How Does Row Placed Fertilizer Fit in Today's Agriculture

Dick Wolkowski
Extension Soil Scientist
University of Wisconsin

Why Starter Fertilizer

- Precision placement
  - Higher nutrient use efficiency
  - Avoid skips and lapping
- Limits fixation of P and K by the soil
- Soils slow to warm in the spring
- Environmental incentives?

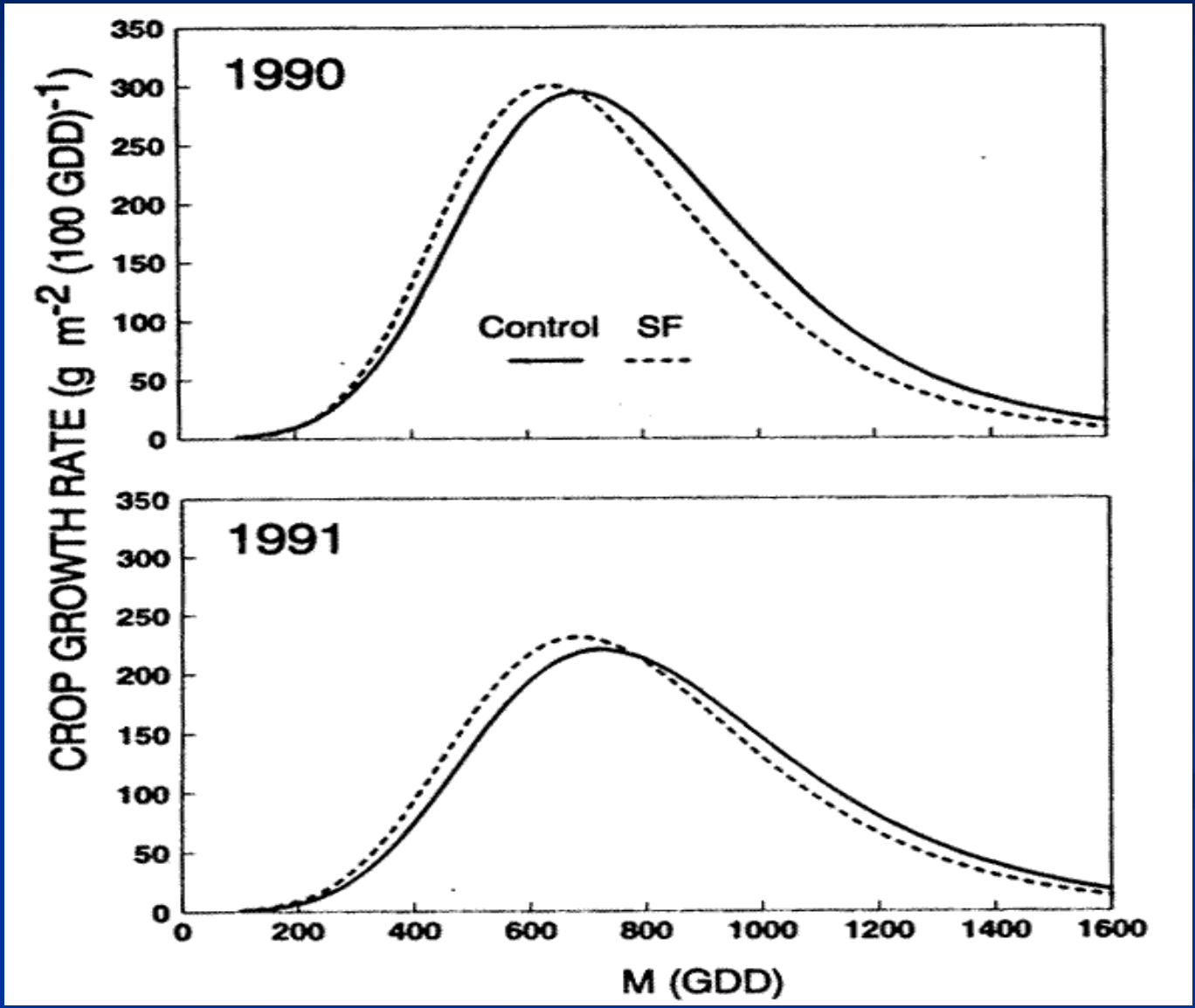
Historically Starter "Was a Good Thing"

- Lower soil test levels
- Smaller planters
- Limited corn acreage per farm
- Lower availability of custom application
- Response often linked to P

Early Season Growth Response Not a Guarantee of Economic Response

- Starter fertilizers stimulate early plant growth and development
- Early season growth response is not a always a predictor of yield response
- Yield response potential lower on high testing soils
- Grain moisture reductions observed with starter

Effect of Starter Fertilizer on Corn Growth Rate



Bullock et al., 1993

Starter Fertilizer Effects on Corn Yield and Moisture, Urbana, IL

	Grain yield		Moisture	
Treatment	1990	1991	1990	1991
	---- bu/a ----		-------- % --------	
Starter	181	140	21.0	22.4
Control	186	138	22.3	23.6

Soil test P = 68 ppm, K = 346 ppm. 10-34-0 starter, 13 lb N and 47 lb P_2O_5/acre

Bullock et al., 1993

Starter Fertilizer Use Has Changed

- Loss of time-use efficiency at planting
- Practicality of mounting and carrying attachments and fertilizer on very large planters
- Cost of attachments
- Lower potential for response on high testing soils

Many Attachment Options When Purchasing a Planter

Source: Kinze Mfg. website

Economics of Starter Fertilizer Attachments in Illinois No-Till Corn

Attachments on 8-row Planter	Total Planter List Price	Field Capacity
	$	ac/hr
No attachments	26,400	9.3
2 x 2-banded fertilizer attachments	34,700	8.0

Starter attachments increased planter price 31 % and slowed planting 14 %

Hibbard et al., 1996

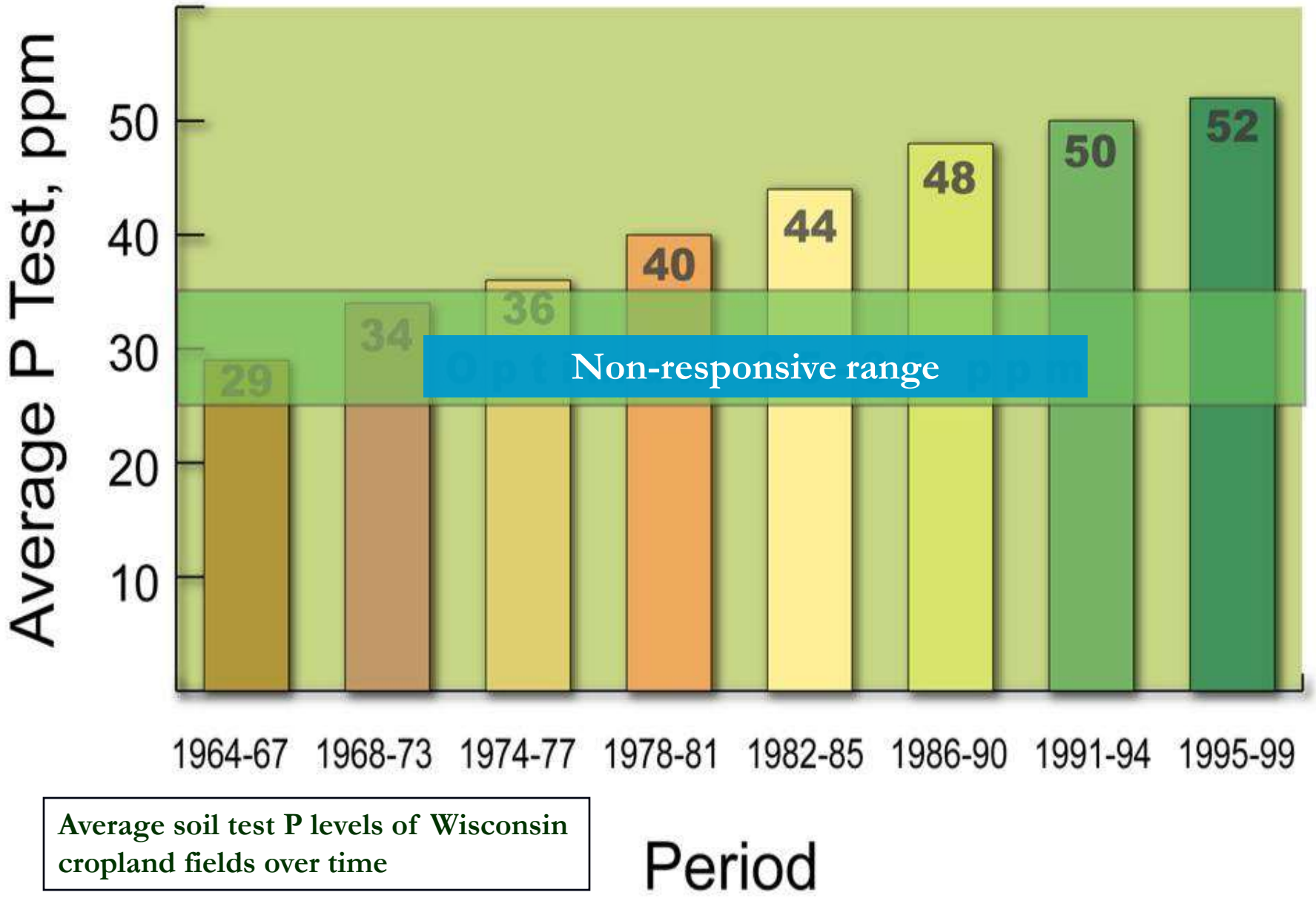
	Avg. cost of 8-row planter with starter since purchase	
Years after purchase	Seed-placed	2 x 2
	---------- $/ac ----------	
2	2.05	4.10
4	1.35	2.70
6	1.10	2.20
8	1.00	2.00
10	0.90	1.80

Cost of starter attachments decreases with time and use (500 acres per year)

What Factors Affect the Probability of Response to Starter ?

