Nitrogen and Potassium Fertilizer Placement Consequences for Corn: A Look at Controlling Factors

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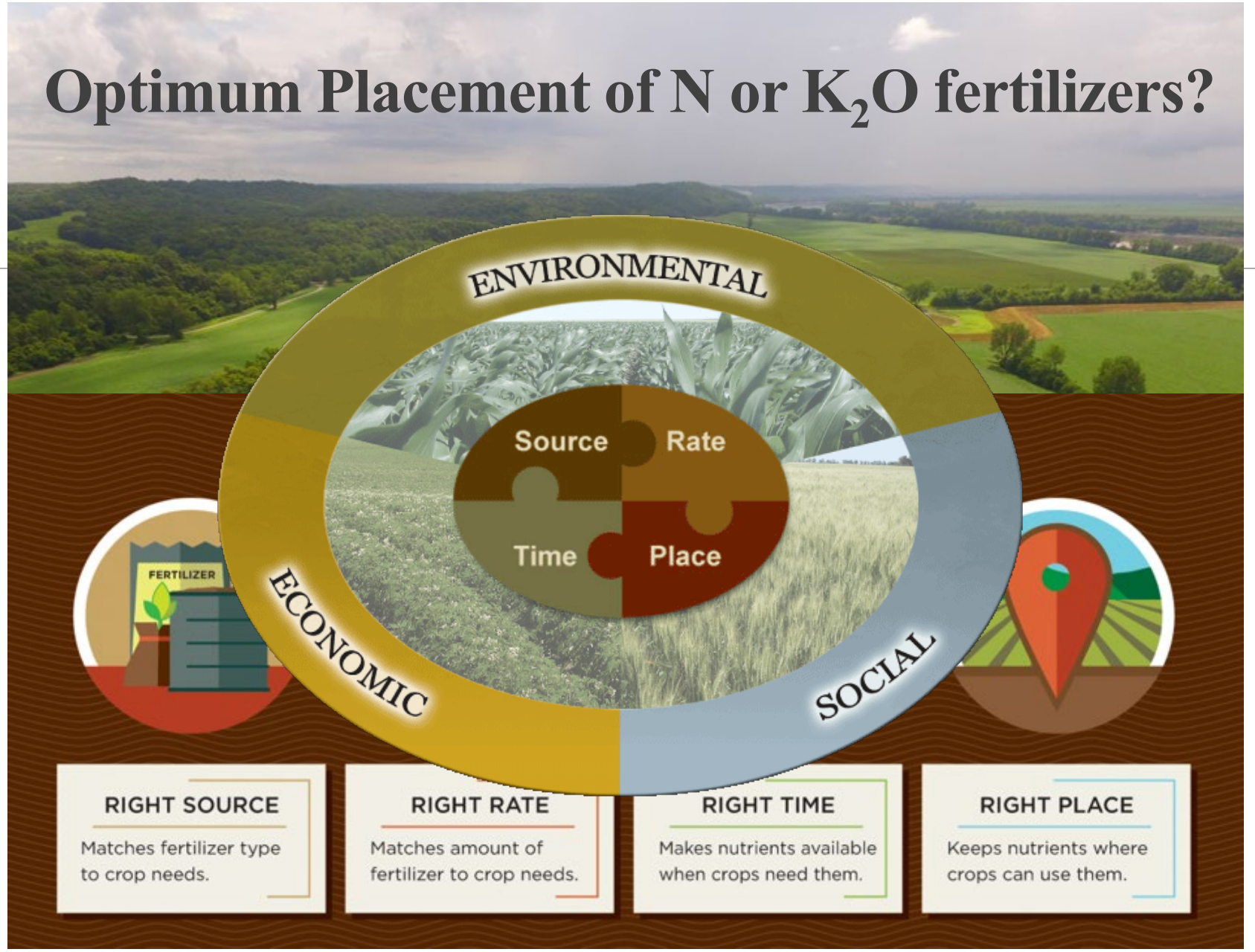
Optimum Placement of N or K_2O fertilizers?



Source: International Plant Nutrition Institute

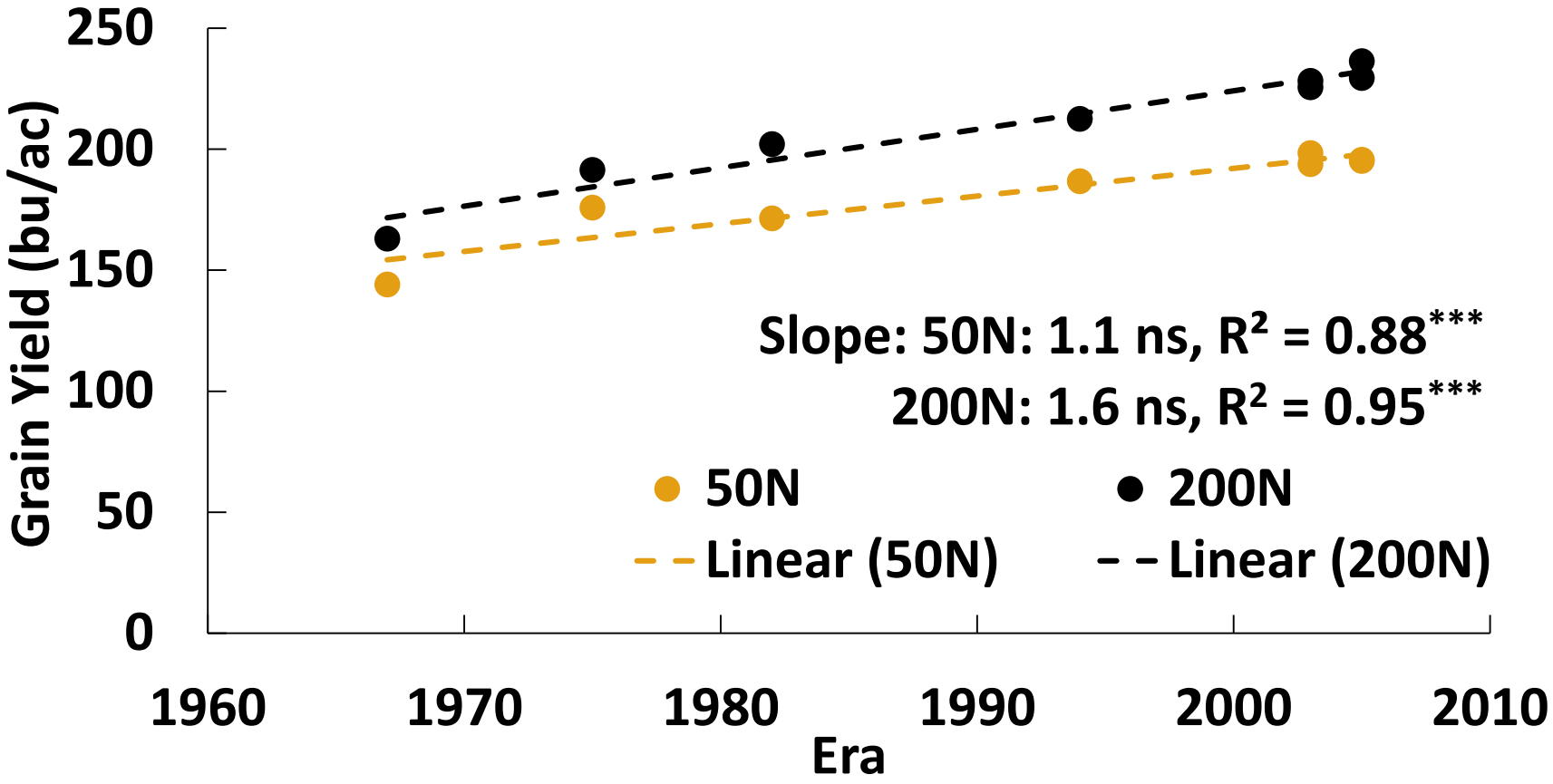
Corn Nitrogen Timing Changes from Before Planting to In-Season (At-plant, Sidedress early to Sidedress late)

Photo Source: Dr. N. Kitchen, USDA-ARS, Missouri

Study of Dekalb Hybrids from 1967 to 2005 and Their Response Changes to Nitrogen and Plant Density Management (2012-2014)

