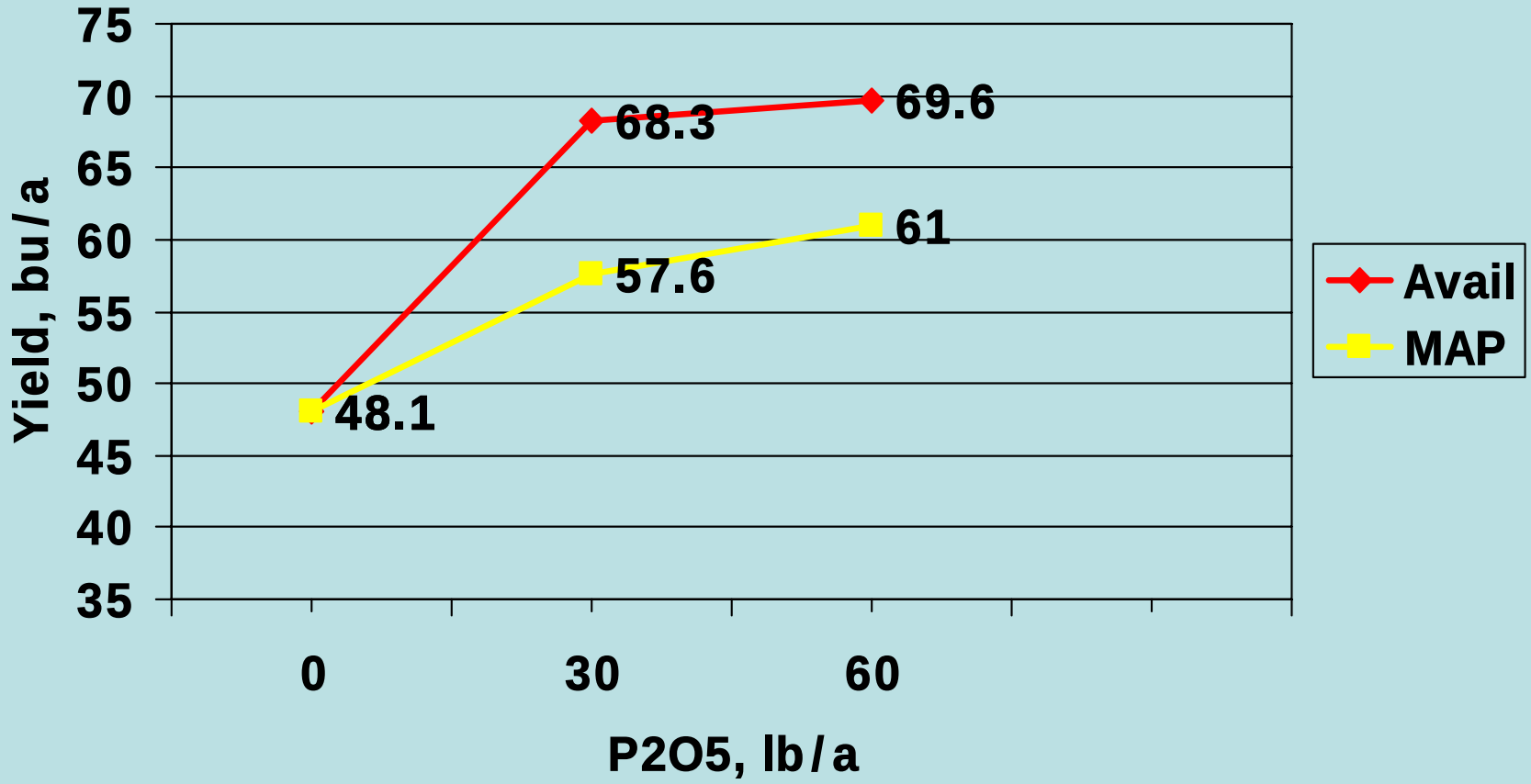
STUDIES WITH SOYBEANS

ENHANCING P AVAILABILITY FOR IRRIGATED SOYBEANS
Kansas

Treatments lb P_2O_5/A	2002 Grain Yield bu/A	2003 Grain Yield bu/A
Control	52d	32d
30 MAP	62c	41c
30 MAP + polymer	70b	57a
60 MAP	62c	47b
60 MAP + polymer	73a	58a

Duncan's multiple range test, 5%. Gordon, Kansas State Univ.
P broadcast preplant. Soil test P: 38 ppm Bray 1. Soil pH: 6.8.
0.25% polymer.

