Low Commodity Prices and Fertilizer Management – Where do we go from here?

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University of Minnesota
EXTENSION

NUTRIENT MANAGEMENT

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Fertilizing Corn in Minnesota

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In Minnesota, corn is grown on more acres than any other crop. Nationally, Minnesota ranks among the top five states in corn production. Average corn yields have improved steadily over the past several decades. While general fertilizer use contributed substantially to yield increases in the past, total fertilizer management which optimizes nutrient efficiency will be needed to increase future production and profitability.

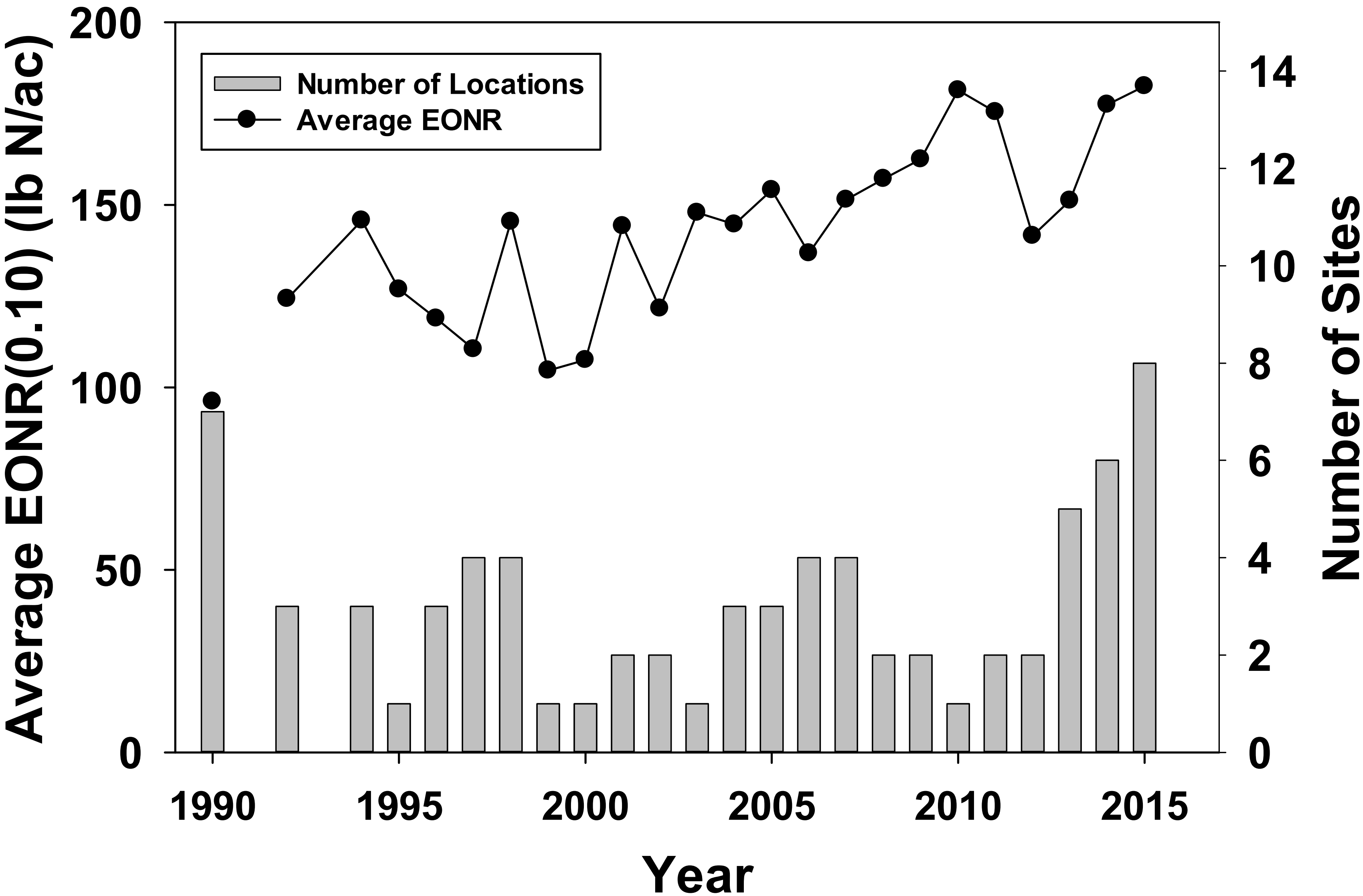
philosophy/approach for determining N rate guidelines for corn.

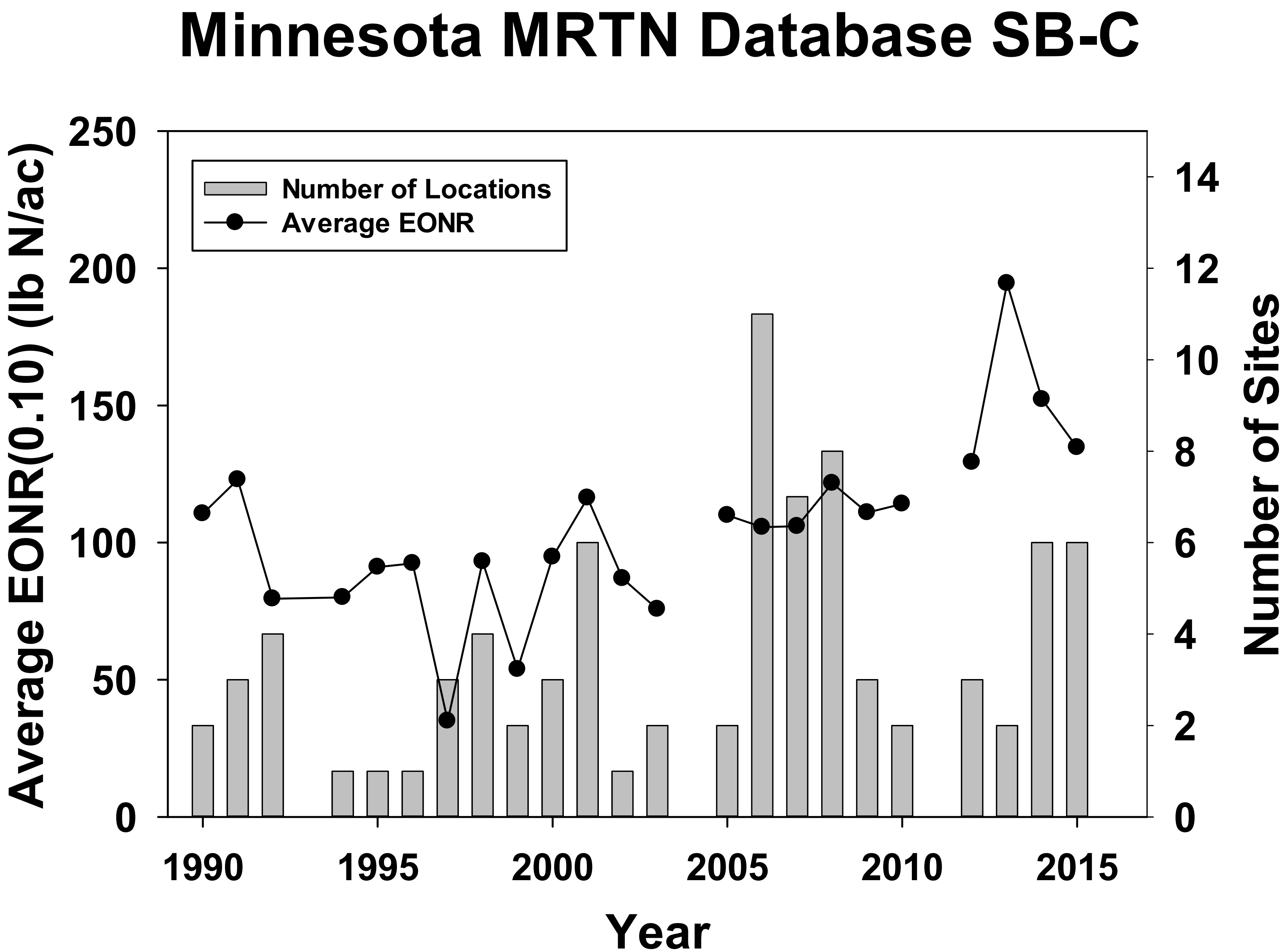
Because of technology improvements in corn production practices such as weed and pest control, expected yield is not as important a factor in determining N rate as it has been in the past. Soil productivity has become a better indicator of N need. A majority of Minnesota soils are highly productive and have generally produced maximum economic corn yield with

