
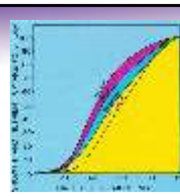


Economics of Soil Fertility Management

Lucas Haag Ph.D., Asst. Professor/Northwest Area Agronomist
K-State Northwest Research-Extension Center, Colby

With Cooperation Of:
Terry Kastens, Ph.D., Emeritus Professor, Agricultural Economics, K-State
Kevin Dhuyvetter, Ph.D., Technical Consultant, Elanco

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Knowledge for Life

Where are we now?

- Historical and Current Price Ratios
- Understanding Crop Response to Fertilizer
- Economics of Soil Testing and Data Quality
- Implications for site-specific management
- Products and Placement
- Current Research

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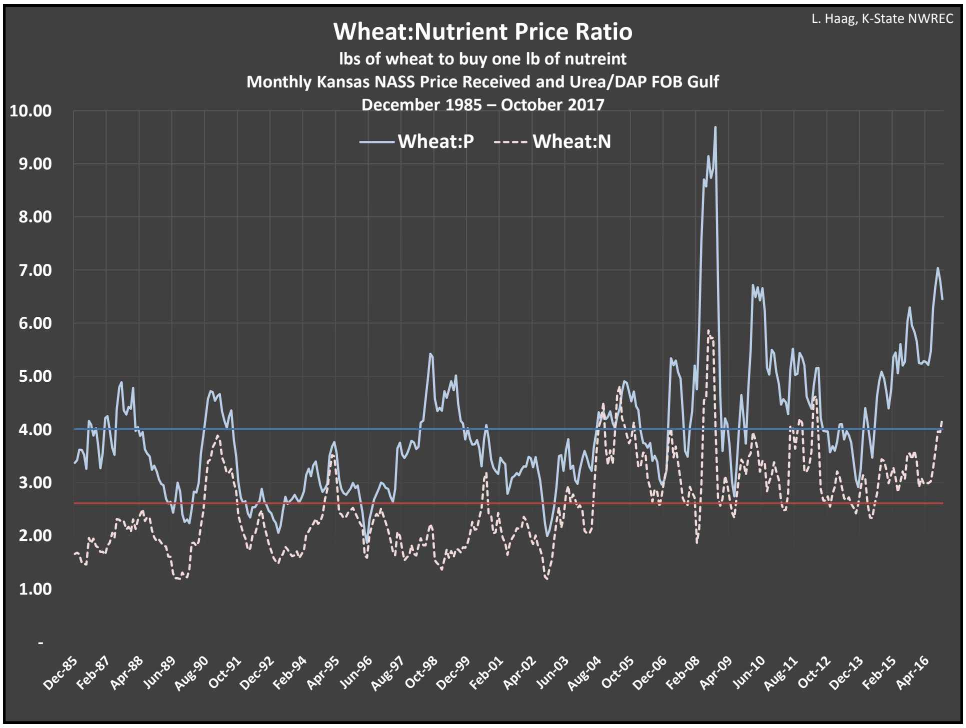
Knowledge for Life


L. Haag, K-State NWREC
Wheat:Nutrient Price Ratio
lbs of wheat to buy one lb of nutreint
Monthly Kansas NASS Price Received and Urea/DAP FOB Gulf
December 1985 – October 2017
Wheat:P
Wheat:N
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
Dec-85
Feb-87
Apr-88
Jun-89
Aug-90
Oct-91
Dec-92
Feb-94
Apr-95
Jun-96
Aug-97
Oct-98
Dec-99
Feb-01
Apr-02
Jun-03
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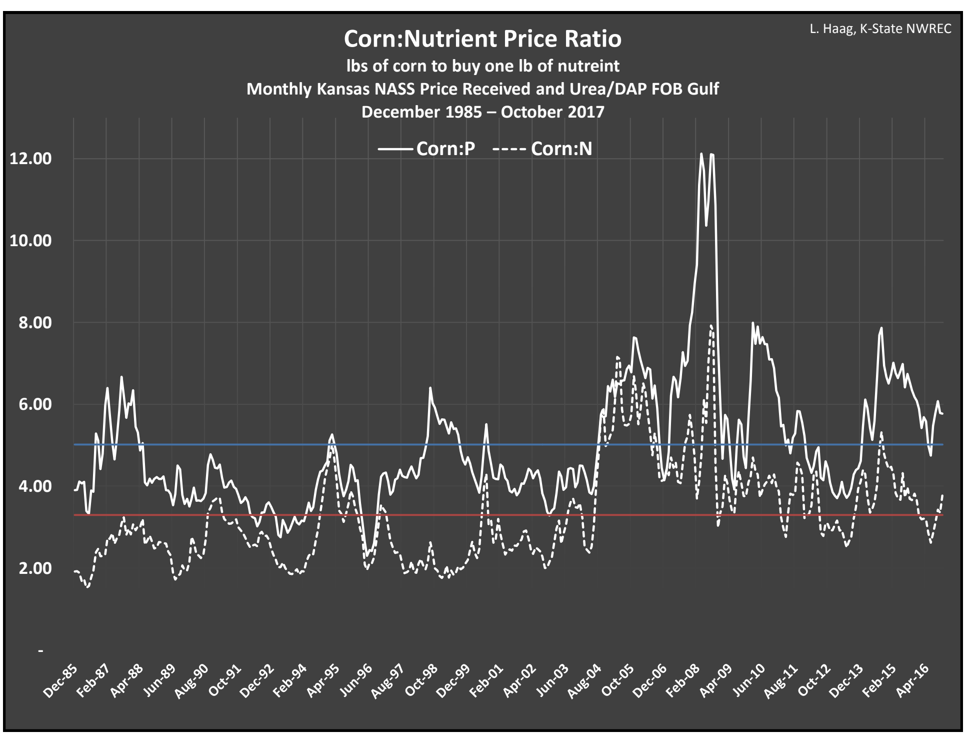
Aug-11
Oct-12
Dec-13
Feb-15
Apr-16


L. Haag, K-State NWREC
Corn:Nutrient Price Ratio
lbs of corn to buy one lb of nutreint
Monthly Kansas NASS Price Received and Urea/DAP FOB Gulf
December 1985 – October 2017
Corn:P
Corn:N
12.00
10.00
8.00
6.00
4.00
2.00
-
Dec-85
Feb-87
Apr-88
Jun-89
Aug-90
Oct-91
Dec-92
Feb-94
Apr-95
Jun-96
Aug-97
Oct-98
Dec-99
Feb-01
Apr-02
Jun-03
Aug-04
Oct-05
Dec-06
Feb-08
Apr-09
Jun-10
Aug-11
Oct-12
Dec-13
Feb-15
Apr-16

Grain:Nutrient Price Ratios

	Historical	Oct. 2017
Corn:Nitrogen	3.29	4.48
Wheat:Nitrogen	2.61	4.47
Corn:Phosphorus	5.02	5.86
Wheat:Phosphorus	4.01	5.85

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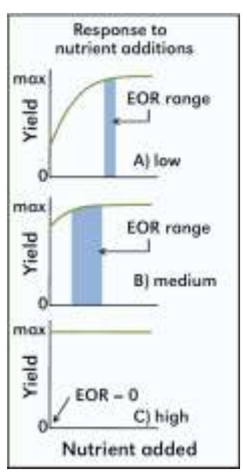
Knowledge for Life

Understanding Crop Response to Fertilizer



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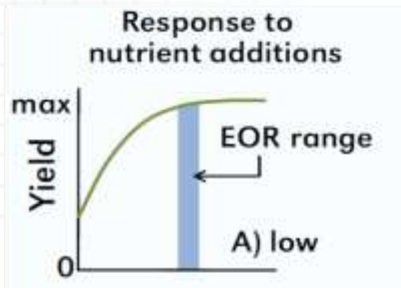
Knowledge for Life

Understanding Crop Response to Fertilizer
Low Soil Test Levels



- Low yields without additional fertilizer
- EOR range is narrow
- Optimum rate is minimally affected by grain:nutrient price ratio

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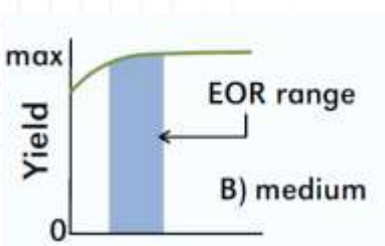
2018 Soil Fertility Update

Knowledge for Life

Understanding Crop Response to Fertilizer
Medium Soil Test Levels



- Expected yield without fertilizer is higher
- Range of potentially optimal rates is wider
- In a single-year decision framework, EOR is very sensitive to grain:nutrient price ratio
- As price ratio↓ EOR ↑

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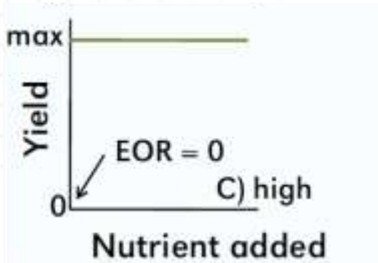
Knowledge for Life

Understanding Crop Response to Fertilizer
High Soil Test Levels



- No or minimal response to added fertilizer

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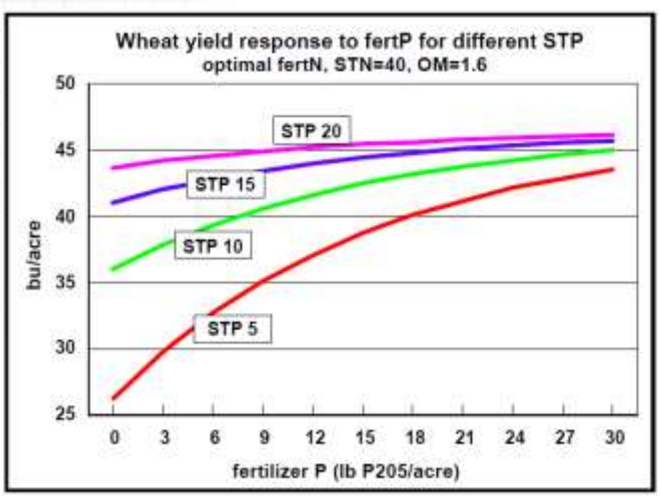
Wheat Response to Soil Test P Level