Avail Soybean Grain Yield 2002-2004



AVAIL POLYMER EFFECTS ON SOYBEANS
Missouri – 2005

Treatments lb P_2O_5/A bu/A	P %	P Uptake lb/A	Yield
0	0.250	2.62	51
50	0.265	3.75	52
50 + Avail	0.315	4.95	56
$LSD_{.10}$	0.048	0.78	2

P applied pre-plant.
Soil pH = 6.0

D. Dunn, Univ. of Missouri

AVAIL EFFECTS ON SOIL TEST P

Missouri - 2005

Treatment lb P_2O_5/A	Bray P-1 lb/A
0	29.5
50	54.0
50 + Avail	73.2
$LSD_{.10}$	6.7

Soybeans. pH = 6.0 D. Dunn, U. of Missouri

POLYMER EFFECTS ON SOIL TEST P

Rice-Missouri

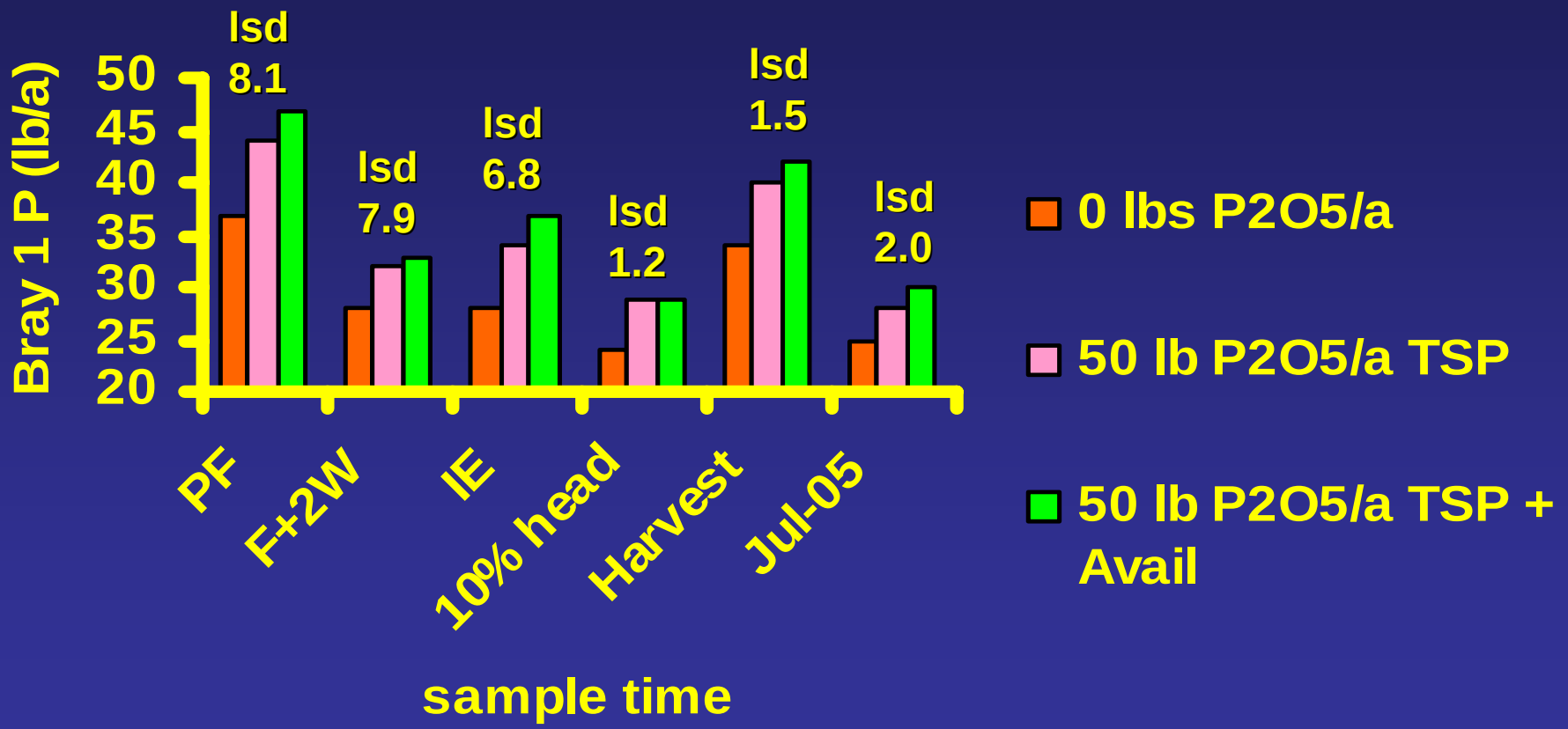
P Rate lb P_2O_5/A	Soil test P - Post flood (Bray 1, lb/A) Untreated TSP	Treated TSP
0	27.5	
25	29.5	33.0
50	31.8	33.2
100	29.5	42.0
$LSD_{.05}$	7.9	

