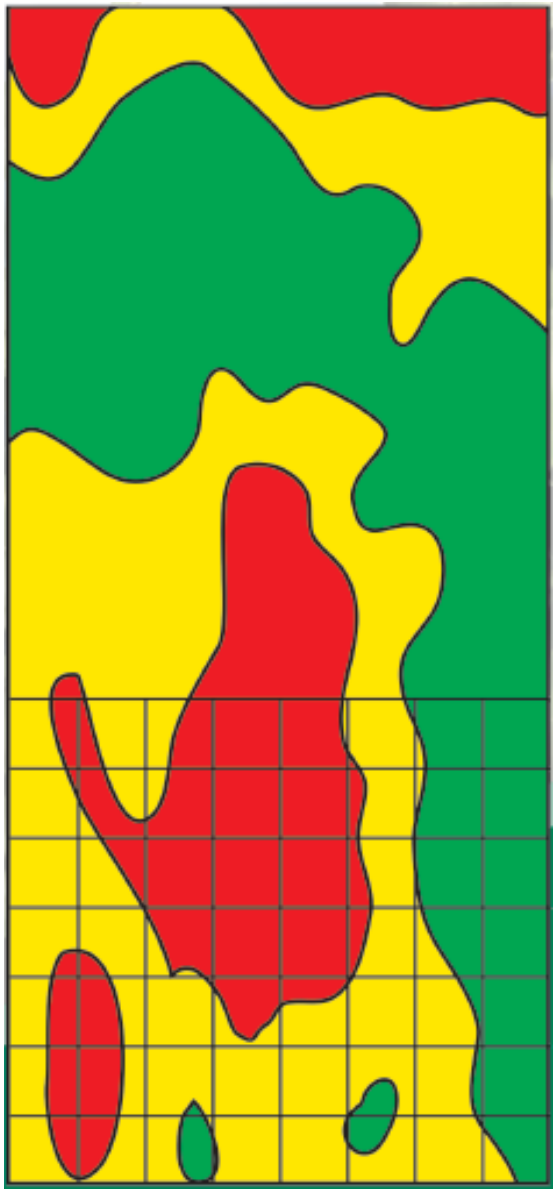
To Broadcast or Band: A Look at Long-term Soil Fertility Management



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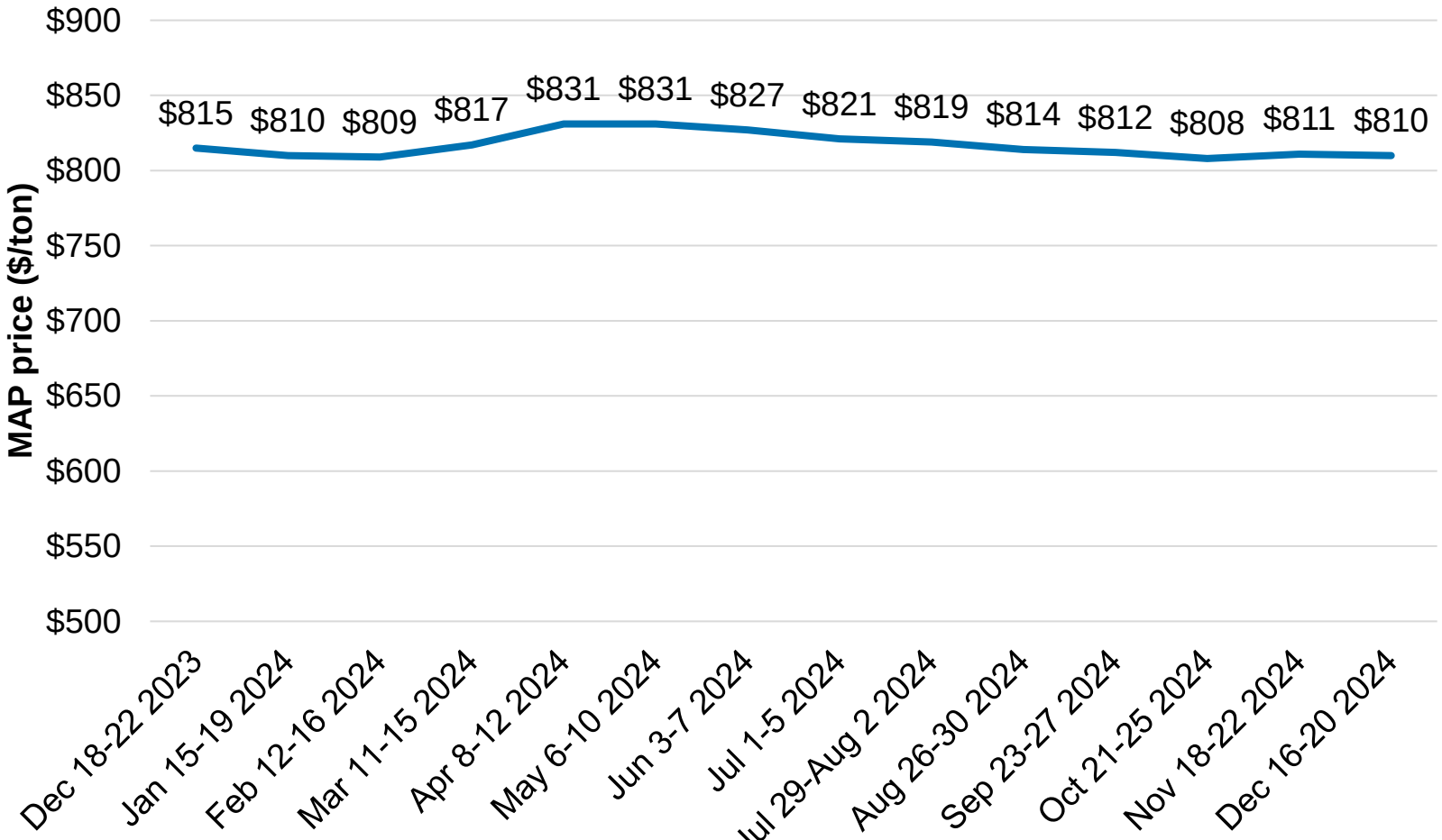
Questions from growers

- Which is better, broadcast or banding?
- How much can I reduce fertilizer rates if I band fertilizer?
- Why aren't my soil test levels increasing? I have been trying to build soil test levels.
- I bought a new strip-till rig!!!

Phosphorus prices remain high
MAP (11-52-0) national average



Quinn, R. 2024. DTN retail fertilizer trends. DTN, 24 Dec. 2024. https://www.dtnpf.com/agriculture/web/ag/crops/article/2024/12/24/fertilizer-prices-now-lower (accessed 2 Jan. 2025)

Comparison of fertilizer placement

Broadcast: surface or incorporated

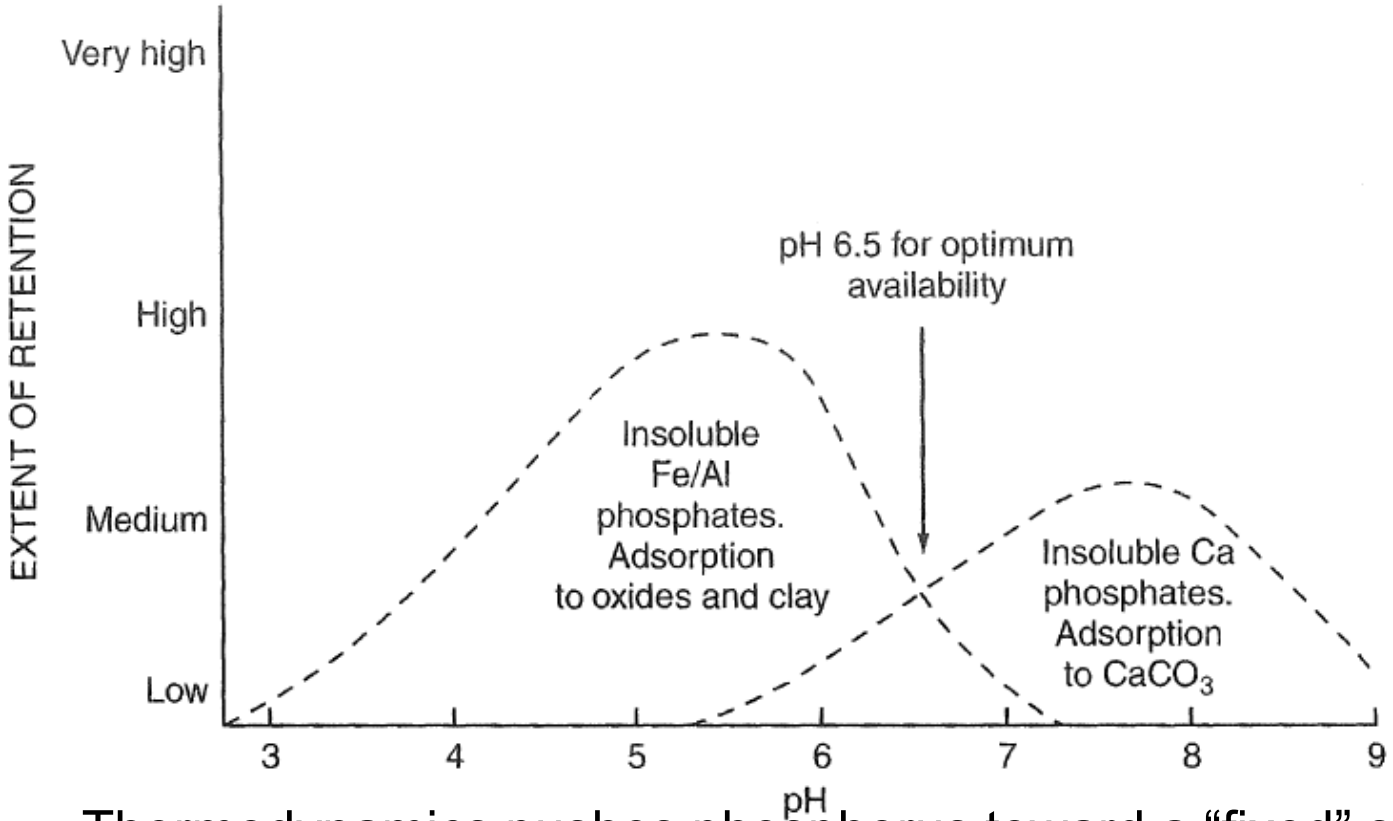
Band: seed-placed, 2x2, or mid-row

Image from http://www.syngenta-us.com/thrive/news/root-health-tools.html

Why do we band fertilizer?

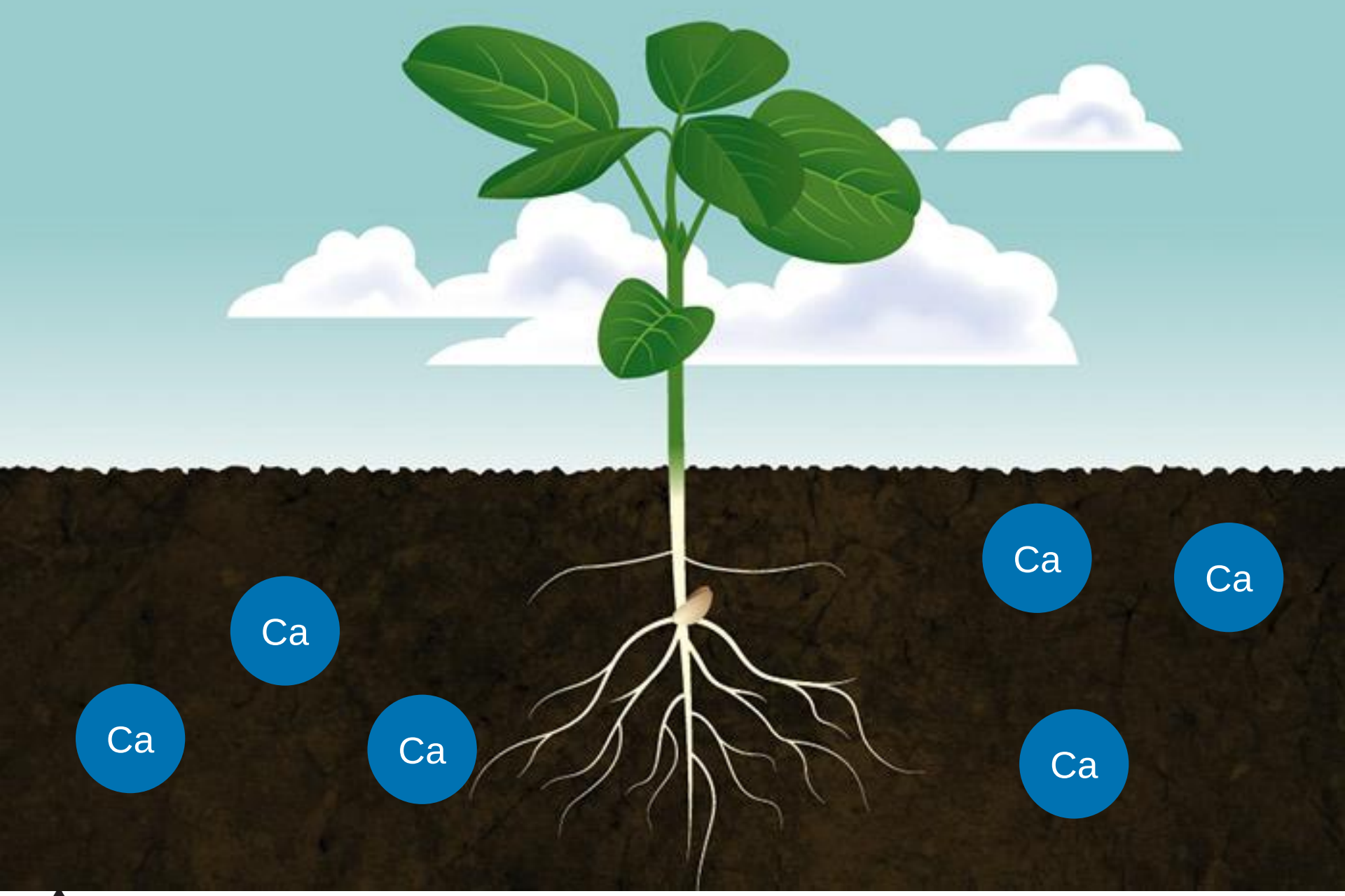
- **Crop response to fertilizer placement**
- Place fertilizer near plant roots
  - **Provide "starter" effect** for young plants
- **Reduce fixation reactions** or "tie-up", less soil interacting with fertilizer
- Combine planting and fertilizer **application in one pass**
- Place fertilizer below soil surface to **reduce environmental losses**

Phosphorus fixation: What are we trying to overcome with banding?



- Thermodynamics pushes phosphorus toward a “fixed” state
- Banding concentrates fertilizer and reduces interaction with soil and fixation reactions

Havlin, J.L., J.D. Beaton, S.L. Tisdale, and W.L. Nelson. 2005. Soil Fertility and Fertilizers: An Introduction to Nutrient Management. 7th ed. Pearson Prentice Hall, Upper Saddle River, NJ.