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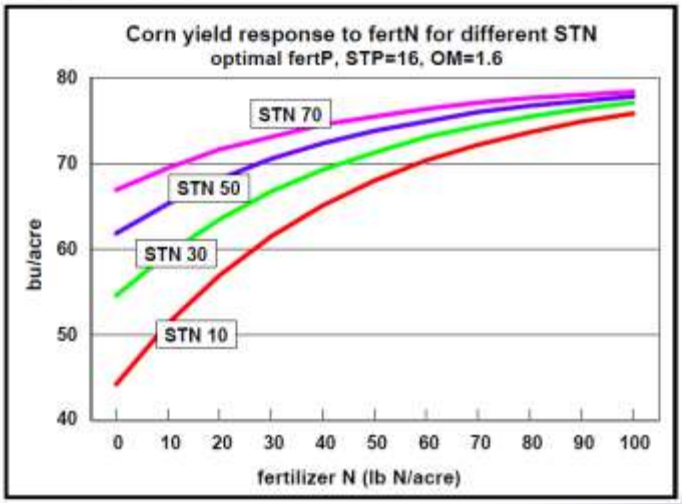
Corn Response to Soil Test N Level



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Knowledge for Life

Understanding Sufficiency vs. Build-Maintain Programs for P and K

- Sufficiency fertility programs
  - Intended to estimate the long-term average amount of fertilizer P required to, on average, provide optimum economic return in the year of application. There is little consideration for future soil test values

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Knowledge for Life

Build-Maintenance

- Apply enough P to or K to build soil test values to a target soil test value over a planned timeframe (e.g. 4-8 years), then maintain based on crop removal and soil test levels
- NOT intended to provide optimum economic returns in a given year, but minimize the probability the P or K will limit crop yields while providing for near maximum yield potential

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Knowledge for Life

P Sufficiency Recommendations for Wheat

From K-State Publication MF2586 – Soil Test Interpretations and Fertilizer Recommendations

Phosphorus Sufficiency Recommendations for Wheat[1]

Olsen (ppm)	Bray P1 Soil Test (ppm)	Yield Goal (Bu/A) 30	40	50	60	70
		Lb P_2O_5/A				
0-3	0-5	50	55	60	60	65
3-6.3	5-10	35	40	40	45	45
6.3-9.4	10-15	20	25	25	25	30
9.4-12.5	15-20	15	15	15	15	15
12.5+	20+	0[2]	0[2]	0[2]	0[2]	0[2]
	Crop Removal[3]	15	20	25	30	35

Nutrient recommendations are for the total amount of broadcast and banded nutrients to be applied. At low to very low soil test levels applying at least 25-50% of total as a band is recommended

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Knowledge for Life

Phosphorus removal values

Crop	Unit	P_2O_5 (lb)
Corn	bushel	0.33
Grain Sorghum	bushel	0.40
Wheat	bushel	0.50
Sunflowers	pound	0.02
Oats	bushel	0.25
Soybeans	bushel	0.80

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Knowledge for Life

P Build-Maintain Recommendations for Wheat

From K-State Publication MF2586 – Soil Test Interpretations and Fertilizer Recommendations

Phosphorus Build-Maintenance Wheat Recommendations

Bray P1 Soil Test	4-Year Build Time Frame Yield (Bu/A)			6-Year Build Time Frame Yield (Bu/A)			8-Year Build Time Frame Yield (Bu/A)		
	30	50	70	30	50	70	30	50	70
(ppm)	- - Lb P_2O_5/A - -			- - Lb P_2O_5/A - -			- - Lb P_2O_5/A - -		
0-5 0-3	94	104	114	68	78	88	54	64	74
5-10 3-6	71	81	91	53	63	73	43	53	63
10-15 6-9	49	59	69	38	48	58	32	42	52
15-20 9-12.5	26	36	46	23	33	43	21	31	41
20-30[1] 12.5+	15	25	35	15	25	35	15	25	35
30+	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]	0[2]

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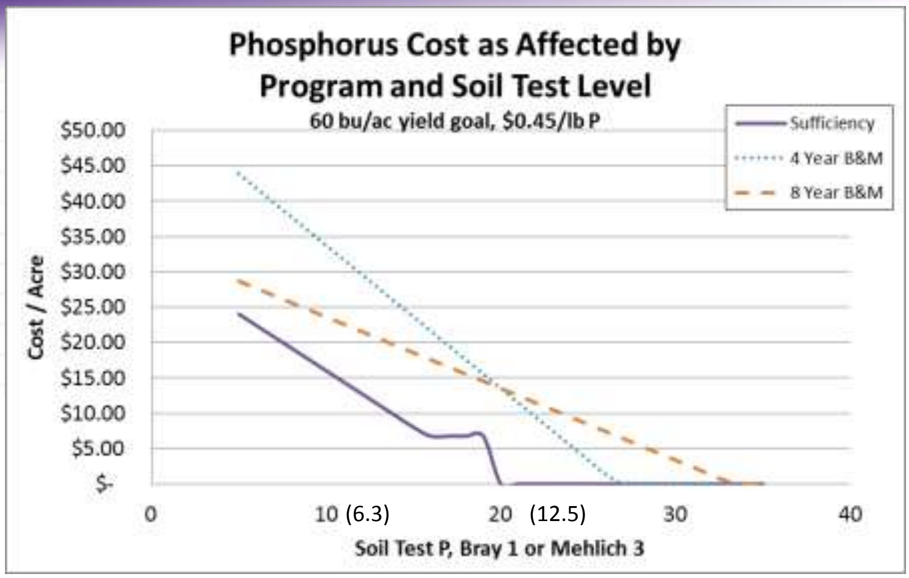
Knowledge for Life



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Grain Sorghum P and K Recommendations

Phosphorus Sufficiency Recommendations for Grain Sorghum[1]

Bray P1 Soil Test	Yield Goal (Bu/A) 40	80	120	160	200
(ppm)			Lb P_2O_5/A		
0-5	50	55	60	65	70
5-10	35	40	45	45	50
10-15	20	25	25	30	30
15-20	15	15	15	15	15
20+	0[2]	0[2]	0[2]	0[2]	0[2]
Crop Removal[3]	16	32	48	64	80

120 bu x 0.4 lb/bu = 48 lb P_2O_5 removed

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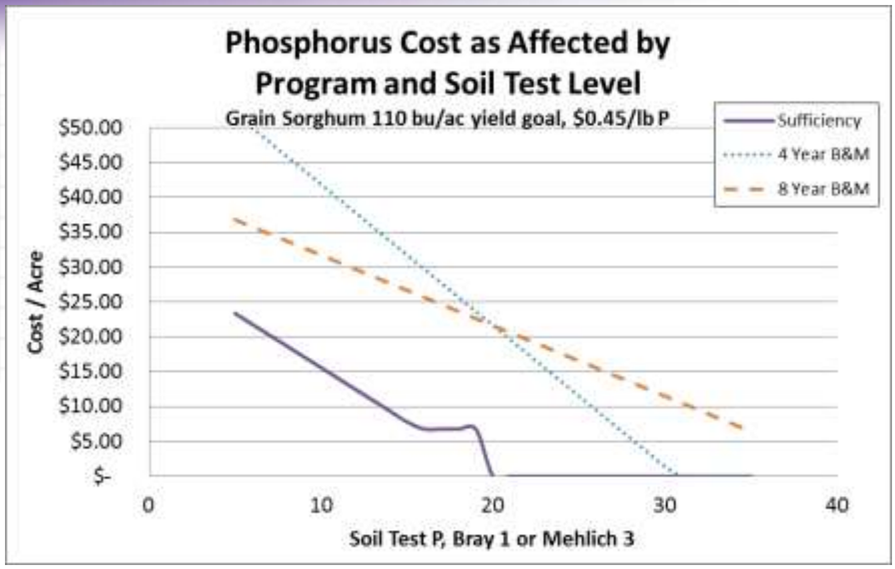
Knowledge for Life



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Factors Affecting Strategy Selection

- Anticipated length of time to recapture soil test building investment
  - Age, length of career
  - Anticipated land tenure
    - Owned land, long-term landlord relationship, short-term lease
- Current-year economics
- Current soil test levels

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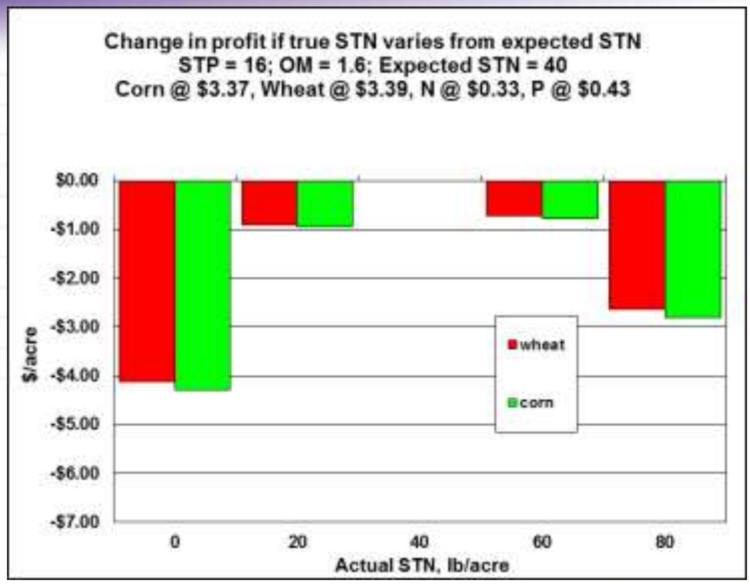

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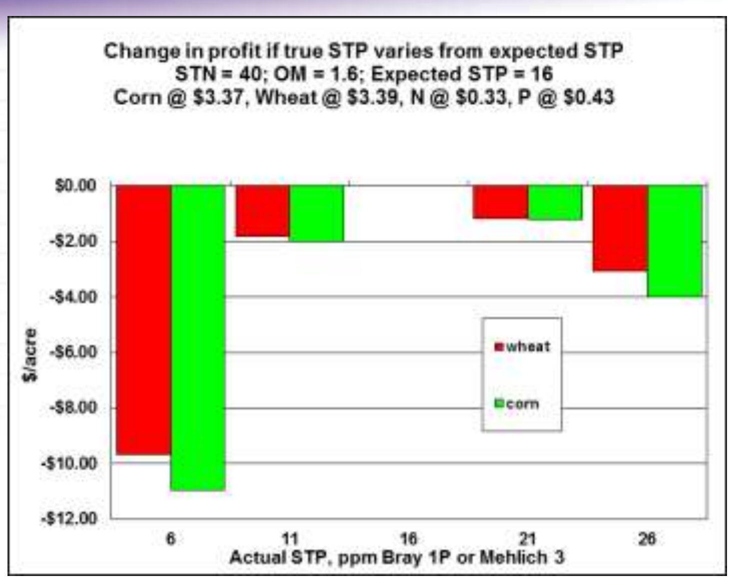
Knowledge for Life