Soil pH 6.6

Dunn, Univ. of Missouri

2004 Soil Test Values

Rice- Missouri



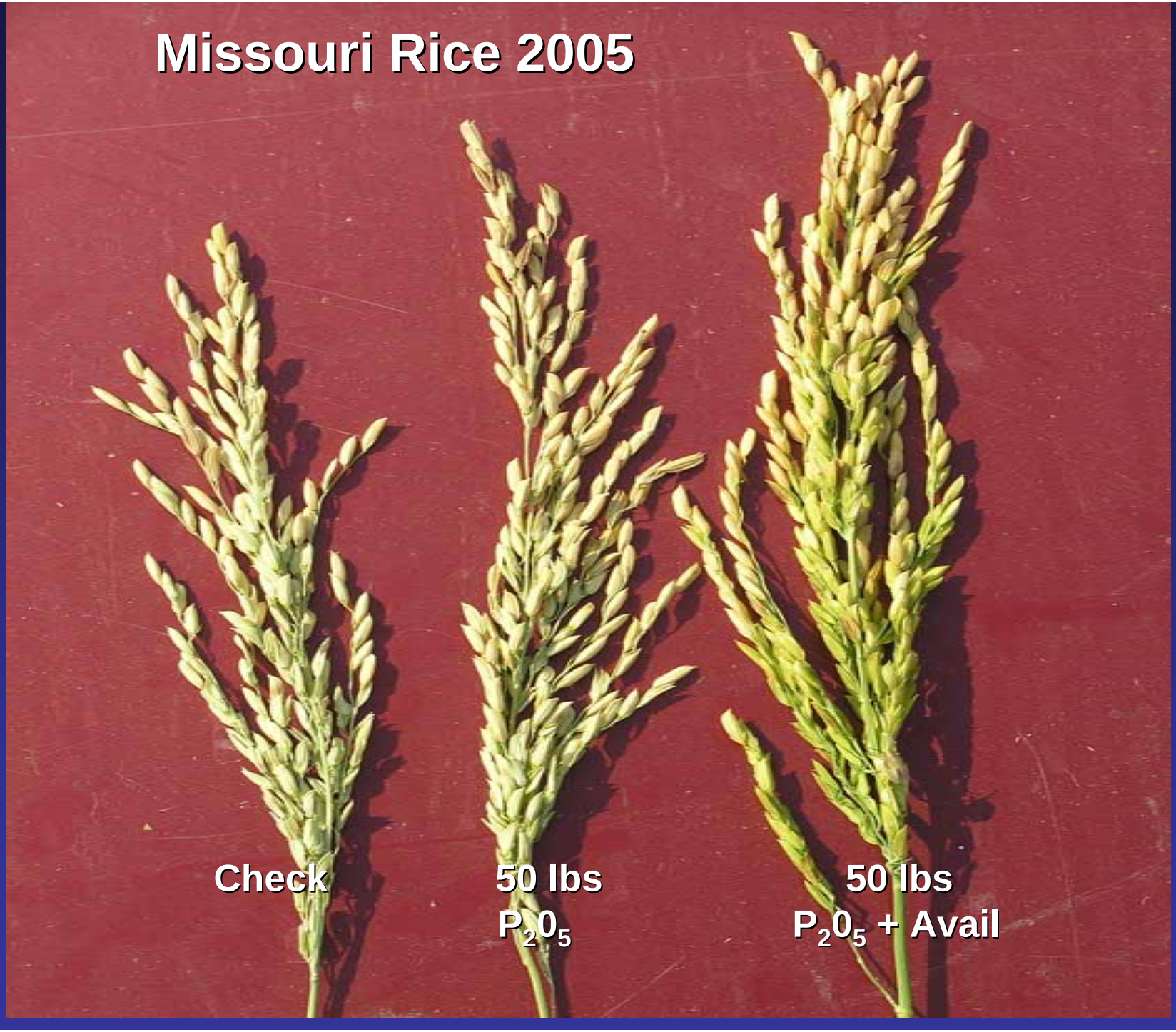
ENHANCING P AVAILABILITY FOR RICE

Missouri--2004

P_2O_5 Rate lb/A	Yield, bu/A		Grain moisture, %	