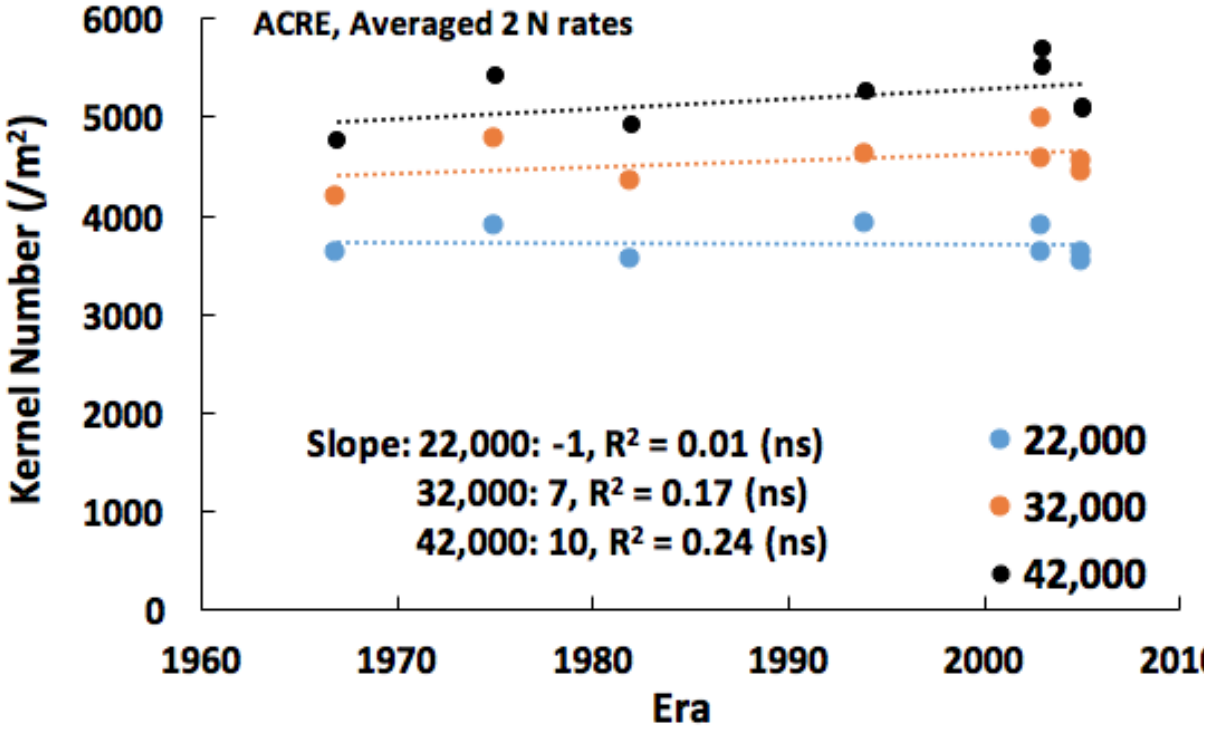
Photo: Agronomy Center, Purdue, 2014

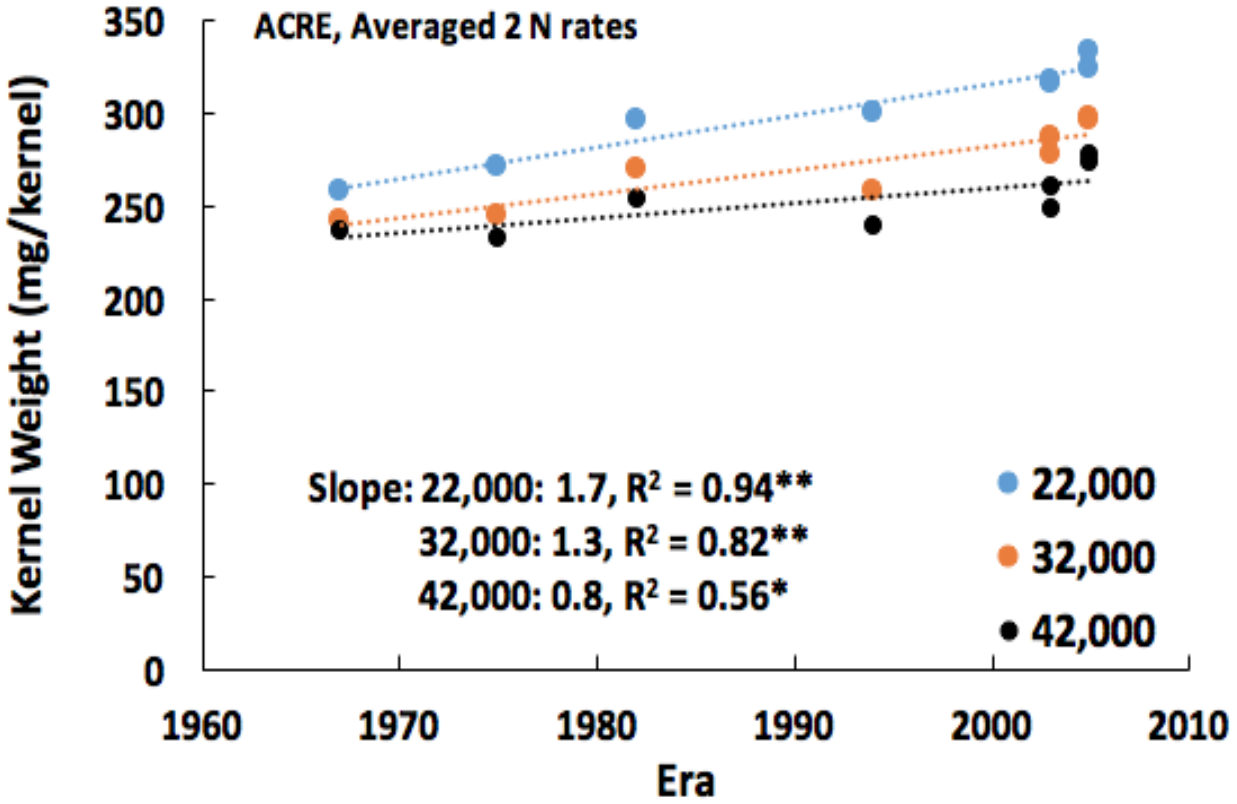
Nitrogen rate effect on Dekalb hybrid yield gains with year of commercial release (West Lafayette, 2013-2014)



Source: Keru Chen et al., Field Crops Research, 2016

Kernel Number and Kernel Weight Gains in Dekalb hybrids with year of commercial release (West Lafayette, 2013-2014)

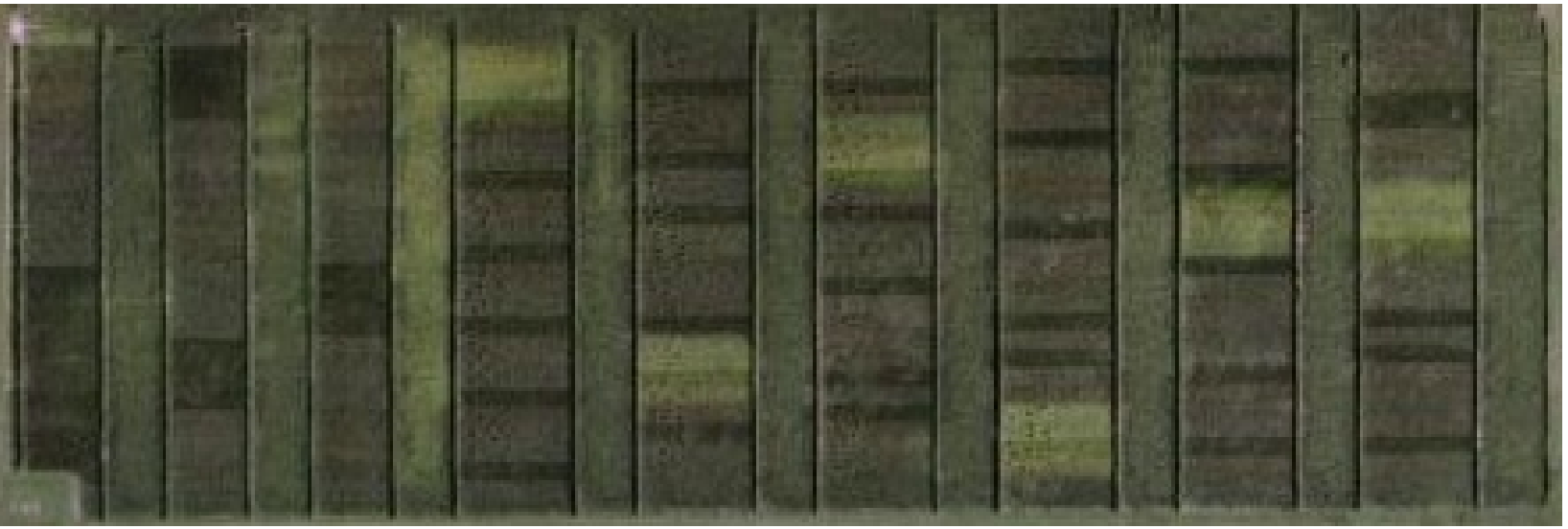




Source: Keru Chen et al., Field Crops Research, 2016

Corn Hybrid Era Gains in Yield and in Recovery of Late-Season N Applications?

N Treatment Name	kg N ha^{-1} @ V3-V4	kg N ha^{-1} @ R1
0_0	0	0
200_0	220	0
150_50	150	50



Hybrids (1946-2015)

1. 352HYB (1946)
2. 354A (1958)
3. 3390 (1967)
4. 3382 (1976)
5. 3335 (1995)
6. 34N42 (2003)
7. P1311 (2015)

Source: Mueller and Vyn, unpublished, 2017

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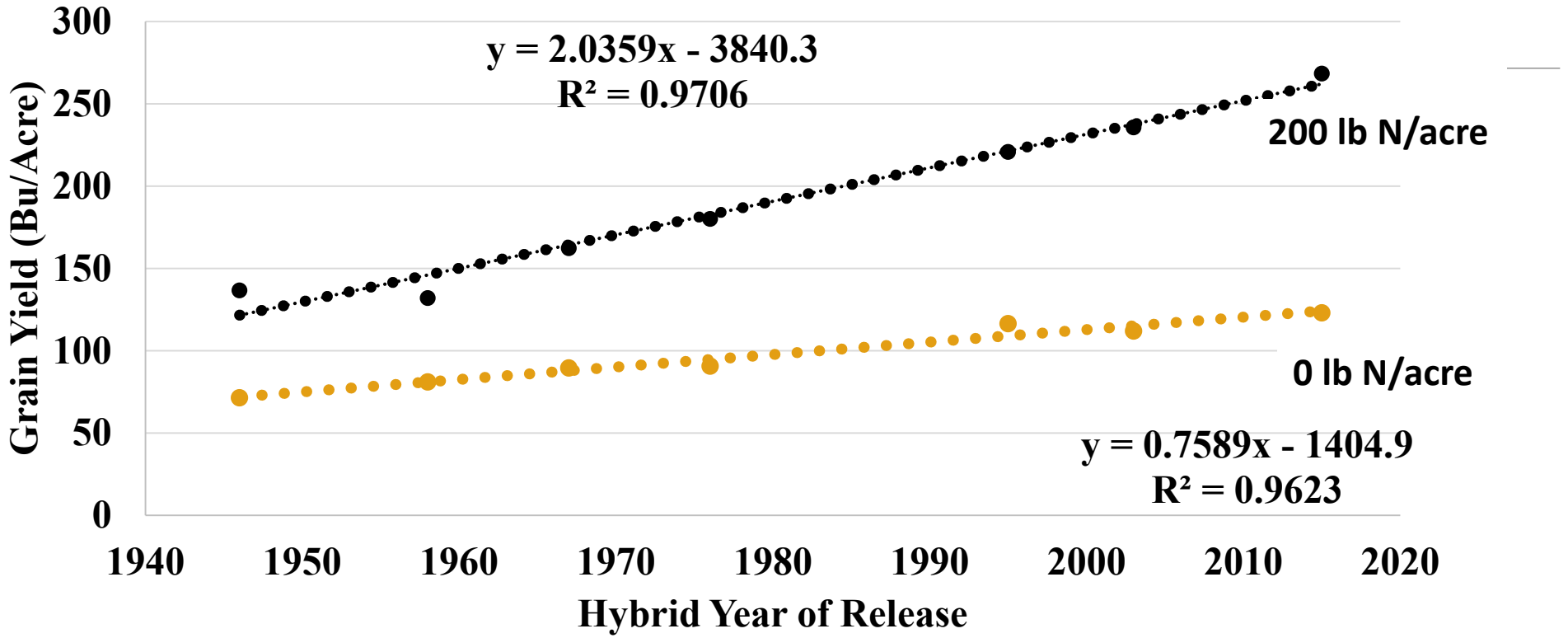
Grain Yield Response to N Rate with Pioneer Era Hybrids (average of 2016-2017)