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Knowledge for Life

Data Quality

- The proceeding economics are based on having good data, as good of a representation of "truth" as we can reasonably obtain.
- Good decisions require good data
- Good soil test data comes from good procedures in the field

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Number of Cores to Make a Good Sample

- Soils vary across very short distances in nutrient supply due to many factors including:
  - Position on the landscape
  - Past erosion
  - Parent material of the soil
- We also induce variability on the soil
  - Band applications
  - Livestock grazing
- To account for this variation you should take 10-20 cores per sample

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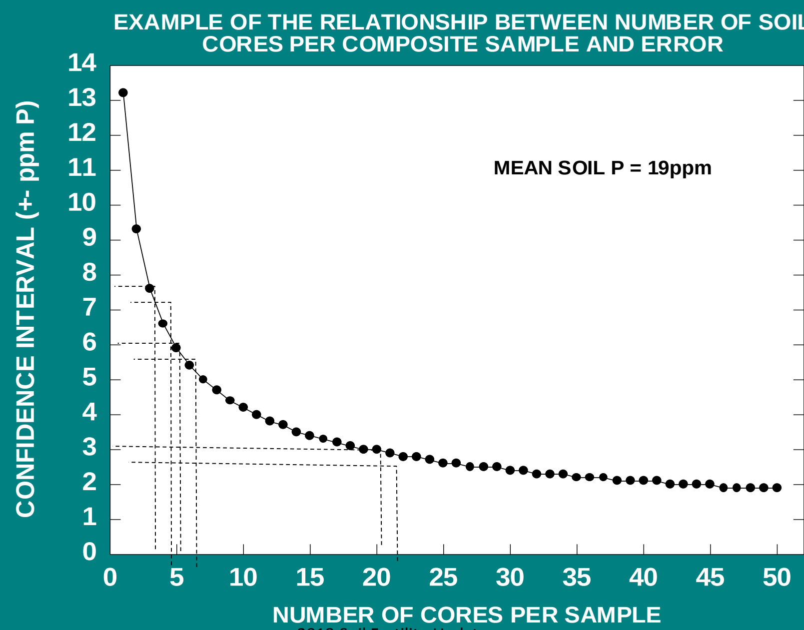
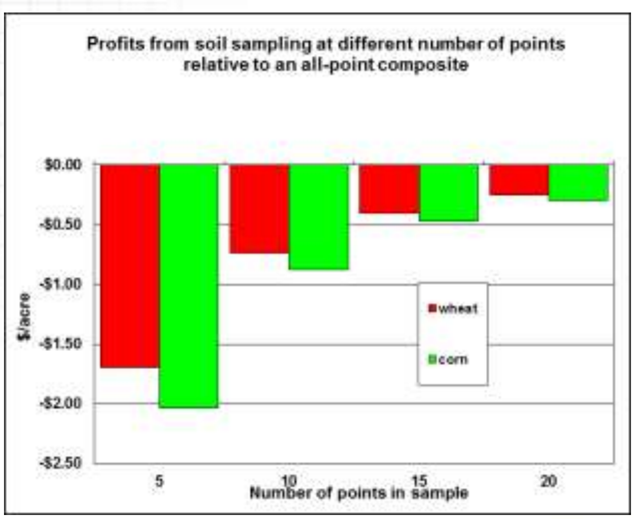
Knowledge for Life



Economics of Accuracy



The Role of Soil Testing

- Generating profits from soil testing is dependent on the tradeoff between the cost of gathering the information (labor and lab fees), and the benefits from having that information (more appropriate fertilizer rates)

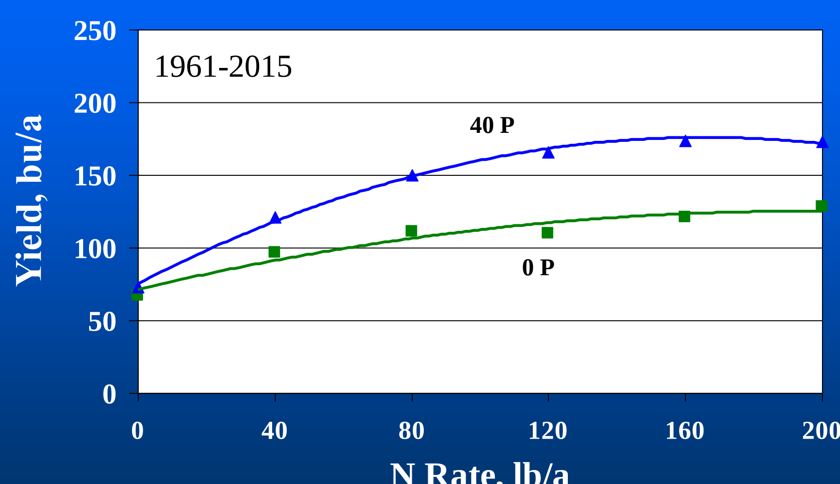
Useful soil tests in Kansas

- Profile Nitrate-N
- Bray P-1 Extractable P
- Olsen Extractable P
- Mehlich III Exractable P
- Exchangeable K
- DTPA Extractable Zn
- Chloride
- Sulfur/Sulfate
- Soil pH
- Lime Requirement / Buffer pH
- Soil Organic Matter

Phosphorus Soil Test Methods

- Bray P1 roughly equivalent to Mehlich III, use for soil pH < 7.0
- Bray P2 – NOT USEFUL!, Developed for rock phosphate applications in Indiana
- Olsen Bicarbonite – Developed at CSU for high pH soils especially > 7.0
- Mehlich III, equivalent to Bray P1, but valid over a wider range of soil pH

Long-term Corn Fertility



Long-term corn fertility, Tribune, KS

Options

- Economics of grid sampling
- In-Furrow Placement of Urea with Wheat
- Humic Acid for Iron Chlorosis in Sorghum
- Wheat Protein

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Knowledge for Life

VRT Phosphorus Example

- No other data is available (i.e. yield data)
- Field is located in NW Kansas and was grid sampled on 2.5 ac grids
- Samples consisted of 15 cores, so an estimated CI of +/- 3.5 ppm

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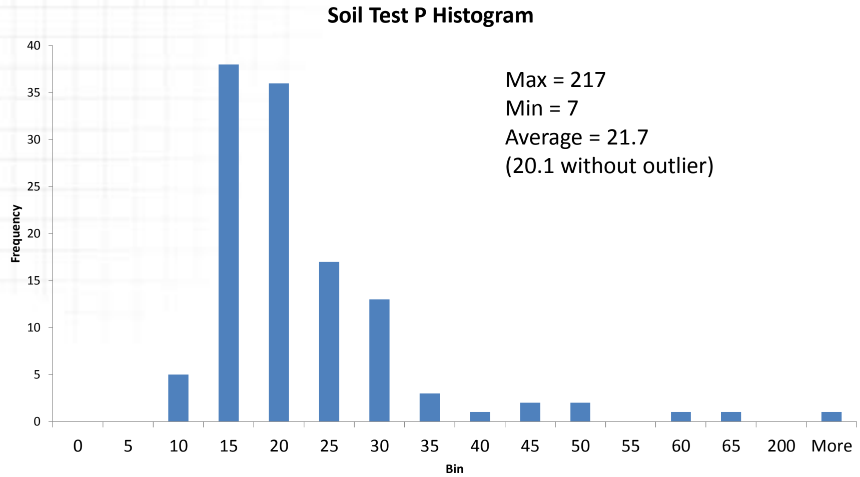
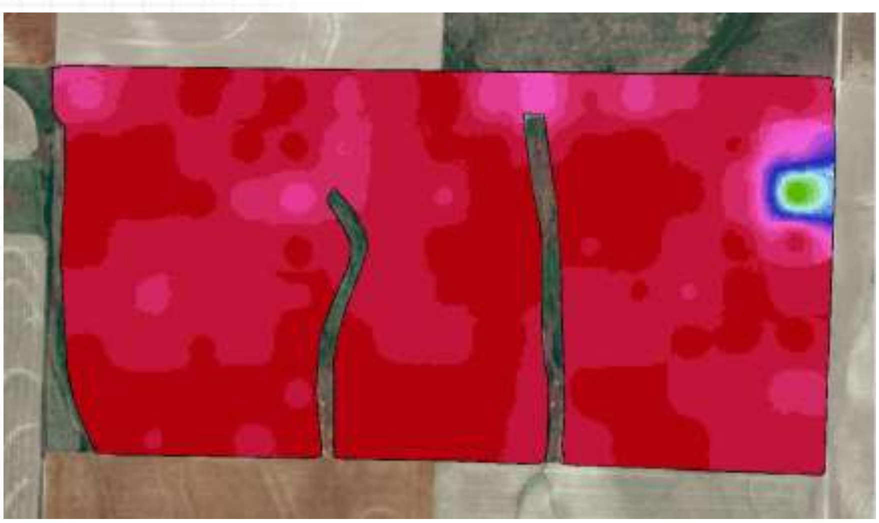
Soil Test Bray P1



2018 Soil Fertility Update

Interpolated Soil Test Phosphorus



NOT A GOOD EXAMPLE OF INTERPOLATION!