MRTN Statistics: MN Database

- Last Update in 2011 (data from 1990-2010)
  - C-C Sites: 61
  - C-Sb Sites: 48
- Proposed Update: 2016
  - C-SB Sites: (1990-2016) 83
  - C-C Sites (1996-2016) 60
  - C-C EONR values are relatively low during the 1990
    - We cannot throw out all of the data without hurting the integrity of the database, but we probably could get rid of some of the early years.

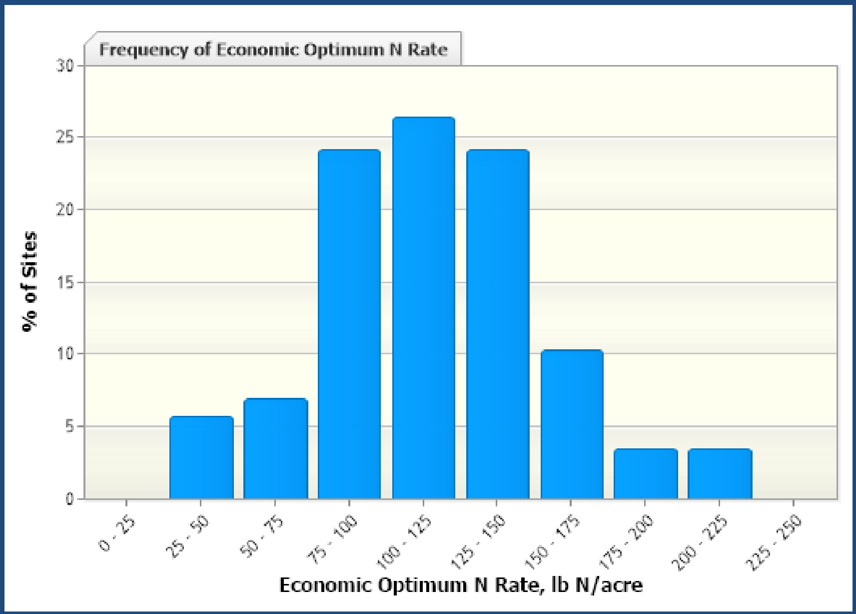
Minnesota MRTN Database C-C

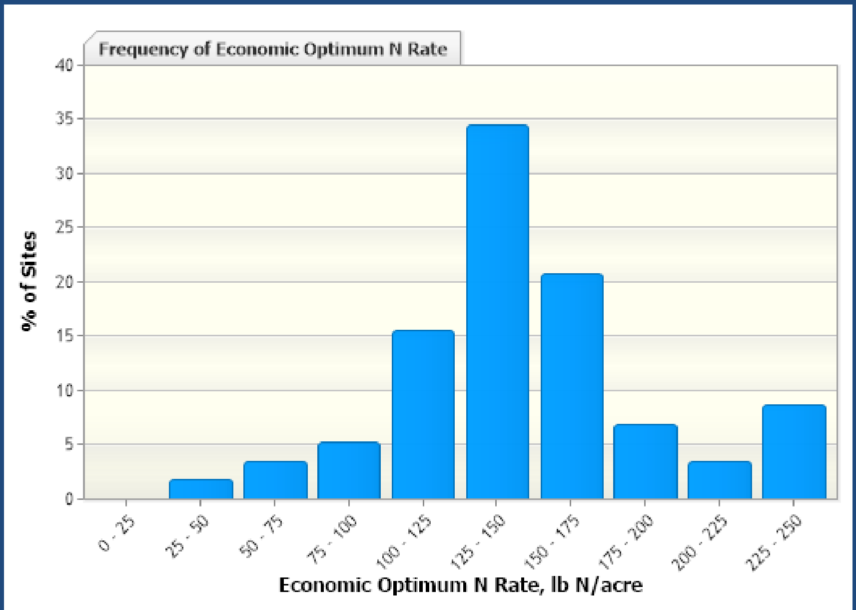


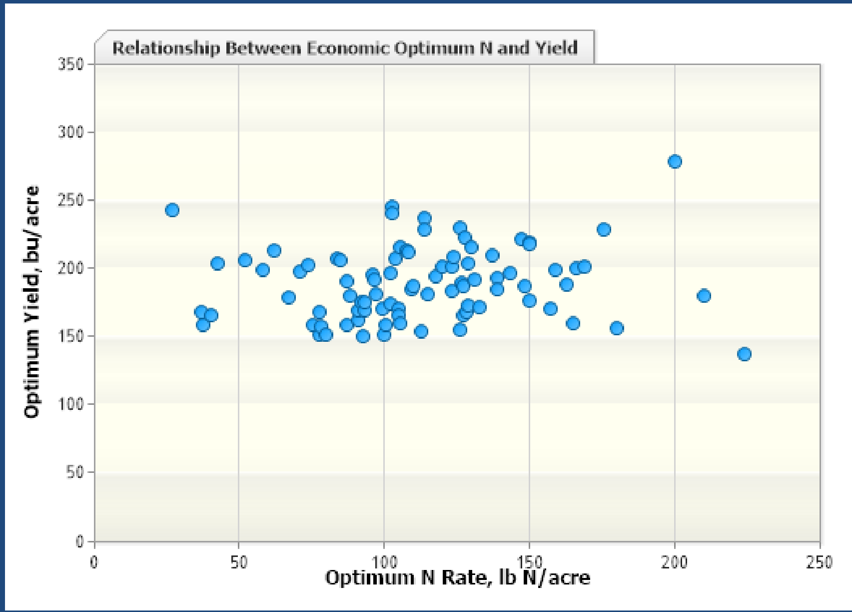

Minnesota MRTN Database SB-C
Number of Locations
Average EONR
Average EONR(0.10) (lb N/ac)
Number of Sites
Year
0
50
100
150
200
250
0
2
4
6
8
10
12
14
1990
1995
2000
2005
2010
2015

