Fertility Management for Wheat Production

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Where are we now?

- Historical and Current Price Ratios
- Understanding Crop Response to Fertilizer
- Economics of Soil Testing and Data Quality
- Products and Placement

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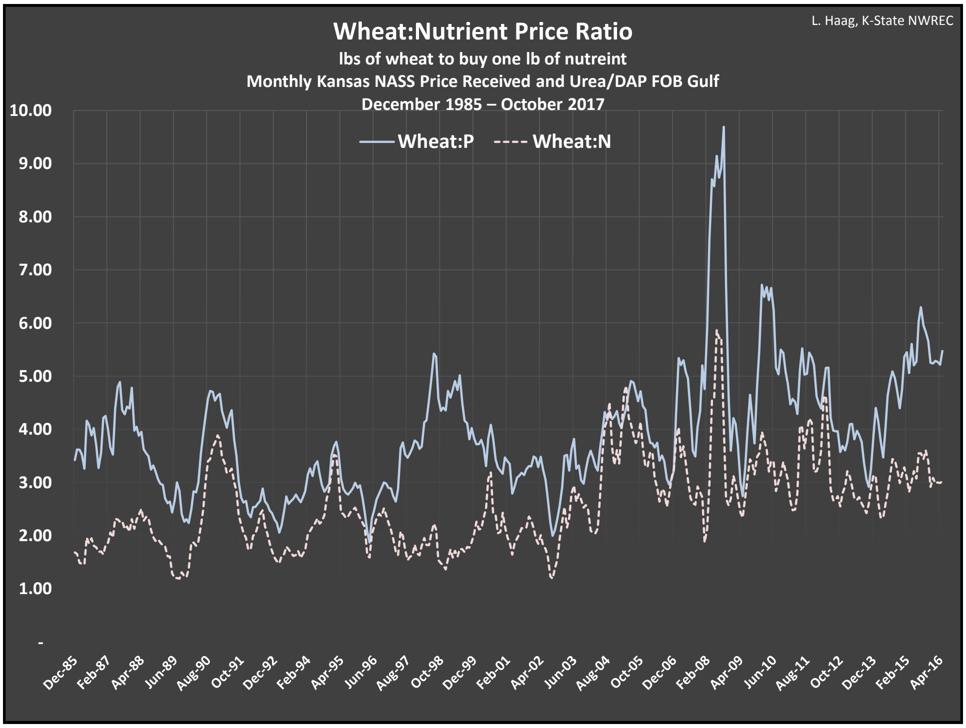
L. Haag, K-State NWREC
Wheat:Nutrient Price Ratio
lbs of wheat to buy one lb of nutreint
Monthly Kansas NASS Price Received and Urea/DAP FOB Gulf
December 1985 – October 2017
Wheat:P
Wheat:N