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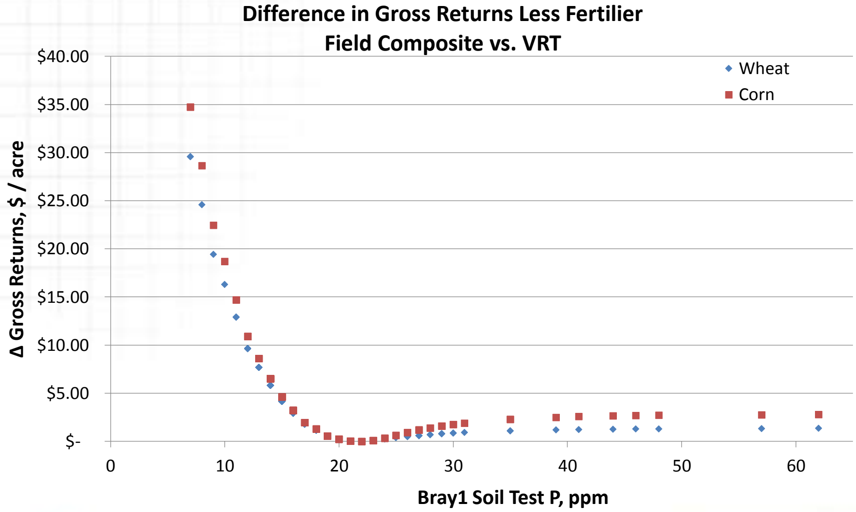
Returns to VRT



2018 Soil Fertility Update

Returns to VRT

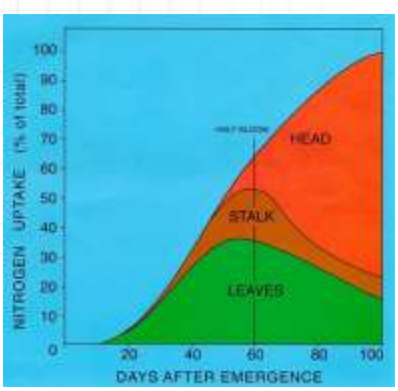
- Average gross return on VRT P for wheat = ***$3.81/acre/year***
- Average gross return on VRT P for corn = ***$4.49/acre/year***
- The above gross figures would need to cover sampling cost and the portion of machinery and labor cost related to VRT implementation

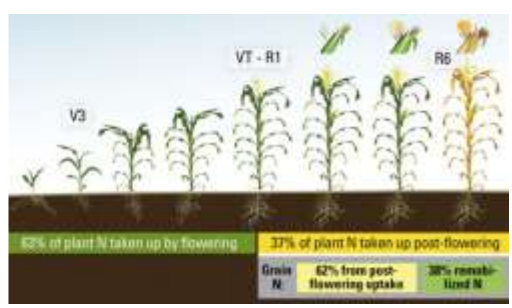
2018 Soil Fertility Update

Can we stretch the value of intensive sampling?

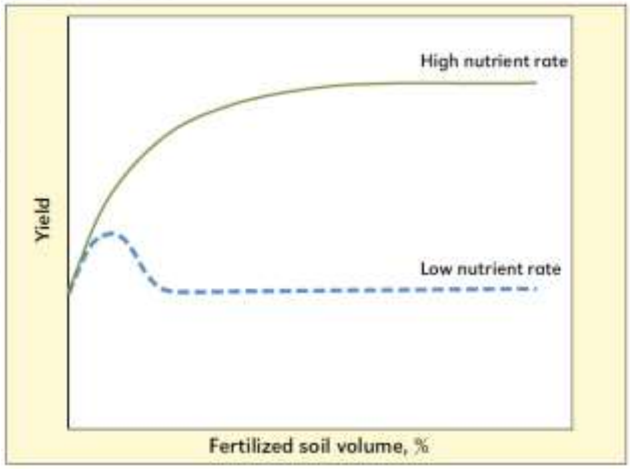
- ROI on intensive sampling increases dramatically as the number crops benefiting from the information increases (spreading fixed cost)
- Checkbook approach for nutrients using initial intensive soil test and removal rates from yield monitor data

Nitrogen Uptake and Key Timings





Placement



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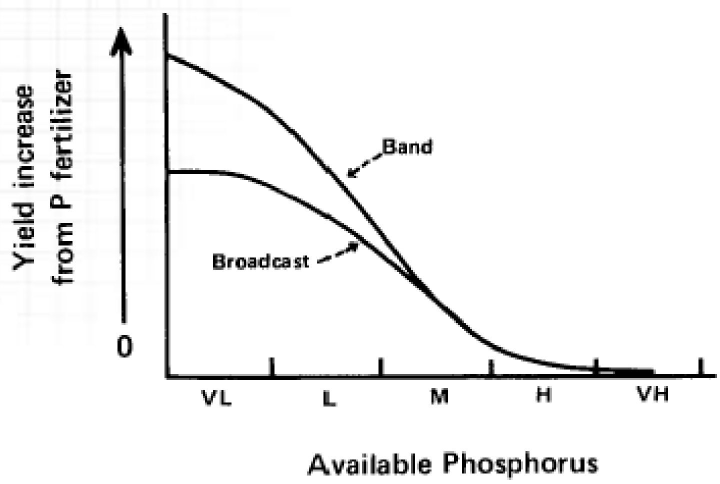
Knowledge for Life

Soil test P and application method



Common generalized depiction of broadcast vs. band

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Knowledge for Life

Interest in fertilizer efficiency through placement

KS, 1932

FIG. 18.—Graphs showing effect on yield of wheat of applying superphosphate broadcast and in the row with the seed.

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Knowledge for Life

Phosphorus removal values

Crop	Unit	P_2O_5 (lb)
Corn	bushel	0.33
Grain Sorghum	bushel	0.40
Wheat	bushel	0.50
Sunflowers	pound	0.02
Oats	bushel	0.25
Soybeans	bushel	0.80

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Crop Removal – the next step

- Calculate crop removal
- Depending on over/under applications after crop removal, soil test levels will change.
- 18 lbs P_2O_5 is required to change STP one ppm.

- One cycle of a W-C-F rotation (using field averages)
  - Wheat yield = 60 bu/a, Corn yield = 110 bu/ac
  - STP = 22 ppm, P_2O_5 applied during seeding = 30 lb/a
  - Wheat Removal = 60 * 0.50 = 30 lbs P_2O_5 removed
  - Corn Removal = 110 * 0.33 = 36 lbs P_2O_5 removed
  - Total Crop Removal = 30+44 = 66 lbs P_2O_5 removed
  - STP change = 66-30=36 lb net removal, 36/18 = 2 ppm estimated drop
  - Final STP = 22 – 2.4 = 19.6 ppm

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Crop Removal – the next step

- Perform crop removal and STP calculations at a site-specific scale for the field
- Potential Decision Rules
  - Land ownership/tenancy makes a difference
  - Decisions based on STP
    - IF STP > 30 then apply 0 or very minimal amount (intentional mining)
    - IF STP is >20 and <30 then apply removal rates
    - IF STP is <20 then apply removal + build (build rate?)
- VRT apply P to meet management goals

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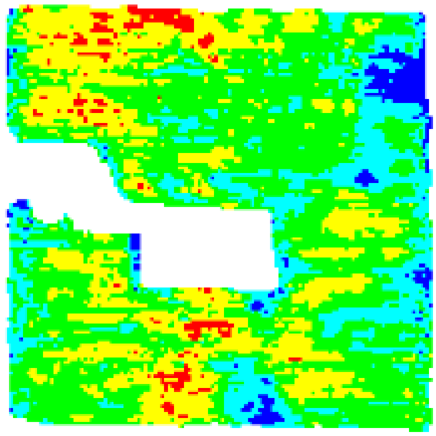
Using yield monitor data to look back… 4 Years of P Removal



P_2O_5 (lbs/ac)

Blue	15 to 45
Cyan	45 to 65
Green	65 to 85
Yellow	85 to 105
Red	105 to 130

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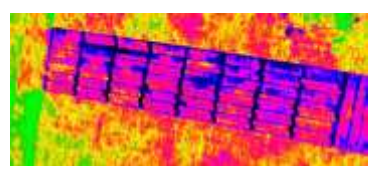
Knowledge for Life

In-Furrow Placement of Enhanced Efficiency Urea Fertilizers in Wheat



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Southwest Research-Extension Center, Tribune
Dorivar Ruiz-Diaz, Soil Fertility Specialist
Department of Agronomy, Manhattan

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Knowledge for Life

In-Furrow Urea

- Current K-State recommendations state no urea should be placed in-furrow with seed
- In the Northern Plains data would suggest that some low levels of urea in-furrow are safe
- New products on the market: ESN, NBPT, etc. may provide some level of safety

In-Furrow Urea Materials and Methods

- Western Sites: No-till into chem-fallow,
  Certified CSU-Byrd, target 1.05 million seeds/ac
- Hunter 2017: No-till into wheat stubble, Certified KSU-Larry
- Hunter 2018: No-till into soybean stubble, Cert. KSU-Larry
- Treatments (in addition to grower practice):
  - 10, 20, 30, 60 lbs/ac N as ESN, NBPT, or Urea
  - MAP to get 10 lbs/ac N (91 lbs/ac of MAP)
  - Control
- Locations:
  - Tribune, Colby, Herndon, and Hunter (2017)
- Measurements

Fall stand count	Spring Vigor
Head Counts	Grain Yield and Protein

Visual – Mitchell Co. 2/9/17

60 lb/ac Urea   60 lb/ac ESN

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Visual response to in-furrow MAP – Mitchell Co. 2/9/17

Control

MAP for 10 lbs of N
(91 lb/ac material)

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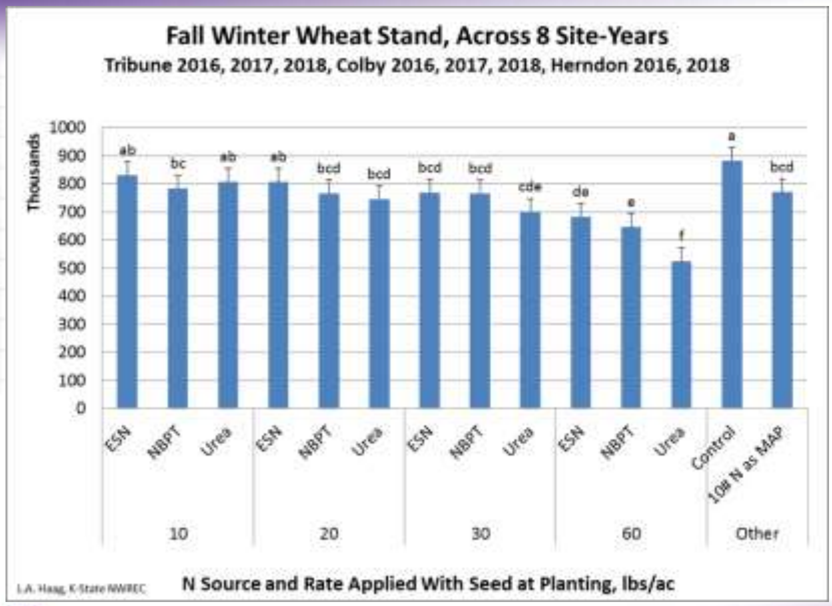