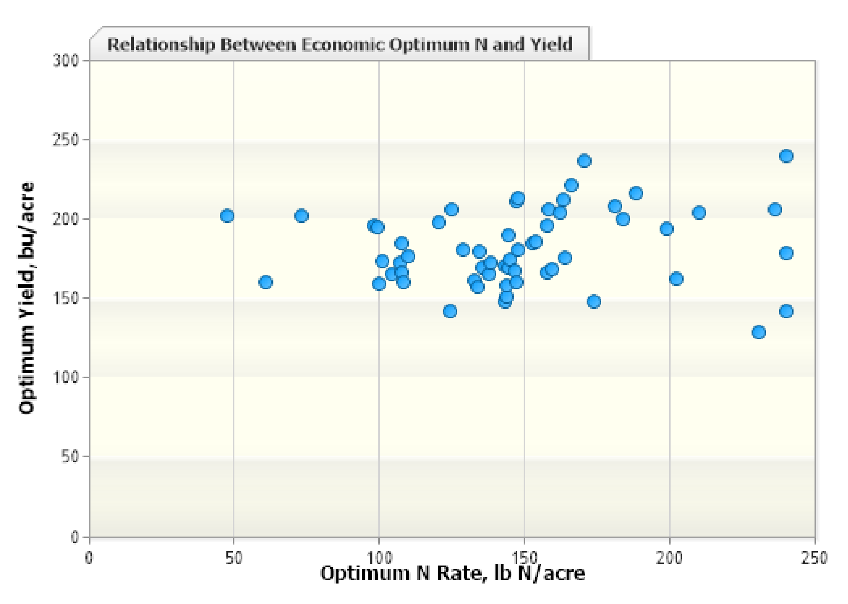
Corn – Soybean (0.10 ratio)

Corn – Corn (0.10 ratio)









CNRC - Comments

- Corn N Rate Calculator website was updated in 2016 and has a different link
  - http://cnrc.agron.iastate.edu/
- The output I have shared can be found on the website
- I have taken over updating the site
  - Goal is to be more consistent with updates
    - i.e. – yearly update

New Table for Print Publication

Table 1. Guidelines for use of nitrogen fertilizer for corn grown following corn or soybean when supplemental irrigation is not used.

N price/Crop value ratio	Corn/Corn		Soybean/Corn	
	MRTN	Acceptable range	MRTN	Acceptable range
	------------- lb N/acre -------------			
0.05	180	160 to 200	140	125 to 160
0.10	155	145 to 170	120	105 to 130
0.15	150	140 to 155	105	95 to 115
0.20	140	130 to 150	95	85 to 105

2015 – N Prediction Methods Study

Stewart, MN Sb-C

- Nicollet Cl
- 96 day RM planted 4/25
- 5.5 GPA 10-34-0
- 22” rows
- 32 lb N @ 2’
- Applied 40 lb of N as a base rate before side-dress

Waseca, MN C-C

- Webster Cl
- 101 day RM planted 5/1
- 2.5 GPA 10-34-0
- 30” rows
- 38 lb N @ 2’
- Applied 45 lb of N as a base rate before side-dress

Methods Used

1. Soil tests – 2’ pre-plant and 1’ PSNT
2. Active sensors – SPAD @ V5, V10, and R2; Crop Circle @ V5 and V10
3. Multispectral images @ V5, V10, and R2
4. Crop models

Crop Models – Side-dress application

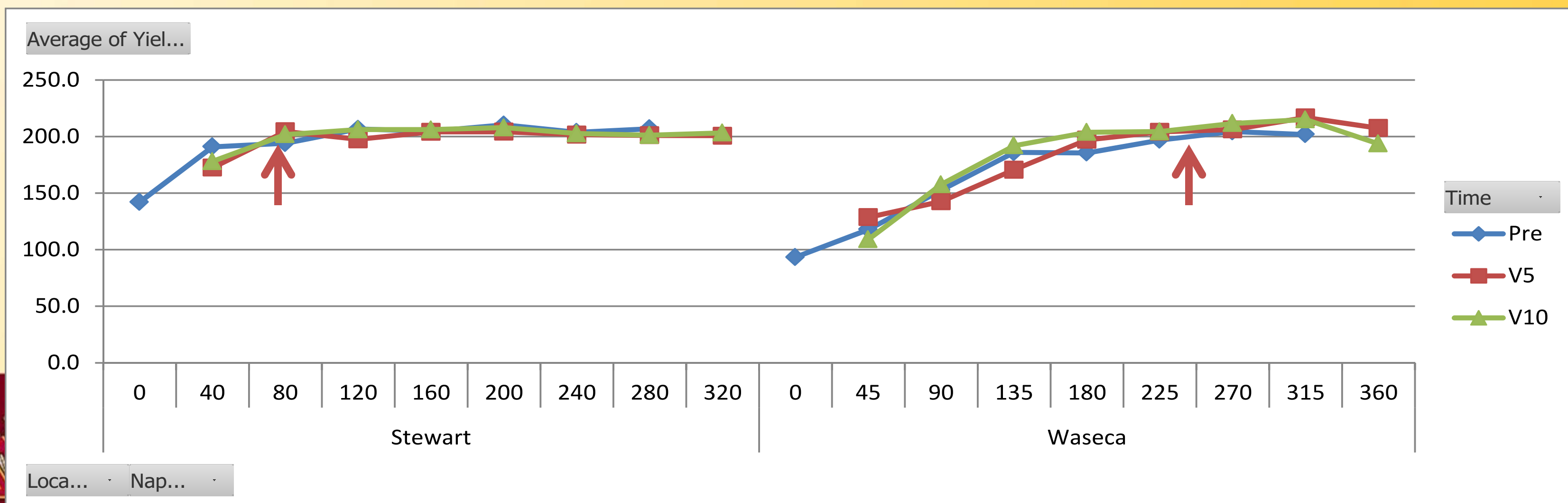
40-45lb N Pre-Plant, 200 bu/ac yield goal