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
-
Dec-85
Feb-87
Apr-88
Jun-89
Aug-90
Oct-91
Dec-92
Feb-94
Apr-95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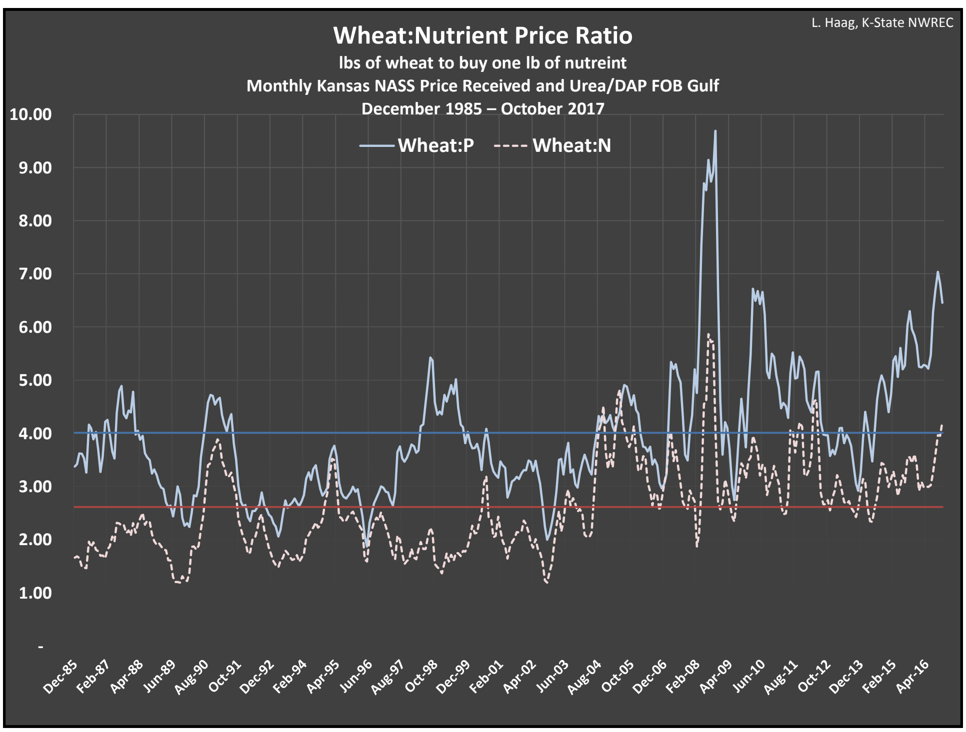
Dec-13
Feb-15
Apr-16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2.00
1.00
-
Dec-85
Feb-87
Apr-88
Jun-89
Aug-90
Oct-91
Dec-92
Feb-94
Apr-95
Jun-96
Aug-97
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Feb-01
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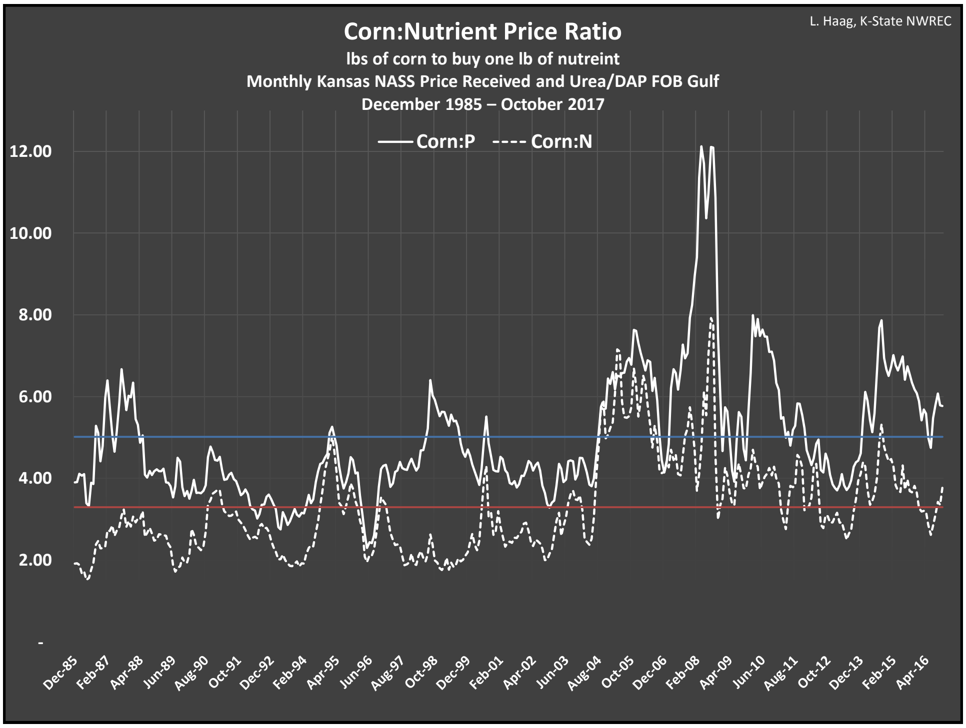
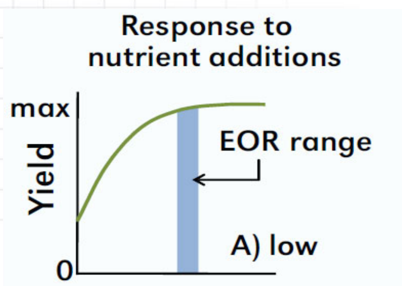