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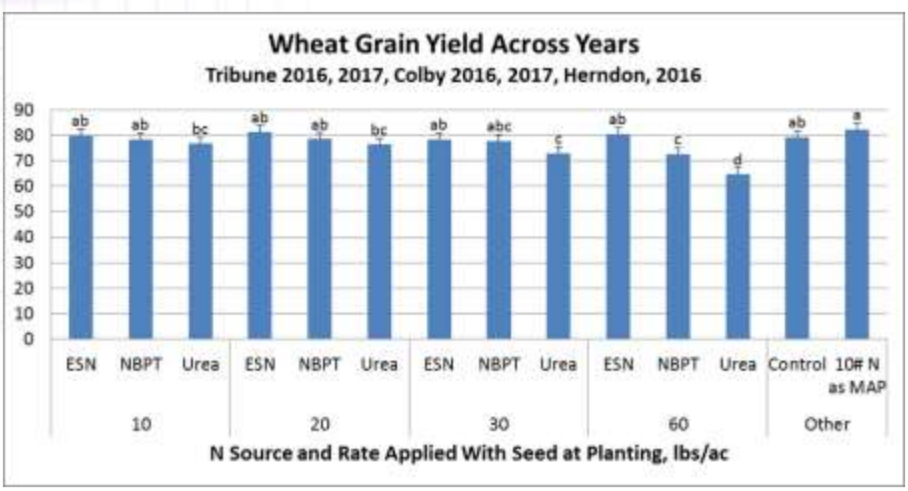

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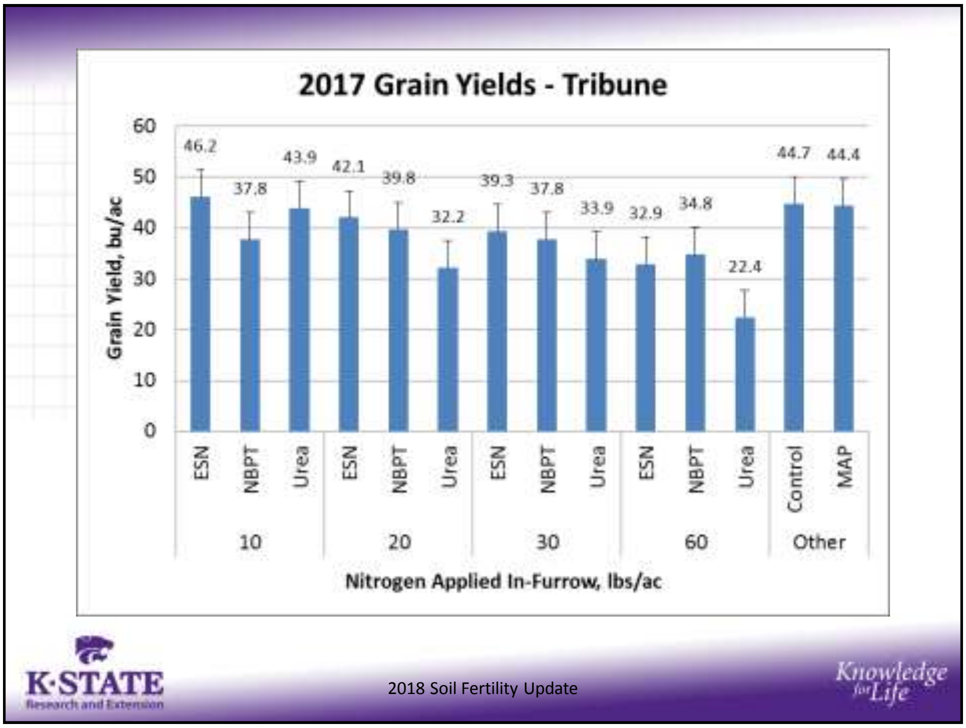
2017 Grain Yields - Tribune
Grain Yield, bu/ac
60
50
40
30
20
10
0
46.2
37.8
43.9
42.1
39.8
32.2
39.3
37.8
33.9
32.9
34.8
22.4
44.7
44.4
ESN
NBPT
Urea
ESN
NBPT
Urea
ESN
NBPT
Urea
ESN
NBPT
Urea
Control
MAP
10
20
30
60
Other
Nitrogen Applied In-Furrow, lbs/ac
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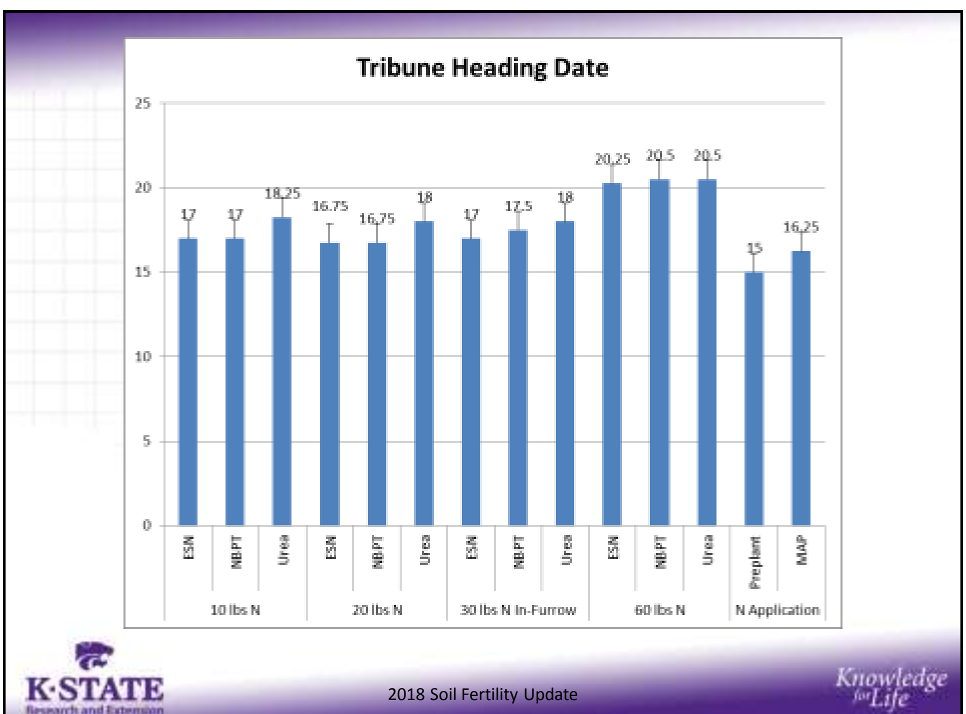
Tribune Heading Date
25
20
15
10
5
0
17
17
18.25
16.75
16.75
18
17
17.5
18
20.25
20.5
20.5
15
16.25
ESN
NBPT
Urea
ESN
NBPT
Urea
ESN
NBPT
Urea
ESN
NBPT
Urea
Preplant
MAP
10 lbs N
20 lbs N
30 lbs N In-Furrow
60 lbs N
N Application
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Conclusions

- Some indication that ESN and NBPT coated urea provides some saftey over untreated urea if used in-furrow
- Not enough site-years yet to truly evaluate the risk of various levels
- Low levels (10 lb/ac) of ESN urea appear to offer minimal risk

In-Furrow Humic Acid in Grain Sorghum – Year 1



Lucas Haag, Northwest Area Agronomist, NWREC-Colby
Jeanne Falk Jones, Sunflower Dist. Agronomist
Alan Schlegel, Agronomist-in-Charge, SWREC-Tribune

Rationale

- We had received reports of in-furrow applications of humic acid reducing the occurrence of iron chlorosis

Materials and Methods

- Two Products Used
  - Raw Humic Acid (Soil Boost), 72% humic acid
  - Humic DG (The Andersons), 70% humic acid
- IDC Tolerant Hybrid, P87P06 used
- Planted in 30” rows, 45,000 seed drop
- 4 Replications per location
- 4 Locations
  - Colby, Wallace 1, Wallace2, Wallace 3

In-Furrow Rates

Product	30" Rate	Equivilent 10" Rate
	lbs/acre	
Raw Chipped Humic Acid	0	0
	10	30
	20	60
	30	90
	40	120
	70	210
Humic DG	7	21
	14	42
	21	63
	28	84
	35	105

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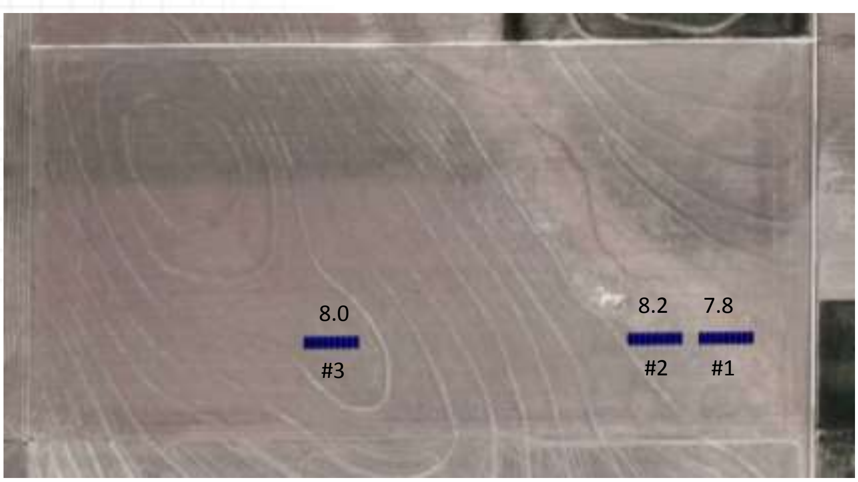
Locations - Wallace