	Uncoated	Avail Coated	Uncoated	Avail coated
0	164		12.2	
25	164	174	12.3	12.0
50	174	179	12.0	11.7
100	183	182	12.1	12.2

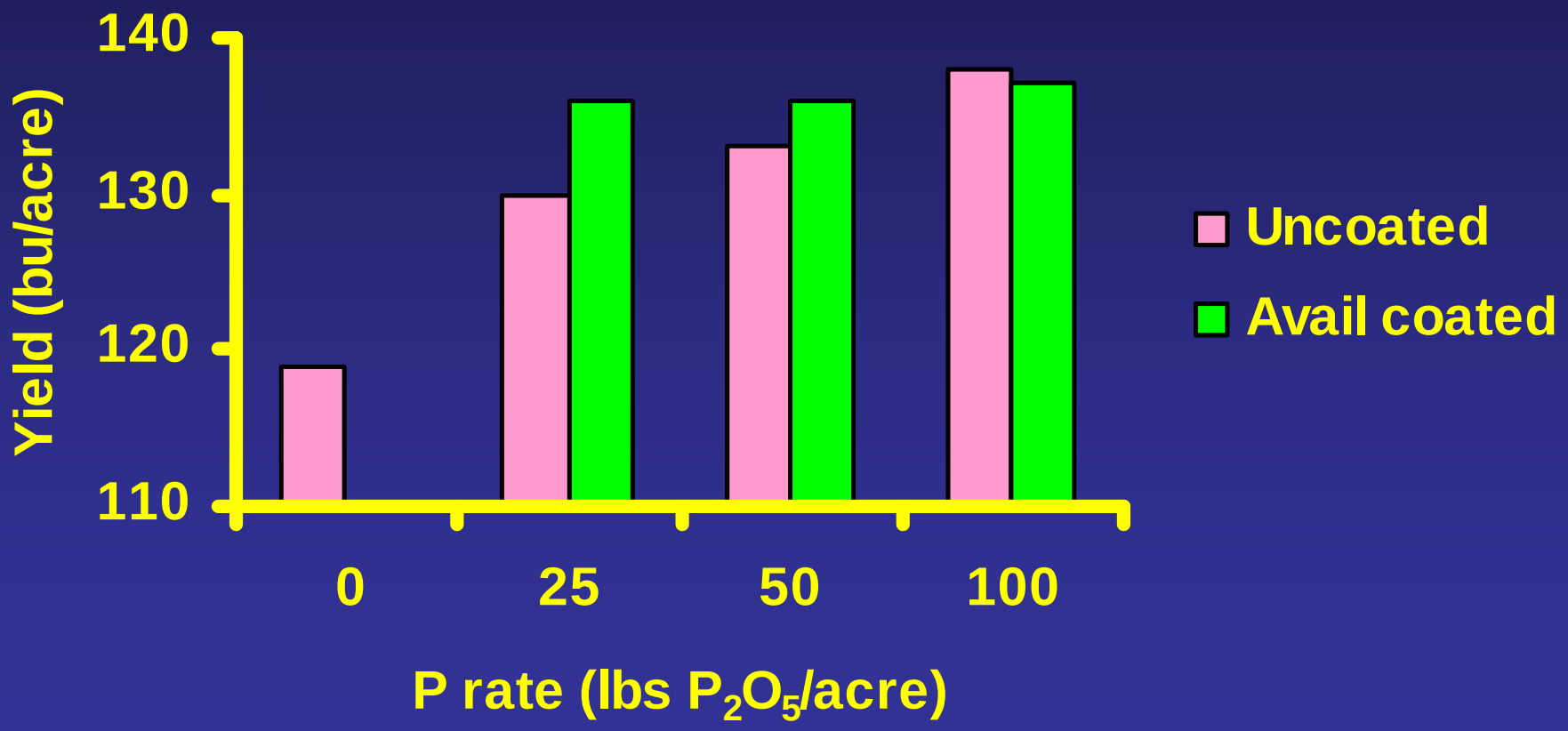
Soil pH = 6.8; Soil test P = 38 ppm Bray-1 Dunn, Univ. of Missouri
P source = TSP preplant