Stewart, MN Sb-C: 40lb N

Model	Stage	Prediction
A	V5	-59 (99)
	V10	-62 (102)
B	V5	-70 (110)
	V10	-35 (75)

Waseca, MN C-C: 45lb N

Model	Stage	Prediction
A	V5	-55 (90)
	V10	-54 (89)
B	V5	-115 (160)
	V10	-105 (150)



Nitrogen Models: Good or Bad

- All models require a return to a yield goal system
- The most difficult factor to predict is N mineralization
  - I think most models overestimate this
- Some of our N loss pathways are underestimated – denitrification
- Soil parameters need to be measured in field
  - SURGO data is not the best information to use
- There is a reasonable end to when we should be looking to side-dress N ~ V10 no later
  - Beyond that should be considered a rescue treatment
- Yield goal is dynamic and is affected throughout the year

Final Points on N Guidelines

- Significant changes were made when N crediting for corn following alfalfa
- Irrigated corn has different suggested N rates than what was shown in the presentation
- The suggested N rates for marginal soils was left out of this update
  - There was no evidence of a difference in N need
- The MRTN based system will still be suggested for use in Minnesota
- z.umn.edu/nutrientmgmt

Phosphorus and Potassium

- The primary changes were made to the expected yield levels
- The guidelines are still mostly based on sufficiency values and not on a build + maintenance
  - Suggestions will be conservative for medium to high soil test levels
- Removal of P and K in grain was included in the update

What is the meaning of low P?

- Think of your soil test as a probability function
- Soils which test low in P or K should have a low potential to supply required nutrients
- Currently it is easier to generate this data for P than for K

Table 8. Corn grain yield response to applied P fertilizer based on soil test category.

BRAY-P1 OR OLSEN SOIL TEST P CATEGORY	EXPECTED TIME P FERTILIZER WILL INCREASE CORN GRAIN YIELD	EXPECTED YIELD WITHOUT P FERTILIZER
	---------------%---------------	
Very Low	87	87
Low	83	90
Medium	27	98
High	13	99
Very High	7	99

AFREC

Agricultural Fertilizer Research & Education Council

Fertilizer Strategies

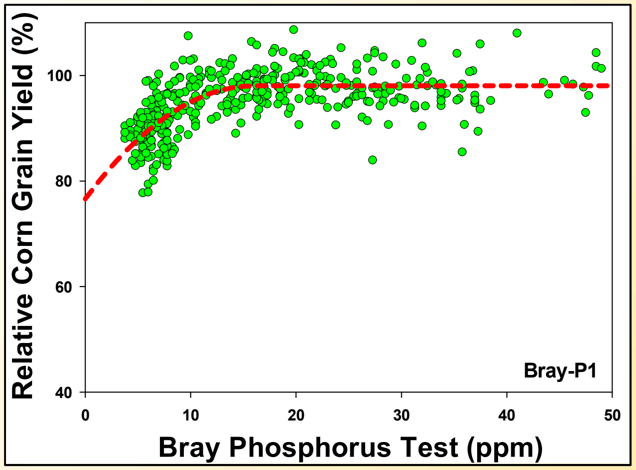
Sufficiency

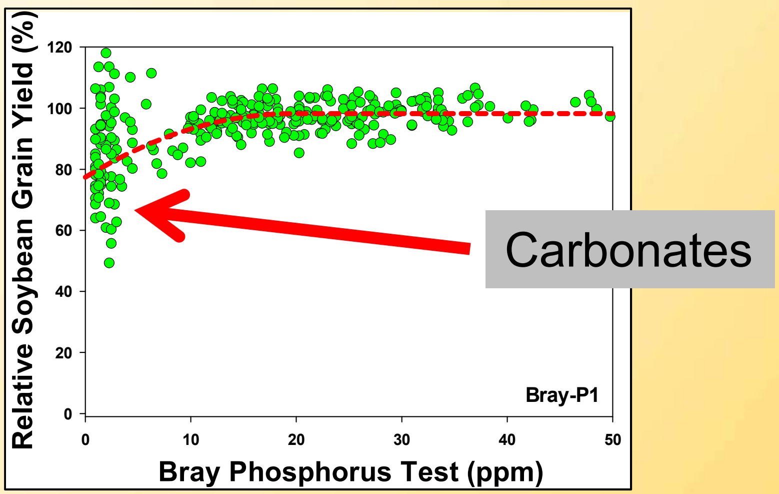
- Apply based on crop needs
- Lower rates of P particularly near the critical level
- More diligent soil sampling
- Maximize economic return to P
- May not achieve the maximum yield each year

Build and Maintain

- Maximize yield potential
- Apply P based on a strategy related to crop removal
- Soil sampling is a monitoring tool
- Less return per lb of P applied near the critical level
- Build rates vary by soil

Critical Soil Test P Levels





Critical soil test P level at selected relative corn grain yield levels			
Soil Test	95%	98%	100%
	--------------------ppm----------------------		
Bray-P1	10	15	16
Olsen	9	12	13
Mehlich-3	14	19	19

Critical soil test P level at selected relative soybean grain yield levels			
Soil Test	95%	98%	100%
	--------------------ppm----------------------		
Bray-P1	12	17	18
Olsen	8	10	11

Critical level is typically defined as the soil test at 95% relative yield

Nutrient Removal Values Updated through 2015

Corn

- P: n=7806
- K: n=4958
- Removal in lbs/bu
  - P_2O_5 – 0.28
  - K_2O – 0.19

Soybean

- P: n=5071
- K: n=4427
- Removal in lbs/bu
  - P_2O_5 – 0.69
  - K_2O – 1.09

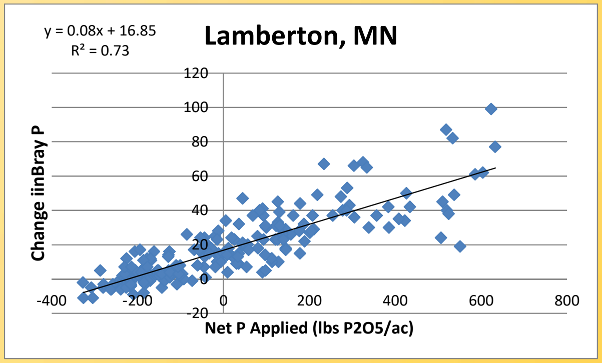
- Values are generated from sites where responses to P or K may or may not have occurred
- Values are median values for removal
  - Actual values may be +/- 10%
  - Mean and median for the dataset are similar