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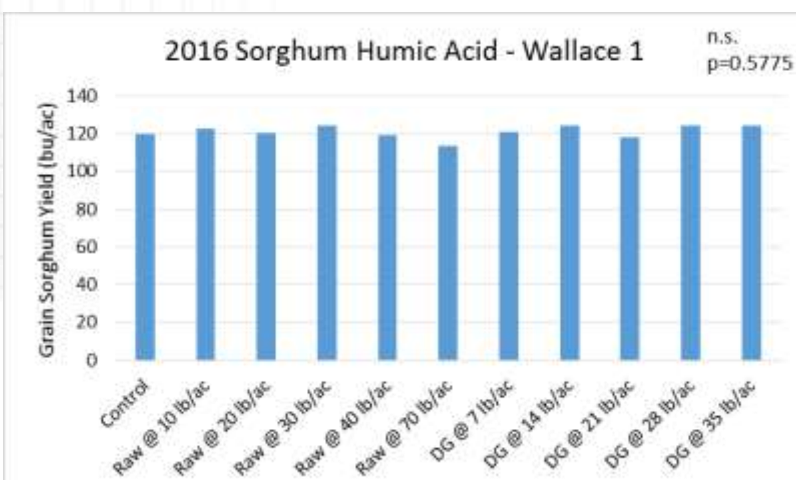
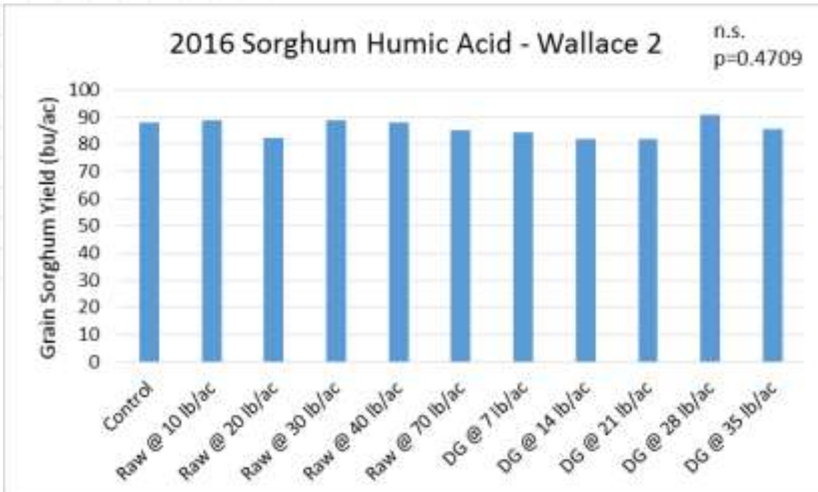
Locations - Colby

Results – Wallace 1



Results – Wallace 2



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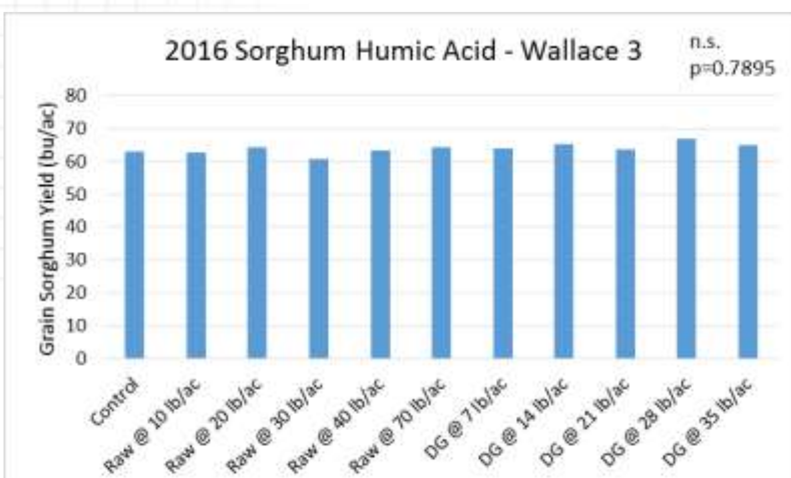
Results – Wallace 3



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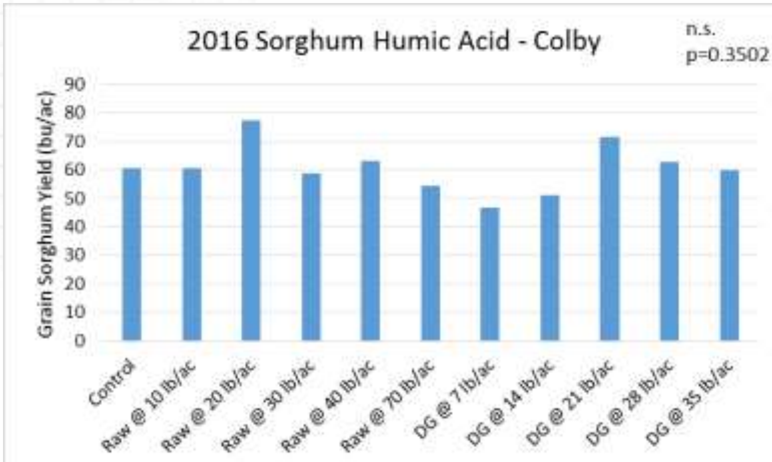
Results - Colby



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Summary

- In year one of the study, across four locations, we did not see a statistical or numerical response to in-furrow applications of humic acid in grain yield or IDC score
- We are considering extending the study another year

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Questions?

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Wheat Protein

Lucas Haag, Ph.D., Northwest Area Agronomist
K-State Northwest Research-Extension Center
Colby, Kansas

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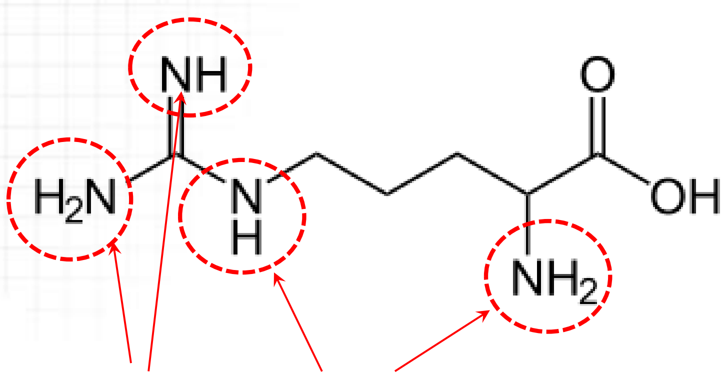
Importance of Protein

- Bread rises because of yeast and gluten
- Gluten – is a "sticky" protein complex
- Proteins are made up of amino acids
- Amino acids are stored in the seed as they are the foundation of plant growth (seedlings)

Amino acid arginine ($C_6H_{12}N_4O_2$)



Amino nitrogen N

32% by weight is N

Making Protein

- Nitrogen is a basic component of amino acids
- Amino acids are the building blocks of plant growth and are stored for seedling development
- The protein in the kernel is generally considered to be laid down first before most of the carbohydrates

Nitrogen Uptake

- Most of the N used by wheat is taken up before flowering and later moved to the kernel during grain fill
- Photosynthesis occurring during grain fill largely determines kernel starch contents

Plant Use of N

FIGURE 2. Approximate cereal growth stages and N application timing effects on yield and protein. This figure was modified from its original (4).

Jones et al., Montana State Univ. EB0206

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N supply effects on Grain Yield and Protein

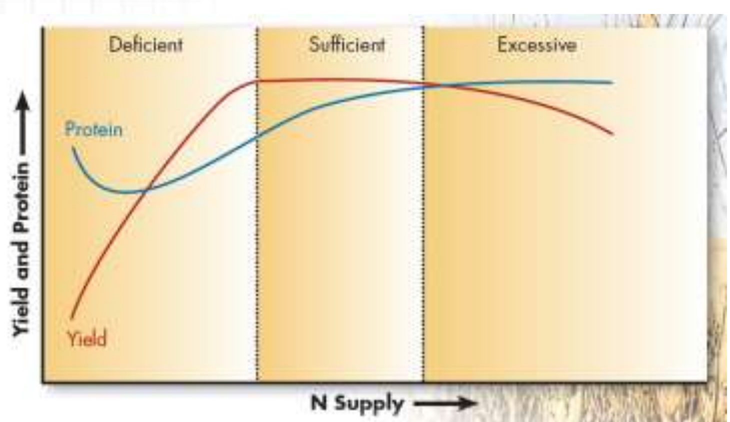

FIGURE 1. The response of wheat yield and grain protein to increasing N (7).

Jones et al., Montana State Univ. EB0206

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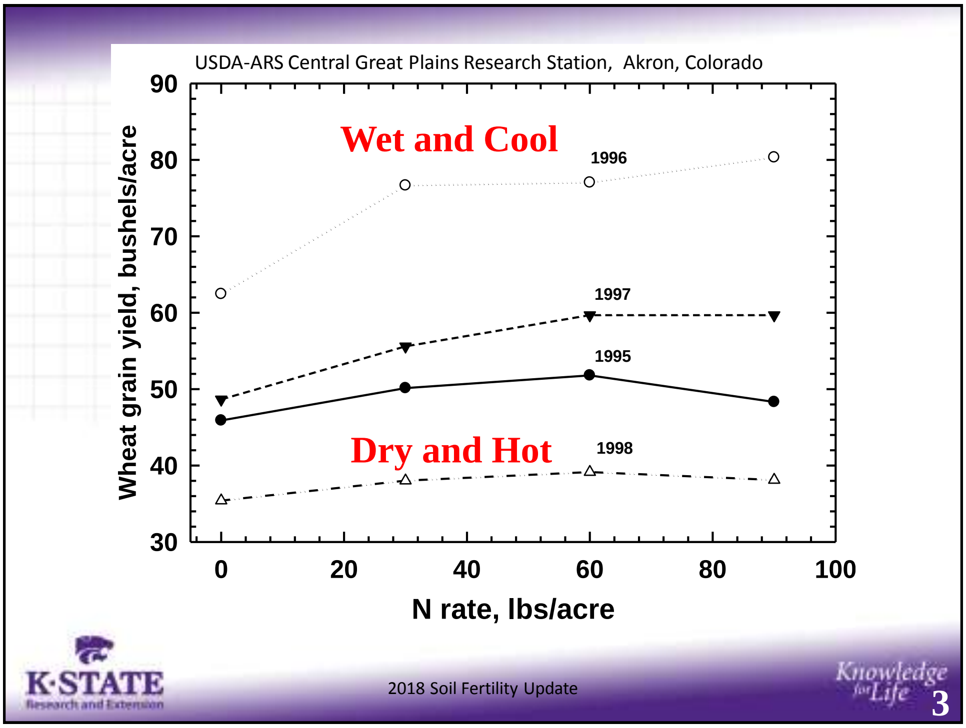
USDA-ARS Central Great Plains Research Station, Akron, Colorado
Wet and Cool
Dry and Hot
1996
1997
1995
1998
Wheat grain yield, bushels/acre
N rate, lbs/acre
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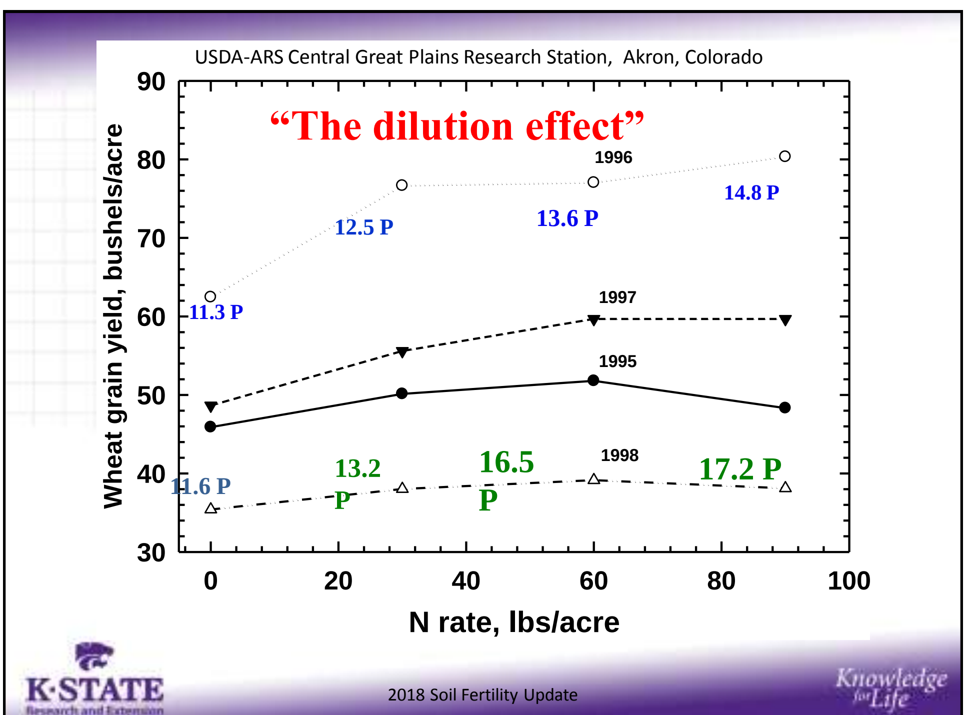
3