- Soil test P and K
- pH
- Organic matter
- Manure use
- Soil texture
- Hybrid maturity
- Planting date
- Previous crop
- Soil type
- Latitude  vs 
- Fertilizer grade
- Soil yield potential
- Weather
- Placement
- Tillage

Soil Test Levels Continue to Increase



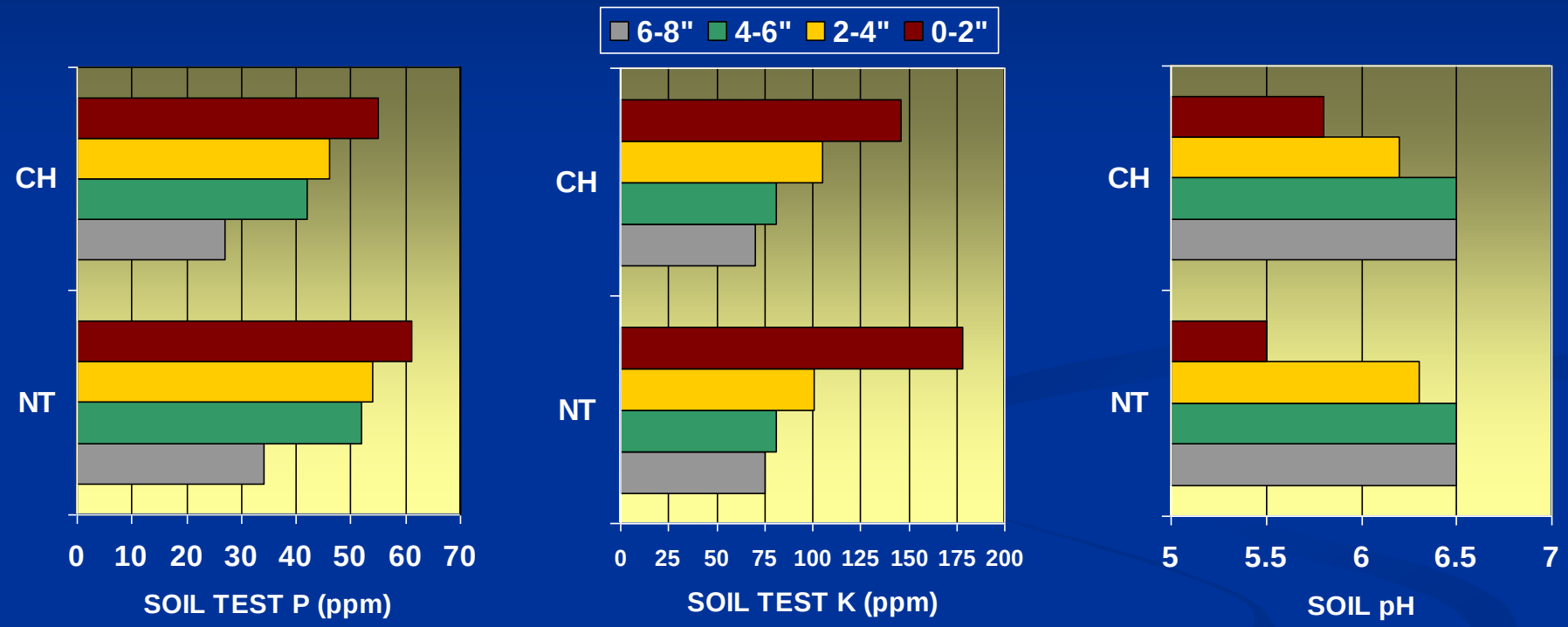
Average soil test P levels of Wisconsin cropland fields over time

Regional Trend for More Conservation Tillage

- Eight Midwestern states:
  - 106 million acres of cropland
  - 37 percent of all U.S. cropland
- 46% of no-till acres in U.S. in the Midwest
- 2002 Midwest data
  - 17 million acres of no-till soybeans
  - 7 million acres of no-till corn
  - Forty-five million acres (42.5 %) used conservation tillage

CTIC Website (2002 data)

Soil Test Stratification Following Five Years of Tillage Management, Arlington, Wis.



Wolkowski, 2003 (corn/soybean rotation)

Fertilizer Placement Affects Corn Root Distribution (0-15 In.)

		Root length (km/m^3)		
Tillage	Fert. placement	Row	Untracked Inter-row	Tracked Inter-row
CH	ROW	17.1	3.0	0.8
CH	INTER-ROW	12.0	4.4	1.4
NT	ROW	19.8	2.5	0.8
NT	INTER-ROW	10.8	6.1	1.5

Kaspar et al., 1991

Conservation Tillage is More Responsive to Banding

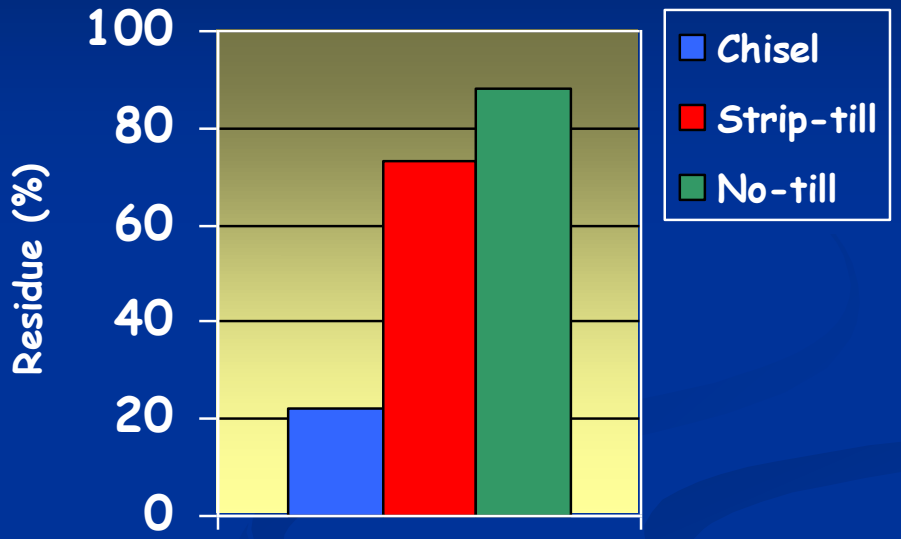
- Positional availability
  - Lack of mixing by tillage
  - Immobilization
- Wheel track vs. non-wheel track effects on root distribution
- Cooler soil conditions
- Reduced K uptake from zones of poor aeration

No-till Corn Yield Response to Starter Fertilizer in Selected Experiments

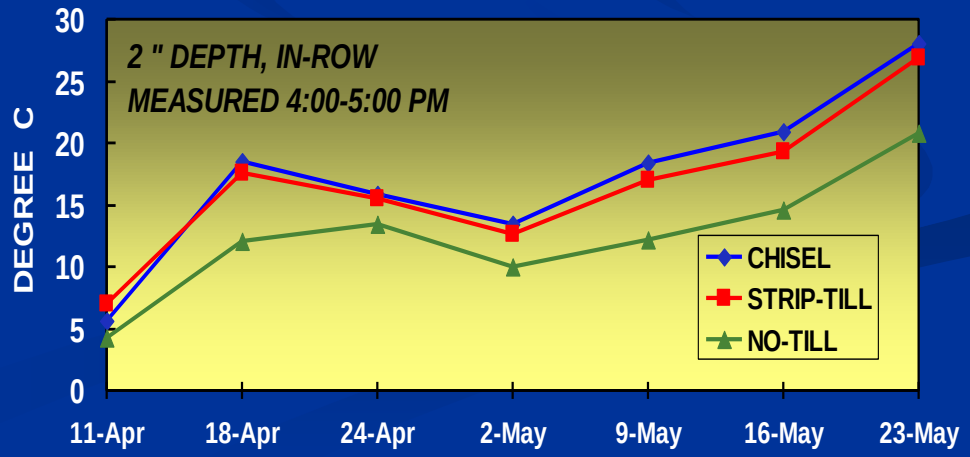
Location	Starter Treatment	Response
Missouri Scharf (1999)	N,P,K; 2 x 2	6 of 6 expts. 13 bu/a incr.
Iowa Buha et al. (1999)	N,P,K; 2 x 2	7 of 9 expts. 4-18 bu/a incr.
Wisconsin Bundy - Widen (1999)	N,P,K; 2 x 2	8 of 12 expts. 15 bu/a incr.
Illinois Ritchie et al. (1996)	N,P,K; 2 x 2	8 of 9 expts. 14 bu/a incr.