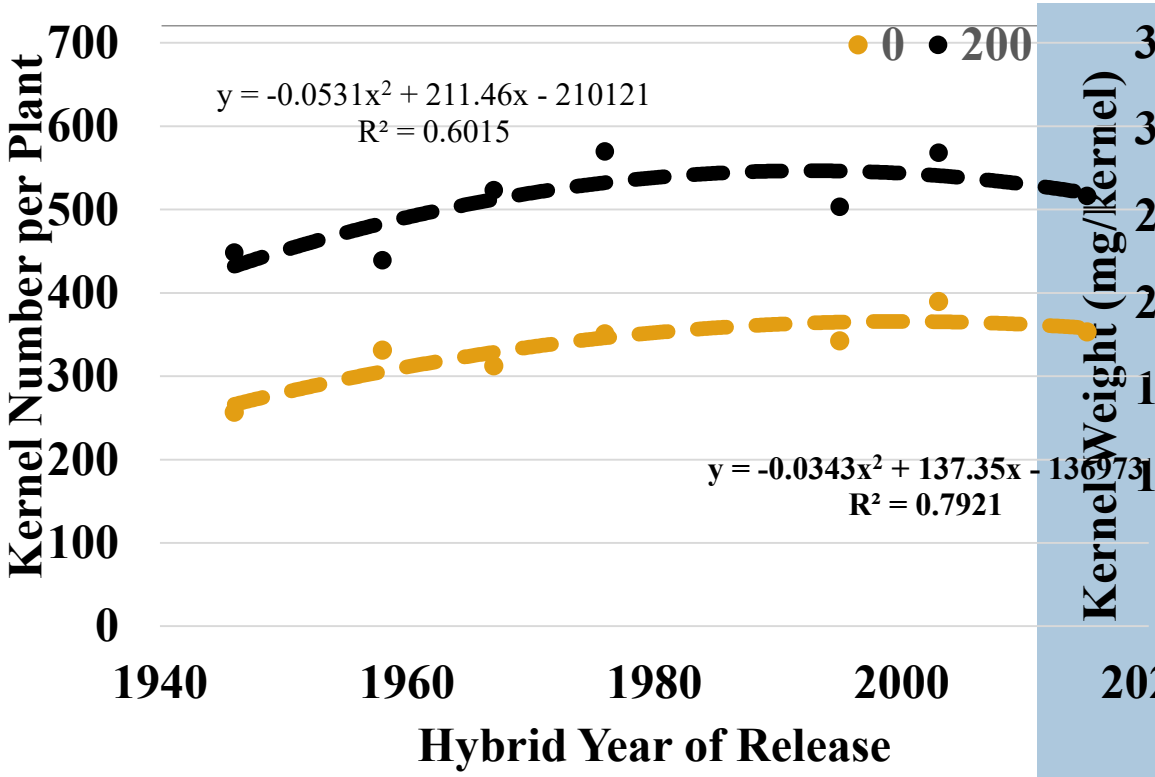
Grain Yield (bu/acre)

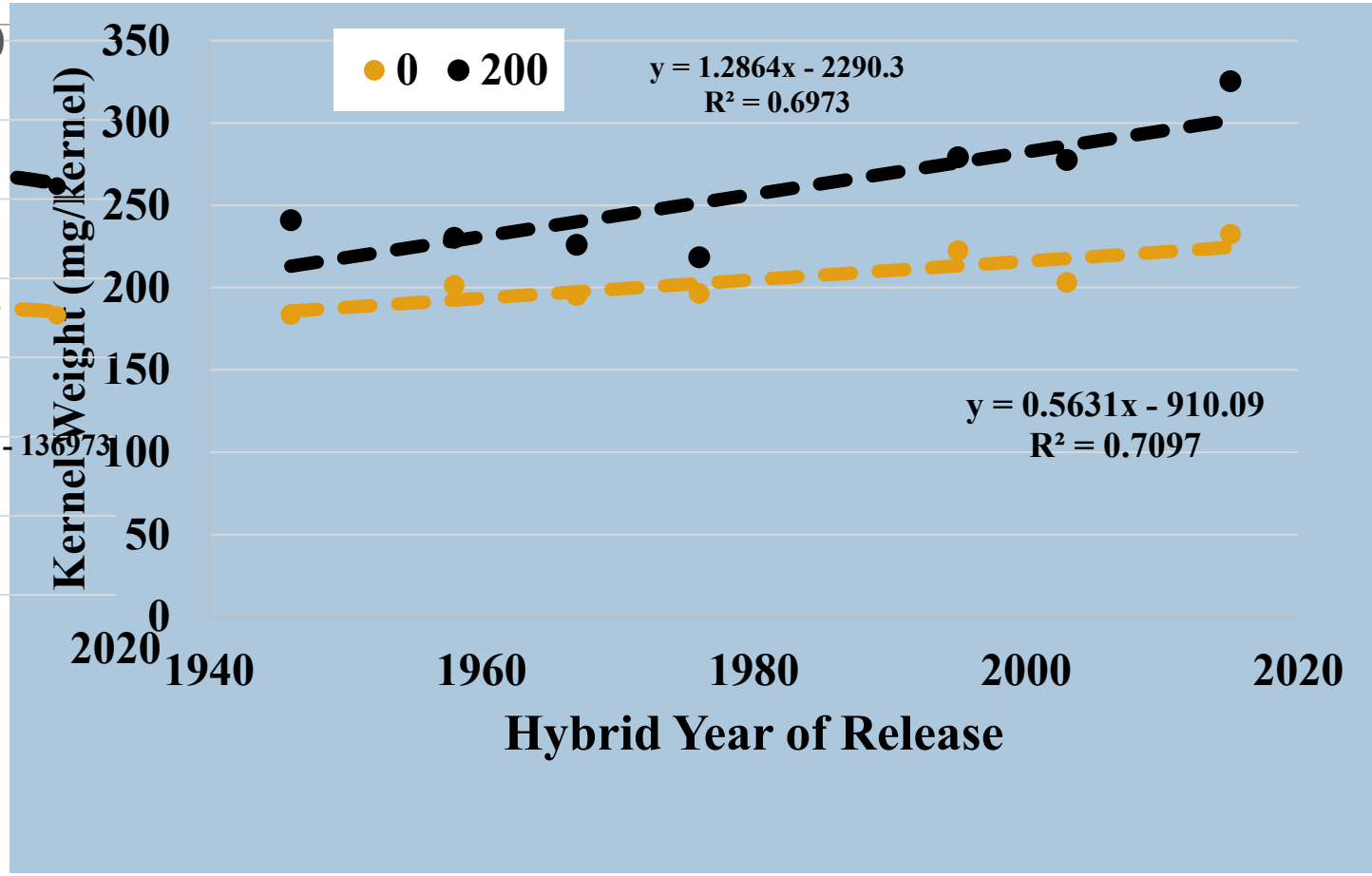


Source: Mueller and Vyn, FCR, 2018

Kernel Number and Kernel Weight Gains in Pioneer "Era" hybrids with year of commercial release

(West Lafayette, 2016-2017)





Source: Mueller and Vyn, unpublished, 2018

Nitrogen Fertilizer Recovery Efficiency (NRE) Matters!

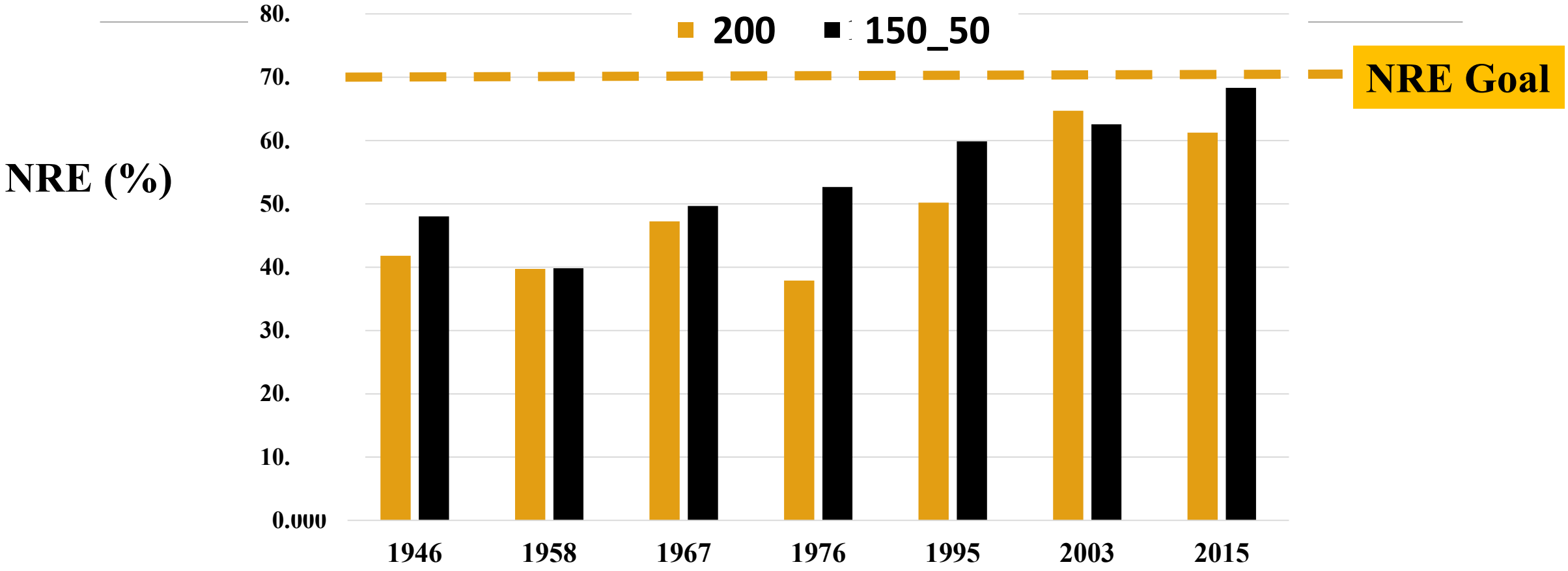
$$\text{NRE (\%)} = \frac{\text{Total N uptake at any N rate (lb/acre) - Total N Uptake at Zero N (lb/acre)}}{\text{Actual N RATE APPLIED (lb/acre)}} \times 100$$

2015 Hybrid

1958 Hybrid

Photo credit: Mike Shuter

Nitrogen Recovery Efficiency with Pioneer Era Hybrids (Two N timing treatments; 2016-2017)