Missouri Rice 2005



Avail Effects on Rice

Missouri--2005



P source TSP

Pre-plant Bray 1 P = 8 lbs/a
pH (salt) = 5.9

POTATOES and ONIONS


Avail
No Avail
EXP
MAP
MAP
120 P_2O_5
Dr. Jeff Stark, Univ. of Idaho

Potato Yield and Return Responses to Enhanced P Availability

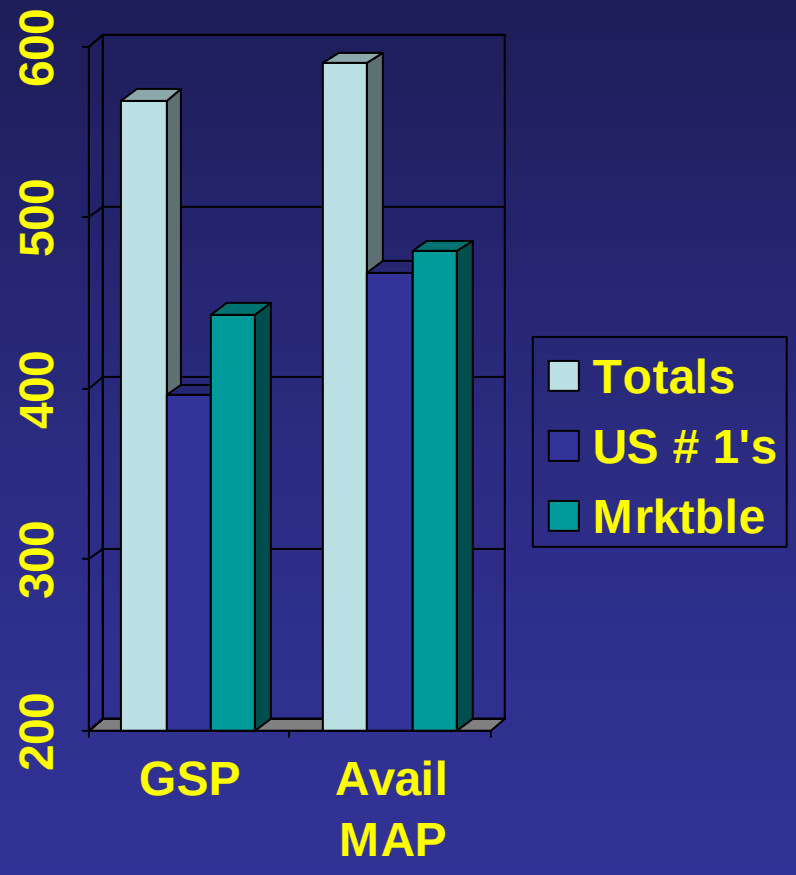
Idaho

Treatment Applied	Yield CWT/A	Petiole P%	Gross Return
Control	311a	.225d	1456
MAP 60 lb P205/Ac	330ab	.253cd	1546
MAP 120 lb P205/Ac	344bc	.275bc	1591
MAP + Exp 60 lb P2O5/A	339ab	.288ab	1575
MAP + Exp 120 lb P2O5/A	369c	.308a	1791