Soil Temperature Affected by Tillage and Crop Residue

Effect on crop residue, Arlington, 1994

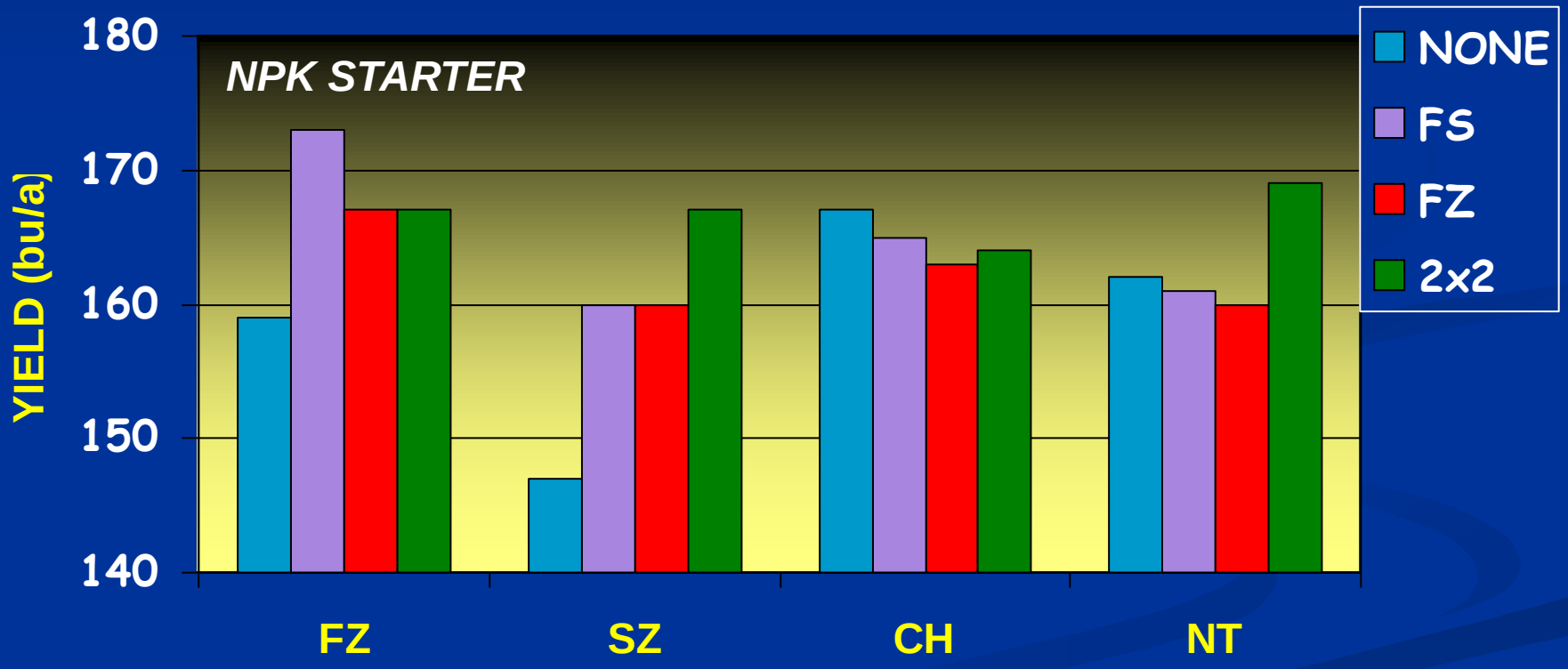


Effect on in-row soil temperature, Arlington, 1994



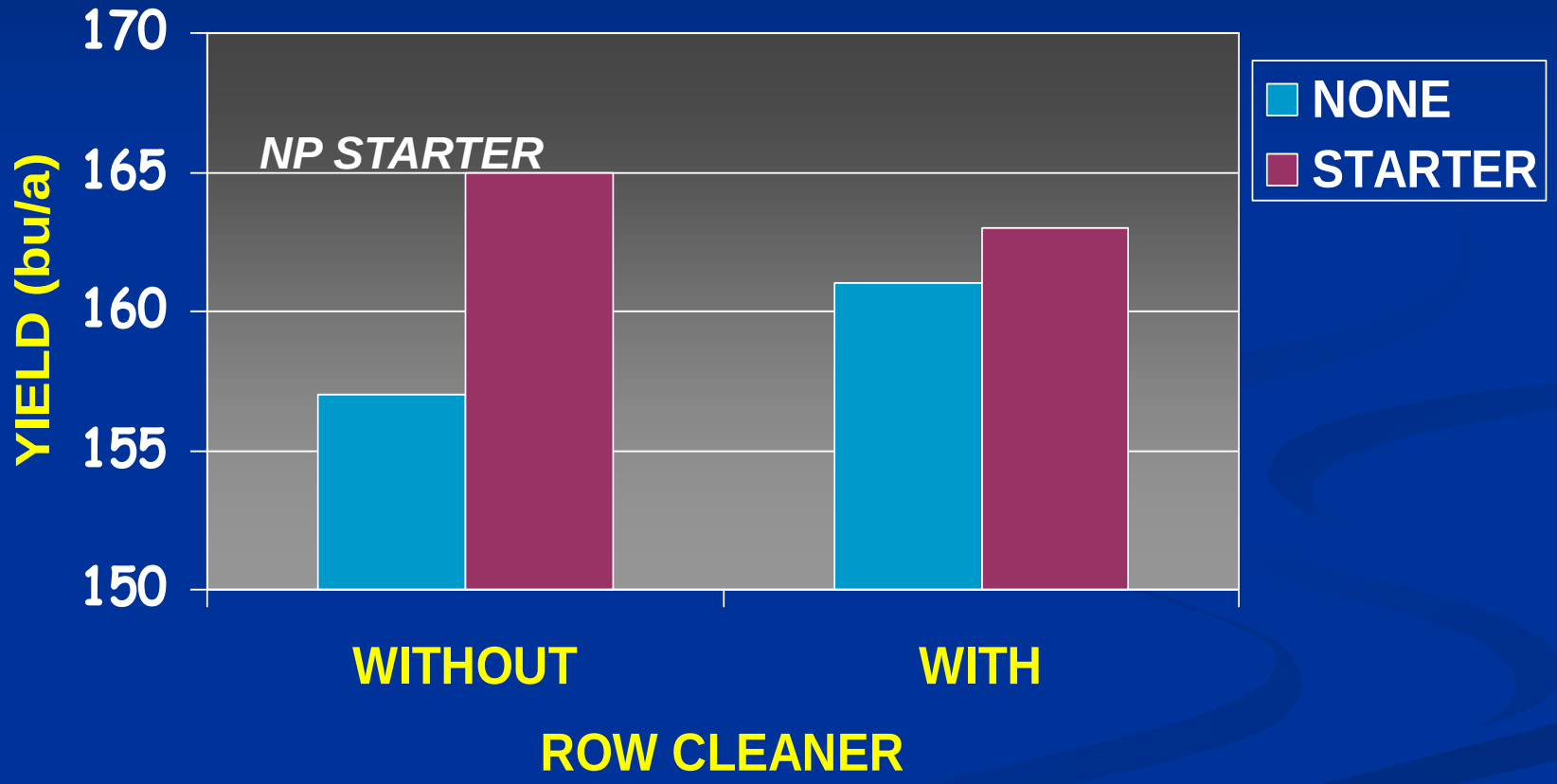
Wolkowski, 2000

Interactive Effect of Tillage and Row Fertilizer, Arlington, 1994-1996 (3 yr. avg.)



Wolkowski, 2000

Interaction Between Starter Fertilizer and Row Cleaners



Vetsch and Randall, 2000

Where Do We Put Starter

- Trend toward lower rates and N or N-P composition using fluids
- More interest in seed-placement
- Is 10-34-0 or similar N-P fertilizer adequate as a starter?
- Is a complete (N-P-K) fertilizer necessary?
- 2 x 2 versus seed