Source: Mueller and Vyn, unpublished, 2018

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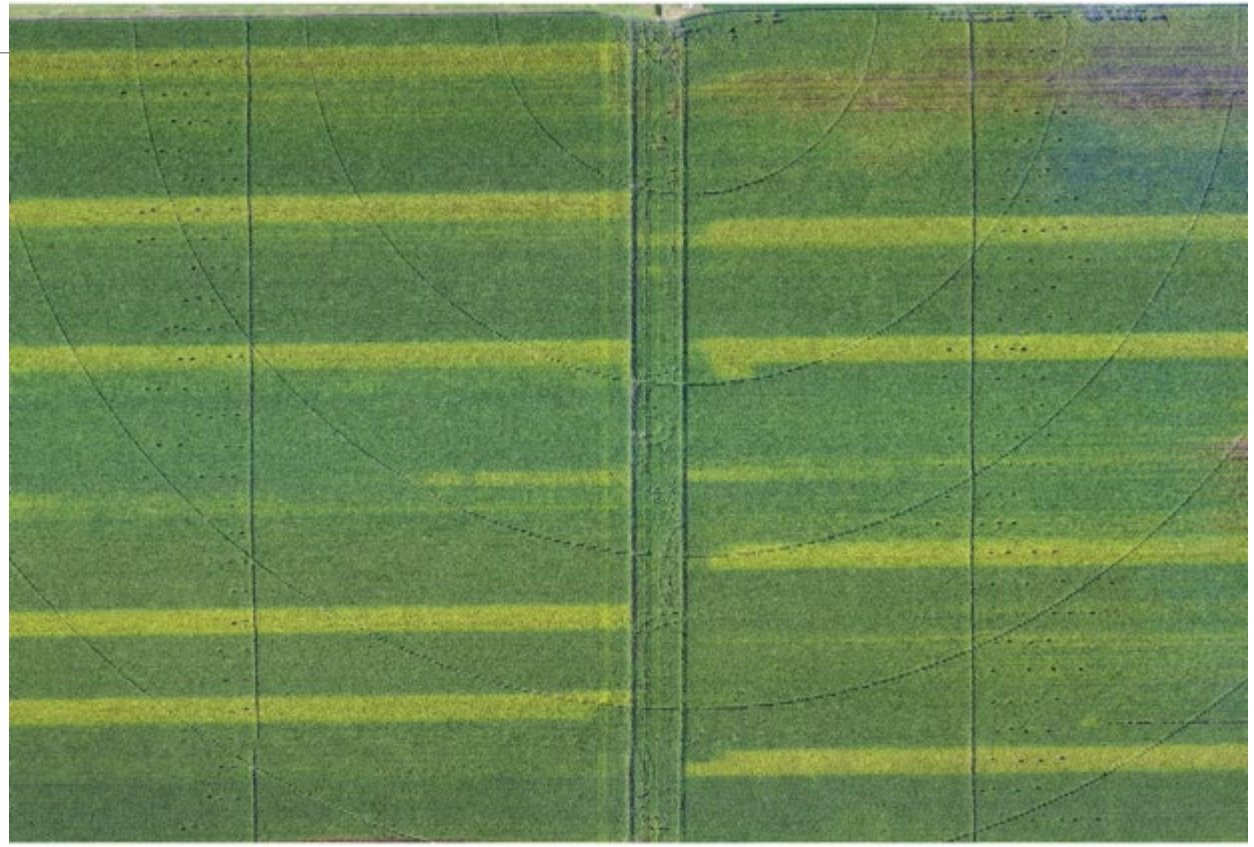
Late-Split UAN applied at V12 by Y-Drops (2015-2017)



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Optimum Banded Placement of Planter-applied UAN (or banded N just prior to planting)?

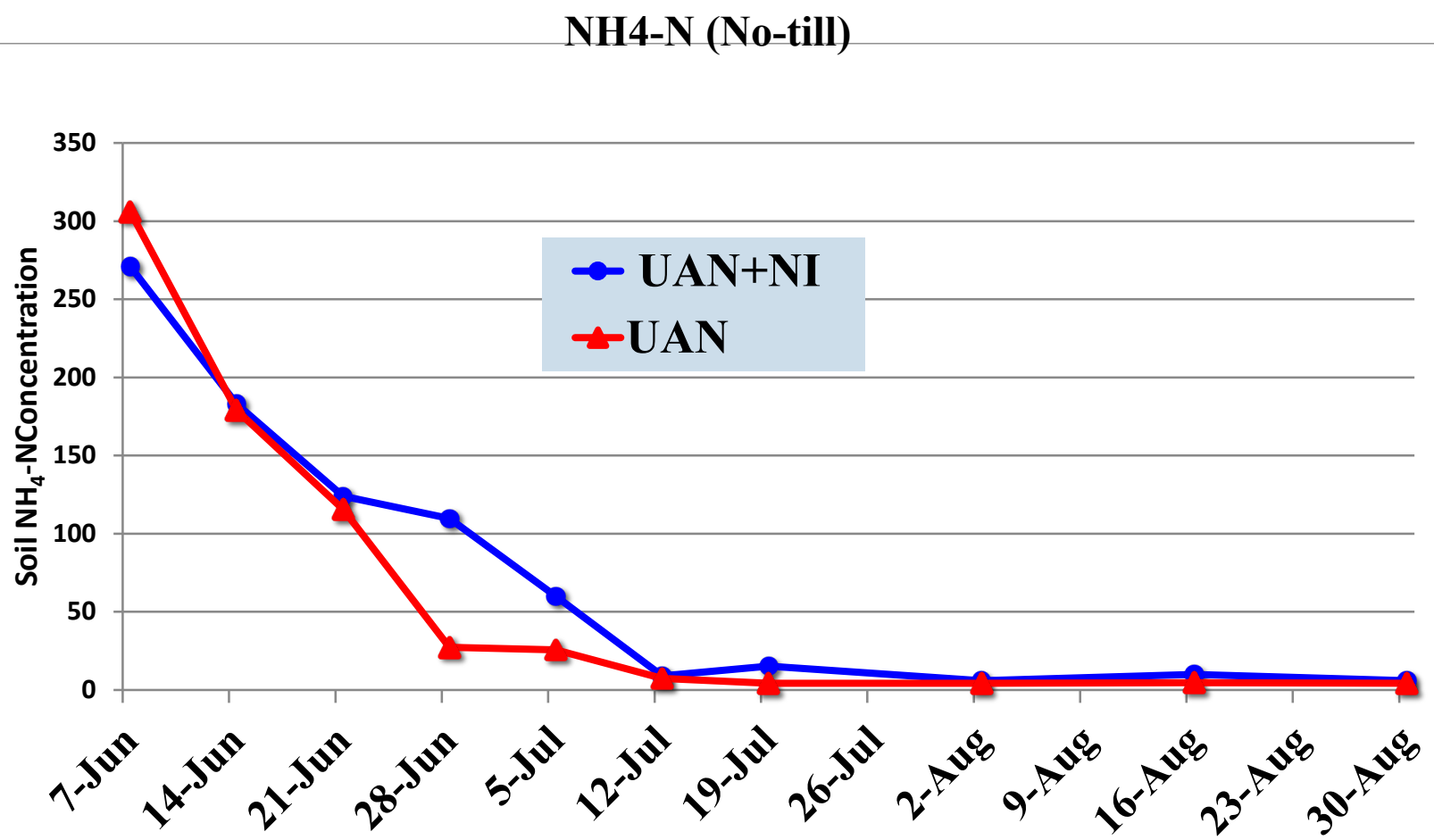
Multi-State Study on Planter N placement:
Illinois, Iowa and Indiana

Persistence of NH_4 in banded N applications

Percent of total N in the NH_4-N form after 21 days of incubation with low (87 mg N kg^{-1}) and high N (868 mg N kg^{-1}) application simulating broadcast and band applications.		
Soil series	**Low**	**High**
	% of total N as NH_4-N	
Tracy	**2**	**85**
Raub	**3**	**62**
Avonburg	**4**	**77**

Source: A. Ferrel (MS student) and J. Camberato, Purdue University

Persistence of Ammonium in Sidedress UAN Band at the 200 pound/acre N rate (0-8”)



Source: Omonode and Vyn, Agron. J., 2017

Planter Applied N - 2018

Source: Brad Berhard and Fred Below

Crop Physiology

Planter Applied N Treatments - 2018

Fertilizer Depth	Fertilizer Distance from Crop Row	Rate of N Applied at Planting
0”	2”	30 lbs N/acre
2”	5”	90 lbs N/acre
4”	8”	180 lbs N/acre

All Treatments Were Balanced for N at the V5 Growth Stage With Y-Drop

Source: Brad Berhard and Fred Below

Surface x 8”

Source: Brad Berhard and Fred Below

Crop Physiology

2018 Y-Drop for Sidedress UAN

Planter Applied N Study

Champaign, IL July 5th, 2018

Source: Brad Berhard and Fred Below

N Placement Effect at Planting on 2018 Yield

(Averaged Across Preplant N Rates)

Depth	Horizontal Distance 2”	5”	8”	Depth Avg
	bushels/acre			
Surface	235	241	237	237
2”	239	241	239	240
4”	242	241	240	241
Distance Avg	239	241	239	

Depth x Distance LSD (0.05) = 8
Depth LSD (0.05) = 6
Distance LSD (0.05) = 4

Source: Brad Berhard and Fred Below

N Placement Effect at Planting on 2018 Yield

(30 lbs of N at Preplant)

Depth	Horizontal Distance			Depth Avg
	2”	5”	8”	
	bushels/acre			
Surface	233	233	235	234
2”	235	233	234	234
4”	233	237	239	236
Distance Avg	234	234	236	

Depth x Distance LSD (0.05) = 14
Depth LSD (0.05) = 8
Distance LSD (0.05) = 8

Source: Brad Berhard and Fred Below

N Placement Effect at Planting on 2018 Yield (90 lbs of N at Preplant)

Depth	Horizontal Distance			Depth Avg
	2”	5”	8”	
	bushels/acre			
Surface	242	247	236	242
2”	241	246	246	244
4”	248	245	247	247
Distance Avg	244	246	243	

Depth x Distance LSD (0.05) = 14
Depth LSD (0.05) = 8
Distance LSD (0.05) = 8

Source: Brad Berhard and Fred Below

Deere Planter N Experiment (2017-2018)

17 treatments with common total of 60 gallons of UAN/acre achieved by V6:

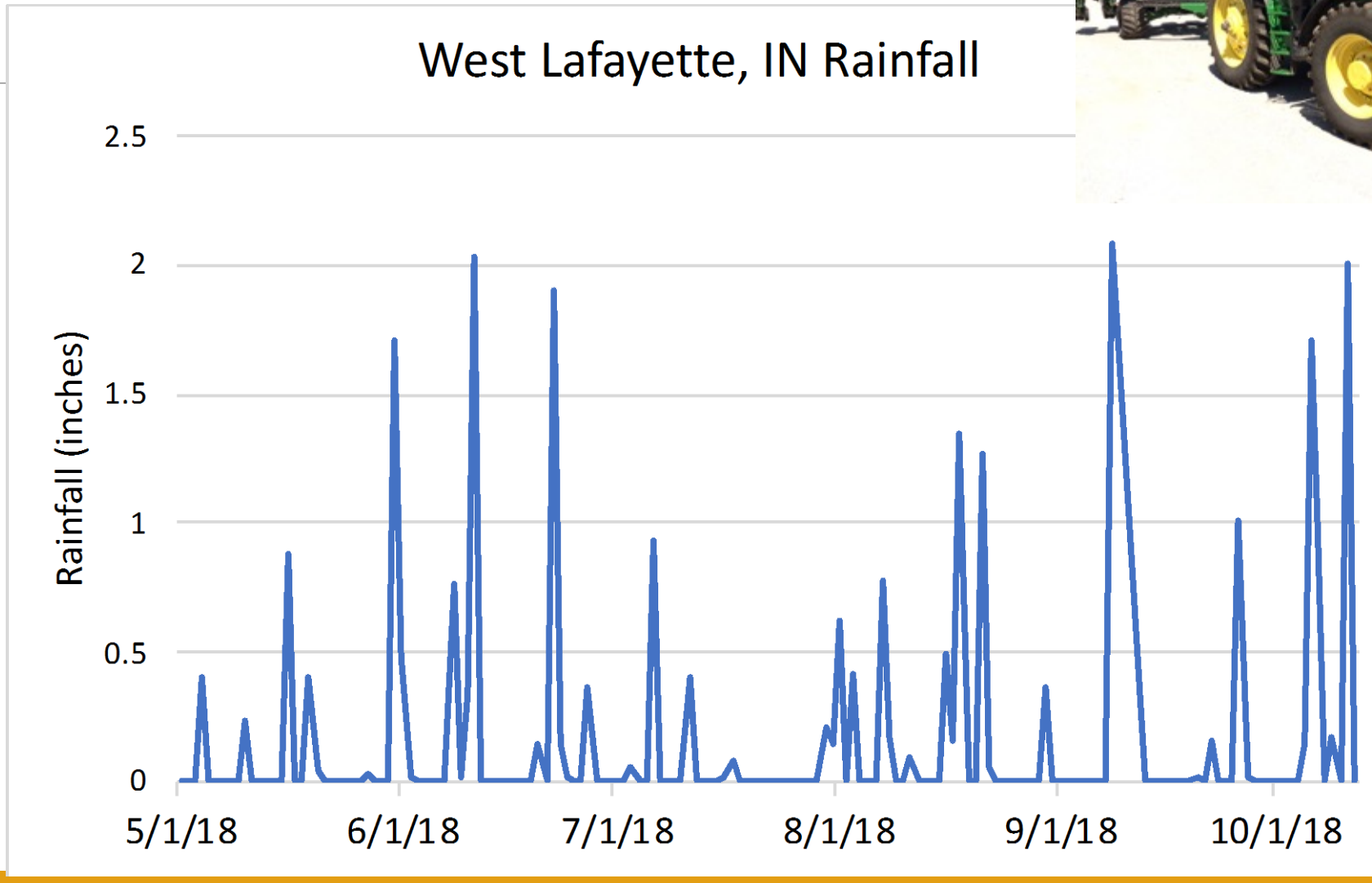
- No starter, all N at sidedress
- Traditional 2” x 2” starter at 10, 30 and 60 gpa
- “Safer?” 4” depth x 2” from-row starter at 10, 30, and 60 gpa
- Starter UAN at 30 gpa at 0”, 2” and 4” depths, banded 2”, 5” and 8 “ from row
- Starter UAN at 60 gpa at 2” and 4” depths, banded 2”, 5” and 8” from row

Placement and at Planting N Rate Impacts on Grain Yield - 2017

Depth	Placement	At Plant N rate (pounds/acre) 30	90	180	Depth Avg
			(bushels/acre)		
Surface	2"		211		211
Surface	5"		229		229
2"	2"	237	217	224	226
2"	5"		232	222	227
2"	8"		225	223	224
4"	2"	219	223	225	222
4"	5"		215	213	214
4"	8"		217	216	216
N Rate Avg		228	221	220	

(Purdue University: Thompson and Vyn, unpublished)

Planter N Trial (May 12, 2018)


West Lafayette, IN Rainfall
Rainfall (inches)
2.5
2
1.5
1
0.5
0
5/1/18
6/1/18
7/1/18
8/1/18
9/1/18
10/1/18

Placement and at Planting N Rate Impacts on Grain Yield - 2018

Depth	Placement	At Plant N rate (pounds/acre) 30	90	180	Depth Avg
			(bushels/acre)		
Surface	2"		179 abc		180
Surface	5"		184 abc		184
2"	2"	192 abc	217 a	180 abc	187
2"	5"		172 bc	191 abc	182
2"	8"		195 abc	205 ab	201
4"	2"	169 bc	202 abc	195 abc	189
4"	5"		185 abc	191 abc	188
4"	8"		203 ab	165 c	184
N Rate Avg		181	192	188	

(Purdue University: Thompson and Vyn, unpublished)

Optimum Banded Placement/Timing of Sidedress N Compared to All N Applied at Planting

Multi-State Study on Sidedress N placement:
Illinois, Iowa and Indiana

Earlier Purdue Studies of Different Late N Placements in 2015 and 2016

Table 1. Effect of delayed N on corn grain yield at three on-farm locations. Timing, rate, and method of application varied at the different locations.

Sidedress N (lb/ac) at growth stage			Grain yield, bu/ac		
V3-V4	V9†	V12-V15	Brookston/Crosby 2015	Brookston/Crosby 2016	Blount/Pewamo 2016
200	0	0	204 a*	196 b*	
150	50	0		198 b	
150	0	0			197 a*
150	0	50 injection		197 b	
150	0	50 Y-drop®		202 a	
100	100	0	208 a		
100	50	50 injection	204 a	197 b	
100	50	50 Y-drop®		201 a	
100	0	50 dribble			195 b
100	0	50 Y-drop®			198 a
75	0	75 dribble			194 b
75	0	75 Y-drop®			194 b
50	150	0	208 a		
50	75	75 injection	206 a		

†All V9 applications were injected with a solid shank coulter on a high-clearance applicator.
*Means followed by different letters differ by LSD test with a probability of >90%.

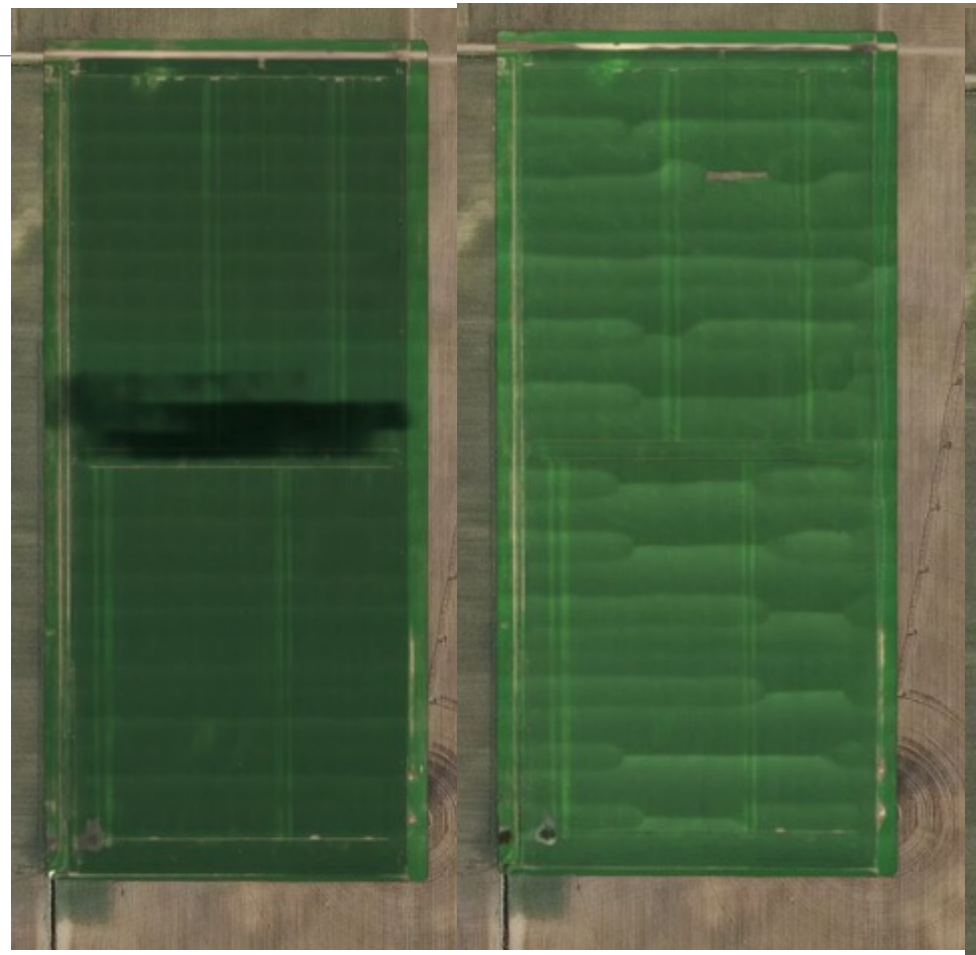
Source: Camberato, 2017. Late-season N application for corn. Soil Fertility Update 7-11-17