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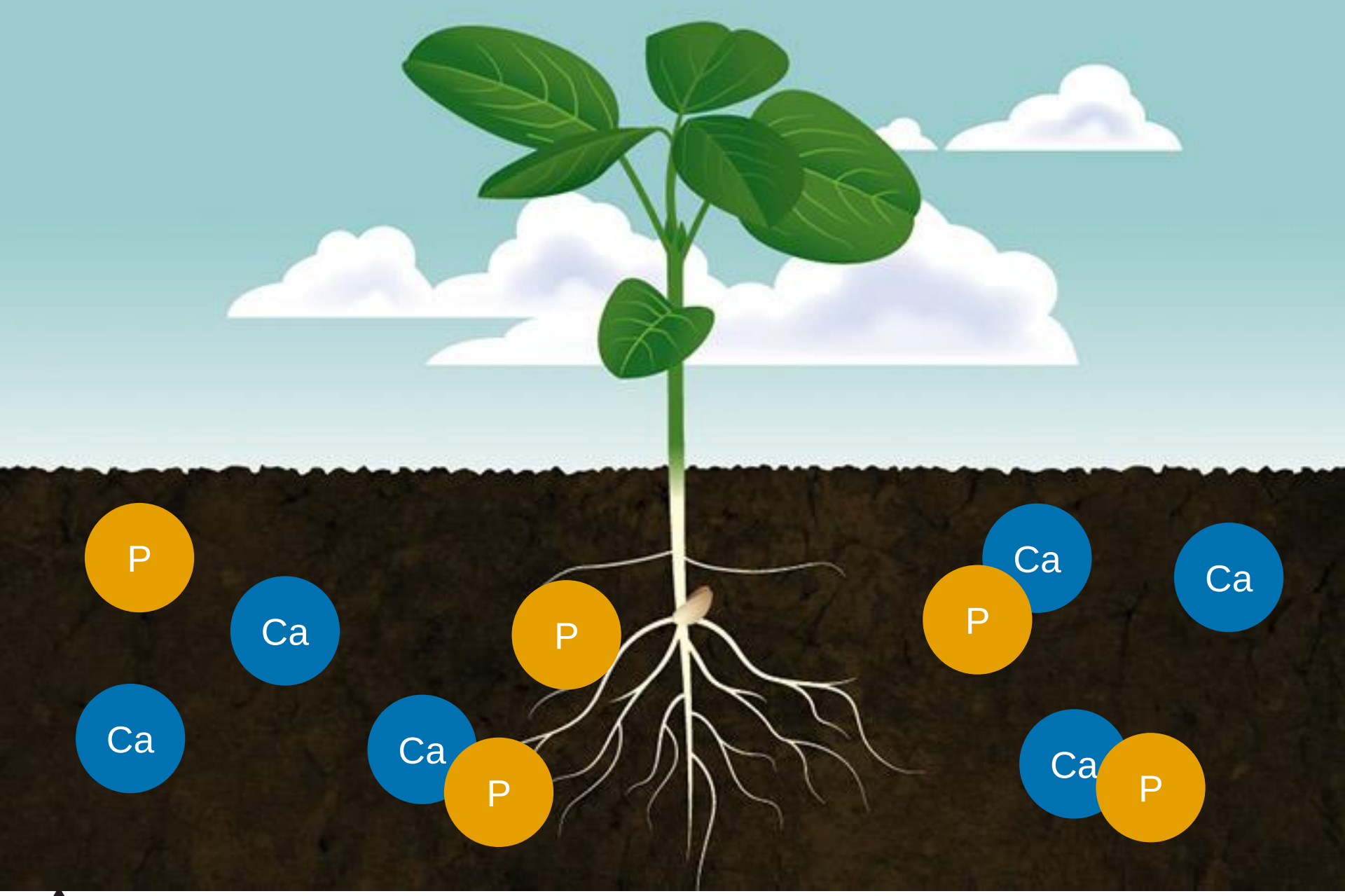

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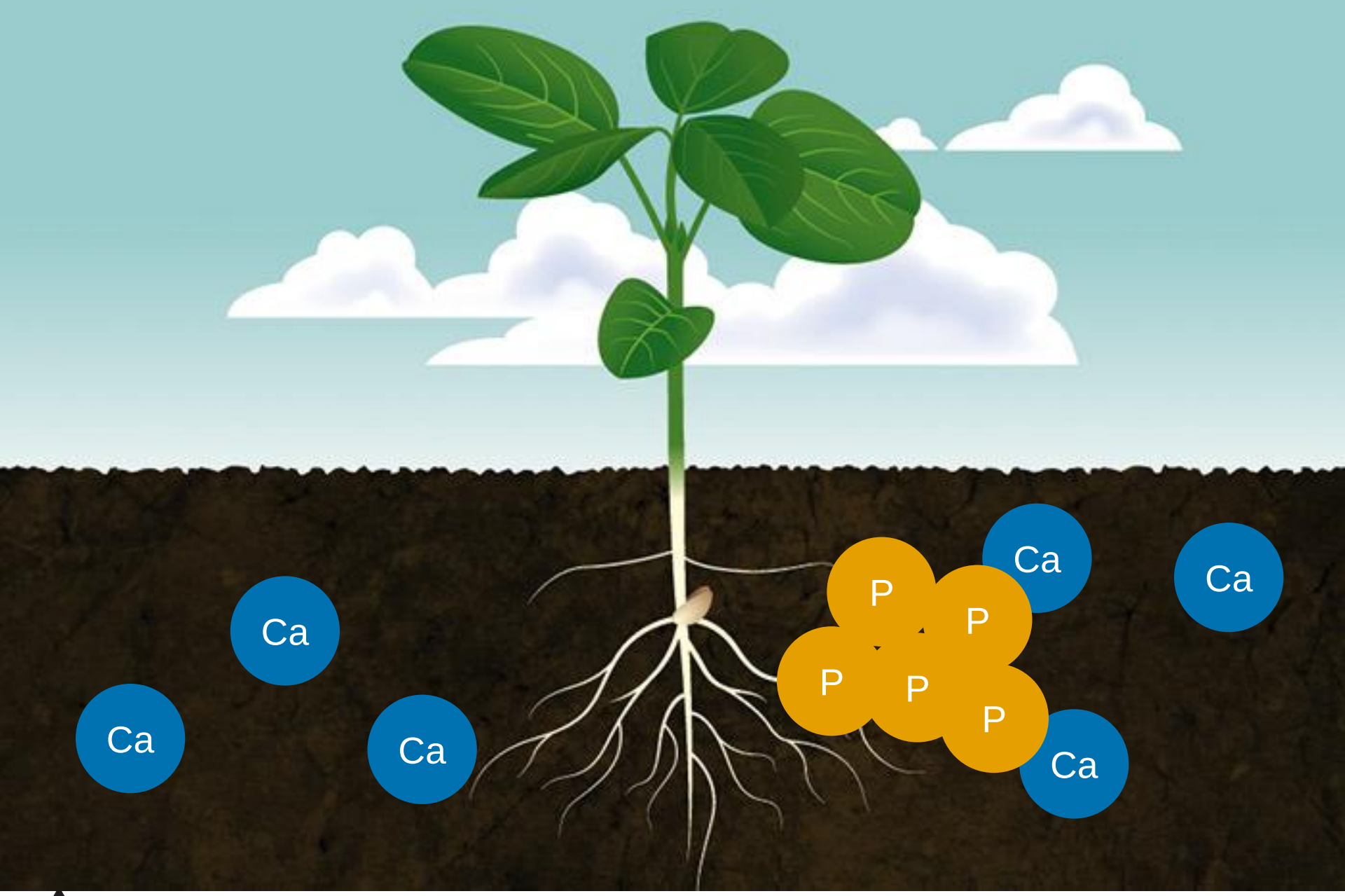

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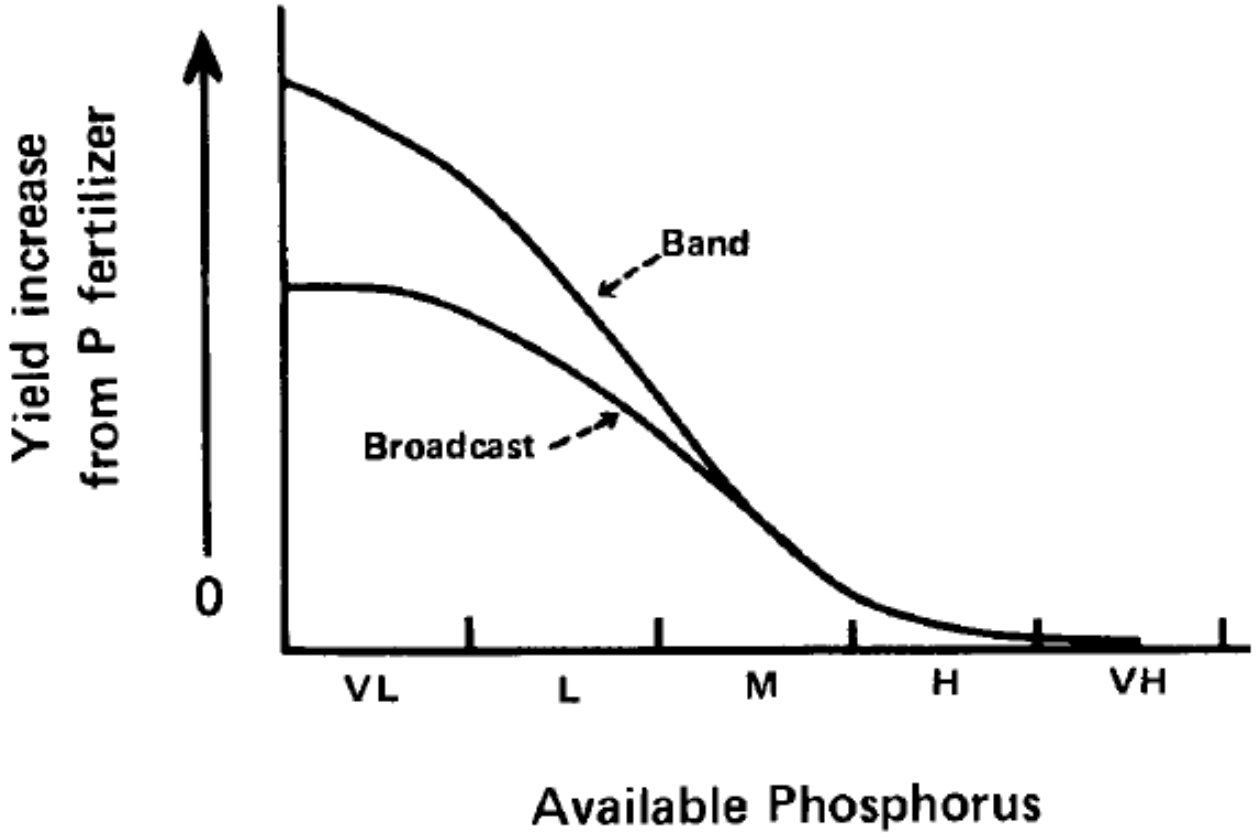
Banding P and K: Where is the gain?



Randall, G.W., and R.G. Hoeft. 1988. Placement methods for improved efficiency of P and K fertilizers: A review. J. Prod. Agric. 1(1):70–79.

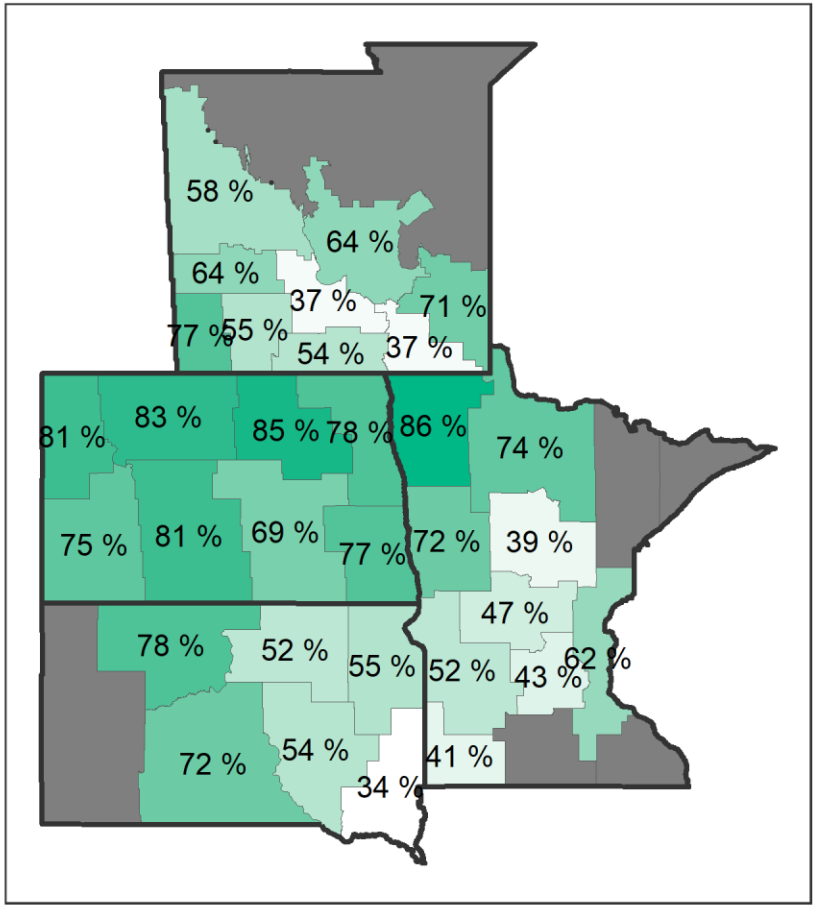
Soil test interpretation categories

Soil test category	Relative nutrient supply from soil	Probability of crop response
Very high	100%	<5%
High	90-100%	5-30%
Medium	70-90%	30-60%
Low	**50-70%**	**60-90%**
Very low	**<50%**	**>90%**

- Banding optimizes efficiency at very low and low soil test levels, where less of the nutrient supply comes from soil
- Residual or “leftover” fertilizer contributes to soil nutrient supply for next year

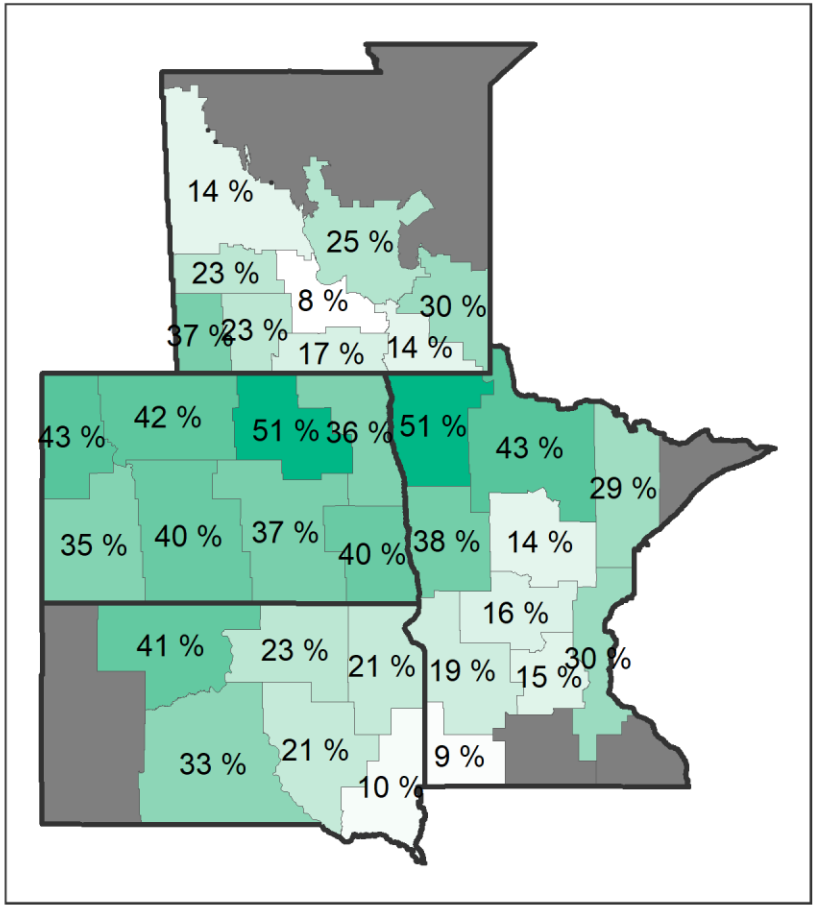
Havlin, J.L., J.D. Beaton, S.L. Tisdale, and W.L. Nelson. 2005. Soil Fertility and Fertilizers: An Introduction to Nutrient Management. 7th ed. Pearson Prentice Hall, Upper Saddle River, NJ.

Soil samples with soil test phosphorus below 15 ppm (Olsen P) in 2024



Data not shown where n< 100
AGVISE Laboratories, Inc.