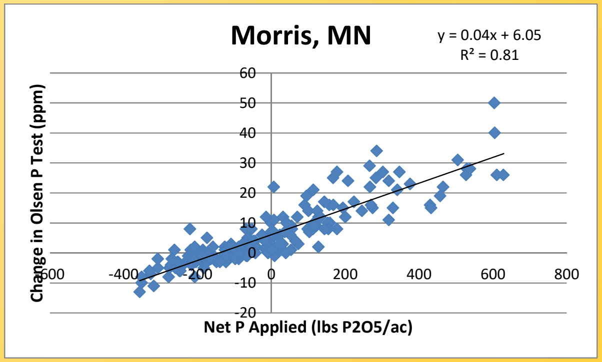
Build and Maintain Strategies

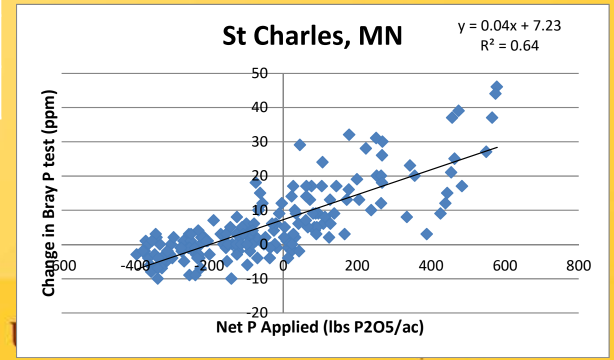
Study	Location	Soil Test Change when applying P or K based on crop removal	Annual P or K application required to Maintain Soil Test
		------ppm yr^{-1}-----	--lb P_2O_5 ac^{-1} yr^{-1}--
Phosphorus	Lamberton	2.4	-30.1
	Morris	0.9	-21.6
	Saint Charles	1.0	-25.8
			--lb K_2O ac^{-1} yr^{-1}---
Potassium	Delavan	12.0	-63.0
	Lamberton	7.9	-52.5

to build 1 ppm

	Lamberton	Morris	Saint Charles
	-------------------------lb P_2O_5/ppm-------------------------		
Bray P-1	14.3	14.3	25.0
Olsen P	25.0	25.0	50.0







Soil Fertility

Driven to Discover℠

Key Points on Build + Maintain

- Exact maintenance is likely not required to maintain soil test values
  - Question – if crop removal is not used will mining of the soil occur?
  - If any P fertilizer is applied drawdown of soil P is slow
- Exact Removal will likely increase soil test P
- Concentration of P in the grain is a moving target so using an average value may apply more or less than removal depending on the hybrid/variety
- Better to build slowly over time

PKS Study Locations

	Year		Bray P1-P			NH_4OAC-K			SOM
Location	Est.		YR 1	YR3	YR5	YR 1	YR 3	YR 5	
				--------ppm-------					-%-
Red Wing	2011	SiL	34	29	20	91	77	73	2.2
Rochester		L	32	28	18	172	169	114	3.4
Becker	2012	LS	20	9	8	86	74	62	2.1
Lamberton		L	14	14	9	107	113	88	4.6

YR3 & YR5 data represents the average value for the control (No P, K, or S)
Colors represent expected response to applied fertilizer
blue – low, green – moderate, red - high

Net Return over the Rotation

		Red Wing				Rochester			
Nutrient	Rate	2 yr	4 yr	6 yr	Total	2 yr	4 yr	6 yr	Total
	lb/ac	---------------------------------$/acre-----------------------------------							
Phosphorus	120	0.0	-48.0	80.0	32	-48.0	-96.0	-8.0	-152
Potassium	100	-4.0	31.0	96.0	123	-40.0	-50.0	4.0	-86
	200	-44.0	47.0	56.0	59	-80.0	-60.0	-11.0	-151
	300	-84.0	30.0	16.0	-38	-120.0	-100.0	-51.0	-271
Sulfur	25	15.5	148.0	180.5	344	-12.5	59.0	73.0	119.5

- P rates are in lb P_2O_5/ac - 0.40/lb
- K rates are in lb K_2O/ac – $0.40.lb
- S - $0.50/lb   Corn $4/bu   Beans $10/bu
- Applied P and K rate may not be the “optimum rate” for each site
- Application cost is not factored into net return

Minnesota's Agricultural Fertilizer Research & Education Council

Net Return over the Rotation

		Becker				Lamberton			
Nutrient	Rate	2 yr	4 yr	6 yr**	Total	2 yr	4 yr	6 yr**	Total
	lb/ac	---------------------------------$/acre------------------------------------							
Phosphorus	120	-16.0	58.0	108	150	-48.0	58.0	40.0	50
Potassium	100	-84.0	-40.0	-40.0	-164	-40.0	40.0	4.0	4
	200	-144.0	-80.0	-80.0	-304	-80.0	0.0	-36.0	-116
	300	-204.0	-120.0	-120.0	-464	-120.0	-40.0	-76.0	-236
Sulfur	25	-12.5	-12.5	-12.5	-37.5	15.5	-12.5	-12.5	-9.5

- P rates are in lb P_2O_5/ac - 0.40/lb
- K rates are in lb K_2O/ac – $0.40.lb
- S - $0.50/lb Corn $4/bu Beans $10/bu
- Applied P and K rate may not be the “optimum rate” for each site
- Application cost is not factored into net return

**only 2016 corn data included

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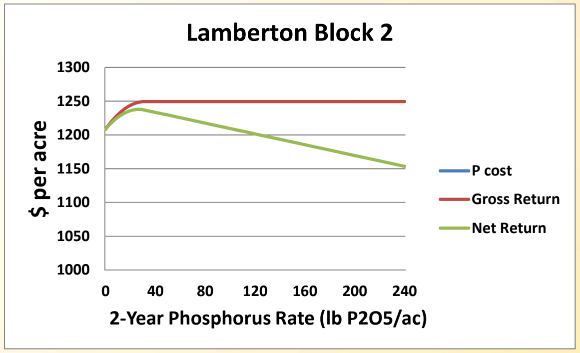
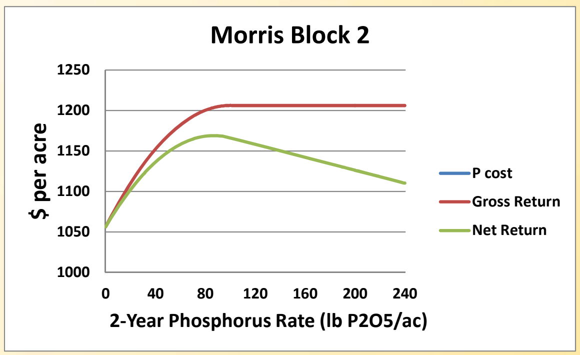
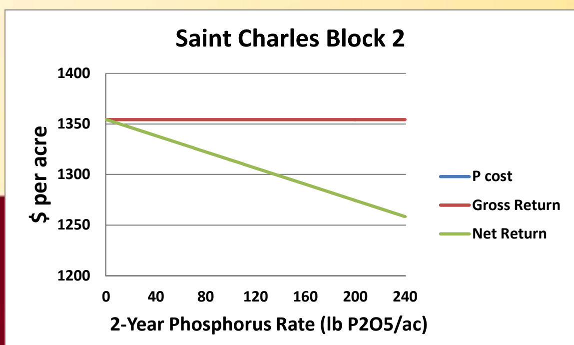
Agricultural Fertilizer Research & Education Council

What is the most economical Rate of P For a 2-year rotation?