Corn Side-dress N Placement Experiment 2017

July 17

July 25

September 8



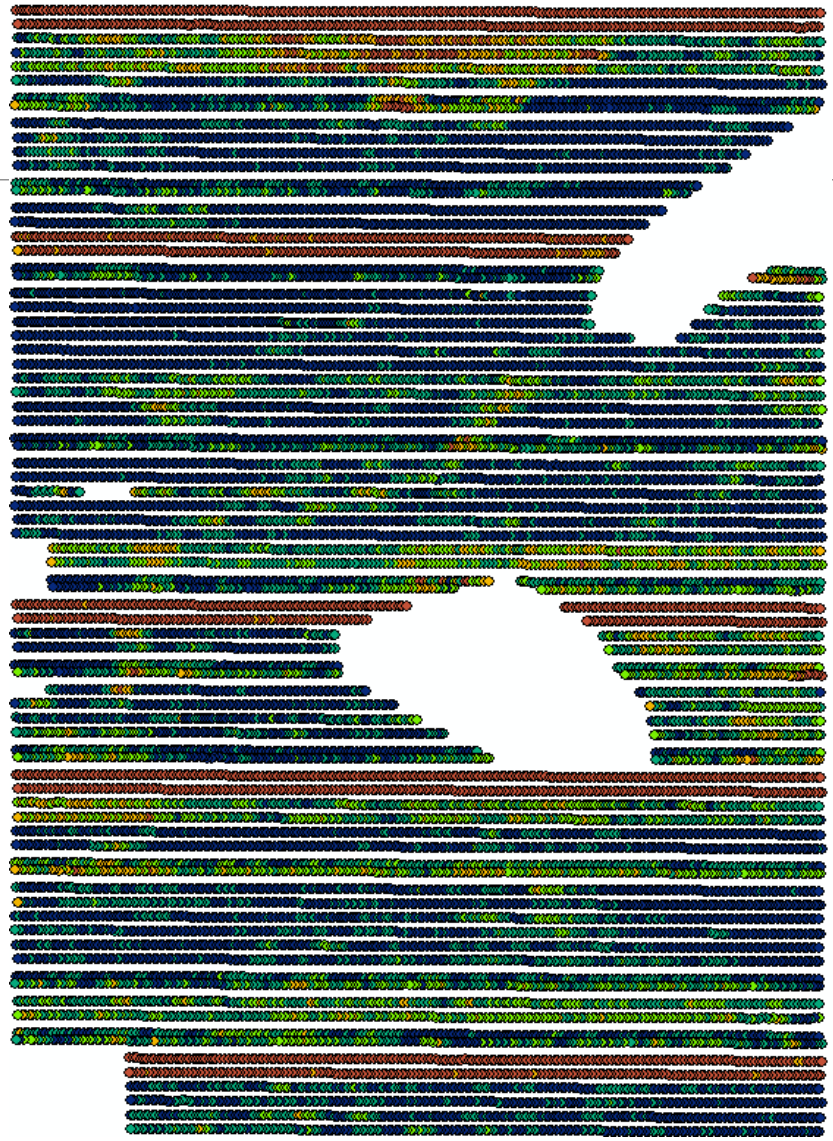
Optimum Sidedress: Treatments

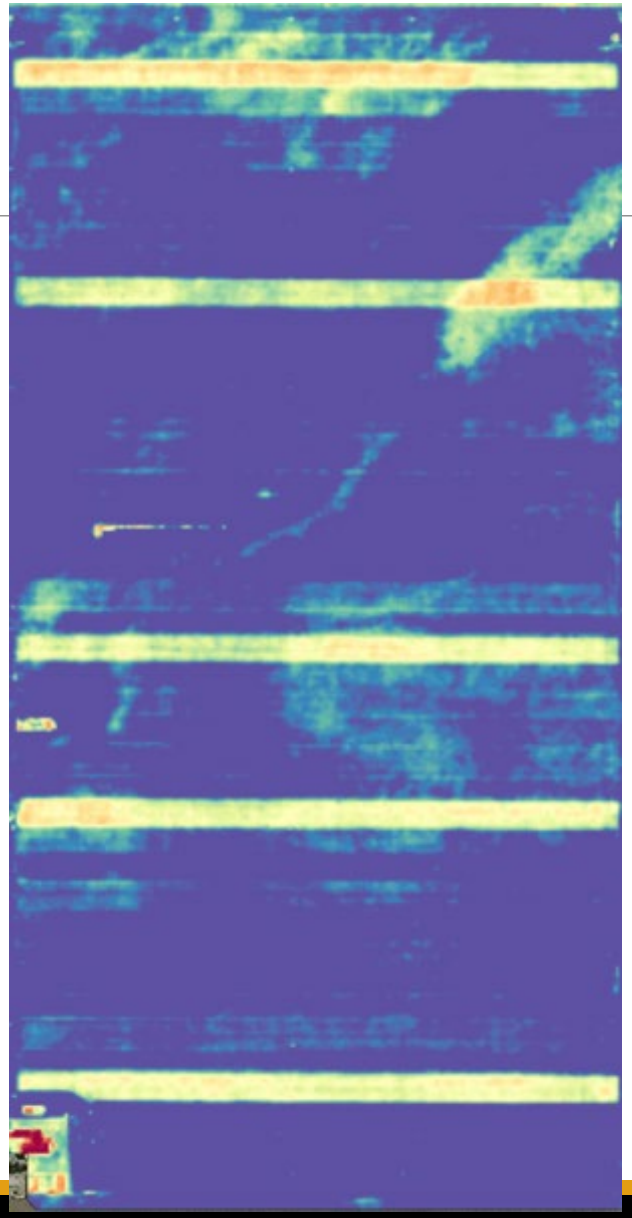
#	ID	Description	N Rate (lb/ac)
1	Zero	Zero N	23
2	AP50	Spring At-plant Broadcast UAN (50%) + Nothing	100
3	V5_str	Spring At-plant Broadcast UAN (50%) + V5 Sidedress UAN with streaming (50%)	180
4	V5_inj	Spring At-plant Broadcast UAN (50%) + V5 Sidedress UAN with coulters (50%)	180
5	V8_urea	Spring At-plant Broadcast UAN (50%) + V8 Broadcast UREA with Agrotain (50%)	180
6	V12_str	Spring At-plant Broadcast UAN (50%) + V12 late-split sidedress UAN with streaming (50%)	180
7	V12_inj	Spring At-plant Broadcast UAN (50%) + V12 late-split sidedress UAN with coulter (50%)	180
8	AP100	Spring At-plant Broadcast UAN (100%)	200

2017 – 4 replications: Plot Size 60' (24 rows) x 1,230 = 1.69 acres
2018 – 5 replications: Plot Size 60' (24 rows) x 1,290 = 1.78 acres

2018 Sidedress N Study in LaCrosse, Indiana

Yield Monitor with P0574





UAV Flight 8/14 NDRE

UAN Placement/timing in LaCrosse, IN

Split Sidedress N Impacts on Grain Yield

Sidedress N Timing and Rate (lb/ac)					Grain Yield (bu/ac)	
AP	V5	V8	V12	Total N	2017	2018
23	0	0	0	23	120 d	69 c
100	0	0	0	100	190 c	148 b
100	80 - str	0	0	180	227 ab	185 a
100	80 - inj	0	0	180	221 ab	179 a
100	0	80 - urea	0	180	217 ab	184 a
100	0	0	80 - str	180	230 a	179 a
100	0	0	80 - inj	180	215 b	182 a
200	0	0	0	200	230 a	187 a

23 lb/ac N applied as start fertilizer

Summary of Some Controlling Factors in "N Placement"

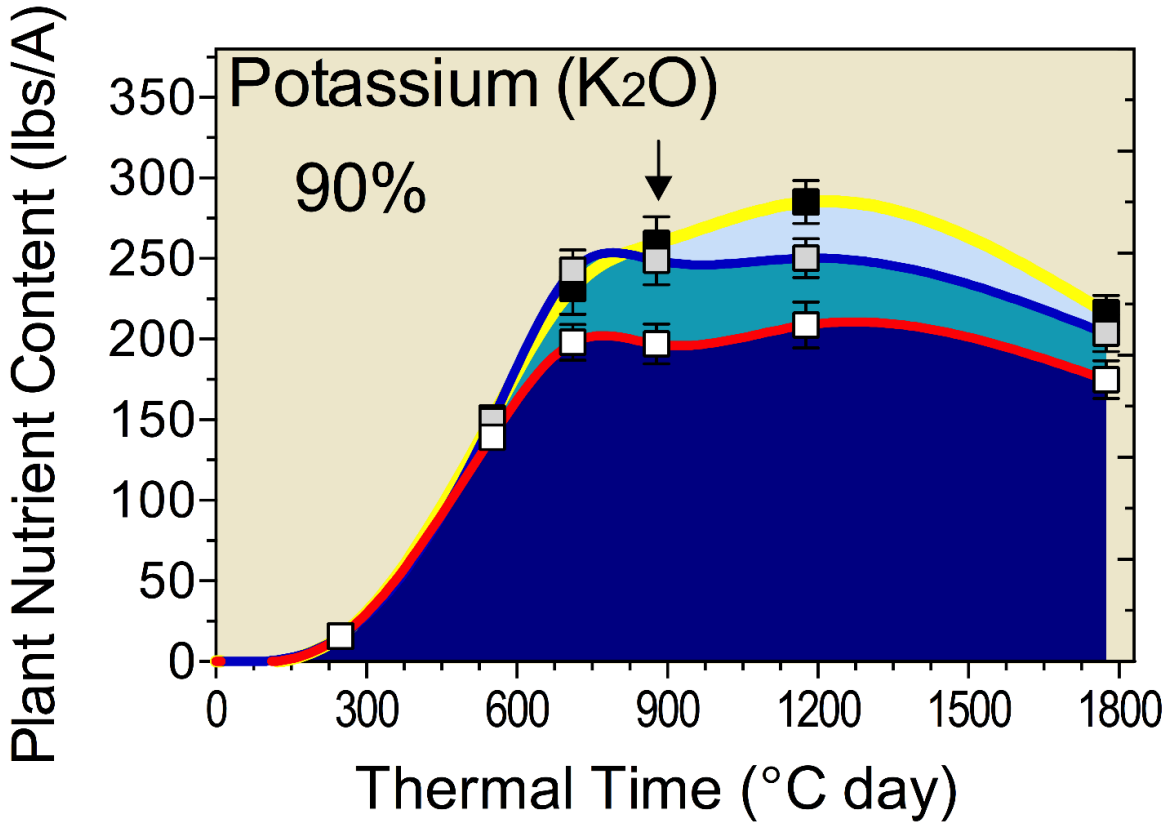
Planter N Placement:

- **N source**
- **Only starter application?**
- **Only banded fertilizer or other salts?**
- **N rate and potential for seedling toxicity**
- **May/June rainfall**
- **Soil texture**

Sidedress N Placement:

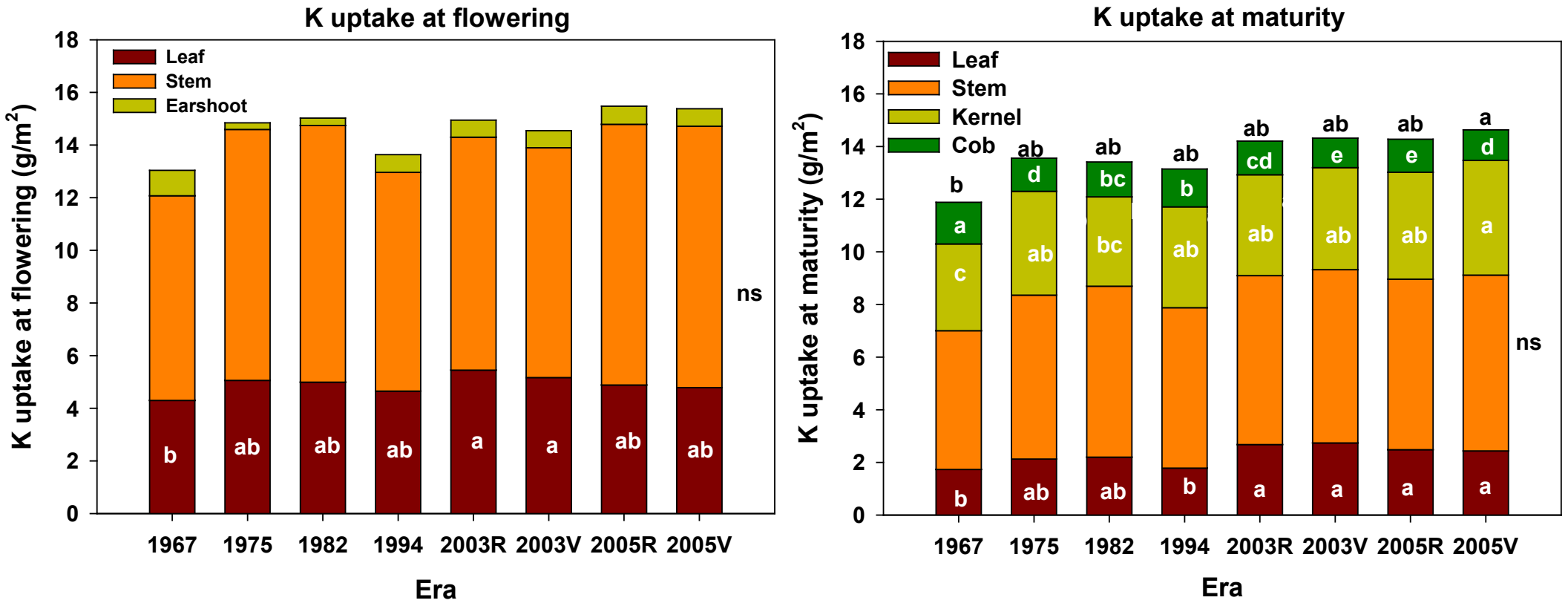
- **Rainfall amount and timing after application.**
- **N rate and timing. Amount of prior N applied relative to corn N demand before the most recent N applied becomes available is critical.**
- **Extent of post-silking N uptake for that hybrid and environment.**
- **N source (inhibitors added?).**
- **Opportunity to increase kernel number or kernel weight**