Soil samples with soil test phosphorus below 8 ppm (Olsen P) in 2024



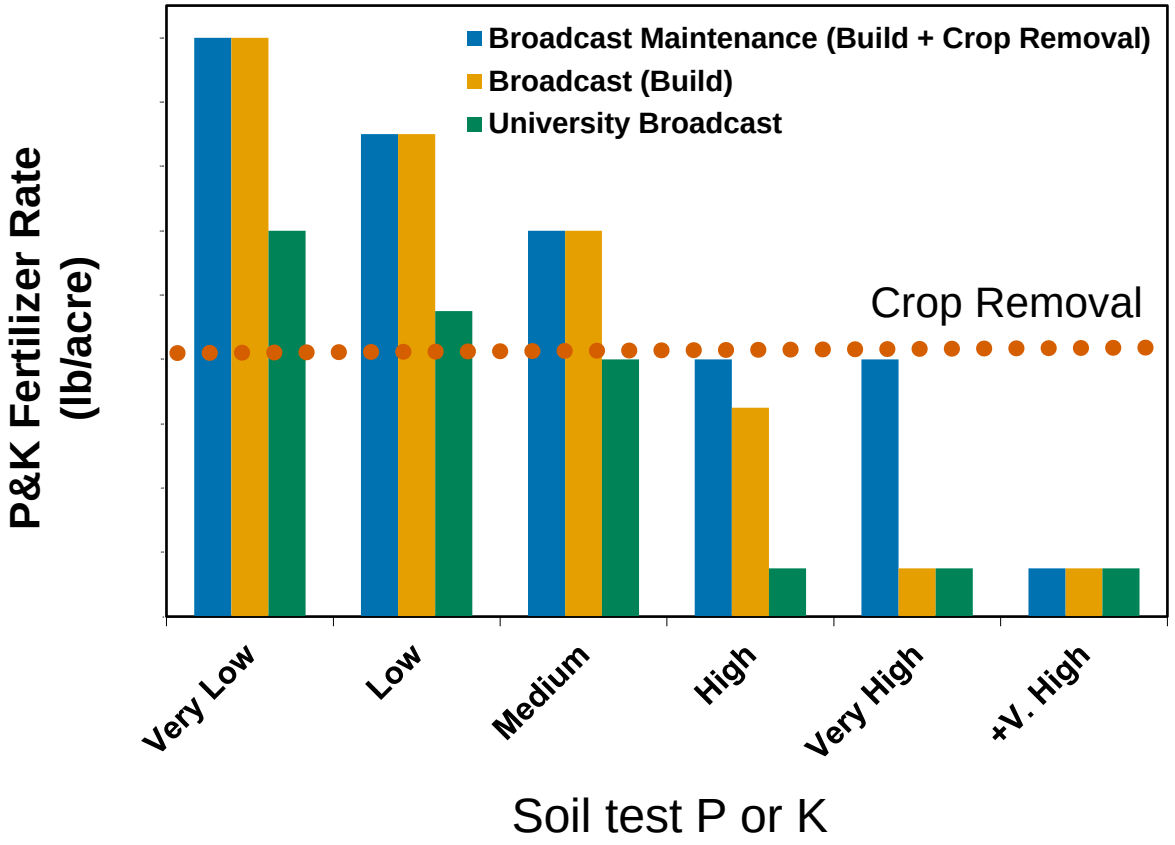
Soils in the very low and low soil test P category

Percent of samples (0-6 inch)

50
40
30
20
10

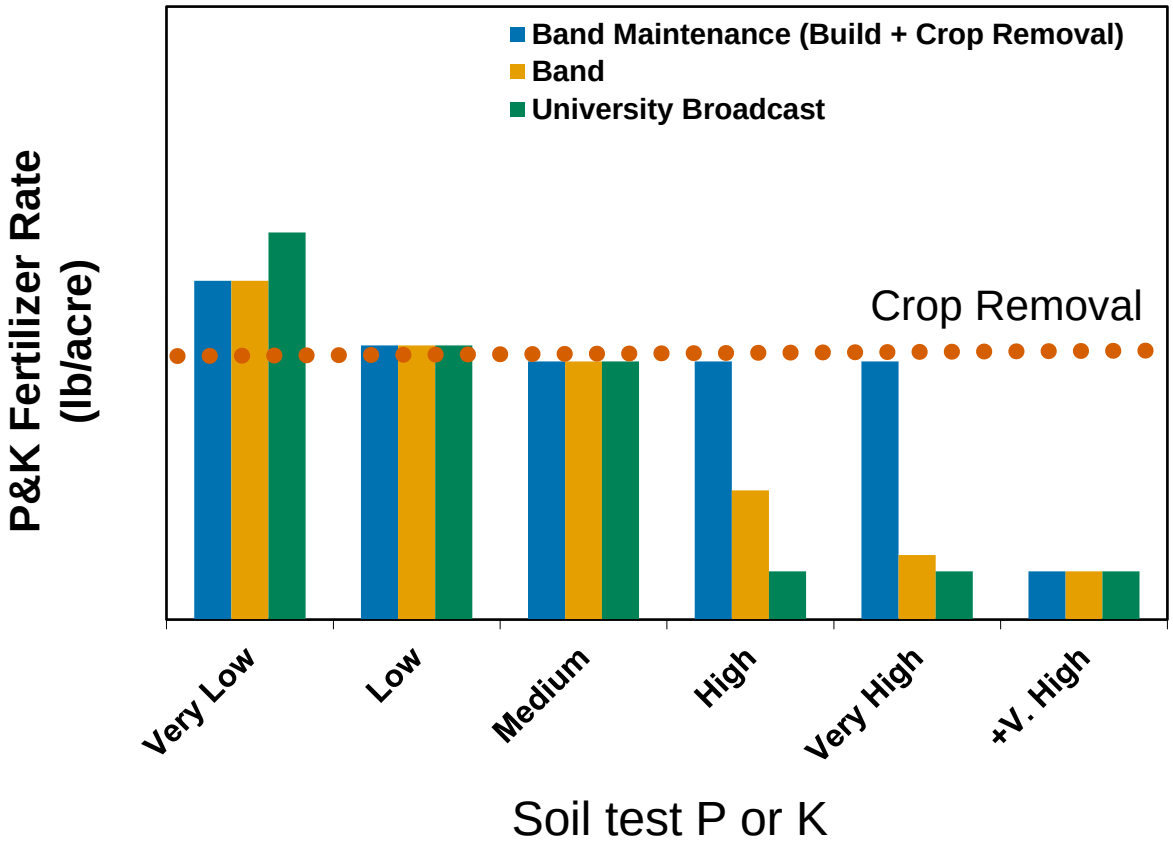
Data not shown where n< 100
AGVISE Laboratories, Inc.

Comparison of broadcast guidelines



AGVISE Broadcast guidelines will build P & K soil test levels to high range over 5-7 years. Rate reduced to starter amount in the high range.

Comparison of band guidelines



AGVISE Band guidelines will build P & K soil test levels to medium range over 5-10 years. Assumes fertilizer is placed at safe distance from seed.

NDSU Wheat Fertilizer Guidelines

Phosphate

The phosphate (P) recommendation in North Dakota currently is based on the Olsen P soil test. The broadcast recommendations appear in **Table 11**.

If the fertilizer is applied as a band, rates in **Table 11** can be reduced by one-third. Reducing rates in low-testing soils will result in soil test levels that do not increase through time.

UMN Corn Fertilizer Guidelines

Table COR-10. Broadcast and band phosphate fertilizer guidelines (lb of P_2O_5 suggested to apply per acre) for corn production based on either the Bray-P1 or Olsen soil methods test reported in parts per million (ppm)*

Expected yield	Broadcast or band	0-5 ppm Bray 0-3 ppm Olsen	6-10 ppm Bray, 4-7 ppm Olsen	11-15 ppm Bray, 8-11 ppm Olsen	16-20 ppm Bray, 12-15 ppm Olsen	21+ ppm Bray, 16+ ppm Olsen
151-175 bu/acre	Broadcast	90 lb/acre	60 lb/acre	35 lb/acre	10 lb/acre	0 lb/acre
151-175	Band	45	35	25	10-15	10-15
176-200	Broadcast	110	75	45	15	0
176-200	Band	55	40	30	10-15	10-15
201-225	Broadcast	130	90	55	20	0
201-225	Band	65	45	30	10-15	10-15
226-250	Broadcast	145	100	60	20	0
226-250	Band	75	50	30	10-15	10-15
250+	Broadcast	160	115	70	25	0
250+	Band	80	60	35	10-15	10-15

Franzen, D.W. 2022. Fertilizing hard red spring wheat and durum. NDSU Ext. Circ. SF712 (revised). North Dakota State Univ., Fargo, ND.
Kaiser, D.E., F. Fernandez, M. Wilson, J.A. Coulter, and K. Piotrowski. 2023. Fertilizing corn in Minnesota. UMN Ext. Circ. COR-1 (revised). Univ. Minnesota, St. Paul, MN.

Manitoba Soil Fertility Guide

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† Soybeans†	
ppm	lb/ac	Rating	S[1]	Sb[2]	B[3]	S[1]	B[3]	S[1]	B[3]	PPI[4]	B[3]	S[1]
0	0	VL	40	40	40	20	40	20	55	110	40	20
	5	VL	40	40	40	20	40	20	55	110	40	20
5	10	L	40	40	40	20	40	20	50	100	40	15
	15	L	35	35	35	20	35	20	45	90	35	15
10	20	M	30	30	30	20	30	20	45	90	30	10
	25	M	20	20	20	20	20	20	40	80	20	10
15	30	H	15	15	15	0	15	20	35	70	15	0
	35	H	10	10	10	0	10	20	30	60	10	0
20	40	VH	10	10	10	0	10	20	30	60	10	0
20+	40+	VH+	10	10	10	0	10	20	30	60	10	0

S[1] – seed-placed rates

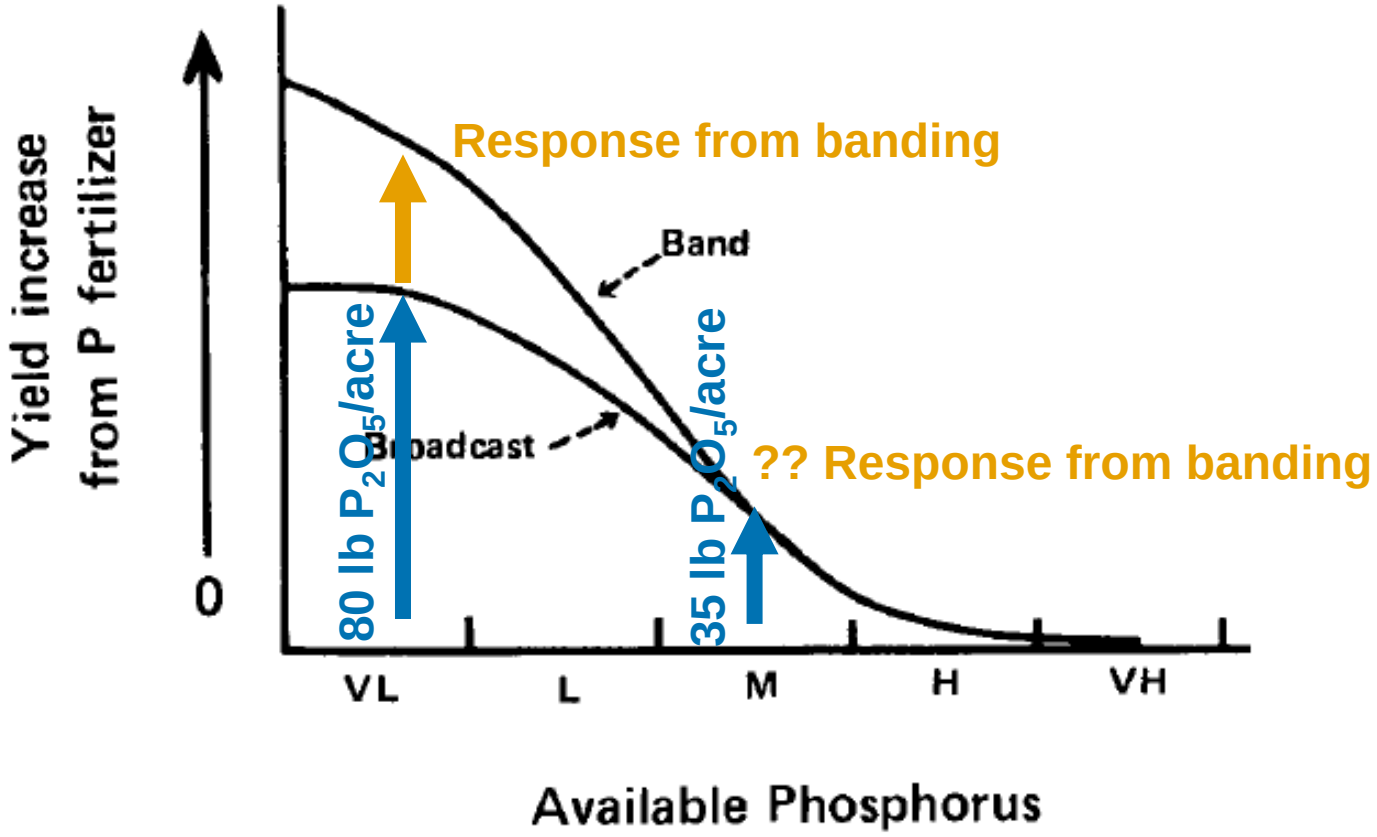
Sb[2] – side banded rates for row crops

B[3] – banded away from the seed

PPI[4] – if P is broadcast, rates must be 2x that of banding to be as effective.

Anonymous. 2007. Manitoba soil fertility guide (revised). Manitoba Agric., Food and Rural Initiatives, Winnipeg, MB.

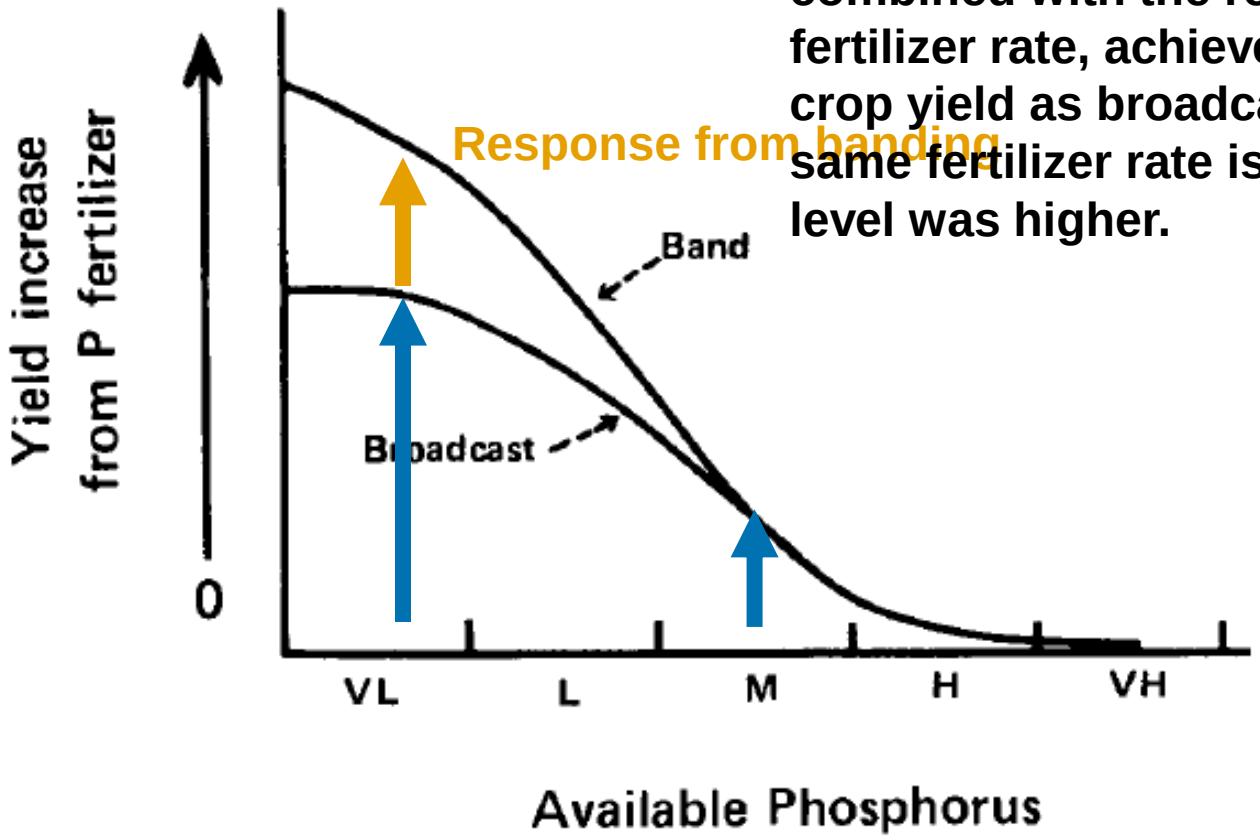
Banding P and K: Where is the gain?



Randall, G.W., and R.G. Hoeft. 1988. Placement methods for improved efficiency of P and K fertilizers: A review. J. Prod. Agric. 1(1):70–79.