Calcareous soil, Aberdeen, ID Jeff Stark, University of Idaho

2006 Potato Grower Trials

- Farbo Farms
- Treasure Valley ID
- 180 lbs/ac P2O5 as
- MAP with and w/o Avail



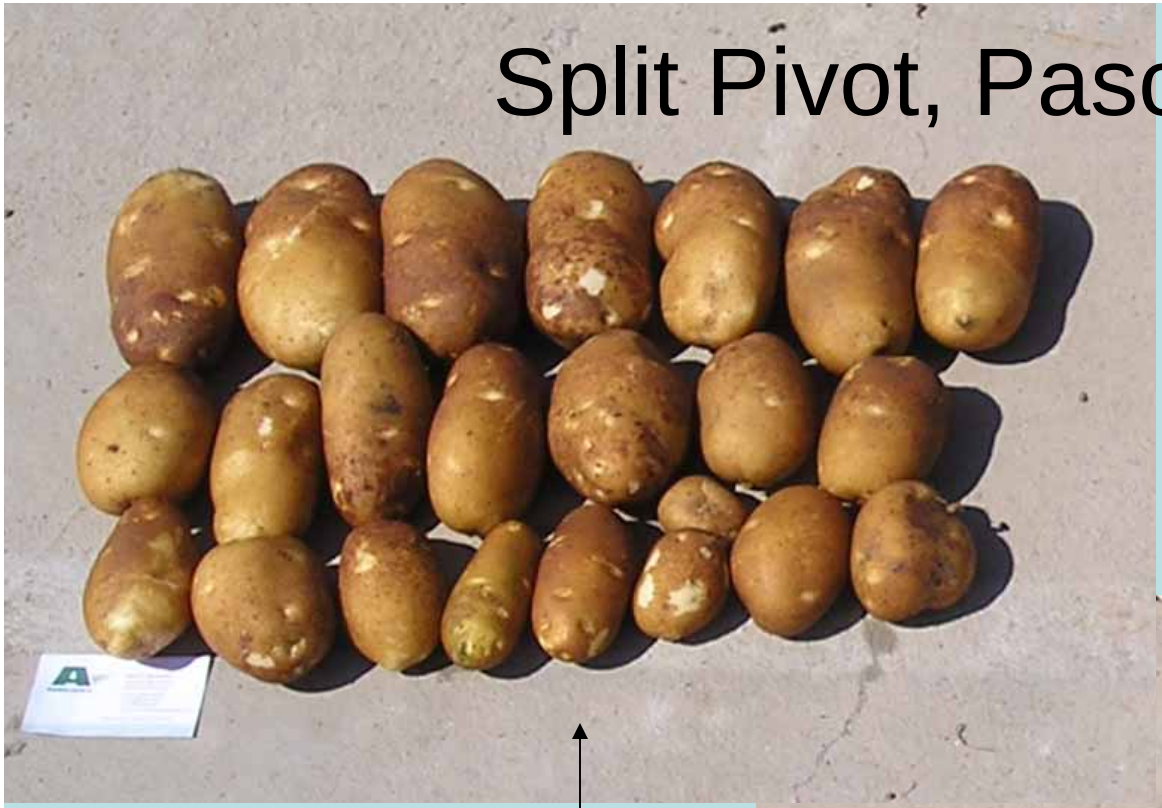
Crop Advisor Introduction of Avail SD to Growers-2006