What About Seed-placement

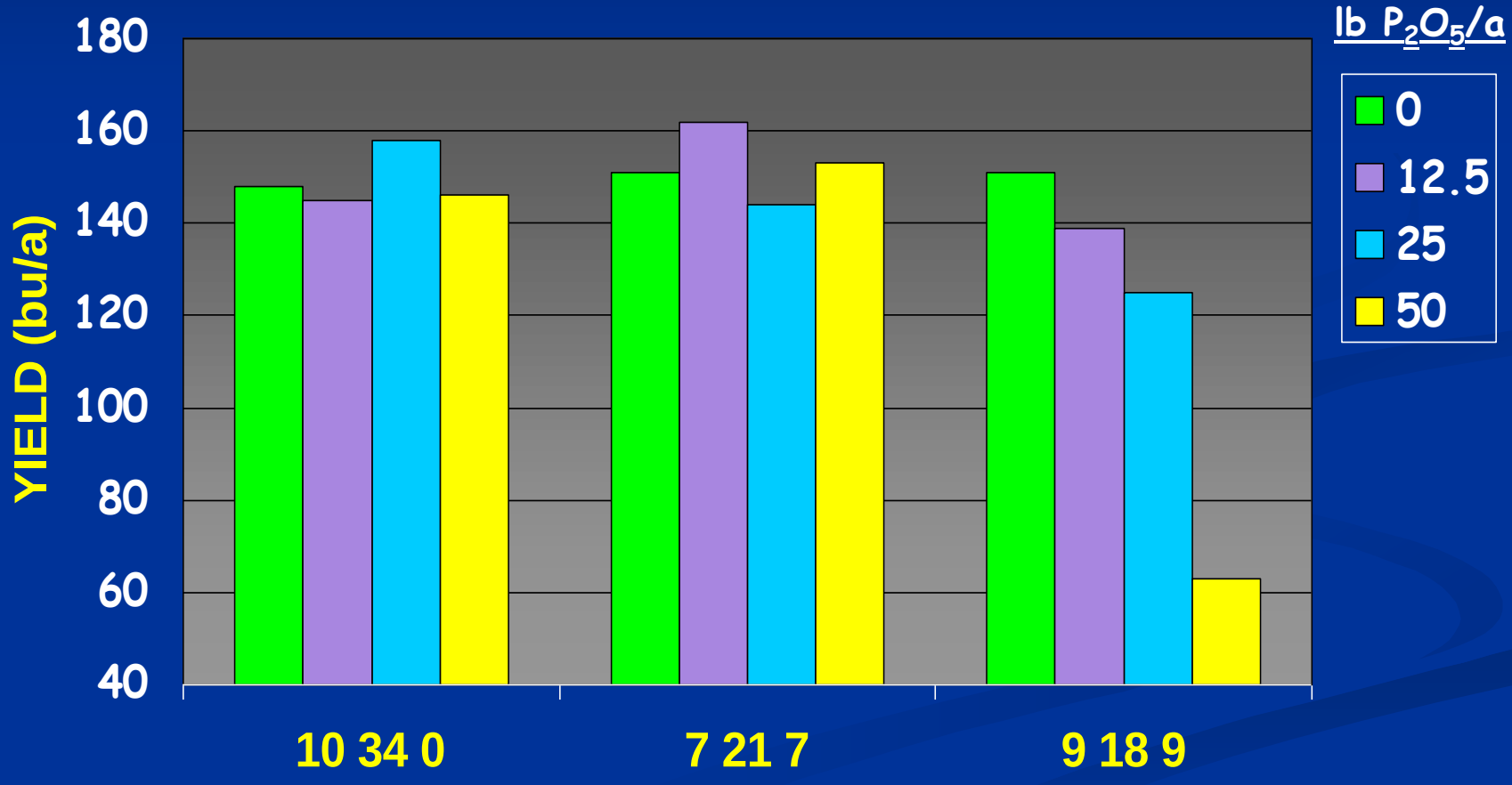
- Some suggest higher availability for seed-placed materials
- Difficult to include K
- Avoid high salt carriers and use on salt-sensitive crops
- No urea, UAN, ATS
- Limit to 10 lb N + K_2O/a
- Use with caution on sandy or dry soils

Comparisons of Liquid and Dry Starter Fertilizers Applied to Corn, Arlington, Wis.

Starter $N+P_2O_5+K_20$	Placement	Corn yield 3 yr. avg.
----lb/a-----		----bu/a----
0+0+0	------	125
3.2+6.5+3.2 “cold”	seed	133
3.2+6.5+3.2 “hot”	seed	128
6+24+24 liquid	2x2	139
6+24+24 dry	2x2	137
LSD (0.10)		11

Wolkowski and Kelling, 1985

Influence of Rate and Type of Seed-placed Fertilizer



Gelderman et al., 1995

Response Potential is Complicated
(Tillage, Planting Date, and Composition)

- Tillage
  - No-till
  - Moldboard plow
- Planting Dates (four)
  - Late April – Late May
- Composition (lb/a, all received 10 lb N/a)
  - Control (0 + 0)
  - P_2O_5 (25 + 0)
  - K_2O (0 + 25)
  - $P_2O_5 + K_2O$ (25 + 25)

Bundy and Widen, 1992

Effect of Tillage and Starter Fertilizer on Corn Yield

Starter $N\text{-}P_2O_5\text{-}K_2O$	Moldboard plow	No-till	Mean
lb/acre	---------- Yield, bu/acre ----------		
10-0-0	153 b	143 b	148 c
10-25-0	157 b	149 ab	153 b
10-0-25	152 b	147 ab	150 bc
10-25-25	164 a	152 a	158 a

Average of four planting dates

(Bundy & Widen, 1992)

Effect of Starter Fertilizer &Tillage on Grain Moisture

Starter N-P_2O_5-K_2O	Moldboard plow	No-till
lb/acre	---------- Moisture, % ----------	
10-0-0	24.5 NS	32.7 a
10-25-0	25.8	28.7 b
10-0-25	25.5	27.3 b
10-25-25	24.7	29.0 b

Data from late May planting date

(Bundy & Widen, 1992)

Planting Date and Tillage Effects on Starter Response

Planting Date	Yield Response	
	MP	NT
	(bu/acre)	
Apr. 23-26	+16	- 2
May 2-3	+ 3	+6
May 11-14	+15	+11
May 23-24	+ 9	+21

Average of 3 years

On-farm Validation

- 100 On-farm sites (total over 3 years)
- Major corn growing areas
- With/without starter
- Field scale strips, 3 reps.
- Production practices, site histories
- Plant height, 8 weeks
- Grain yield w/, w/o starter

Bundy and Andraski, Wis.

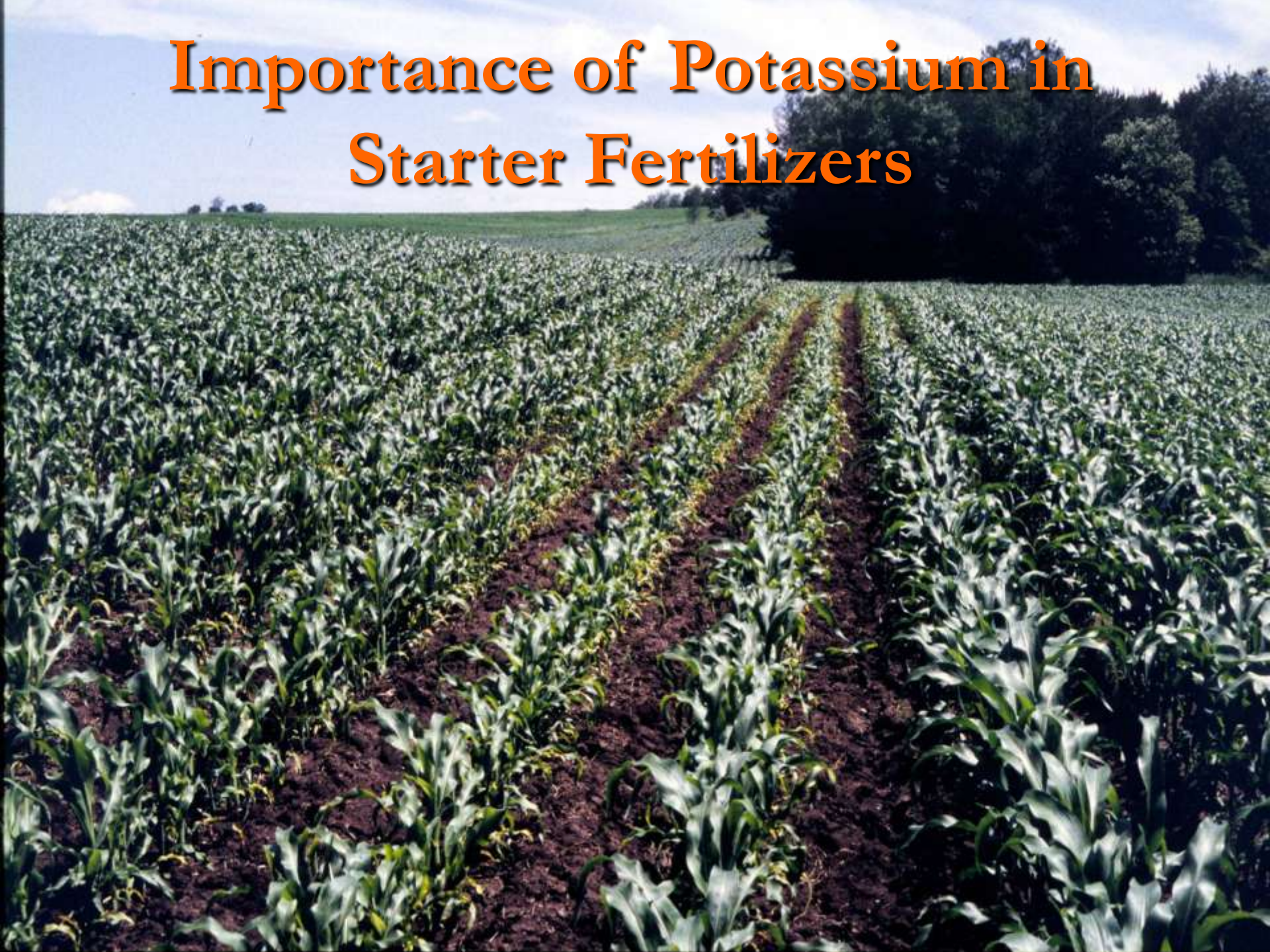
Overall Results

- Average starter rate = 15+26+32
- Most soil tests excessively high
  - P = 93% EH
  - K = 73% EH
- Average yield response: 4 bu/acre
- Economic return (4.5 bu/a) positive at 40% of sites