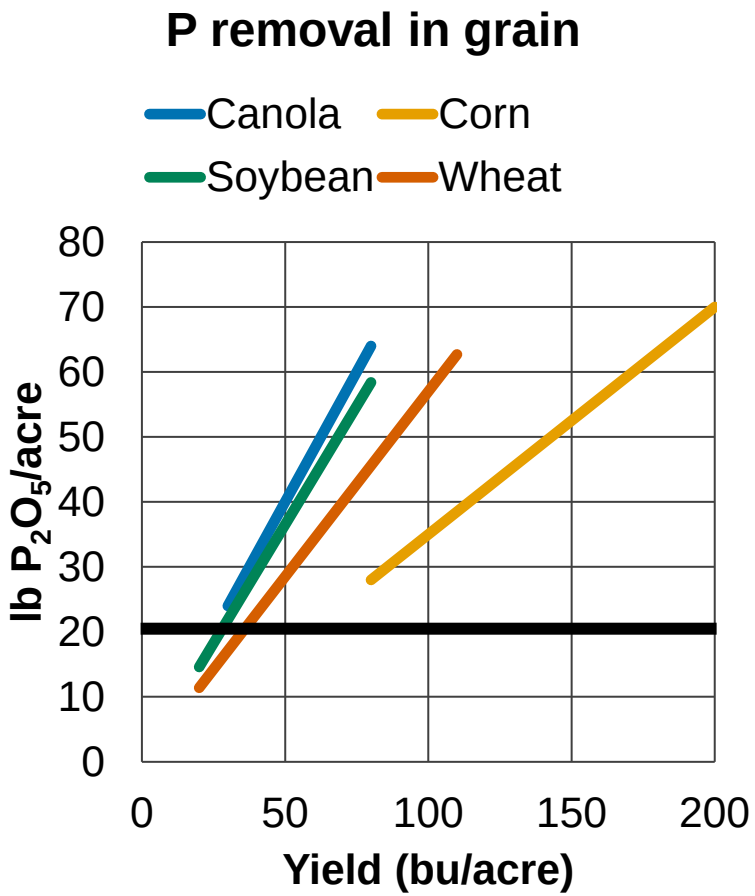
Banding P and K: How did we get reduced fertilizer rates?

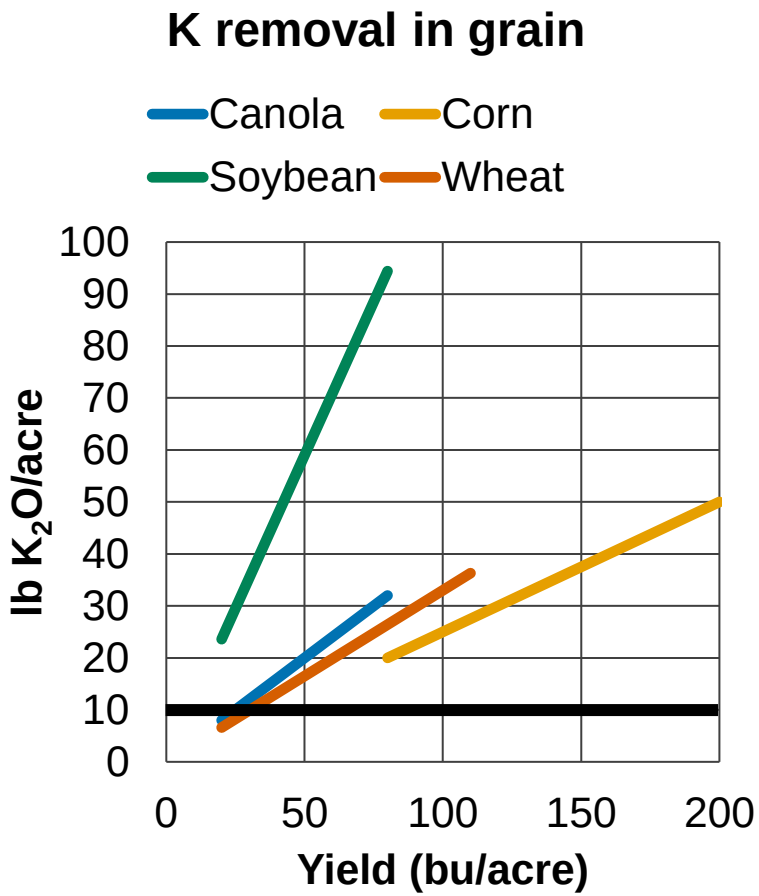
Crop response to banding, when combined with the reduced fertilizer rate, achieves similar crop yield as broadcast. Allows same fertilizer rate is if soil test level was higher.



Randall, G.W., and R.G. Hoeft. 1988. Placement methods for improved efficiency of P and K fertilizers: A review. J. Prod. Agric. 1(1):70–79.

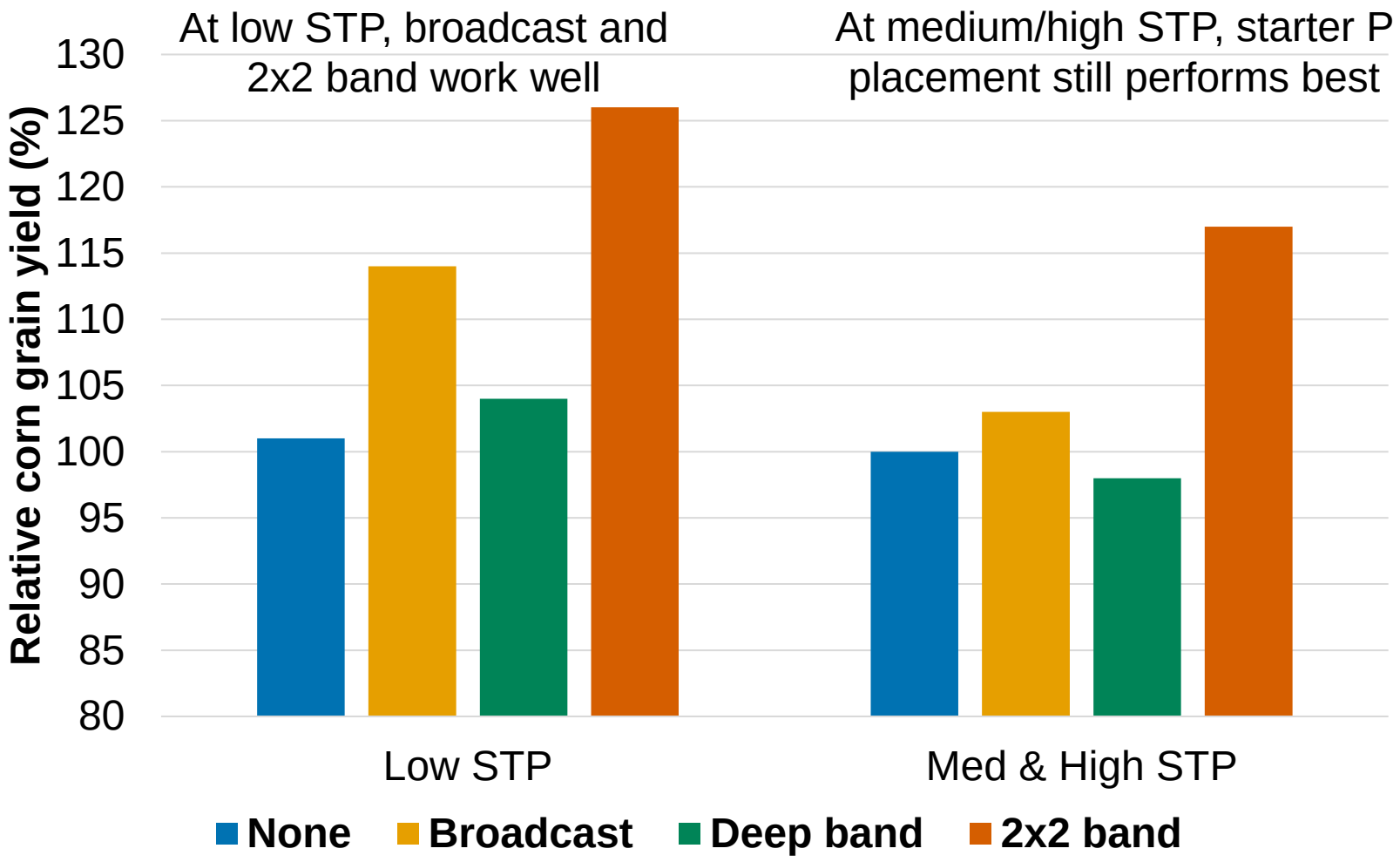
Crop removal is the same, regardless of placement





Canola bushel weight: 50 lb/bu, 2000 lb/acre = 40 bu/acre

Soil test phosphorus influences fertilizer placement effectiveness in corn



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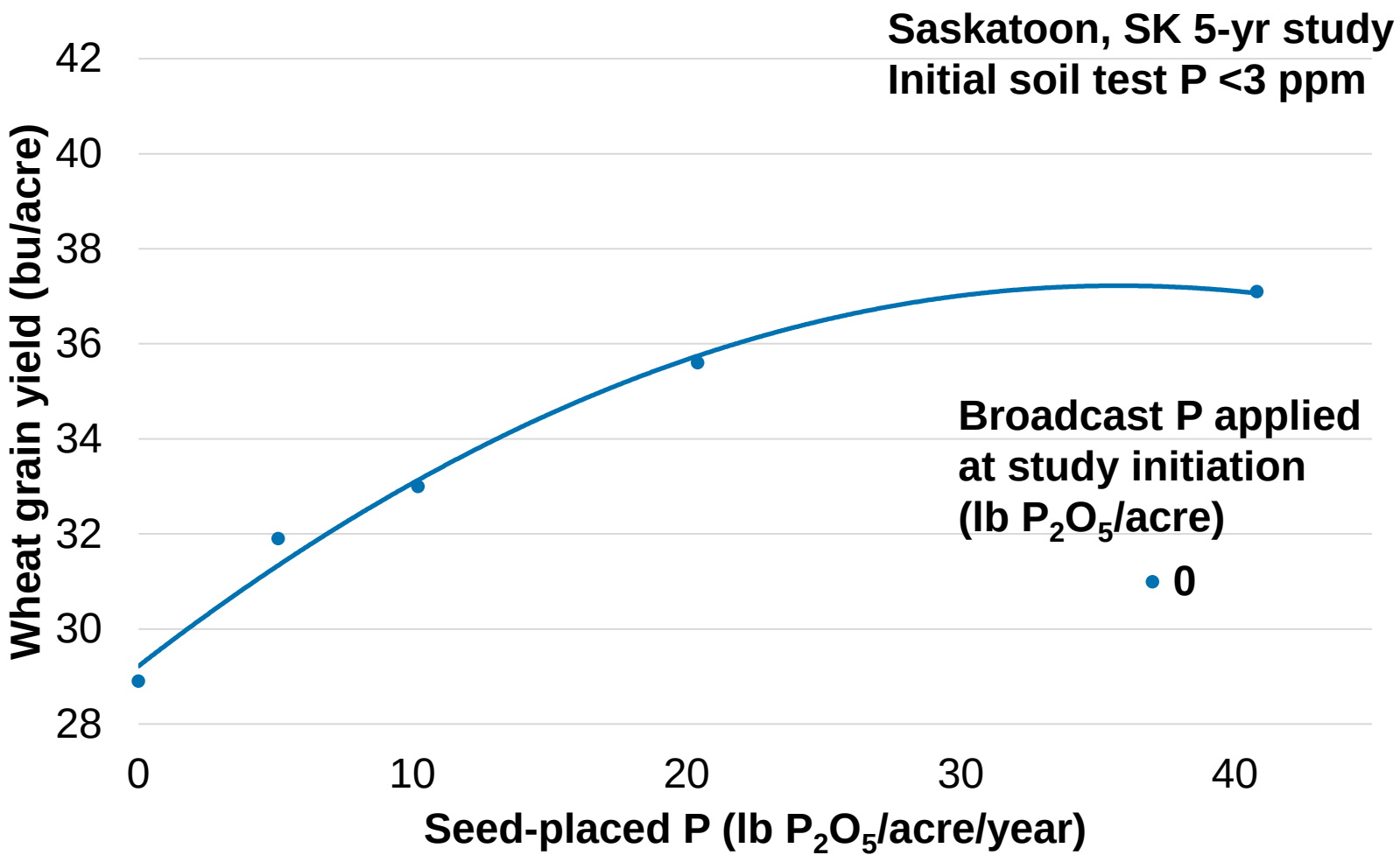
Seed-placed P and soil test P interaction: Wheat grain yield



Wagar, B.I., J.W.B. Steward, and J.L. Henry. 1986. Comparison of single large broadcast and small annual seed-placed phosphorus treatments on yield and phosphorus and zinc contents of wheat on Chernozemic soils. Can. J. Soil Sci. 66(2): 237–248.

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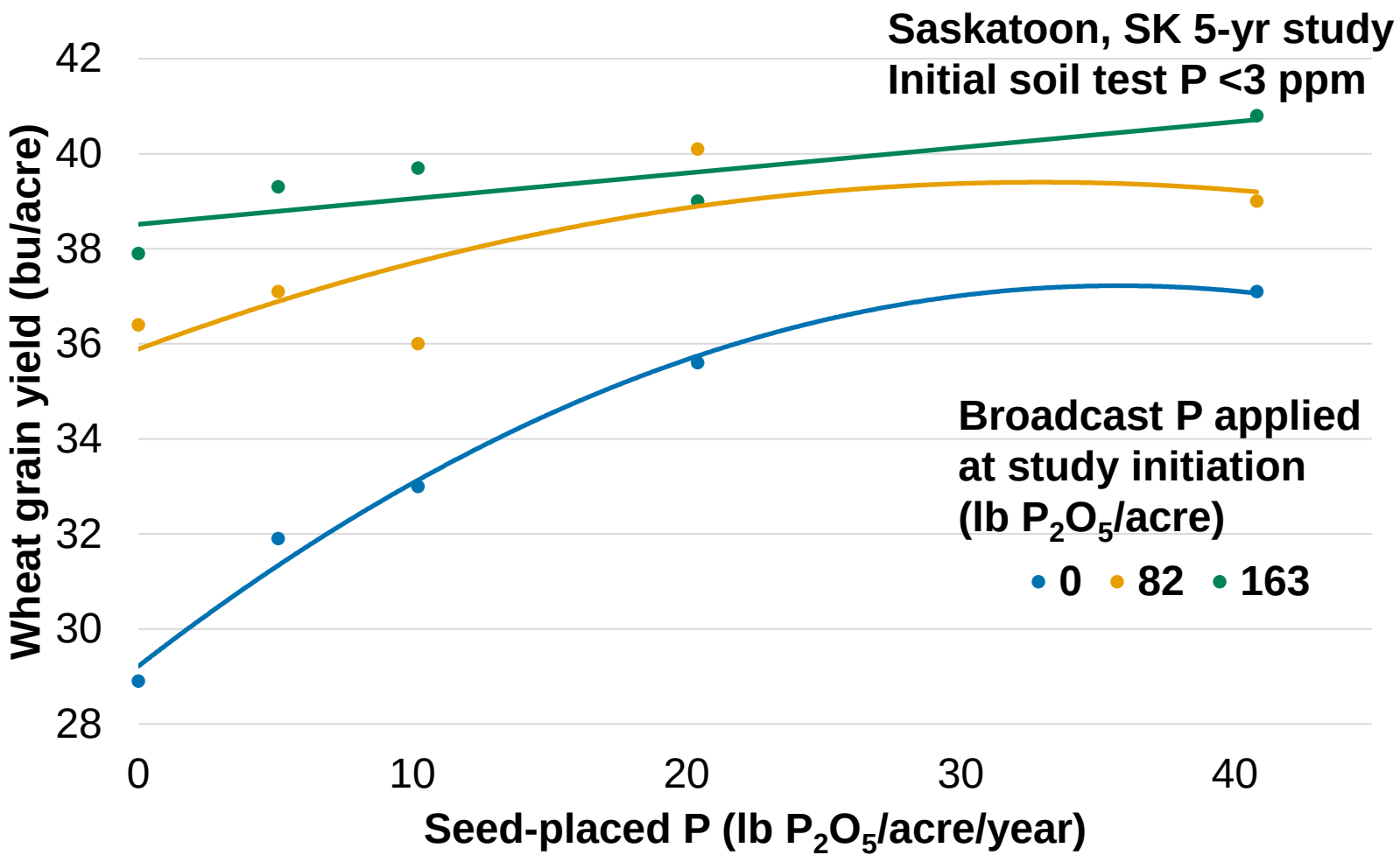