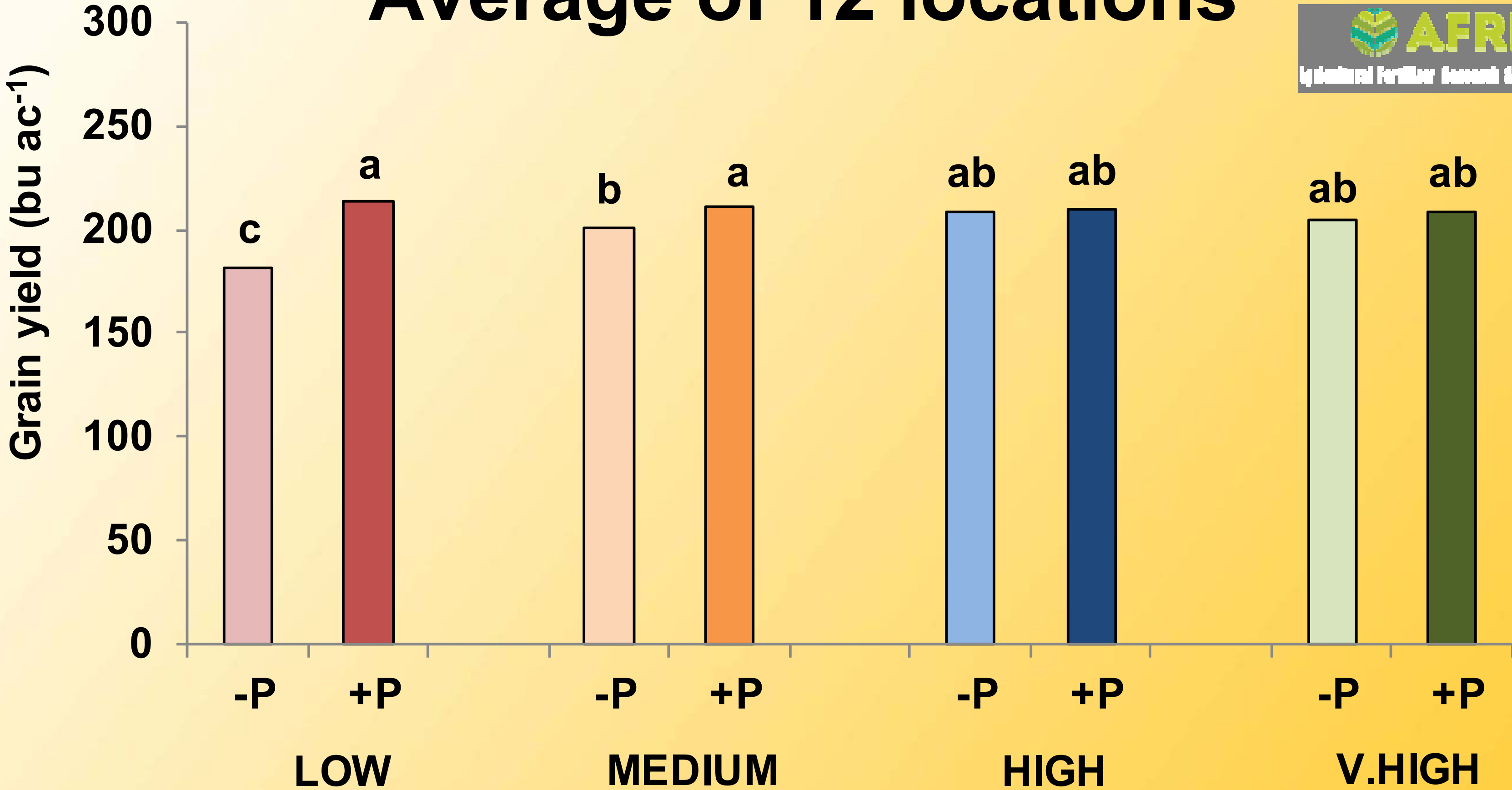


$4 Corn
$10 Soybean
$0.40/lb P2O5

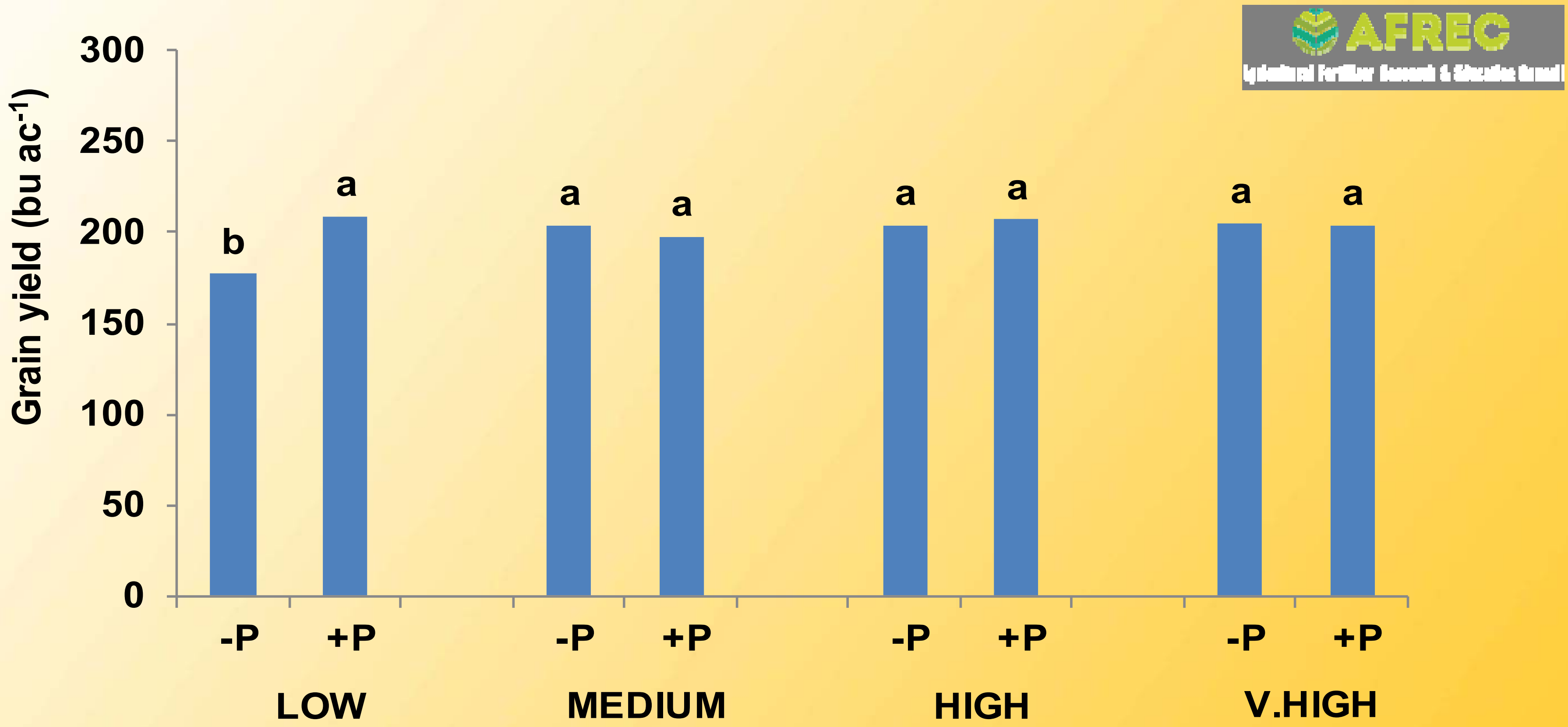
	Block	EOPR
		-lb P_2O_5/ac-
Lamberton	1	42
	2	27
Morris	1	50
	2	87
Saint	1	0
Charles	2	0