USDA-ARS Central Great Plains Research Station, Akron, Colorado
"The dilution effect"
1996
1997
1995
1998
11.3 P
12.5 P
13.6 P
14.8 P
11.6 P
13.2 P
16.5 P
17.2 P
Wheat grain yield, bushels/acre
N rate, lbs/acre
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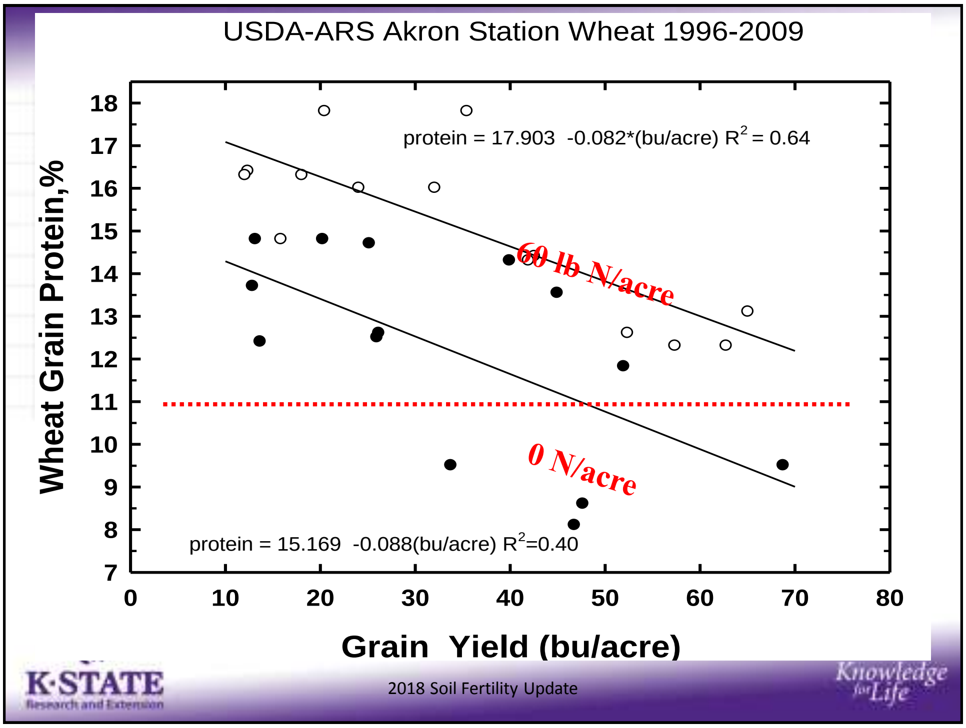
USDA-ARS Akron Station Wheat 1996-2009
protein = 17.903 -0.082*(bu/acre) R2 = 0.64
60 lb N/acre
0 N/acre
protein = 15.169 -0.088(bu/acre) R2=0.40
Wheat Grain Protein,%
Grain Yield (bu/acre)
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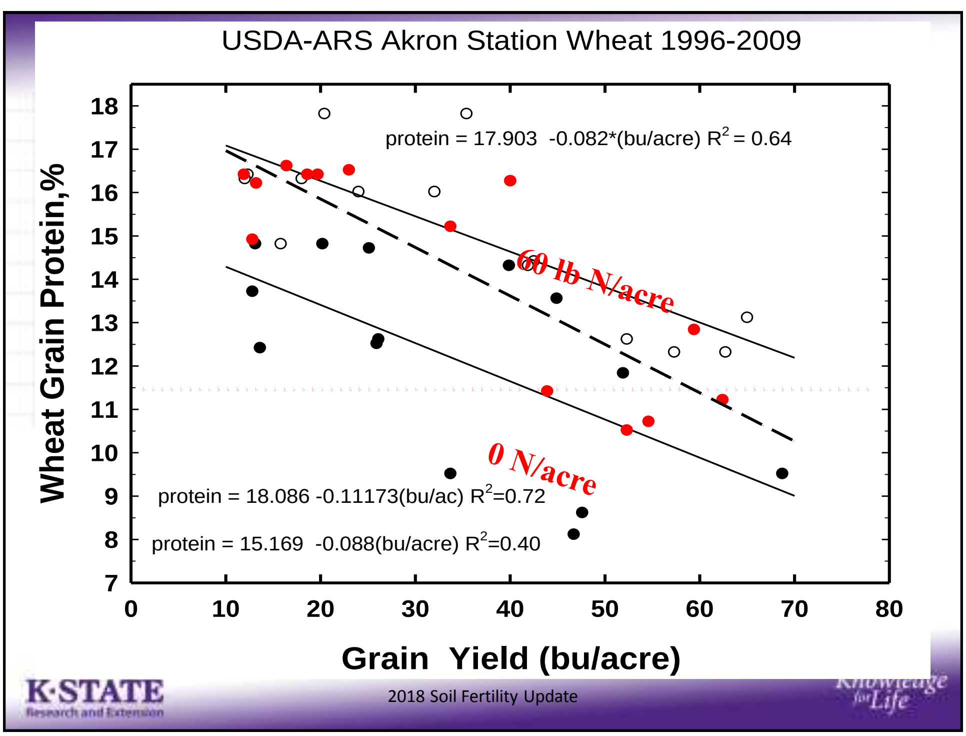
USDA-ARS Akron Station Wheat 1996-2009
protein = 17.903 -0.082*(bu/acre) R2 = 0.64
60 lb N/acre
0 N/acre
protein = 18.086 -0.11173(bu/ac) R2=0.72
protein = 15.169 -0.088(bu/acre) R2=0.40
Wheat Grain Protein,%
Grain Yield (bu/acre)
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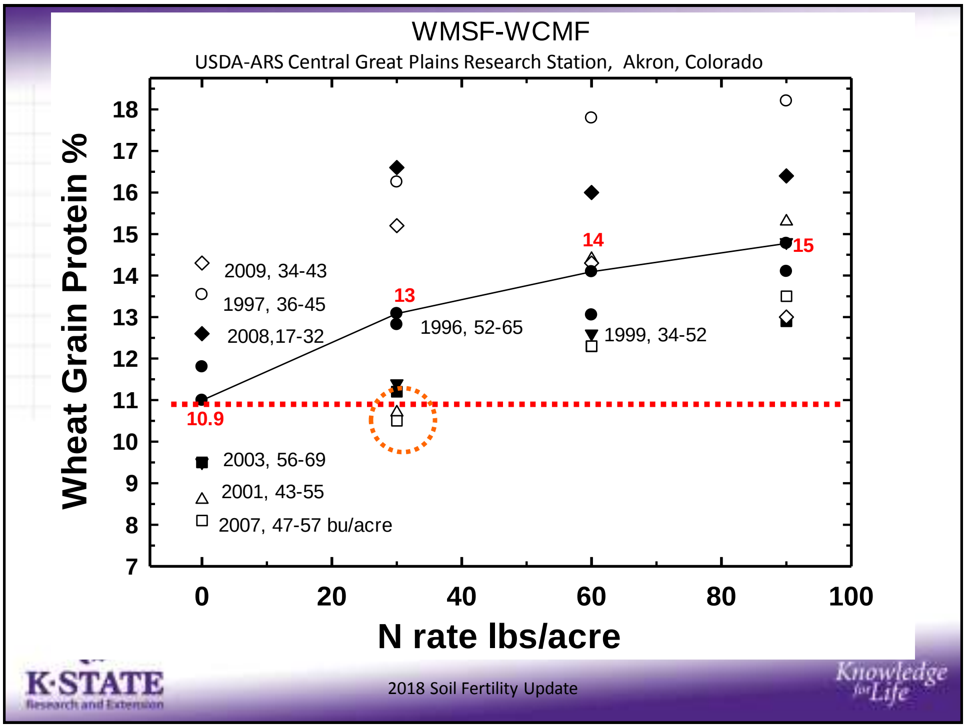
WMSF-WCMF
USDA-ARS Central Great Plains Research Station, Akron, Colorado
Wheat Grain Protein %
N rate lbs/acre
2009, 34-43
1997, 36-45
2008,17-32
1996, 52-65
1999, 34-52
2003, 56-69
2001, 43-55
2007, 47-57 bu/acre
10.9
13
14
15
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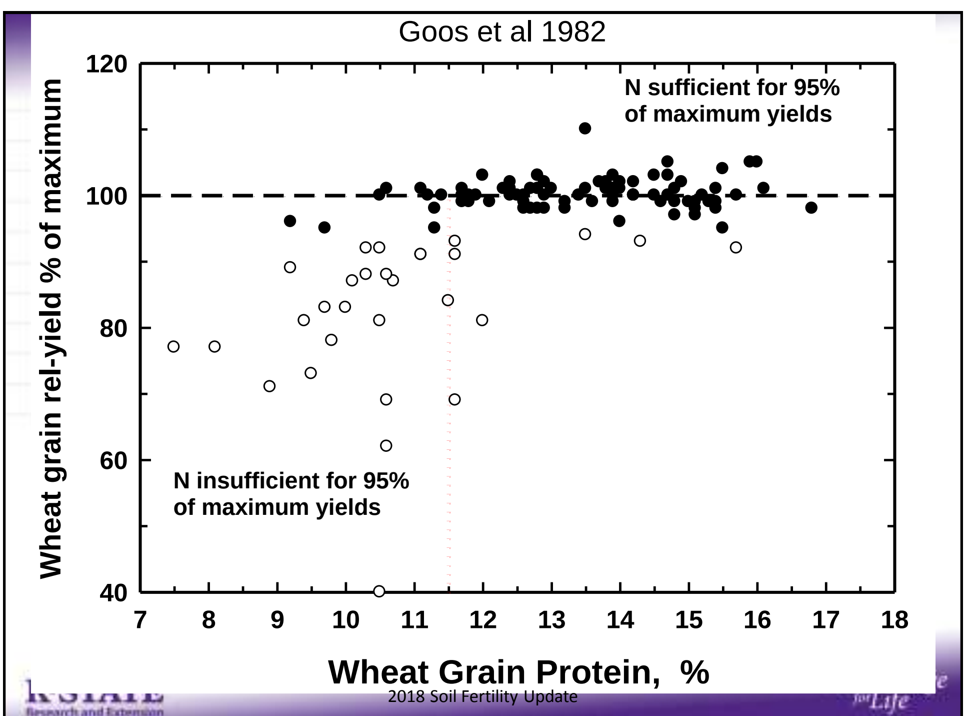
Goos et al 1982
Wheat grain rel-yield % of maximum
Wheat Grain Protein, %
N sufficient for 95% of maximum yields
N insufficient for 95% of maximum yields
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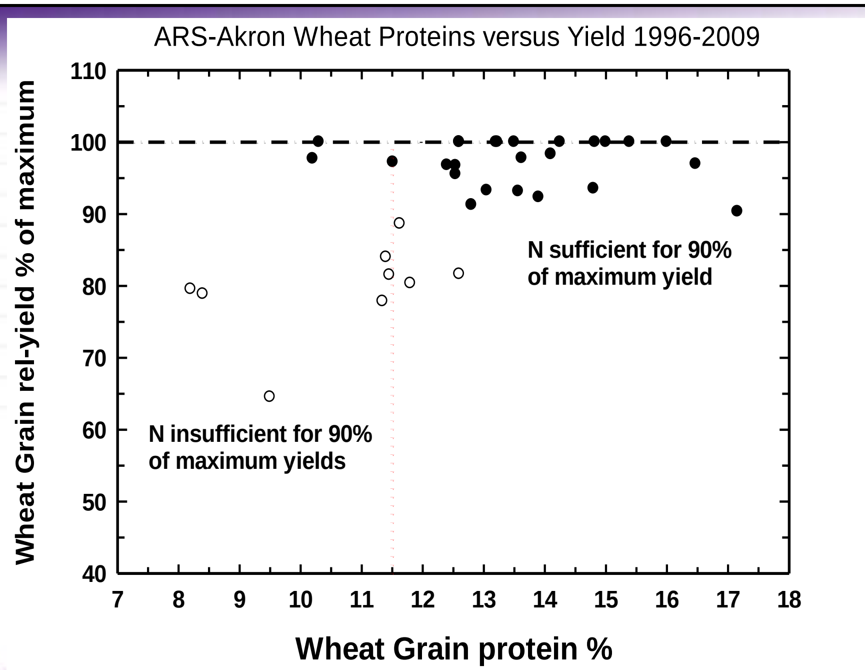