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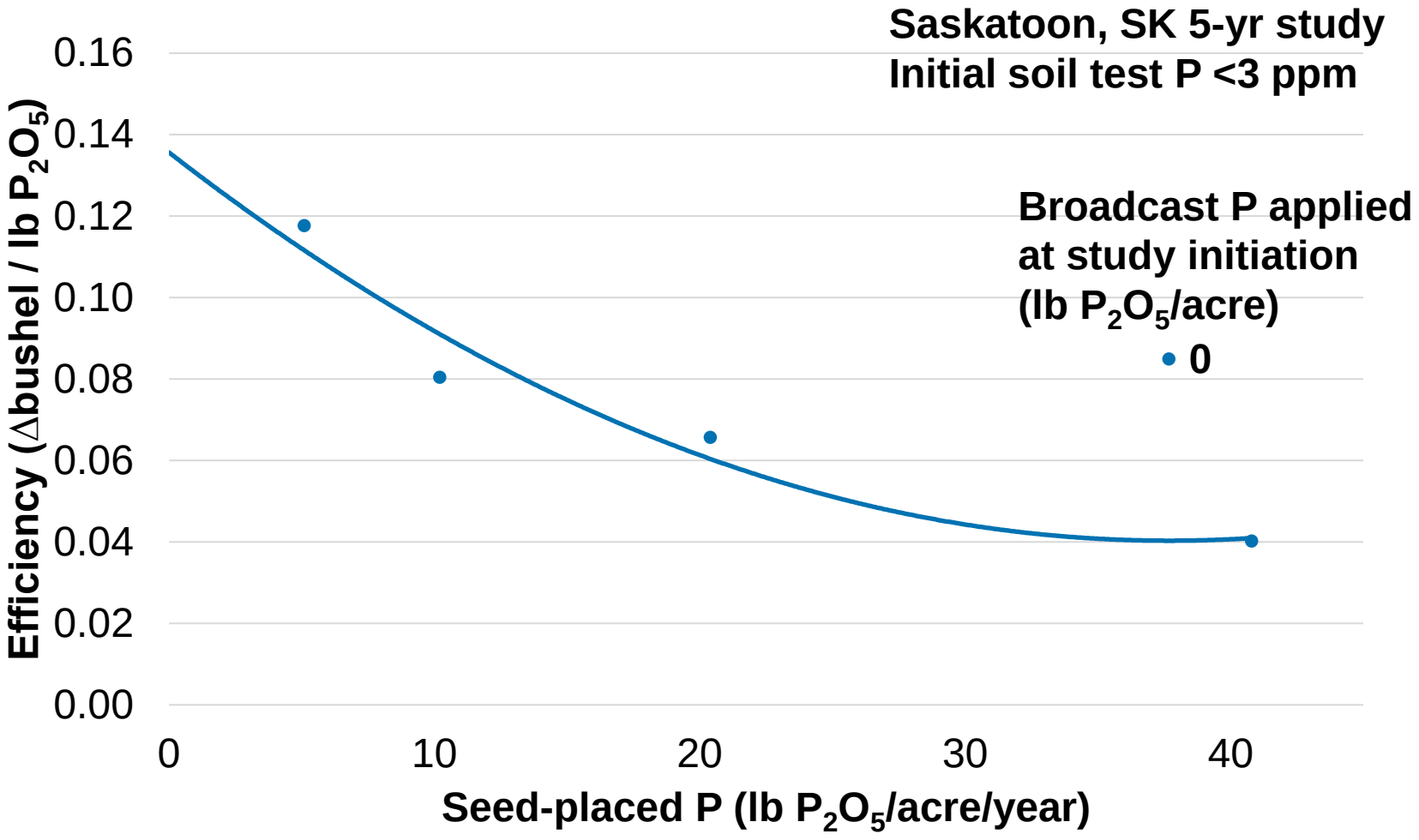
Seed-placed P and soil test P interaction: Fertilizer efficiency



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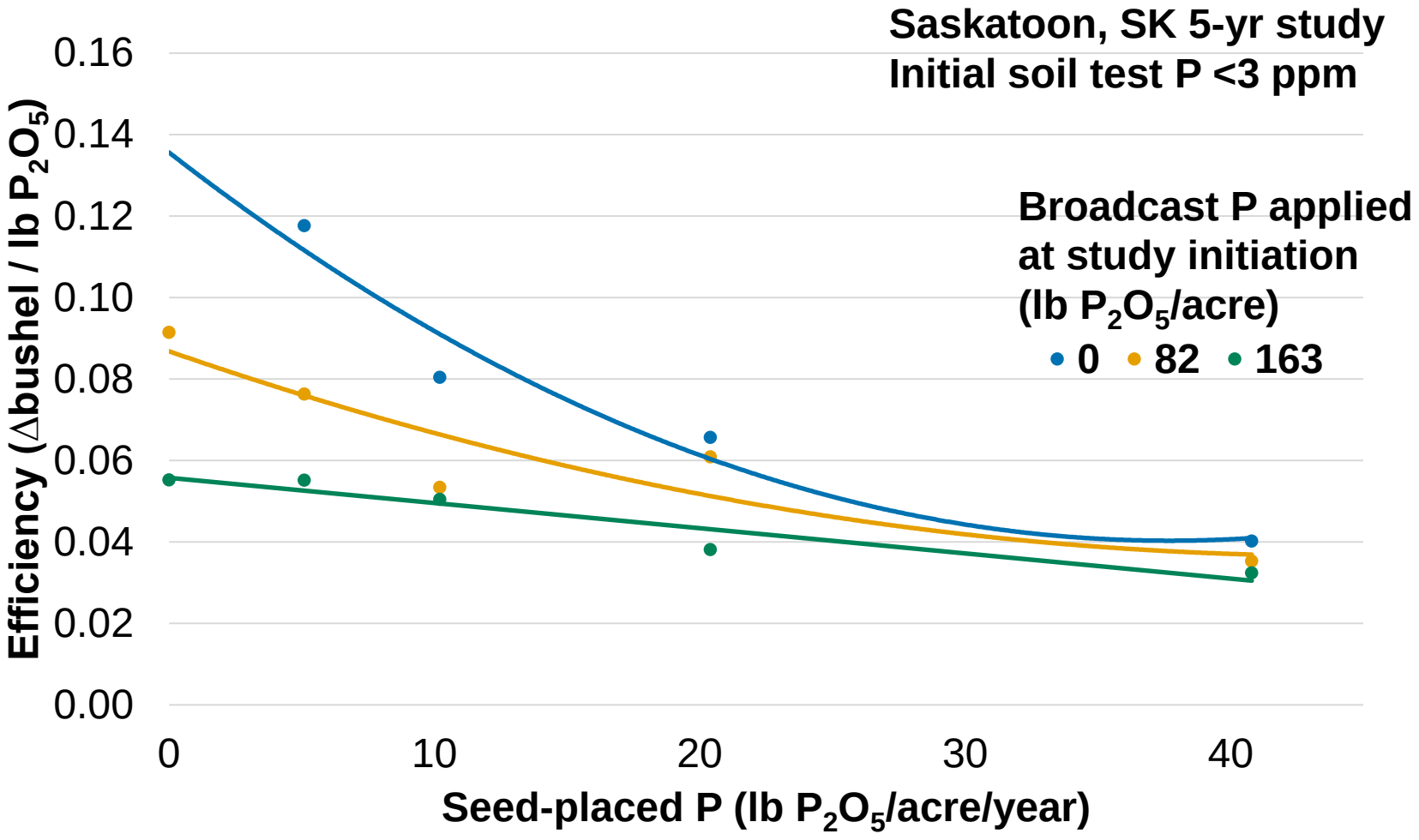

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Why don’t we try to maximize phosphorus use efficiency (PUE) alone?

- Efficiency vs. effectiveness
- While PUE itself may be high, effective grain yield has fewer bushels of grain to spilt among other costs
- Higher risk placed on PUE alone limits the efficiency of other inputs
- Partial profitability to phosphorus is not optimized

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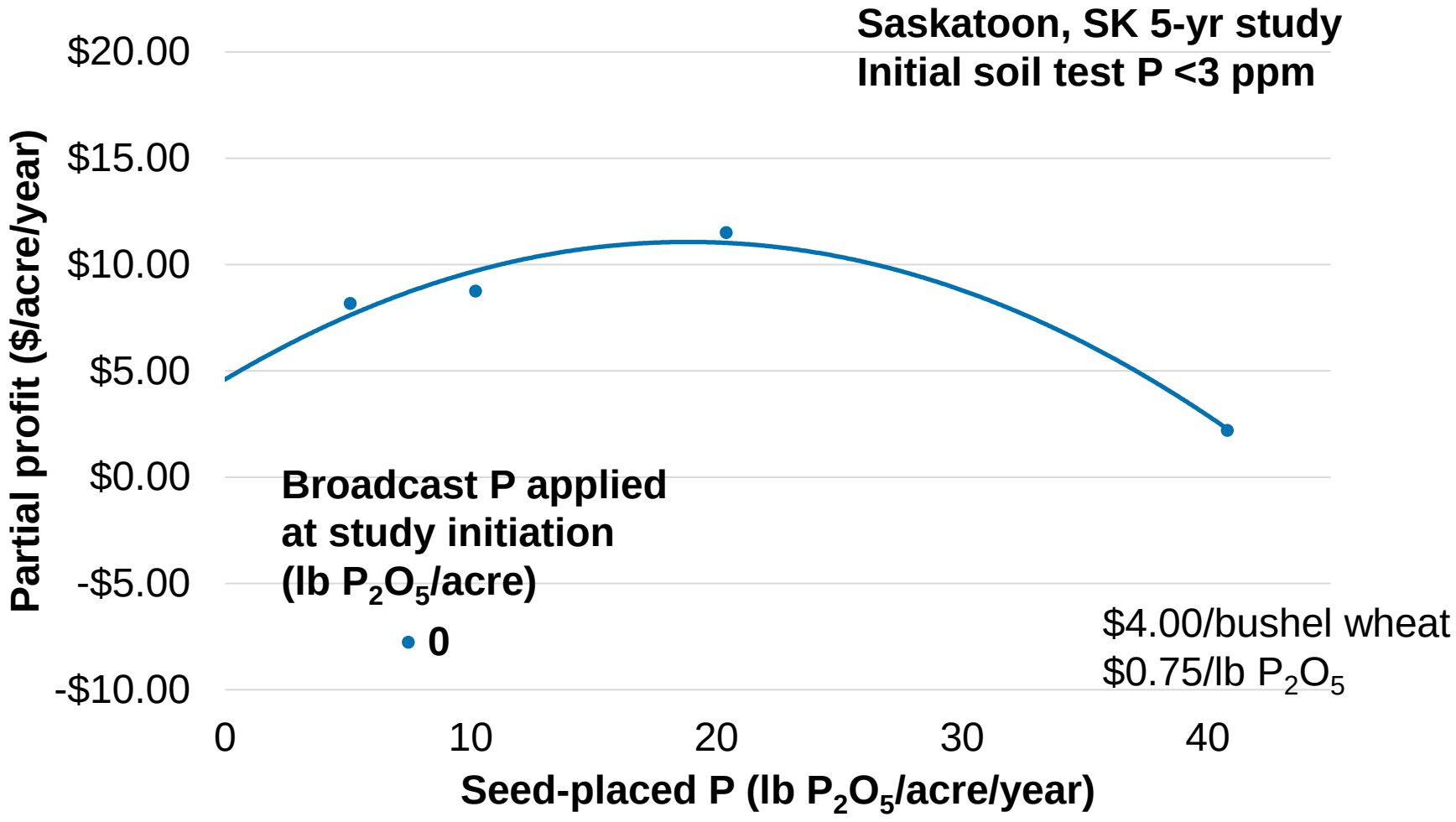
Seed-placed P and soil test P interaction: Partial profitability



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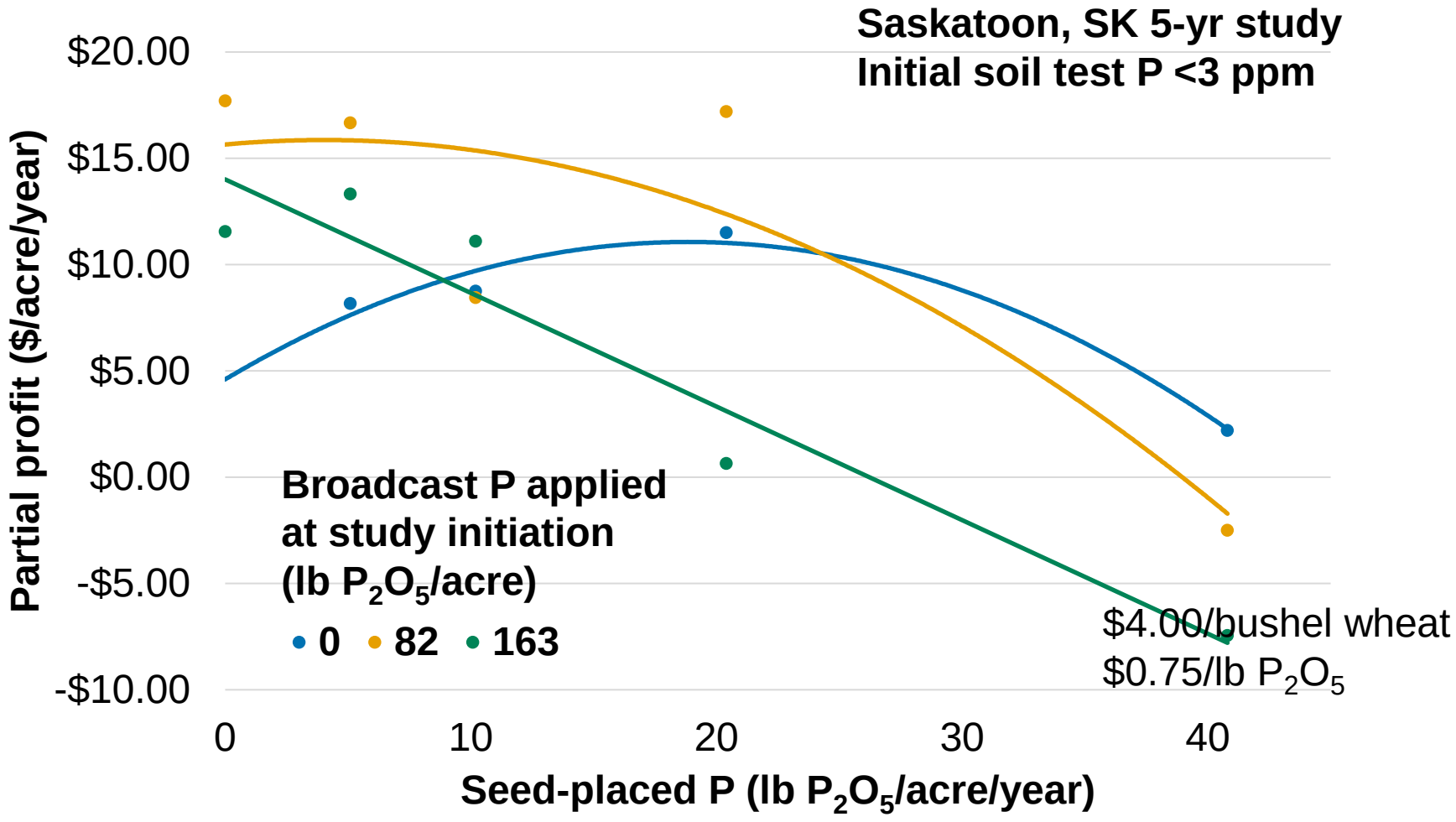
Seed-placed P and soil test P interaction: Partial profitability



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Mid-presentation summary

- Banding fertilizer reduces fixation in soil, limits the soil volume involved; greatest “bang for your buck” per unit applied
- Crop response to placement is a function of soil test level
  - Low soil test will show greatest crop response to fertilizer placement and banding fertilizer
  - Crop response to placement begins to diminish in the medium to high soil test range
- Crop removal is the same, regardless of placement

Seed-placed fertilizer rates limited in modern seeding equipment

5-inch sweeps, 10-inch spacing

Max. 50 lb/acre N + K_2O

1-inch disk, 7.5-inch spacing

Max. 25 lb/acre N + K_2O

Seed-safe fertilizer rates may not meet crop removal

Crop	Yield (bushel/acre)	P removal (lb P_2O_5/acre)	Seed-safe limit (lb P_2O_5/acre)	P balance (lb P_2O_5/acre)
Canola	**50**	**40**	**20**	**-20**
Soybean	**50**	**35**	**20**	**-15**
Wheat	80	45	50	+5
Corn	**200**	**55**	**45**	**-10**