Relationship Between Selected Site Factors and Response to Starter (pr>F)

Soil pH	0.99	Soil test P	0.63
Manure use	0.93	N in starter	0.62
P in starter	0.91	K in starter	0.36
Soil OM	0.91	Yield potential	0.31
Crop residue	0.87	Planting date	0.29
Texture	0.77	Soil test K	0.05
Previous crop	0.64	Rel. maturity	0.05

Importance of Potassium in Starter Fertilizers



Research Shows the Value of K in Starter Compared with Broadcast

Site 1		Site 2		Site 3	
Trmt	Yield	Trmt	Yield	Trmt	Yield
K_2O (lb/a)	bu/a	K_2O (lb/a)	bu/a	K_2O (lb/a)	bu/a
0	114	0	137	0	132
40 (2 x 2)	143	45 (2 x 2)	180	45 (2 x 2)	166
100 (bdct)	136	105 (bdct)	158	105 (bdct)	144
200 (bdct)	140	--	--	--	--

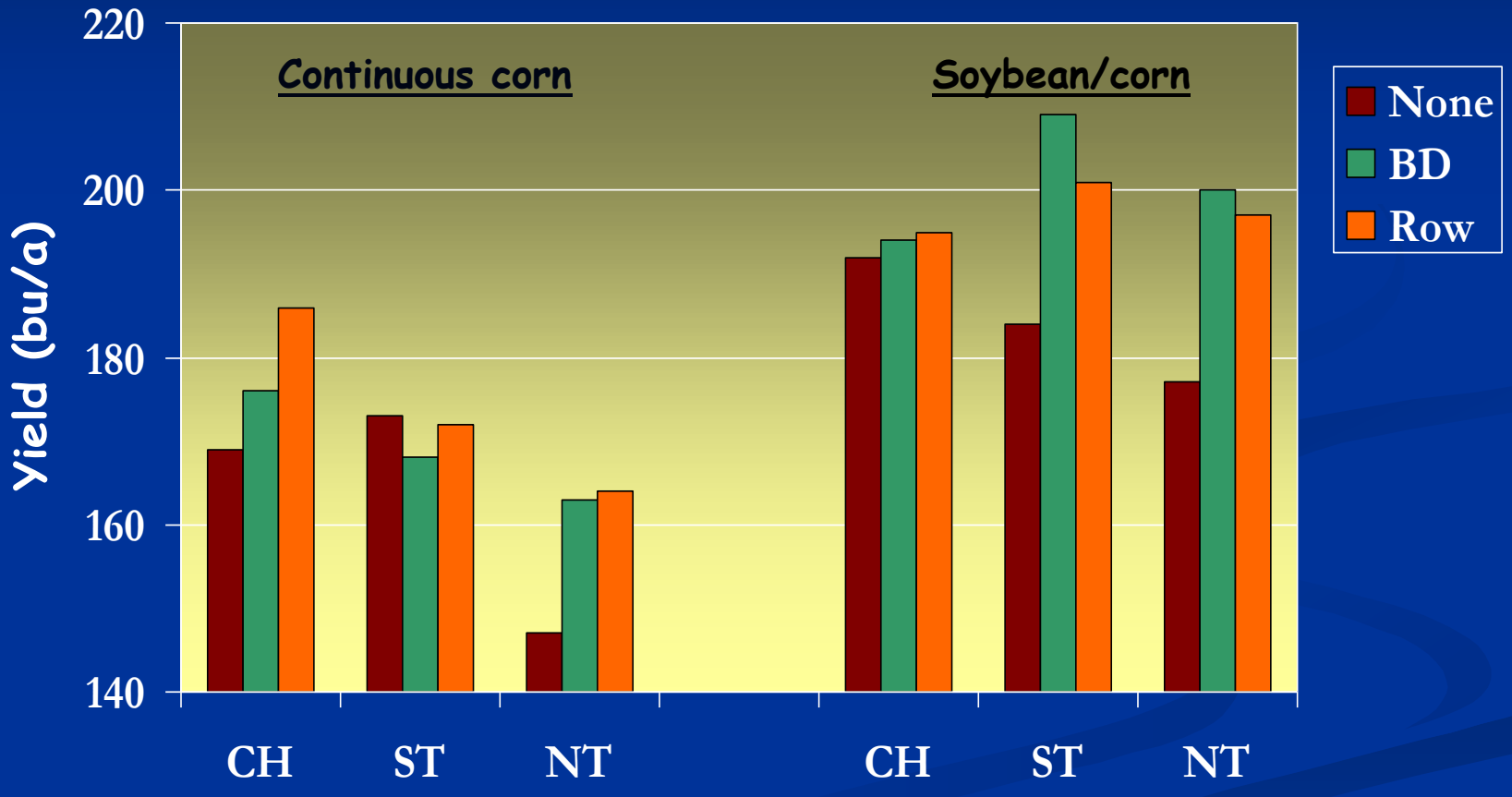
Wagar and Rehm, 2004

Effect of Rotation, Tillage, and Fertilizer on Corn K Concentration 45 DAP, Arlington, Wis., 2001

	CC			SbC		
	CH	ST	NT	CH	ST	NT
	------- % -------			------- % -------		
NONE	2.23	2.37	2.35	1.65	1.34	1.40
BDCT	2.35	2.19	2.51	2.51	2.18	1.40
2 x 2	2.85	3.26	2.81	2.46	2.58	2.16

Wolkowski, 2003

Response Of Corn To Tillage And Fertilizer Placement, Arlington, Wis. 2001-2003



Wolkowski, 2004
200 lb 9-23-30/a

Evaluaton of Response to K in Long-term Calibration Plots

- Long-term plots with wide range of soil test K (VL to EH, 60 to 265 ppm).
- Response to NPK starter (100 lb/a 9-23-30) across range of soil test K levels.
- Corn yield responses measured over 4 yr. (1993 to 1996)
- Spring disked & chisel plowed in 1993 and 1996, no-till in 1994 and 1996

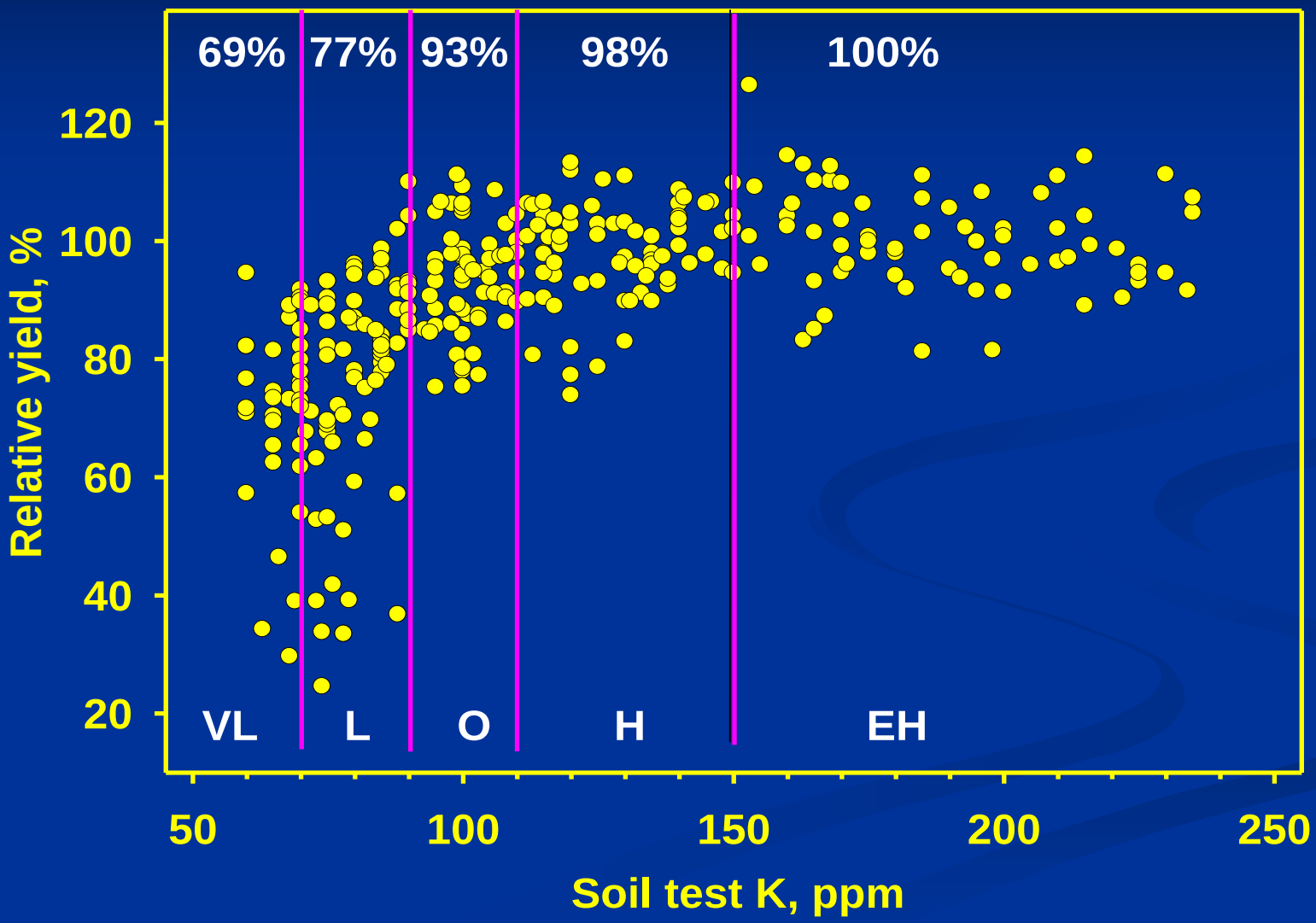
Bundy and Andraski, Wis.