Potassium Uptake in Growing Season Over Time in Corn at Three N Rates



Ciampitti et al., 2013 Agronomy Journal

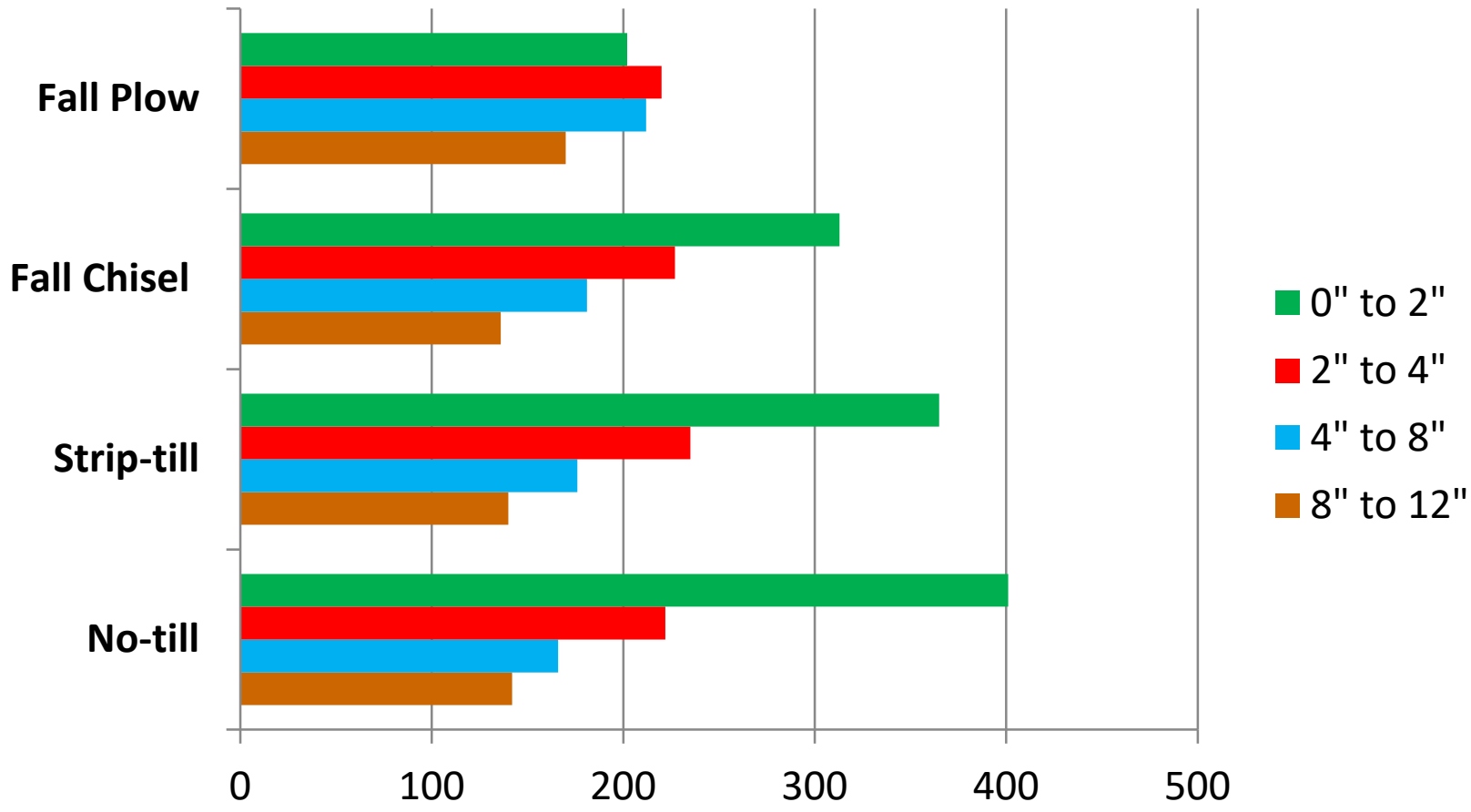
Hybrid Era Influence on Internal Plant K Distribution at Flowering and at Maturity



Tendency for more total K content retained in grain and leaves at R6

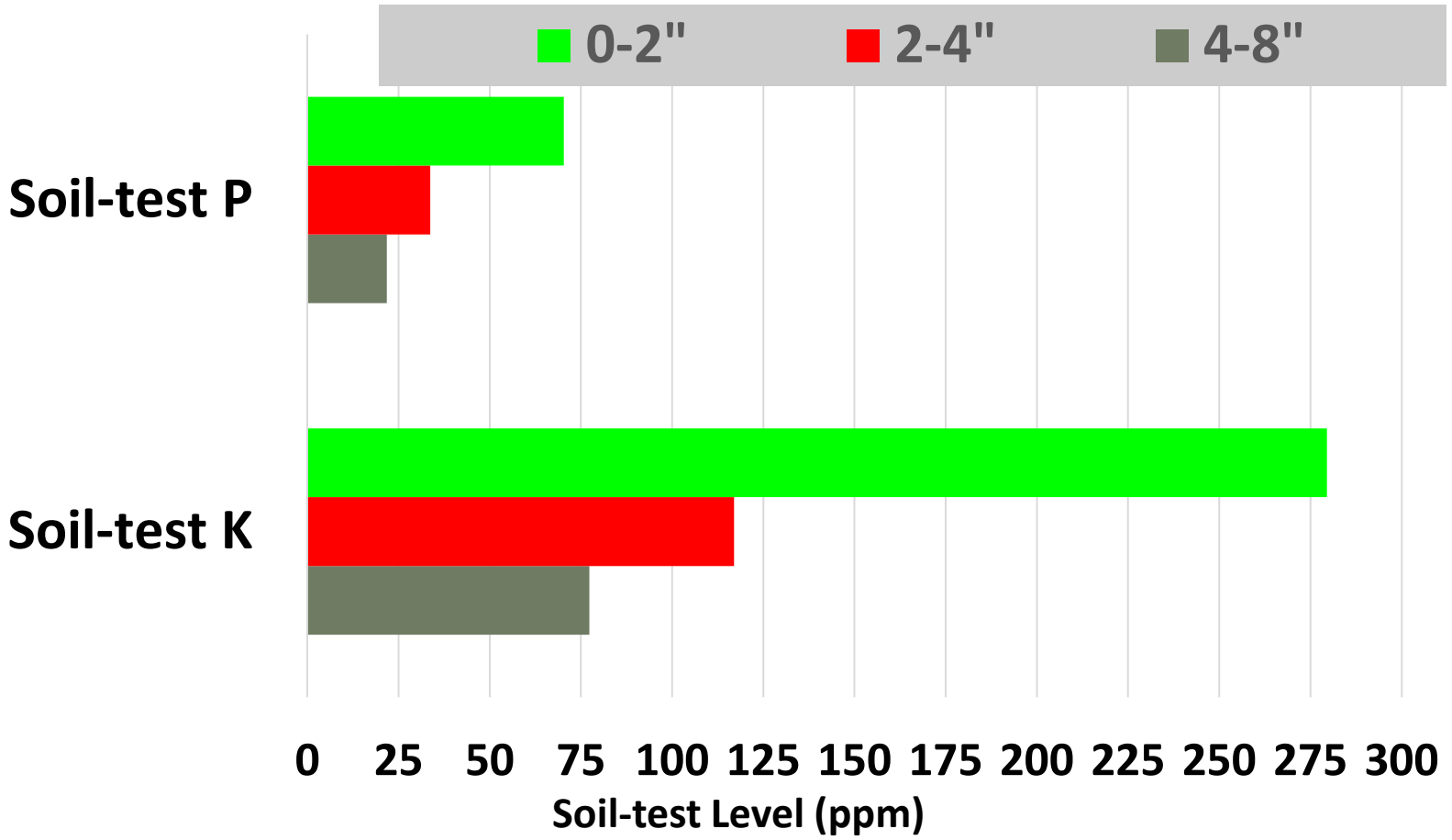
Source: Chen and Vyn, 2018, unpublished.

Long-term Tillage Influence on Soil-test K (ppm)



Source: Vyn, West and Verhagen, Unpublished, 2018

Stratification for P and K in Strip-till Corn and No-till Soybean Rotation with only Starter P (corn) and no Broadcast P or K in 4 Years