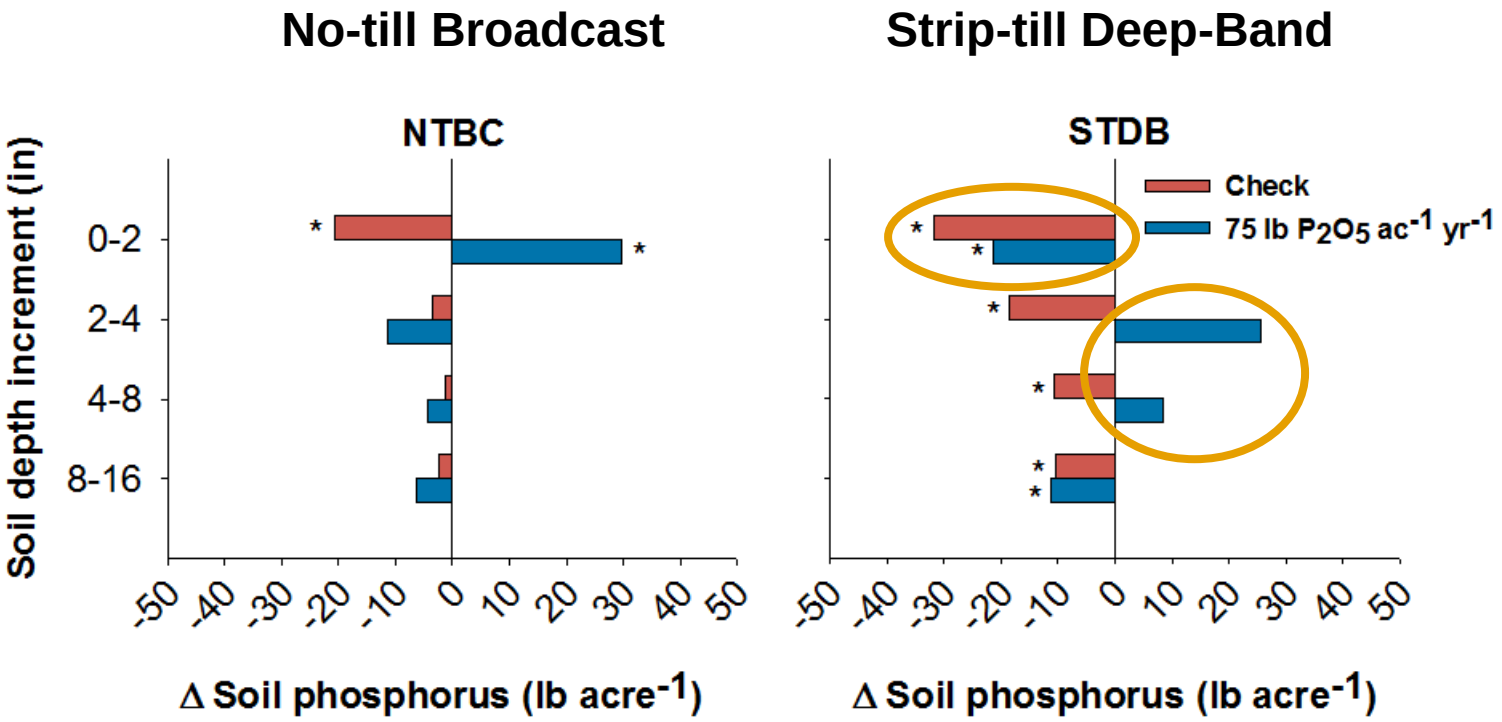
Seed-safe limit based on 1-inch disk or knife opener and 7.5-inch row spacing for canola, soybean, wheat using monoammonium phosphate (11-52-0), adequate soil moisture, medium-fine soil texture, 10% stand loss; 30-inch row spacing for corn using ammonium polyphosphate (10-34-0), adequate soil moisture, medium-fine soil texture, 5% stand loss.

AGVISE LABORATORIES

Gelderman, R.H. 2008. Decision aid for estimating seed-placed fertilizer rates. South Dakota State Univ., Brookings, SD.

What about strip-till P and K?

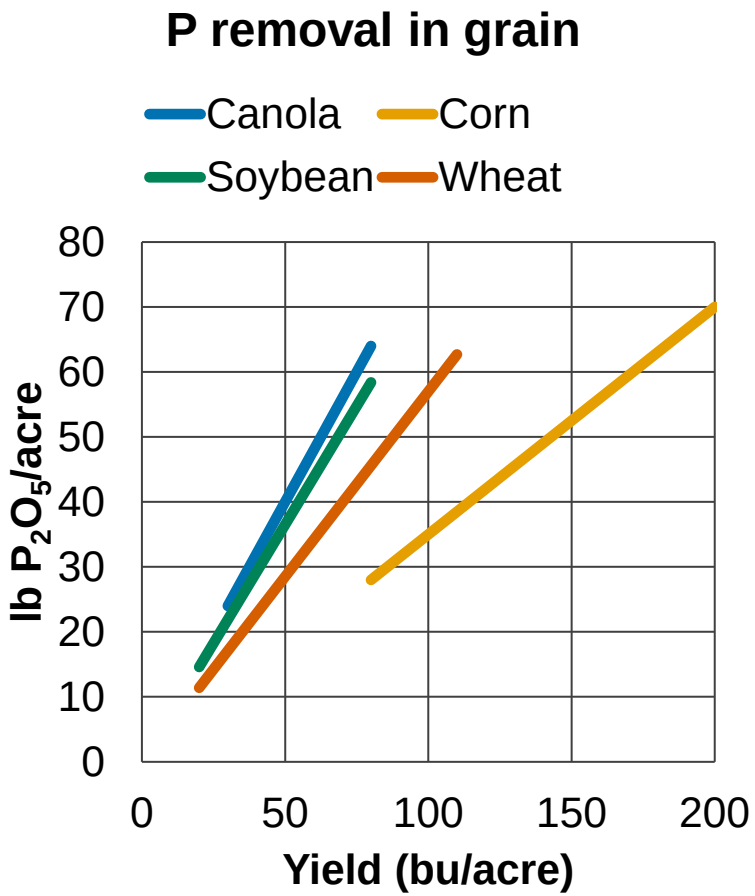
Tillage and placement does not change root architecture or nutrient uptake in soil

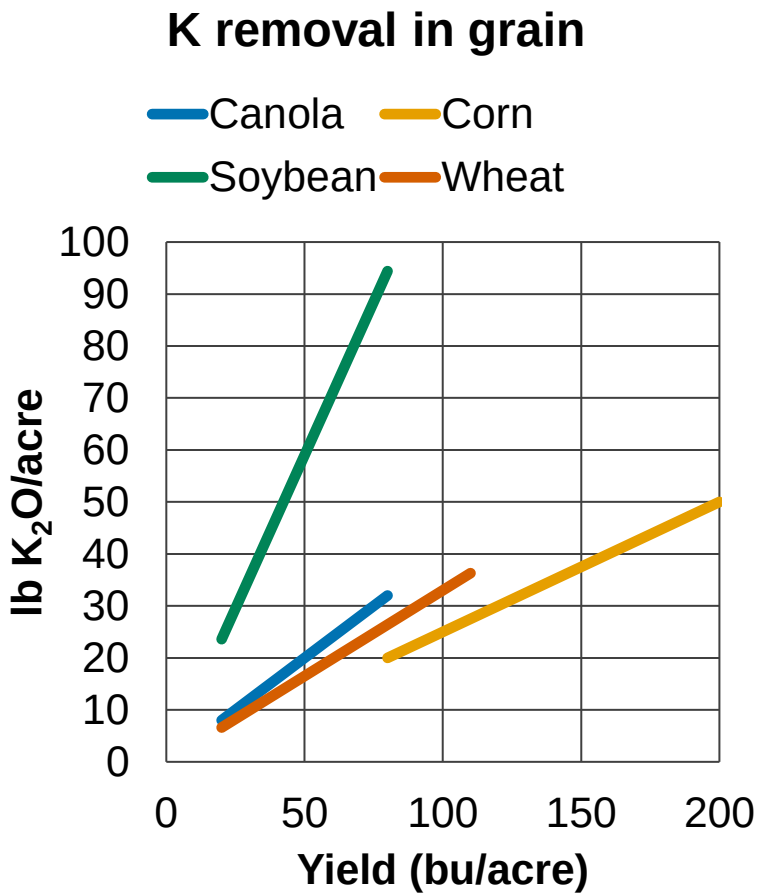


Fernández, F. G., & Schaefer, D. (2012). Assessment of soil phosphorus and potassium following real time kinematic-guided broadcast and deep-band placement in strip-till and no-till. Soil Science Society of America Journal, 76(3), 1090–1099.

Fernández, F. G., & White, C. (2012). No-till and strip-till corn production with broadcast and subsurface-band phosphorus and potassium. Agronomy Journal, 104(4), 996–1005.

Crop removal is the same, regardless of placement





Canola bushel weight: 50 lb/bu, 2000 lb/acre = 40 bu/acre

Let's walk through some scenarios

- Do we like growing high yielding crops? Yes.
- Do we like higher soil test levels? Yes, it means I need to apply less fertilizer and fewer crop yield limitations to that nutrient.
- Do we like banding fertilizer? Yes, it means I can apply maximize efficiency and reduce potential losses.
- Do we like fertilizing soybean crops? I do, but I know my neighbor skips the soybean year…

Let's walk through some scenarios

- Corn-soybean rotation
  - Corn yield: 200 bushel/acre
  - Soybean yield: 50 bushel/acre
- Starting at 5 ppm Olsen P, assume buffering capacity at 18 lb P_2O_5/ppm
- Accounting for crop removal each year
- Comparing "build" vs. "sufficiency" rate
- Comparing broadcast P vs. banding P with reduced rates (50% broadcast)
- What happens if you skip the soybean year?

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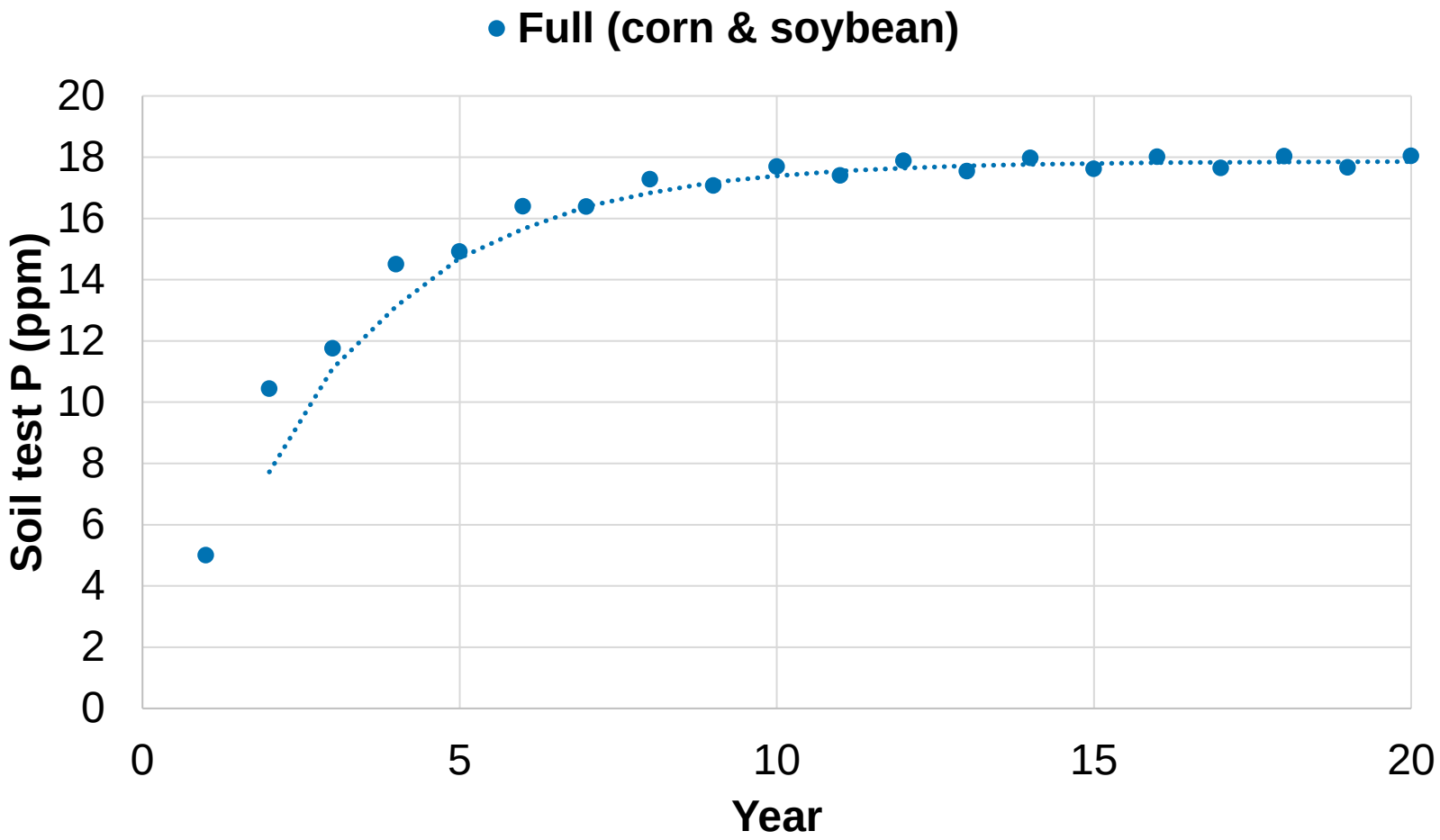
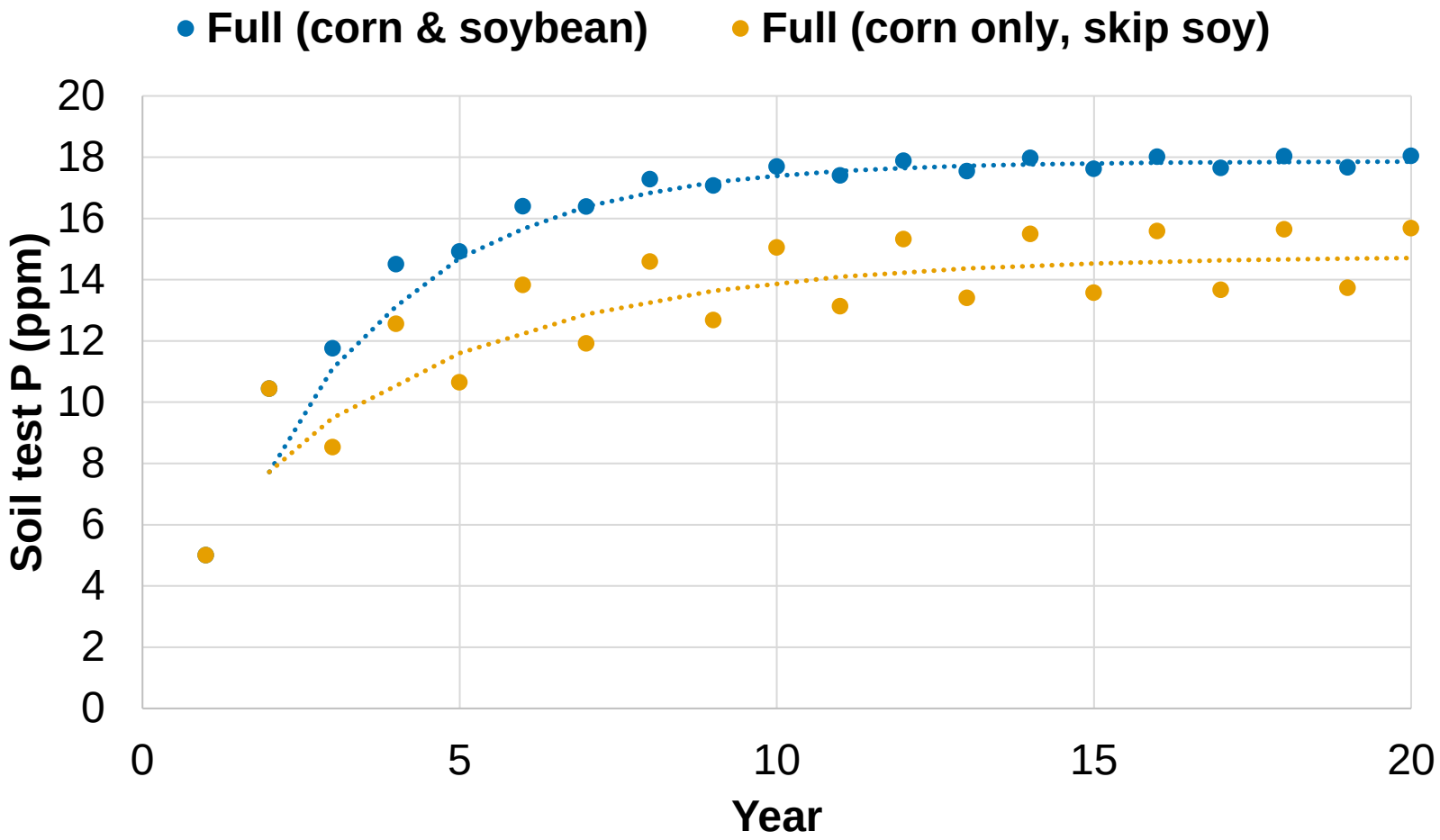
Corn-soybean rotation				Broadcast: full rate corn and soybean				
Year	Crop	STP	Yield Goal	Fertilizer I	Remove P	delta P	buffer STP	delta STP
1	corn	5	200	154	-56	98.0	18	5.4
2	soybean	10.4	50	58	-35	23.7	18	1.3
3	corn	11.8	200	105	-56	49.3	18	2.7
4	soybean	14.5	50	42	-35	7.5	18	0.4
5	corn	14.9	200	83	-56	26.6	18	1.5
6	soybean	16.4	50	34	-35	-0.1	18	0.0
7	corn	16.4	200	72	-56	16.0	18	0.9
8	soybean	17.3	50	31	-35	-3.6	18	-0.2
9	corn	17.1	200	67	-56	11.0	18	0.6
10	soybean	17.7	50	29	-35	-5.3	18	-0.3
11	corn	17.4	200	65	-56	8.7	18	0.5
12	soybean	17.9	50	28	-35	-6.0	18	-0.3
13	corn	17.5	200	64	-56	7.7	18	0.4
14	soybean	18.0	50	28	-35	-6.4	18	-0.4
15	corn	17.6	200	63	-56	7.1	18	0.4

Soil test P “build” scenario



Starting at 5 ppm Olsen P; “full” broadcast (build) rate, reduced rate at 1/2 “full” broadcast.