Growing Season Characteristics

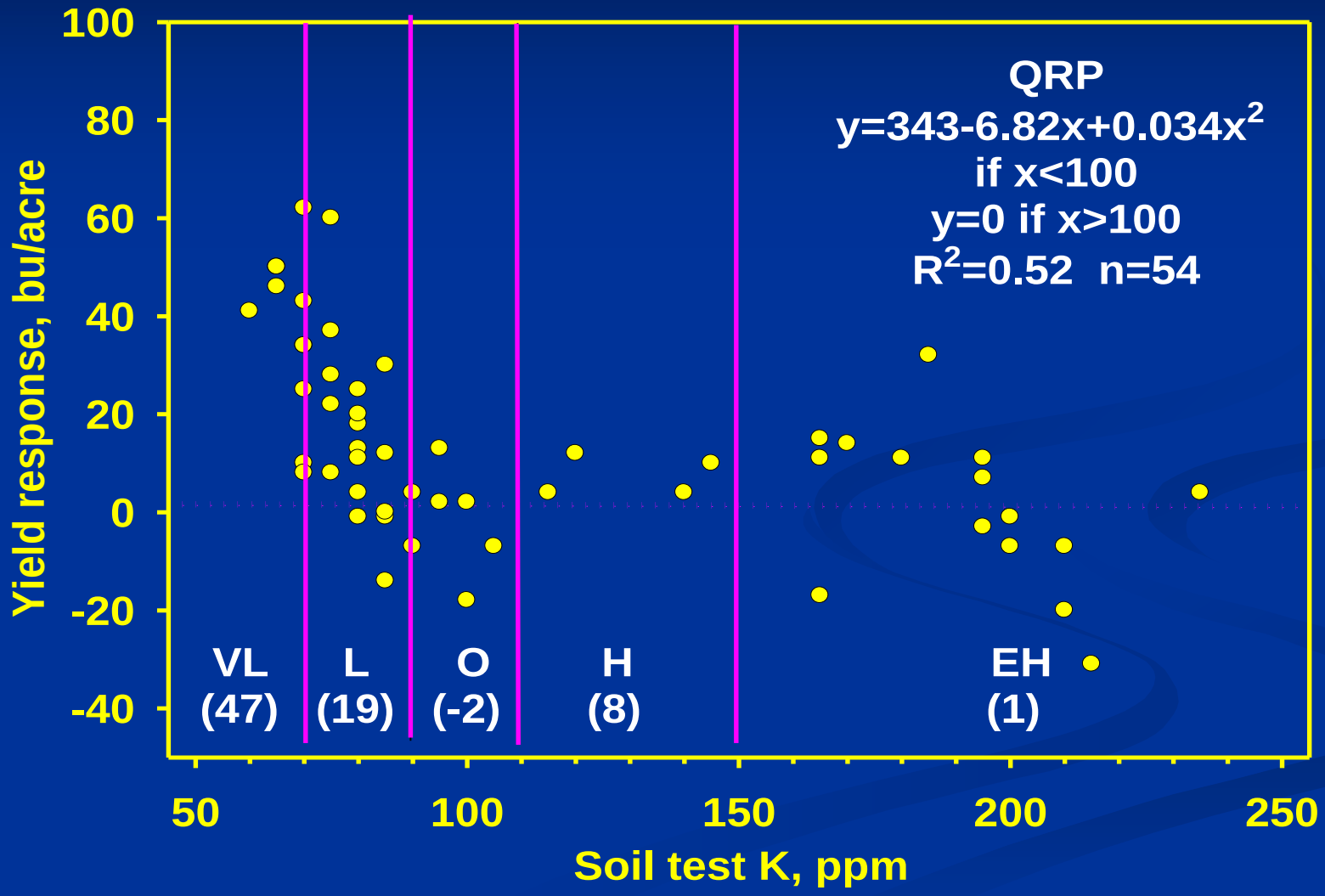
Year	PDRM*	F.F. days	GDD
1993	225	154	2055
1994	228	189	2293
1995	227	145	2413
1996	228	170	2043

* Planting dates: Apr. 30 to May 3; RM=105

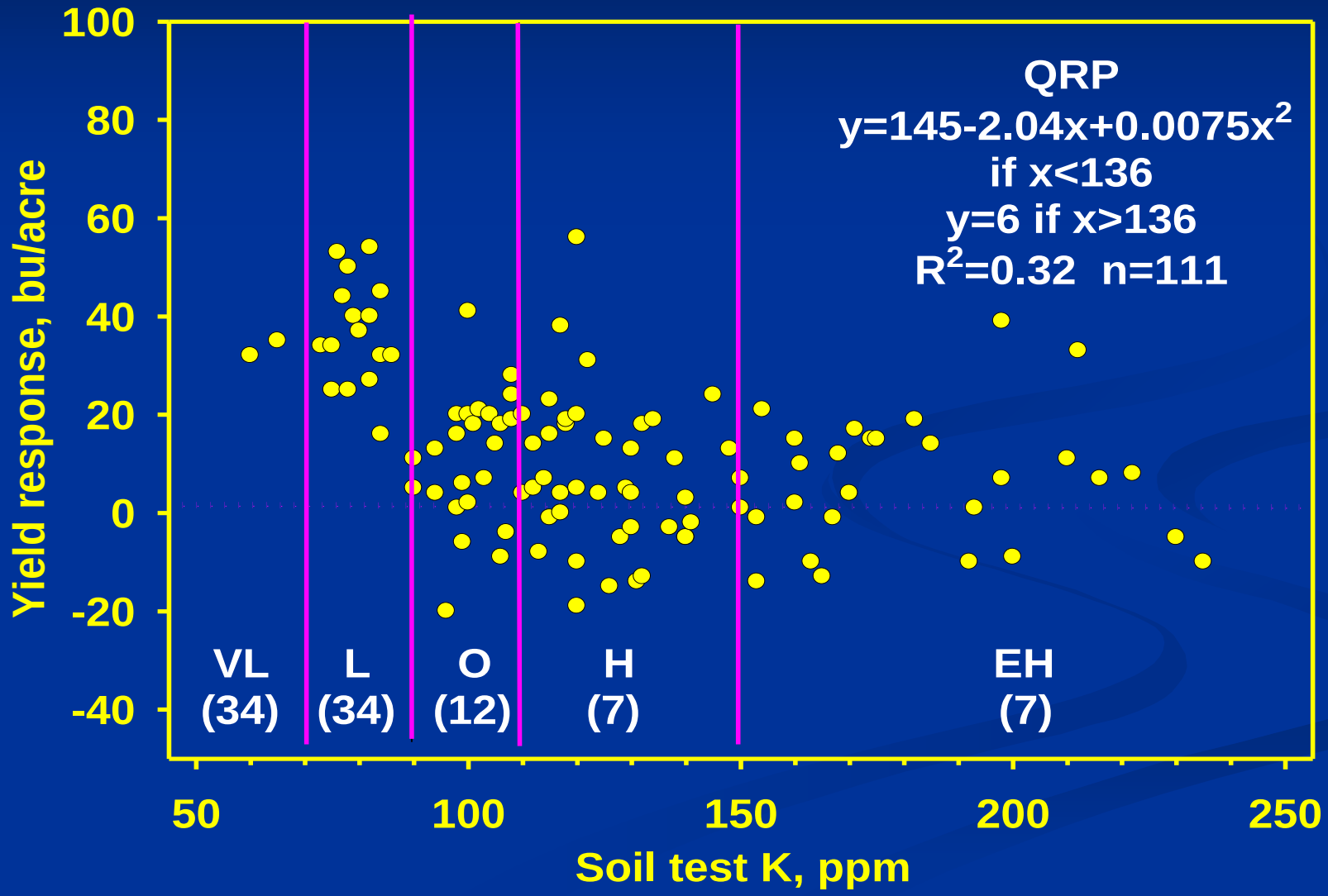
Soil K Response Relationship Relative to Current Soil Test Interpretation Ranges at Arlington, 1993 To 1996