10-34-0—Grower Standard Practice

Avail SD w/10-34-0

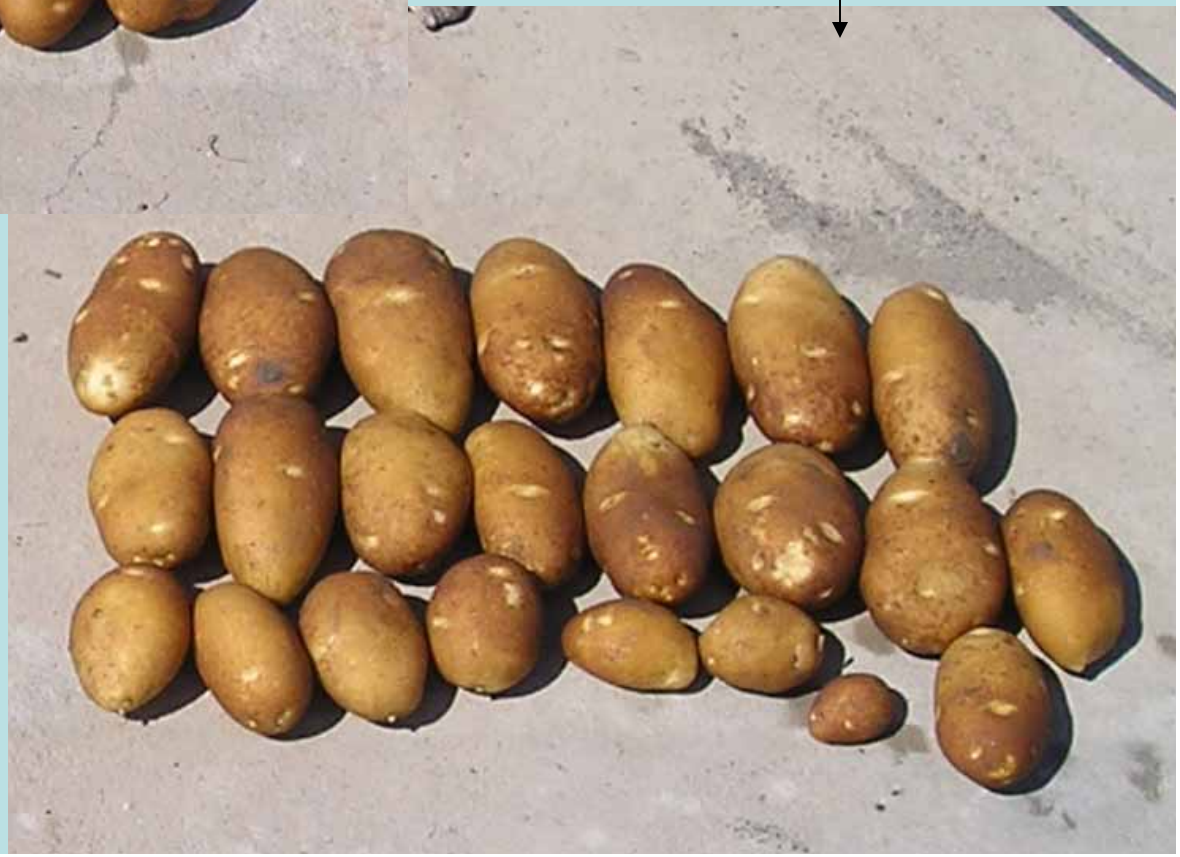

Grower Standard Practice
Avail SD w/10-34-0

Split Pivot, Pasco, WA



No Avail

Avail



RESEARCH CONTINUES

- Polymer rates in fluid starters
- P rates x polymer interactions
- Time of application..fall vs spring
- Large scale field trials
- Polymer effects on soil reaction products
- Other polymer applications

Growers Comments

- I went from 50 acres of onions w/Avail SD in 2005 to 1000 acres in 2006. I owe the positive change in my onion production and quality to Avail P Technology.

- Larry Meyers—L & L Farms—Othello WA August 2006

New Rock Springs Applicator 11-52-0 w/Avail

- Avail (base)
- Metered application
- ½ gpt rate
- 2 x 250g totes
- 50g / RR car = 10 cars
- 2nd pump to be installed

  (as back-up)
- Replaces 2nd wax coating

Avail Impregnation--RS

Rock Springs Application

- After Avail application….
- Ribbon Blender
- Thorough product mix
- 250 TPH
- No lost time at RS

Post - application

Scandia, Hedges – Dry Transloads
Avail (base) - Applications

Economics

- Grower costs of Avail is about .08/lb of P_2O_5
- Grower costs of Avail SD or Avail OS is about $150.00/gallon and applied at either .5 % or 1.5% by volume.

SUMMARY

- Polymer coatings of P materials have been and continue to be effective
- Slowed solubility a factor in lessening germination damage in sensitive crops
- Delayed P fixation reactions improve P use efficiency
- Cost effective
- Large scale use underway—5 million + acres 2007

Thank You

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