Soil test P “build” scenario



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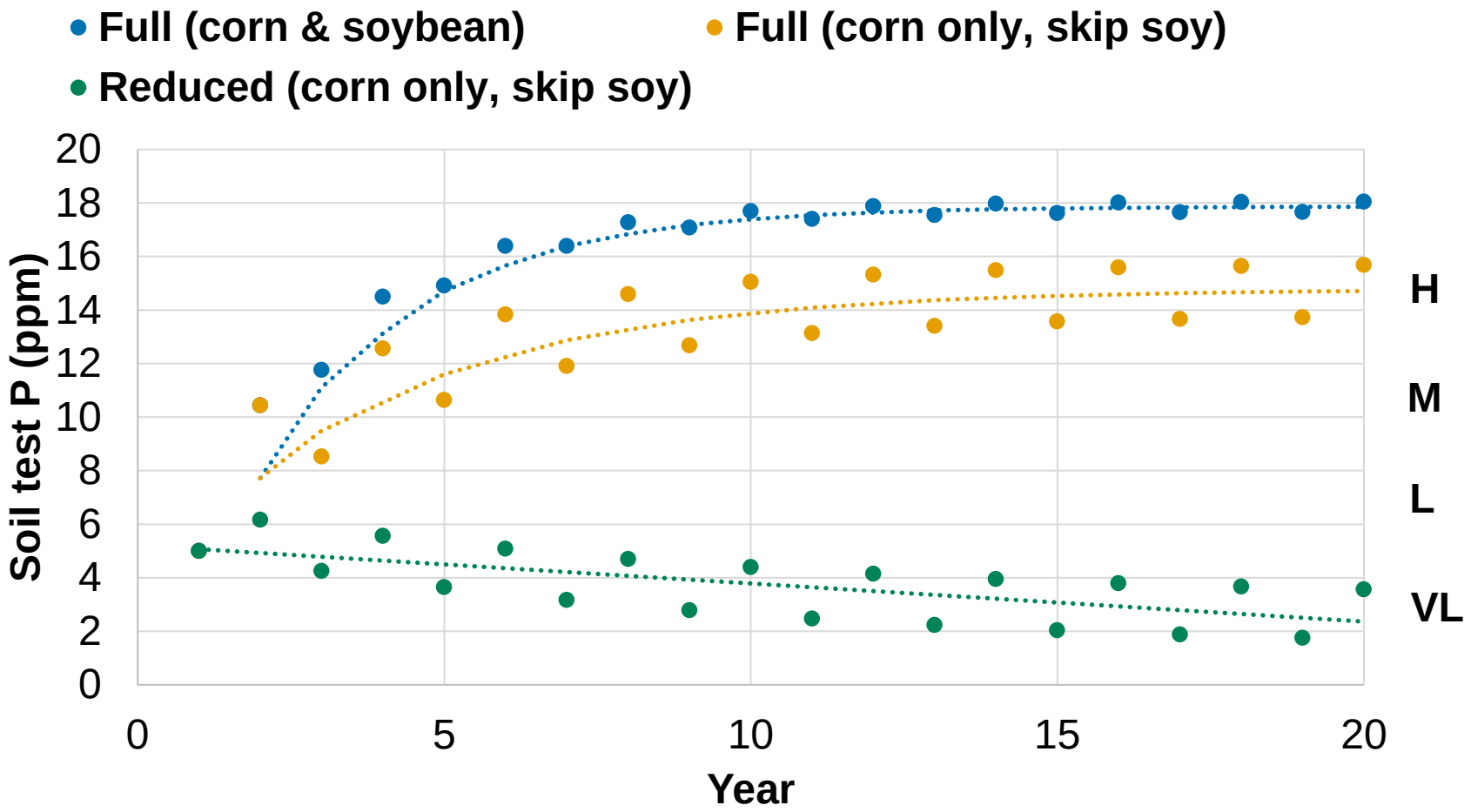
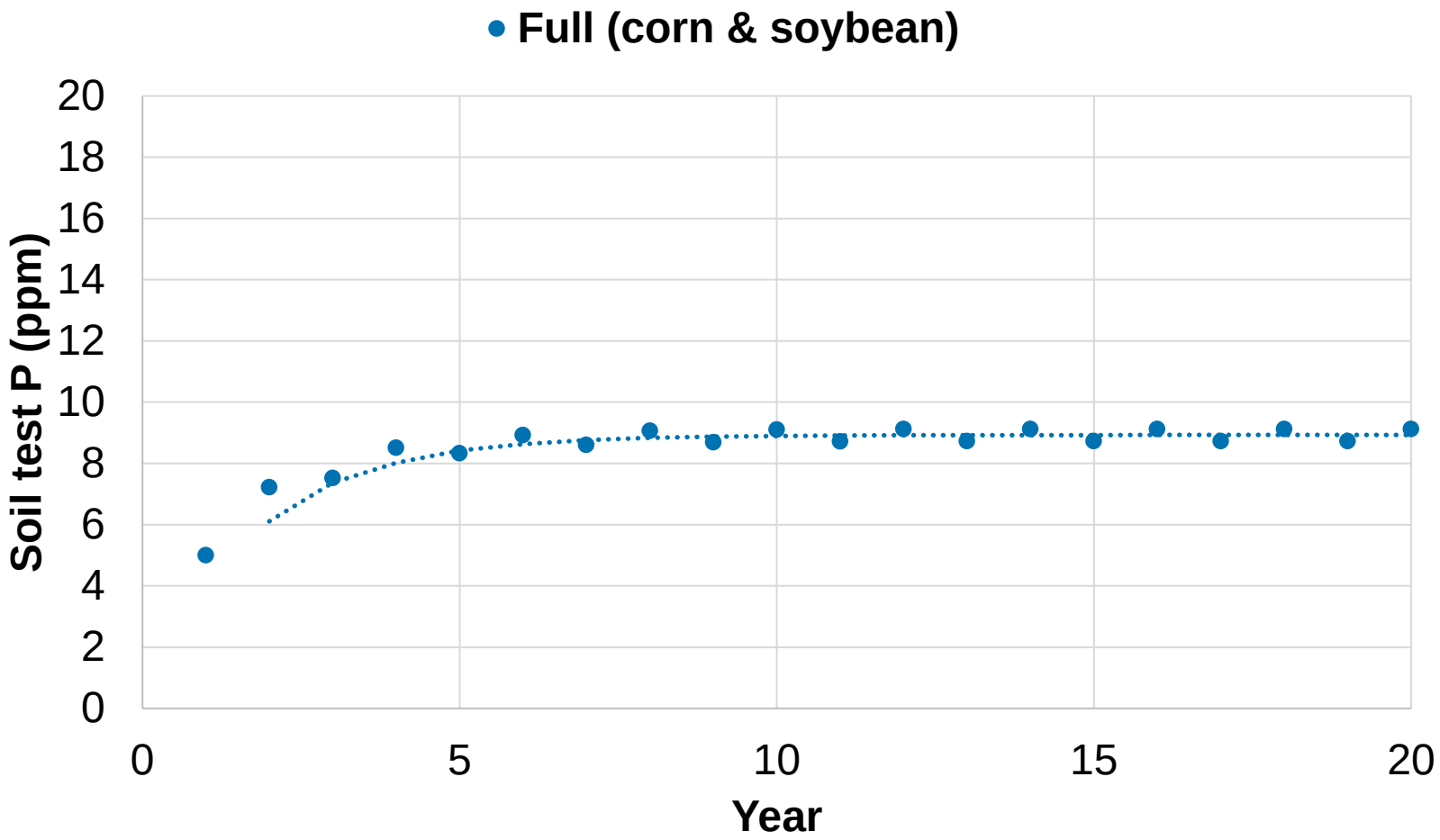
Soil test P “build” scenario



Starting at 5 ppm Olsen P; “full” broadcast (build) rate, reduced rate at 1/2 “full” broadcast.

Soil test P “sufficiency” scenario



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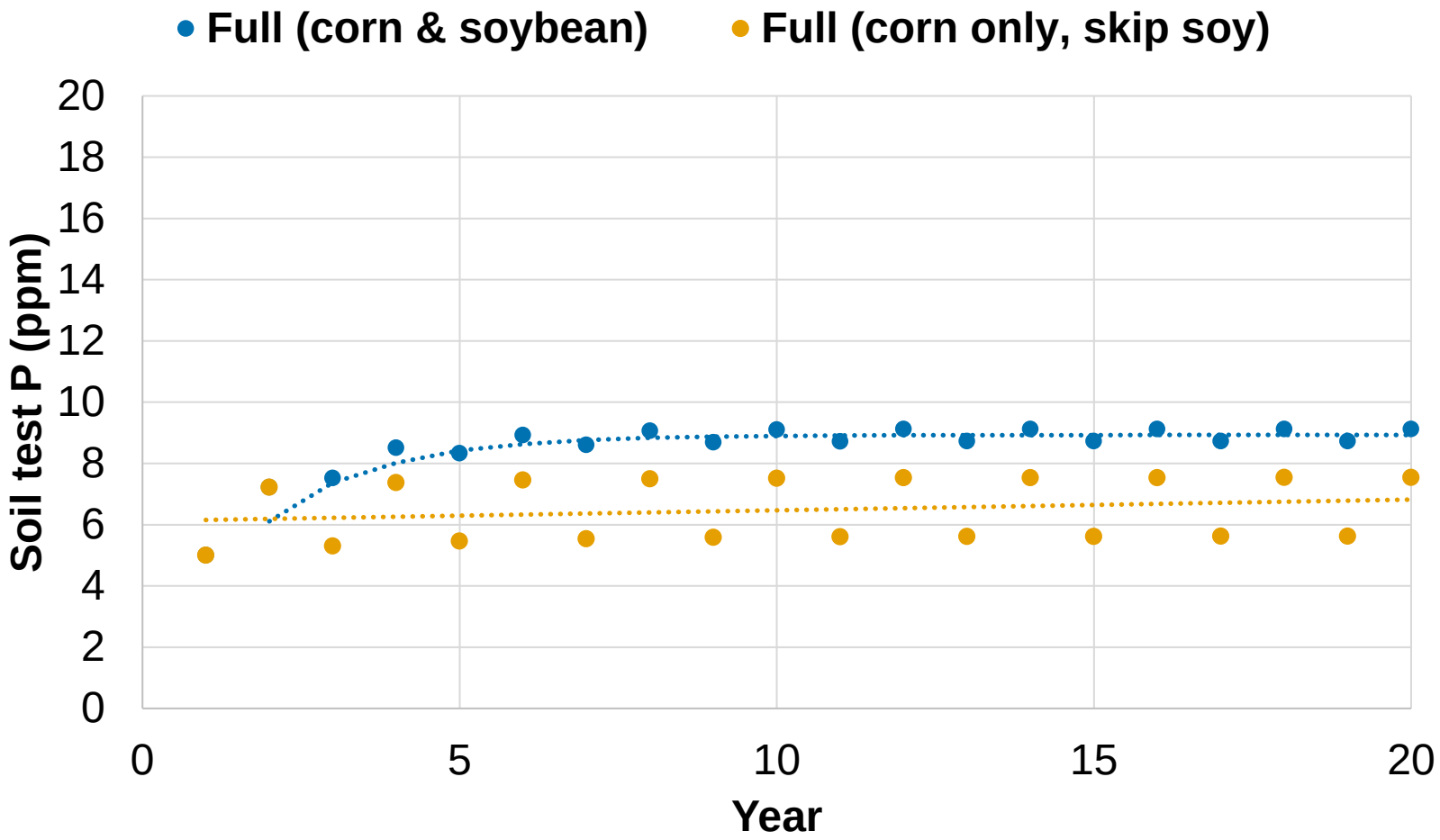

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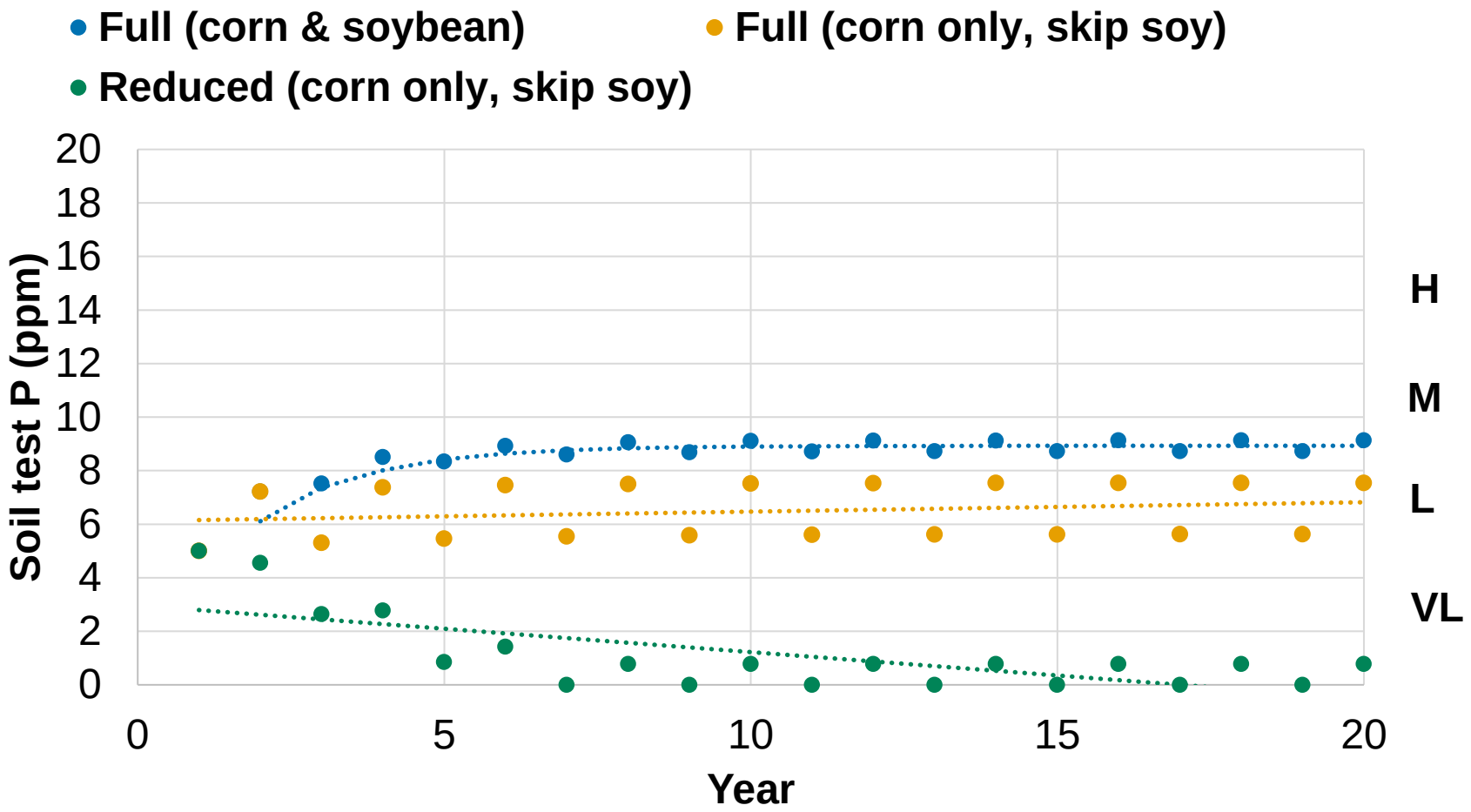
Soil test P “sufficiency” scenario



Starting at 5 ppm Olsen P; “full” broadcast (build) rate, reduced rate at 1/2 “full” broadcast.