- Beginning soil test P was low for all blocks except for Morris B1 which was medium
- Soil pH: Lamberton 5.4; Morris 8.0; St Charles 6.3
- Values were averaged over 8 years of data
- EOPR – economic optimum P rate

2-Year Summary –
Corn Response to P based on STP Class
Average of 12 locations



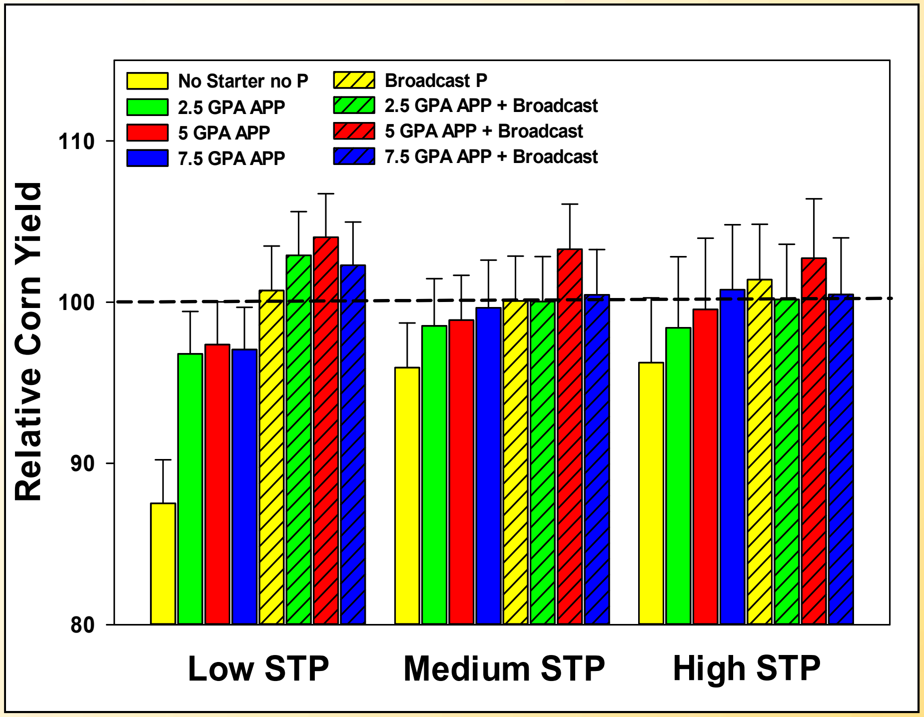
2016 Corn Response to P applied based P applied in 2015 - Average of 6 locations

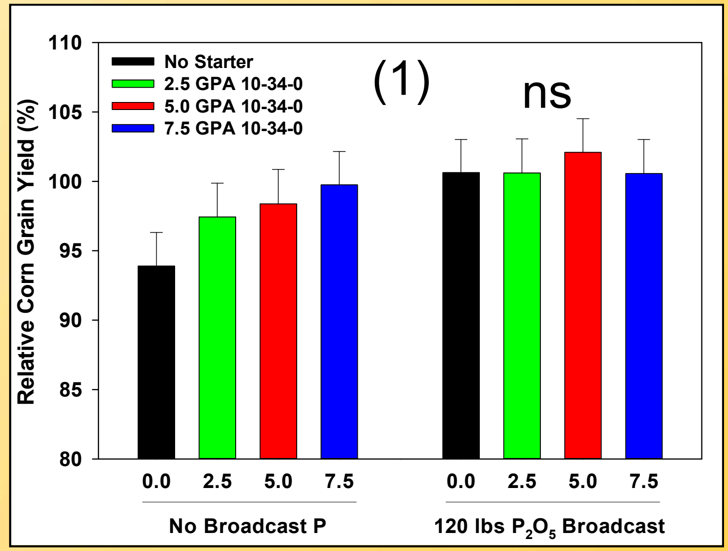


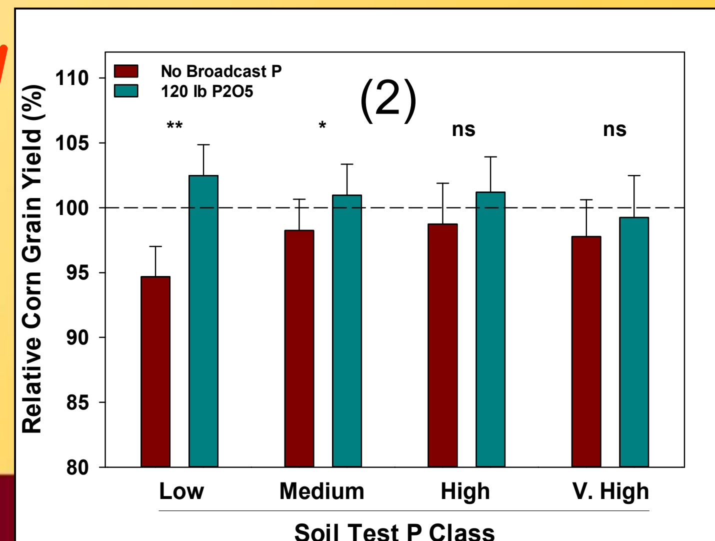
Economics of P Fertilization

- It is difficult to evaluate economics of a maintenance type strategy
  - In the short term it costs more
  - In the long term???
- Data indicates a sufficiency type approach would be more profitable
  - How long can that approach be maintained?
  - Soil sampling needs to be increased
- How do low-input, starter only strategies fit