Understanding Crop Response to Fertilizer Low Soil Test Levels



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

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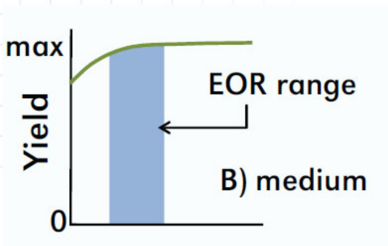
Understanding Crop Response to Fertilizer Medium Soil Test Levels



- 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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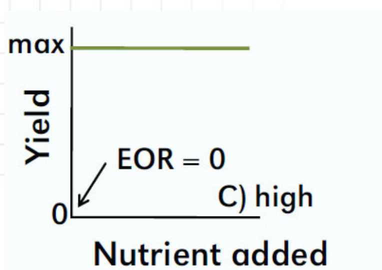
Understanding Crop Response to Fertilizer High Soil Test Levels



- No or minimal response to added fertilizer

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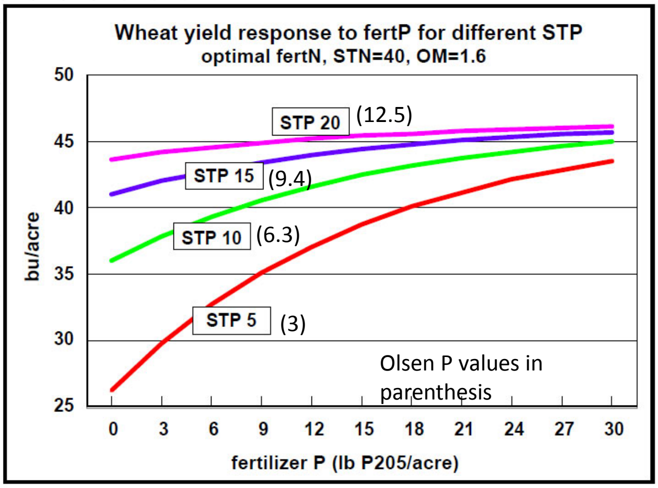
Wheat Response to Soil Test P Level



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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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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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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	Yield Goal (Bu/A) 30	40	50	60	70
	(ppm)	- - - - - - - - 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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P Build-Maintain Recommendations for Wheat

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

Phosphorus Build-Maintenance Wheat Recommendations[5]

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[4] 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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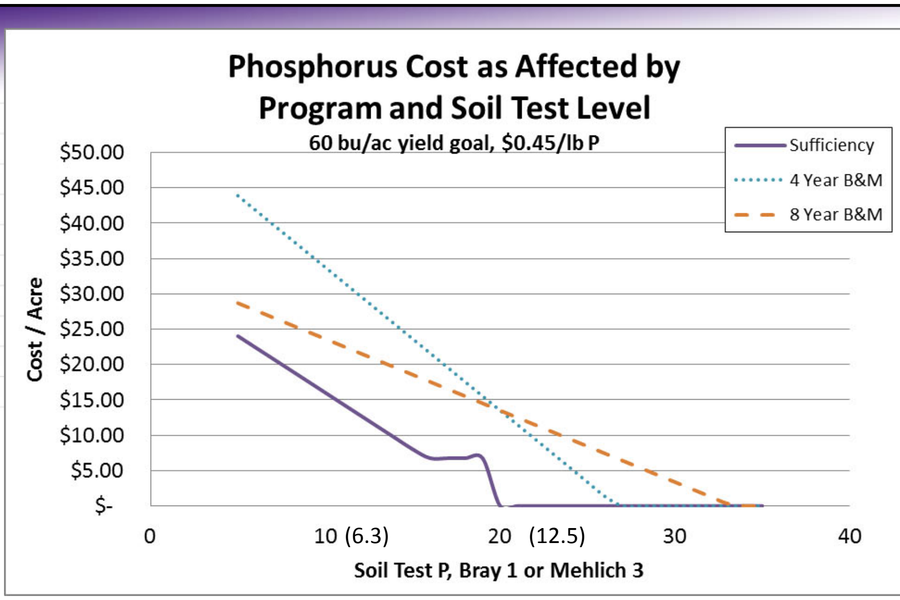