Summarizing the soil test P scenarios after 20 years

Difference between full broadcast Build and Sufficiency over 20 years is 8 lb P_2O_5/acre/year

Application	Rate	Timing	Ending STP (ppm Olsen P)	Total P applied – 20 years (lb P_2O_5/acre)
Building				
Broadcast	Full rate	Corn & Soybean	18	1133
	Full rate	Corn only	15	1063
Band	Half rate	Corn only	3	845
Sufficiency				
Broadcast	Full rate	Corn & Soybean	9	972
	Full rate	Corn only	7	916
Band	Half rate	Corn only	0	663

Reduced rates or not accounting for soybean P removal will mine P faster, resulting in lower soil test P.

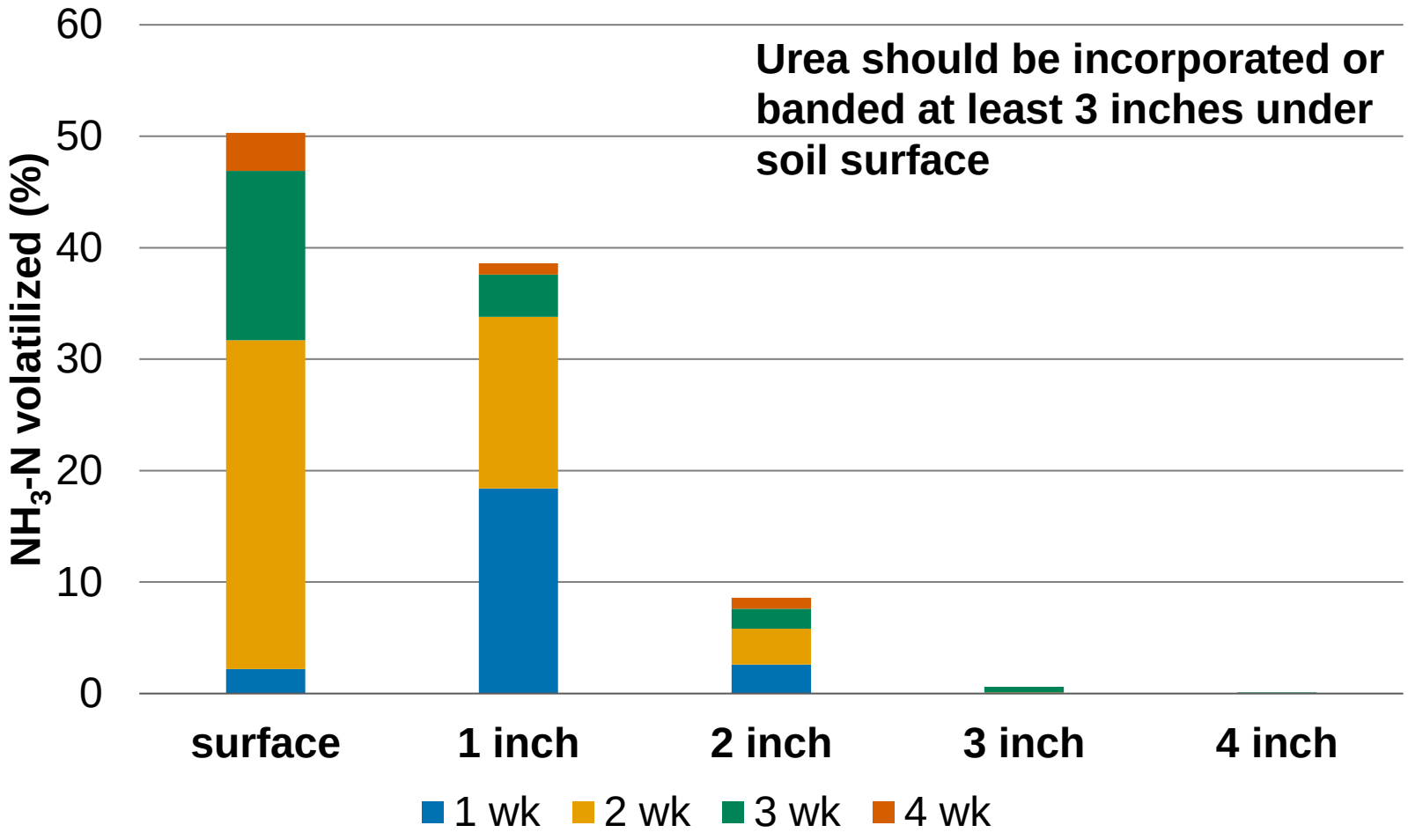
Smart strategies for banding fertilizer

- Know how you want to manage soil fertility: Are you a “build and maintain” person or “sufficiency” person?
- Banding fertilizer improves efficiency and **can** allow you to reduce rates, but should you reduce them if soil test levels are low?
- Skipping fertilizer for one year will still incur crop nutrient removal. You will eventually have to pay the piper.

Where is banding fertilizer almost fool-proof?

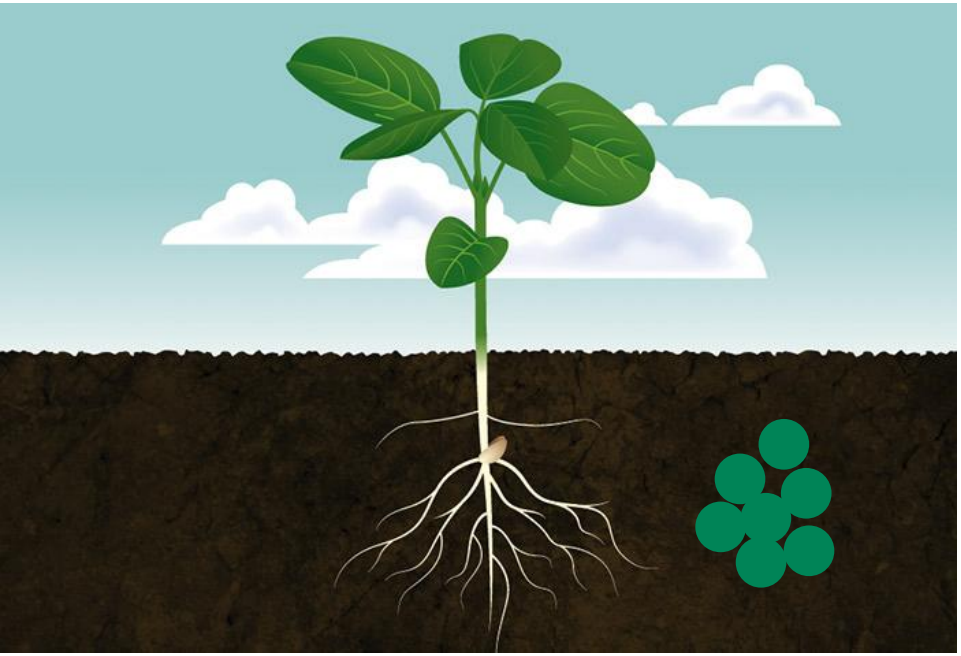
- Reducing environmental losses of nitrogen and phosphorus
  - Reduced ammonia volatilization
  - Reduced nitrate leaching and denitrification
  - Reduced surface P loss in runoff

Incorporating urea reduces ammonia volatilization



Rochette, P., D.A. Angers, M.H. Chantigny, M.-O. Gasser, J.D. MacDonald, D.E. Pelster, and N. Bertrand. 2013. Ammonia volatilization and nitrogen retention: How deep to incorporate urea? J. Environ. Qual. 42(6):1635–1642.

Banding nitrogen slows nitrification, maintains safe NH_4^+ form longer



- Localized region of ammonia toxicity (NH_3) around band slows bacterial transformation to nitrate (NO_3^-)
- Reduced nitrate leaching and denitrification
- Source effectiveness: Anhydrous ammonia > urea > UAN

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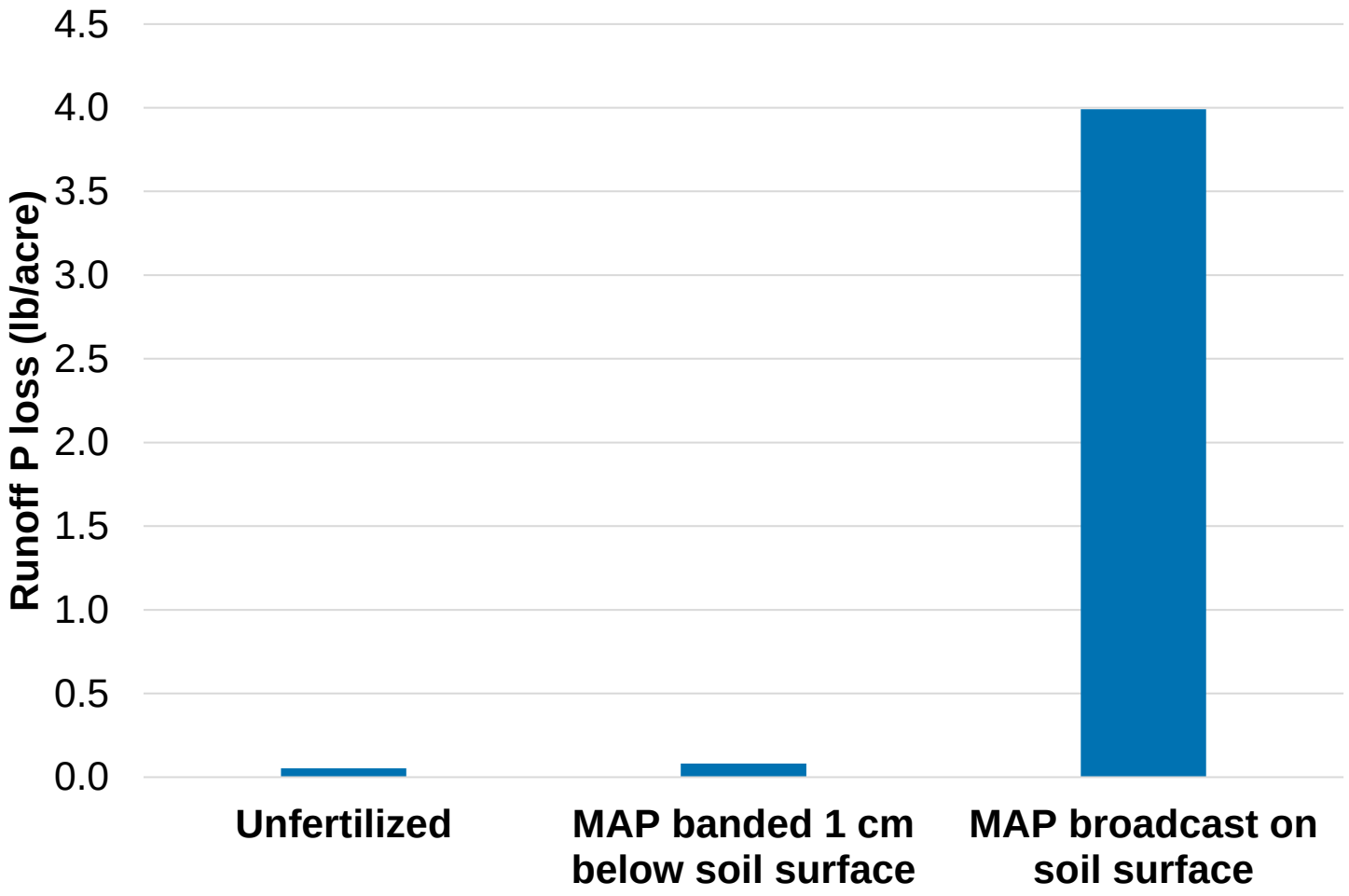
Banded P reduces surface P loss



Smith, D.R., R.D. Harmel, R. Haney, M. Williams, and K.W. King. 2016. Managing acute phosphorus loss with fertilizer source and placement: Proof of concept. Agric. Environ. Lett. 1:150015.

Proper potassium placement is important in drought years

Image from https://twitter.com/CropProKerrie/status/1141461188045180929

Seed-placed phosphorus, c. 1916

Image from https://www.wisconsinhistory.org/Records/Image/IM11498

Ortho- vs. polyphosphate sources

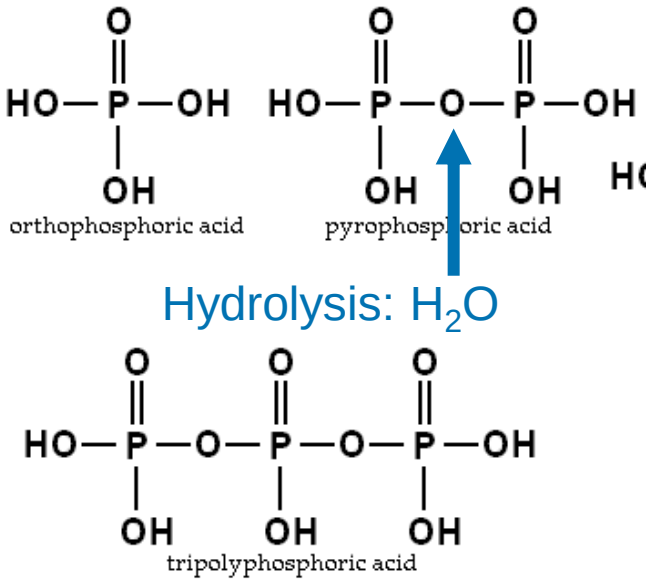
Chemical name	Abbr.	Grade	Form	Orthophosphate (PO_4^{3-})	Polyphosphate ($P_2O_7^{2-}$)
Single superphosphate	SSP	0-18-0-12S	dry	100%	
Triple superphosphate	TSP	0-45-0	dry	100%	
Monoammonium phosphate	**MAP**	**11-52-0**	**dry (or fluid)**	**100%**	
Diammonium phosphate	DAP	18-46-0	dry (or fluid)	100%	
Ammonium polyphosphate	**APP**	**10-34-0**	**fluid**	**~30%**	**~70%**

Most common fluid P source is APP (10-34-0), allows higher P concentration. Fluid ortho-P sources are dissolved MAP/DAP blends with lower possible P concentrations.

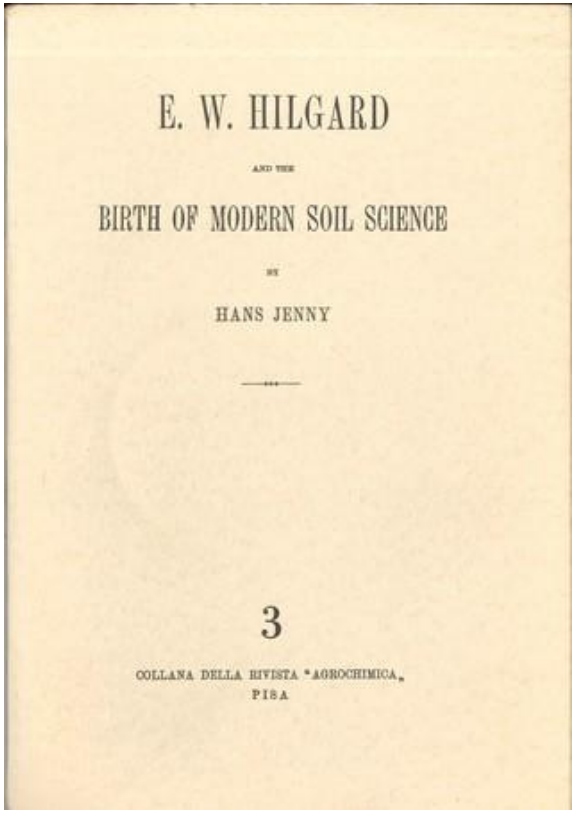
Does ortho- vs. poly-P matter?

Fact: Plant roots can only take up orthophosphate (PO_4^{3-})
Myth: Polyphosphate ($P_2O_7^{2-}$) sources are not available in time

- Polyphosphates are linked chains of orthophosphate, allows higher P concentration
- Poly-P rapidly splits into ortho-P in soil, usually 50% within one week
  - Hydrolysis is slower in cool and dry soils
- 10-34-0 still contains ~30% ortho-P
- Bonus: Poly-P can carry up to 2% Zn in solution, ortho-P can only carry 0.5% Zn



Chang, C., and G.J. Racz. 1977. Effects of temperature and phosphate concentration on rate of sodium pyrophosphate and sodium tripolyphosphate hydrolysis in soil. Can. J. Soil Sci. 57(3):271–278.



"It is our right to use, but not abuse, the inheritance which is ours, and to hand it down to our children as a blessing, not as a barren, inert incubus, wherewith to drudge through life as a penalty for their fathers' wastefulness.

"That no land can be permanently fertile, unless we restore to it, regularly, the mineral ingredients which our crops have withdrawn.

– E.W. Hilgard (1860), *Report on the Geology and Agriculture of the State of Mississippi*

Thank you for your kind attention!

Are there any questions?

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