Source: Vyn, Global Maize Trial, West Lafayette, 2014

Indiana Corn Yield Responses to K_2O Placement and Timing

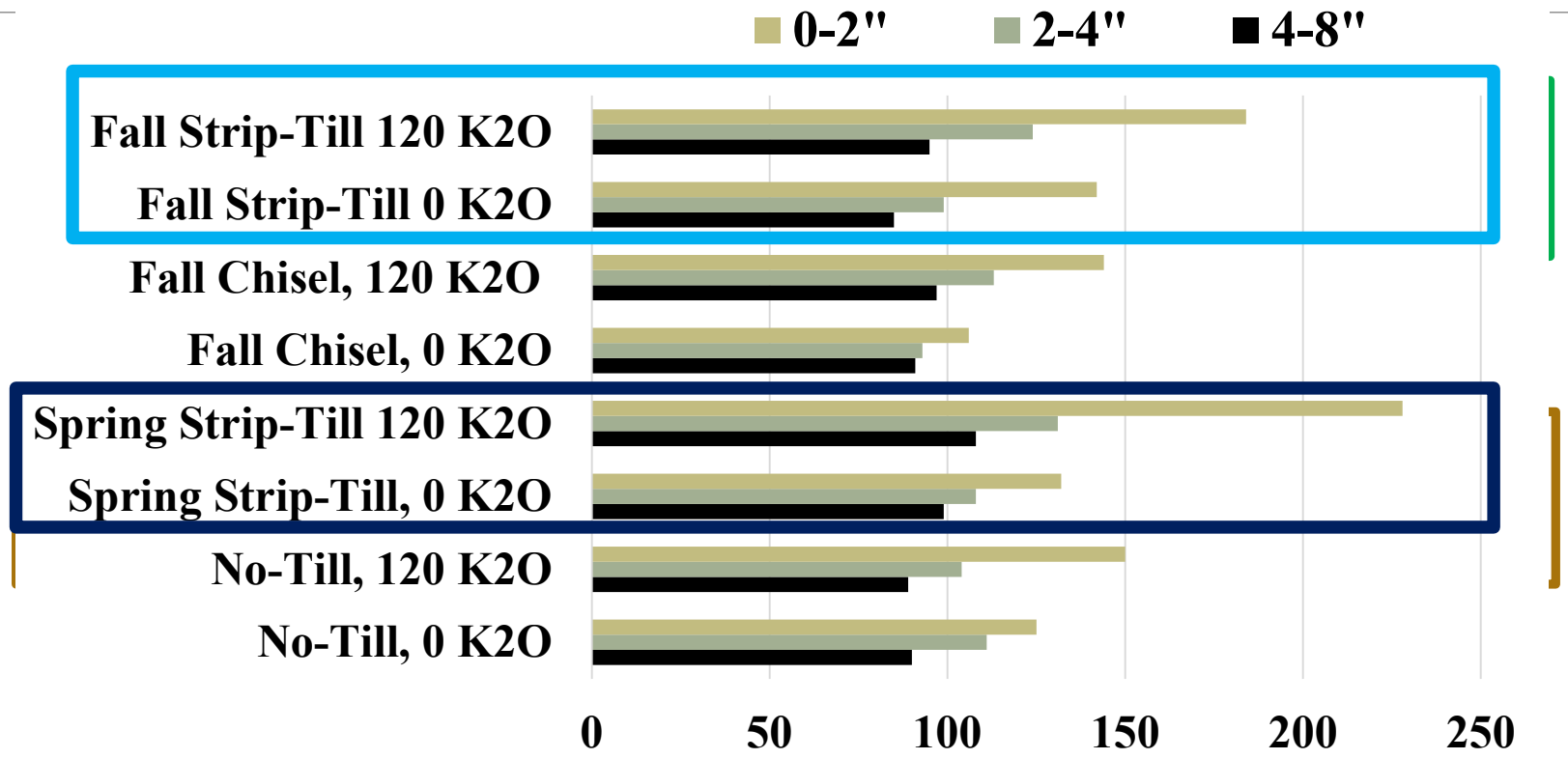
Tillage System	K_2O timing	Aspire K product rate (lb/acre)	3-year Mean 2016-2018 (bu/acre)
No-till	NA	0	230 d
No-till	Spring	200	240 bc
Fall Strip-till	NA	0	236 cd
Fall Strip-till	Fall	100	245 ab
Fall Strip-till	Fall	200	250 a
Spring Strip-till	NA	0	232 d
Spring Strip-till	Spring	100	245 ab
Spring Strip-till	Spring	200	249 a
Fall Chisel	NA	0	241 bc
Fall Chisel	Fall	200	249 a

Soil-Test K mean: 154 ppm in 2016; 95 ppm in 2017, and 143 in 2018.

Average Yield Gain with 200 rate: 8 bu/ac in 2016; 15 bu/ac in 2017, 14 bu/ac in 2018

Source: Vyn and Schwarck, 2018, Unpublished

Tillage and K_2O Rate Consequences for In-row Soil-test K at 3 depth increments (West Lafayette, IN, 2017)



Source: Vyn and Schwarck, 2018, unpublished
K Source: Aspire (58% K_2O, 0.5% B)

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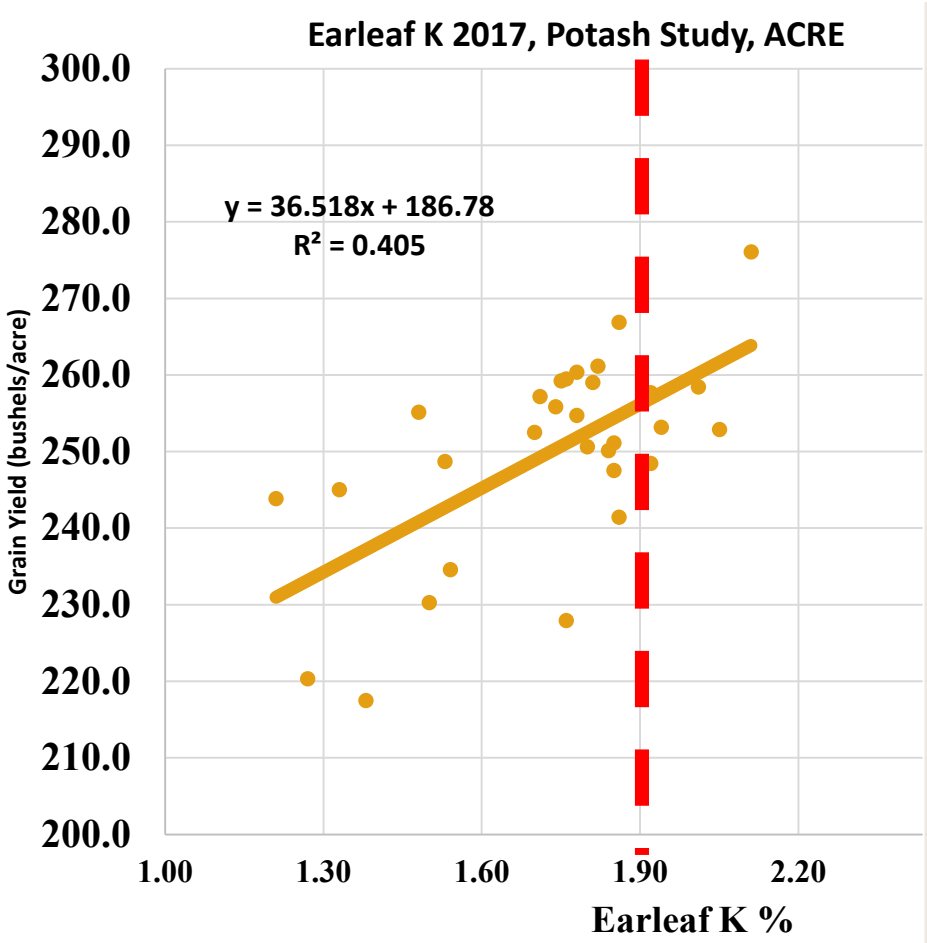
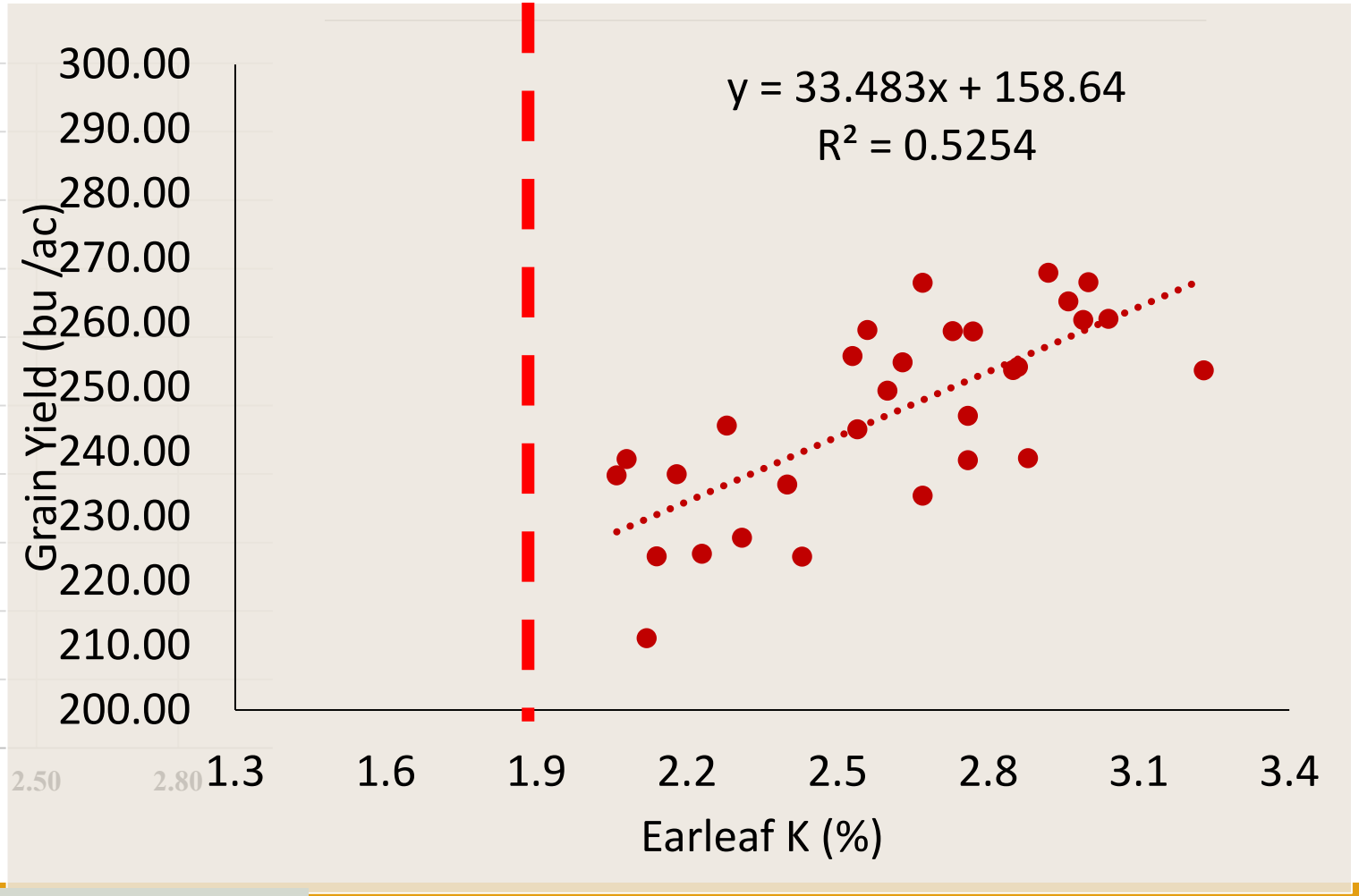
Mosaic

Ear-leaf K Concentration Relationship to Final Yield in Indiana Experiments (2017- 2018)





Source: Vyn and Schwarck, 2018

Summary of Some Controlling Factors in Corn Response to "K Placement"

Pre-plant K Placement:

- Overall soil-test K
- Degree of soil K stratification
- Tillage system
- Timing (fall versus just prior to planting)

Post-plant K Placement (?)

- Timing relative to K uptake timing in corn
- Rate of K applied.
- Rainfall timing
- K source?

Acknowledgments

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IPNI and 4R Nutrient Stewardship
The Mosaic Company
Monsanto Company/Climate Corp
John Deere Crop Production Systems Innovation

Equipment:

John Deere Cropping Systems Unit

Seed:

Pioneer Hi-Bred, Int'l.
Monsanto
Dow AgroSciences

Thank You