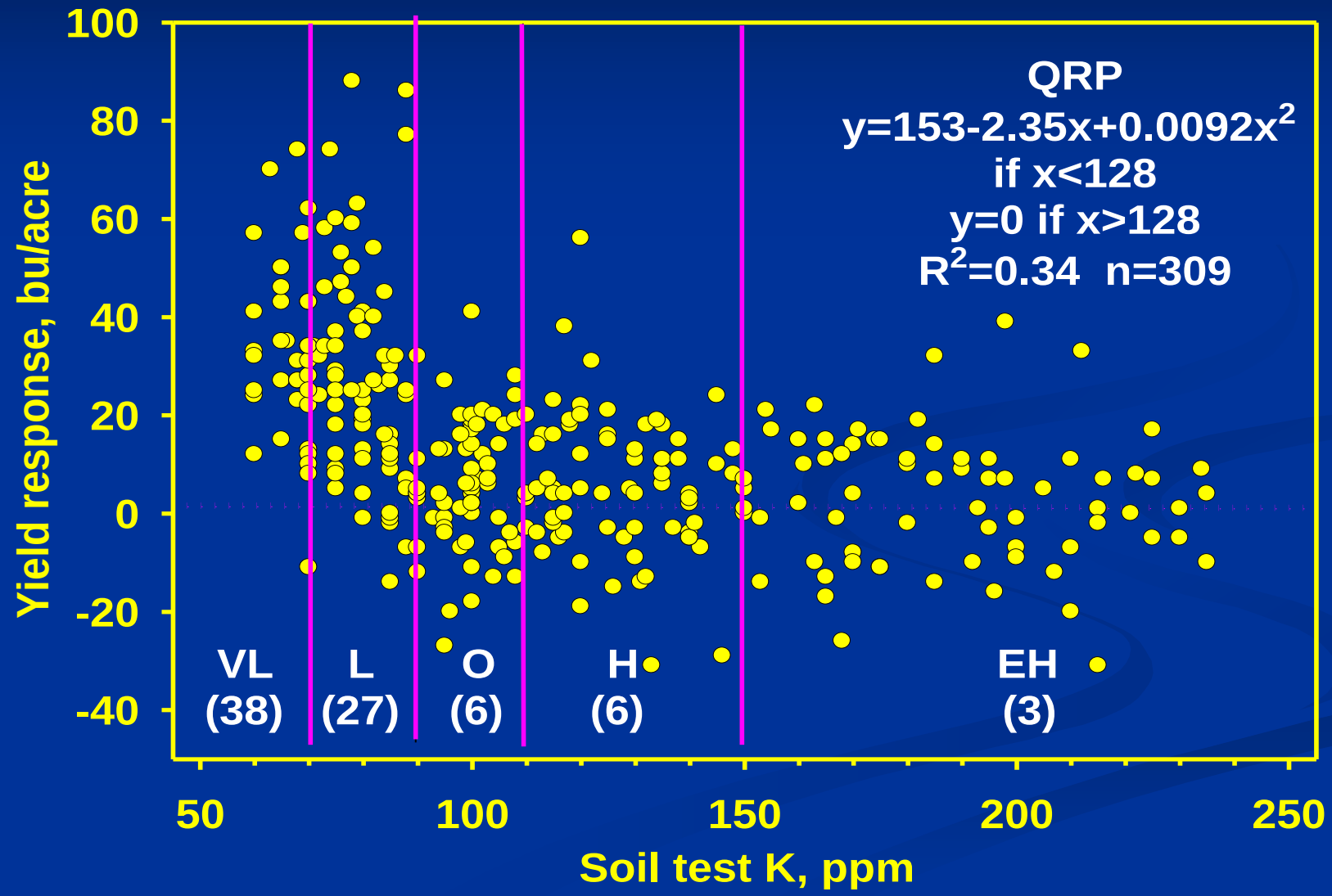
Relationship Between Soil Test K Level and Yield Response to Starter Fertilizer at Arlington, 1995



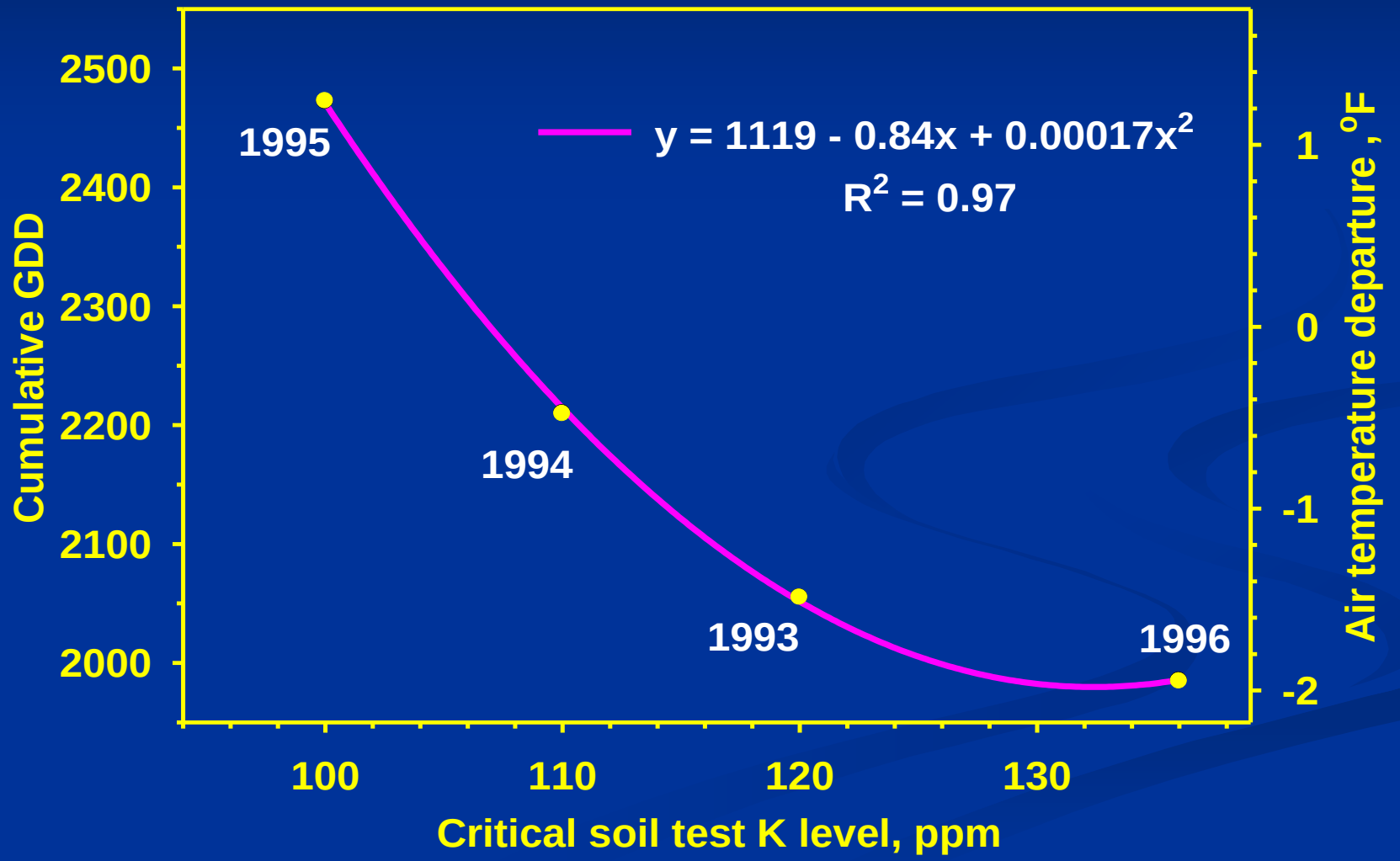
Relationship Between Soil Test K Level and Yield Response to Starter Fertilizer at Arlington, 1996



Relationship Between Soil Test K Level and Yield Response to Starter Fertilizer at Arlington, 1993-1996