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Factors Affecting Strategy Selection

- 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

General KSU N Rec's for Wheat

Nrec = [Yield Goal x 2.4*] – PNST – (%SOM x 10) – PCA– Irrigation Nitrate – Manure

additional adjustments for tillage and grazing

Previous Crop	Yield Goal 30	50	70
Corn	22	70	118
Wheat	22	70	118
Sorghum	52	100	148
Sunflower	52	100	148
Soybean	22	70	118
Alfalfa	2	50	98

%SOM = % Soil OM x 10 = 20
PCA = Previous Crop Adjustment
Corn = 0, sorghum = -30
Wheat = 0, sunflower = -30
soybean = 0, fair alfalfa =+20
Fallow = +20**
PNST = 24 in. N Soil Test = 30
Irrigation Nitrate = ppm N x 0.226/inch
Manure = 0
No-till = 20
Grazing = 40 per 100 lbs gain

*2.4 is the estimated amount of N taken up by the whole plant, roots, straw and grain, assuming a 50% NUE.

Higher probability of significant profile N

- Medium-fine textured soils
- Recent history of excessive N rates
- Previous crop
  - o Lower than expected yield
  - o Drought affected
  - o Previously destroyed stands of alfalfa/clovers
- Manure application
- Warm, late falls and/or early, warm springs

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Average soil nitrate levels

Previous crop	Number of samples	Average Profile NO3 lb/acre
Alfalfa	1	103
Corn	11	65
Fallow	12	154
Sorghum	9	70
Soybean	4	84
Wheat	38	65