Starter Response 2012-2015







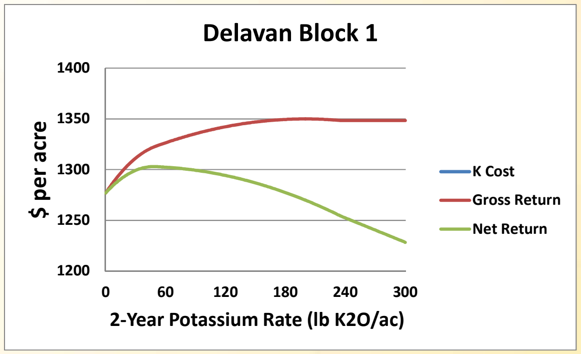
1) Response to starter across soil test P classes only when broadcast P was applied
   - Response to 2.5 GPA
2) Response to broadcast P, but only when soil P was less than 15 ppm olsen

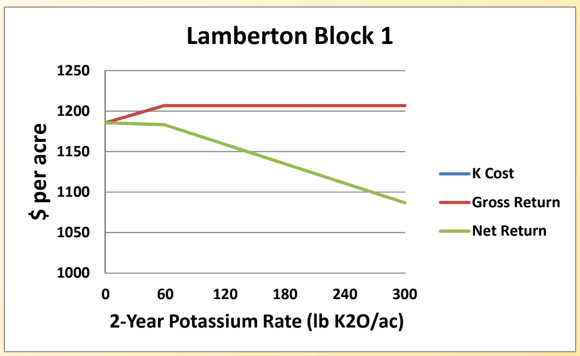
Why did starter increase yield regardless of STP class but broadcast P did not?

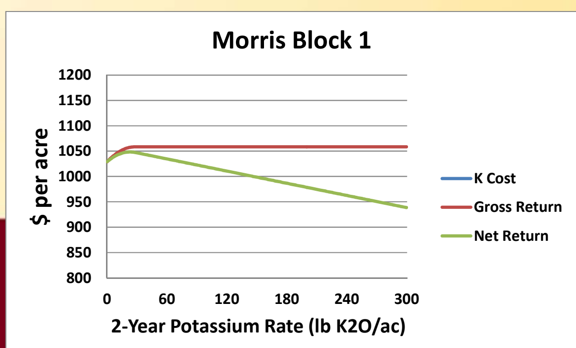
Low Input Strategy-Summary

- Increased early growth DOES NOT indicate where an increase in yield will occur
- Yield response is still dictated by soil test of the soil where the treatment is applied
- Starter should supplement the entire fertility program
- 2.5-5 Gallons of 10-34-0 is a good option
- Applying more than 5 GPA 10-34-0 is risky and there is no economic benefit
- Decreased grain moisture is a possibility but target fields where grain moisture content a harvest will be >20%
  - Do not band a rate that provides more P_2O_5 than the crop needs factoring in all amounts of P applied.

What is the most economical Rate of K For a 2-year rotation?







$4 Corn
$10 Soybean
$0.40/lb K2O

	Block	EOKR
		-lb K_2O/ac-
Delavan	1	48
	2	27
Lamberton	1	0
	2	24
Morris	1	23
	2	28

- Beginning soil test K was High for all blocks except for Lamberton B1 which was medium
- Values were averaged over 8 years of data
- EOKR – economic optimum K rate

P&K: Where do we go from here?

- Suggested rates in the new publication should result in a slow build of P and K for low soil tests – then what do you do?
- There is no overwhelming evidence to economically justify maintaining high-very high soil test
  - More economically justified to apply maintenance for medium-high soil tests
- Is there a future for reductions in P or K application when banding?
- I would strongly caution against using yield maps from the previous crop to generate fertilizer maps
  - How accurate is your yield monitor?
- Can starter fertilizer be incorporated and maintain high yield

Sulfur Guideline Changes

- New guidelines assume a sulfate source is being used
- Application of elemental S is risky if being applied to a S deficient situation
- No reason to exceed a rate of 25 lbs S/ac

Table 12. Broadcast Sulfate-Sulfur guidelines for corn grown in Minnesota

	0-6" Soil Organic Matter Concentration		
Crop Rotation	**0-2%**	**2-4%**	**4%+**
	lb S/acre as SO_4-S		
Soybean/Corn	10-25	10-15	0*
Corn/Corn	10-25	10-15	5-10**
Sandy Soils	25	25-25	15-25

*Research data suggest that a rate of 10 lbs of sulfate S may be warranted when corn follows soybean on poorly drained calcareous soils

**A low rate of S is suggested when corn follows corn and SOM is 4% or greater. A rate of 10-15 lbs of S is suggested for corn following corn on reduced tillage in the presence of high levels of surface residue

Sulfur Guideline Footnotes

- We are suggesting a set rate of S being applied for corn on corn in high residue situations
- Sulfur research projects are underway:
  - Comparing application methods of liquid ATS
    - Thiosulfate is a source of sulfate and elemental S
  - Fall versus spring rate and source on poorly drained soils with organic matter % >4.0
  - Timing and source in SE Minnesota
- Sulfur mineralization is affected by year
- Sulfur can carry over in medium and fine textured soils

Chelated Zinc With 10-34-0 - Corn

Site	Control	10-34-0	10-34-0 + Zn	ST – Zinc
	-------------------bushels/ac-------------------			--ppm--
Murdock ’12	194	192	192	2.8
Waseca ‘12	188	189	200**	1.4
St Charles ’13	204	198	197	1.7
Willmar ’13	159b	173a	172a	1.0
Prinsburg ’14	200	209	204	2.6
Stewart ‘14	162	167	162	1.3
Becker ’15	179	192	184	1.1
Lamberton ‘15	214	213	212	0.6
Becker ’16	228	234	228	1.8
Lamberton ‘16	201	201	201	0.5

- 2.5-6 gpa + 1 qt/ac (10% fully chelated zinc with citric acid/EDTA)
- **Indicates a potential response to Zn. Individual plot yield was highly variable for the treatment (min 168 and max 228), no response for treatment with Zn only.

Take Home Message on Zn

- Rate and critical soil test level (0.75ppm) seem to still hold – better response when <0.5ppm
- We have not seen hard evidence that Zinc deficiencies in corn are occurring in situations not traditionally responsive to Zn
  - Likely will not benefit a starter program for high Zn soils
- The current research on Zn-chelates do not overwhelmingly support application in starter to all acres
- Recommendation – Target low testing field areas with broadcast zinc for the highest return

Thank You
Questions?

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