Increasing Grain N and Protein

2011 Crop Year   All plots received 30 pounds N at seeding

N added Feekes 9	Randolph Yield	Randolph Protein	Rossville Yield	Rossville Protein	Scandia Yield	Scandia Protein
0	39	12.2	52	12.2	20	13.9
25	38	11.9	58	12.6	23	15.3
50	40	12.1	55	13.1	23	16.3

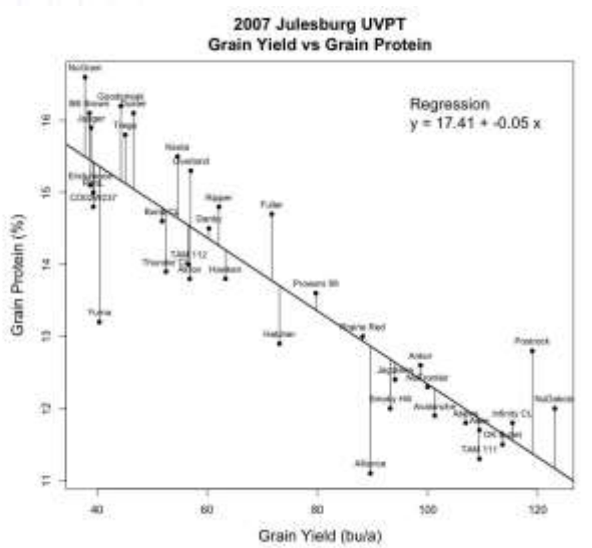
N added Feekes 9	Gypsum Yield	Gypsum Protein	Nfarm F Yield	Nfarm F Protein
0	34	13.6	60	12.7
30	46	13.6	64	13.2
60	42	15.3	66	14.3
90	38	16.3	65	15.6

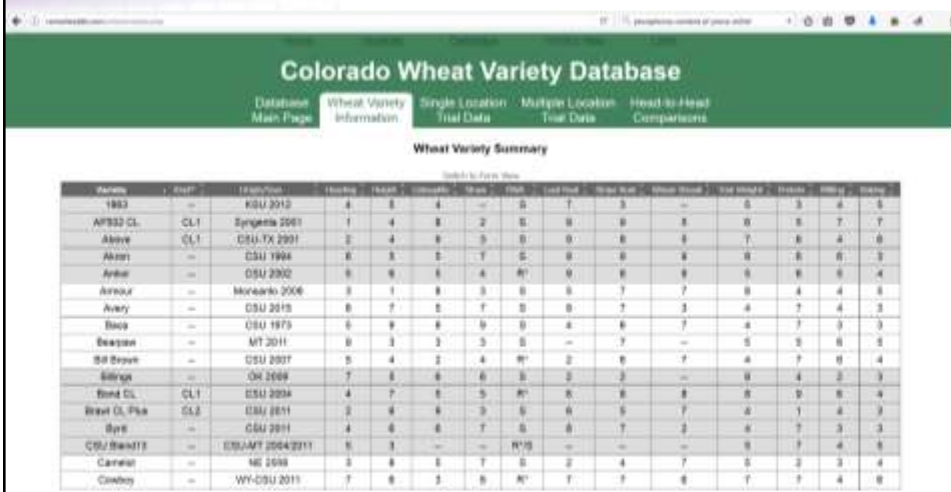
2012 Crop Year

What Role Does Variety Play?

- Anyone who wants to have a conversation about varieties and protein without talking yield isn't really having a conversation
- Varietal differences have been difficult to identify, takes large datasets
- Work by CSU and others has looked at Grain Protein Deviation as a potential indicator

Grain Protein Deviation





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CSU Variety Database Protein Ratings for common Kansas Varieties

Northwest Varieties	Protein Score
Avery	7
Brawl CL Plus	1
Byrd	7
Hatcher	8
Langin	6
SY Monument	5
TAM114	3
WB-Grainfield	6
Tatanka	7
LCS Chrome	4
T158	4

North Central Varieties	Protein Score
Winterhawk	5
SY Wolf	4
Overley	1
KanMark	5
Larry	5
SY Monument	5
TAM114	3
WB-Grainfield	6
WB-Cedar	3
WB-4458	2

Relative grain protein content (grain protein deviation), 1=very high to 9=very low

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Closing Thoughts on Protein

- Selecting a variety with a good protein score doesn't mean you can get by with less N
- Varieties with a good protein score will still be affected by dilution at high yields
- Protein can be used as a valuable post-hoc evaluation of your N program
  - If protein is consistently less than 11.5% then you are leaving yield on the table!

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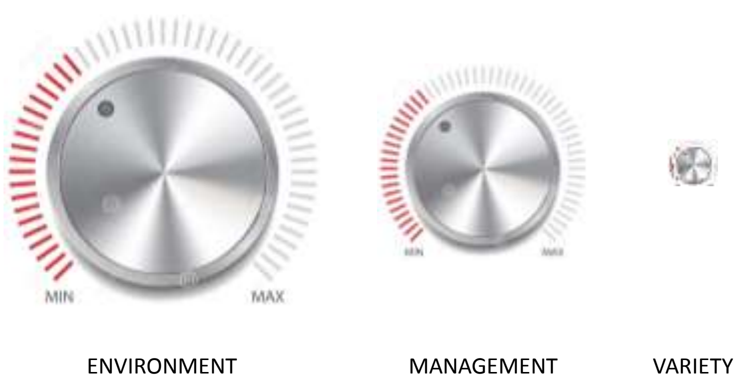
Protein Control Module



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Challenges to Protein Management

- Semi-arid environment
  - Timing of N is key to maximizing protein response
  - Need moisture to move the N
    - Slow release N?
- Are you going to get paid?

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Other Thoughts for 2018 Crop Planning

- Good 2017 wheat, with low protein (<11.5)
- In some areas a record fall 2017 crop
- Wheat yield potential >>> Top-dress Decisions
- Environmental Effects on Applying N
- Even at current prices, broad sweeping reductions in fertilizer application without any guiding information could cost you money

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Questions?

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