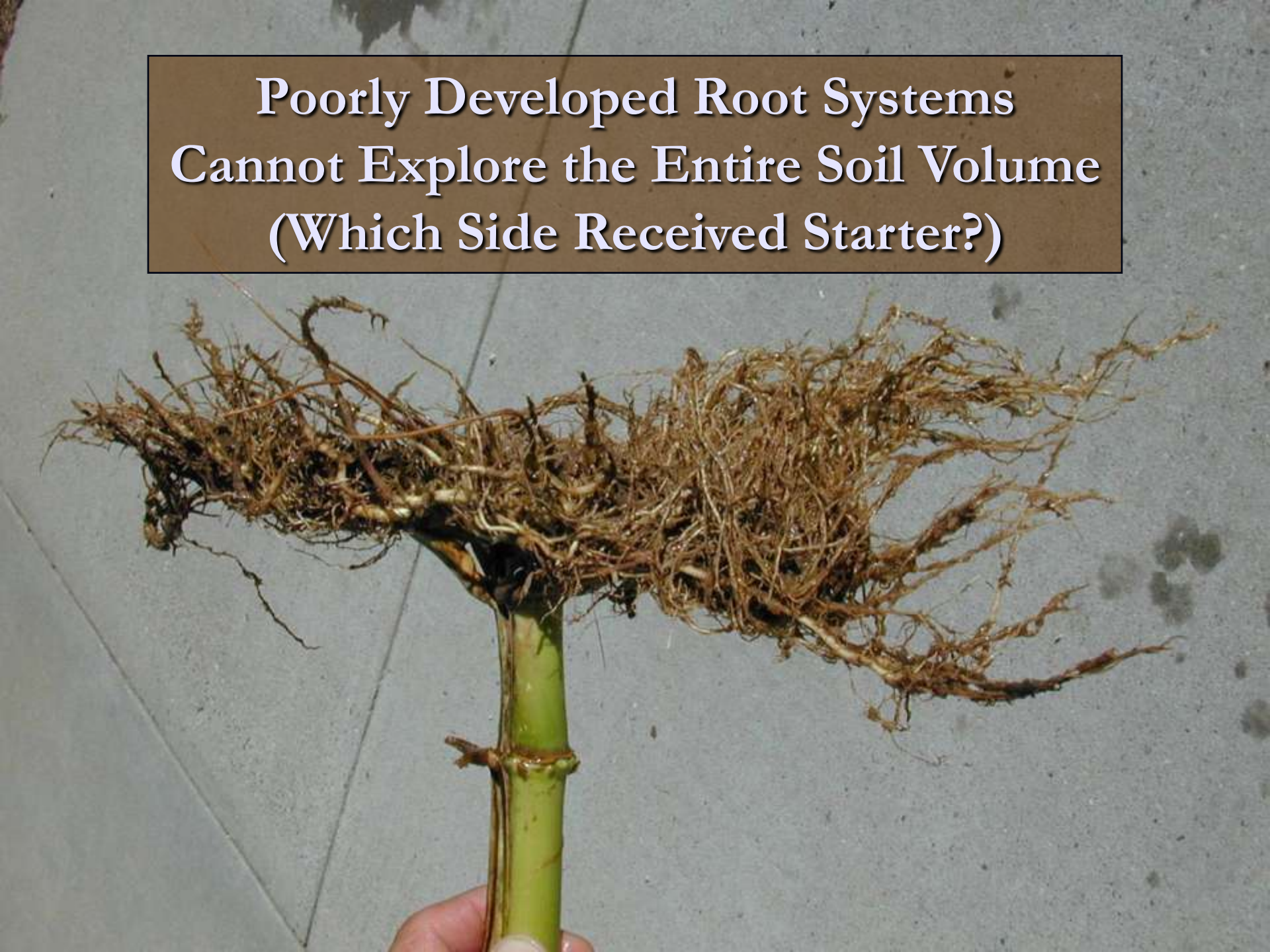


Relationship Between Temperature (GDD And Departure – May to September) and Maximum Soil Test K Level Where Yield Response Occurred to Starter Fertilizer



Soil compaction destroys structure, reduces porosity, increases resistance to root growth, and limits aeration needed for root respiration

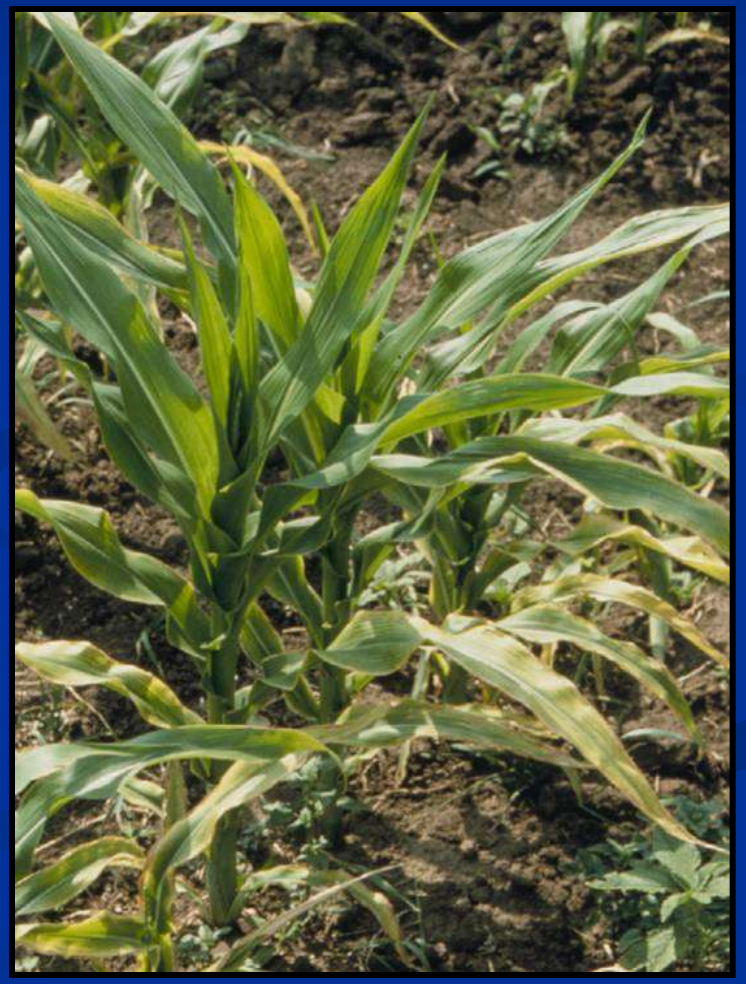
Poorly Developed Root Systems Cannot Explore the Entire Soil Volume (Which Side Received Starter?)



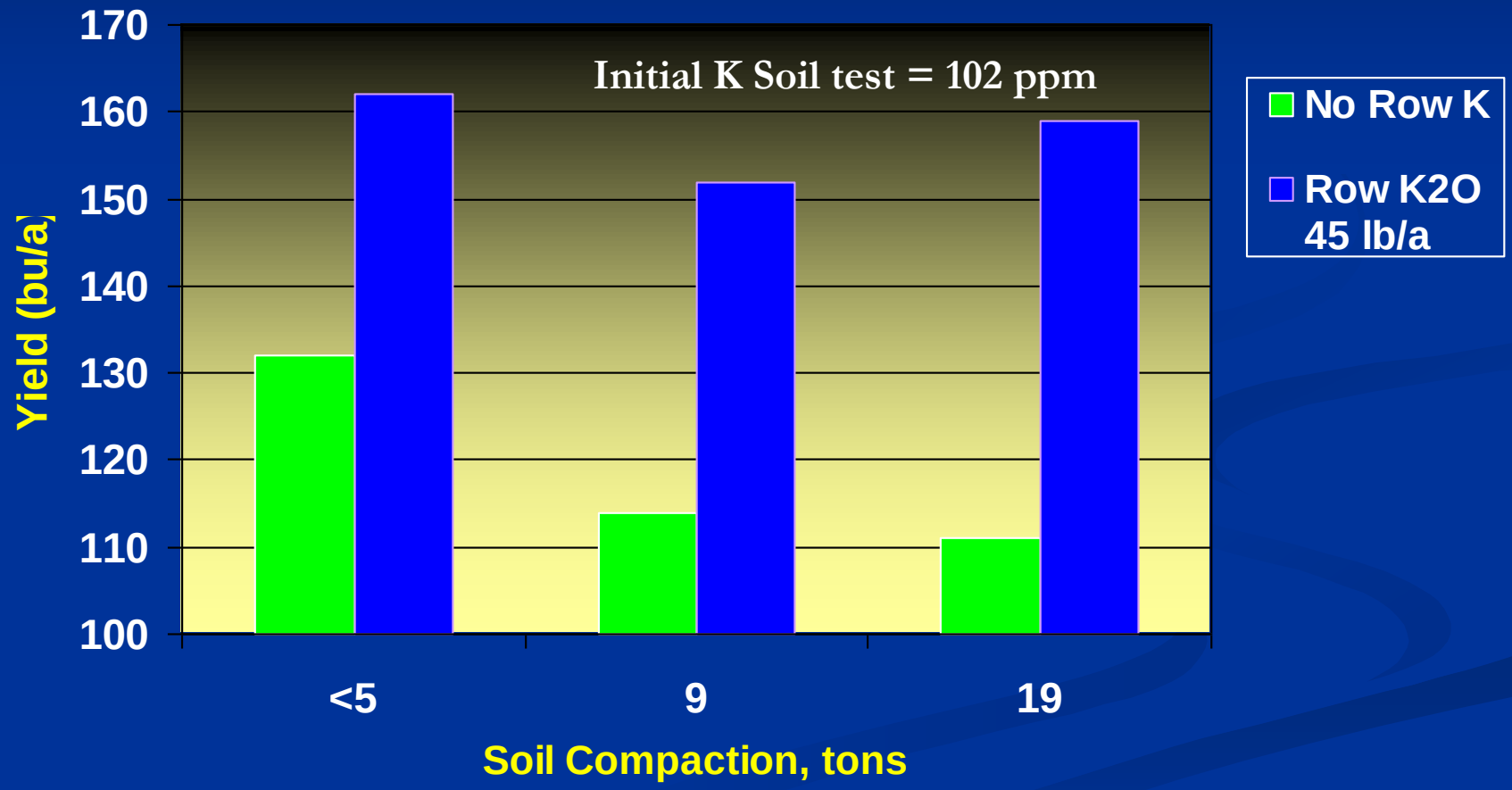
Compaction Affects Nutrient Uptake

Potassium Affected Most

- Compaction reduces porosity and limits root growth
- Lowers soil O_2 and slower replenishment from the atmosphere
- O_2 needed for root respiration and active uptake of K
- Compacted soils are often responsive to K fertilization



Row K Effects on Corn Yield with Increasing Soil Compaction



Wolkowski, 1989

Summary

- Are we be finished with starter?
  - Research shows it is worth the time and expense in many situations
- N or N-P starters may not maximize response
  - Complete (NPK) starters give a more consistent response
- Research shows K in starter is important
  - Reduced tillage
  - Low K soils
  - Compacted soils

Summary

- Frequency and size of response to starter is influenced by GDD accumulation
  - Response to starter occurred at higher soil test K levels in cooler growing seasons
- Use a complete starter
  - Use fluids containing K
  - Risks with seed placement
  - Recommend 10+20+20 ($N+P_2O_5+K_2O$) for soils slow to warm in the spring