Fall sampling before wheat, range: 4-313

From a set of 75 samples. Soil testing lab. K-State, 2008

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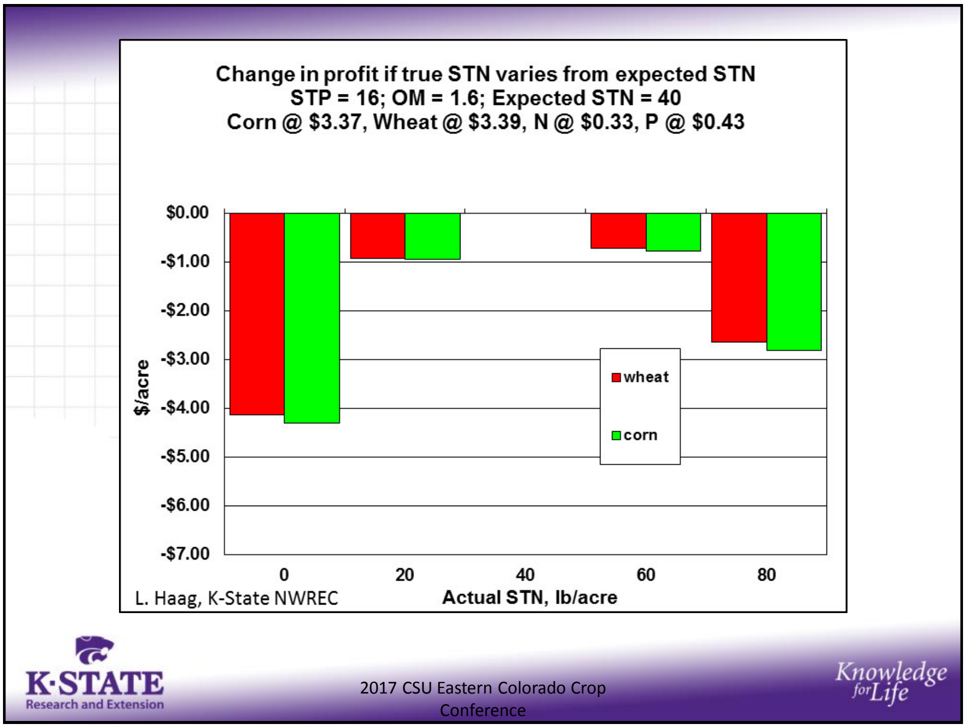
Change in profit if true STN varies from expected STN
STP = 16; OM = 1.6; Expected STN = 40
Corn @ $3.37, Wheat @ $3.39, N @ $0.33, P @ $0.43
$0.00
-$1.00
-$2.00
-$3.00
-$4.00
-$5.00
-$6.00
-$7.00
$/acre
wheat
corn
0
20
40
60
80
Actual STN, lb/acre
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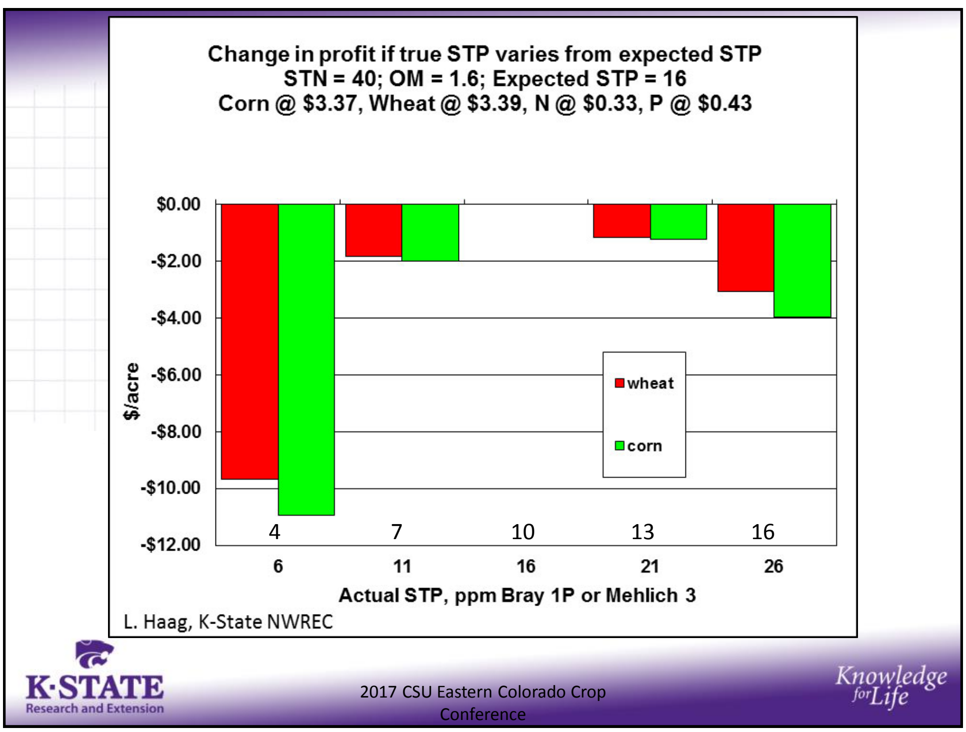
Change in profit if true STP varies from expected STP
STN = 40; OM = 1.6; Expected STP = 16
Corn @ $3.37, Wheat @ $3.39, N @ $0.33, P @ $0.43
$0.00
-$2.00
-$4.00
-$6.00
-$8.00
-$10.00
-$12.00
$/acre
wheat
corn
4
7
10
13
16
6
11
16
21
26
Actual STP, ppm Bray 1P or Mehlich 3
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Data 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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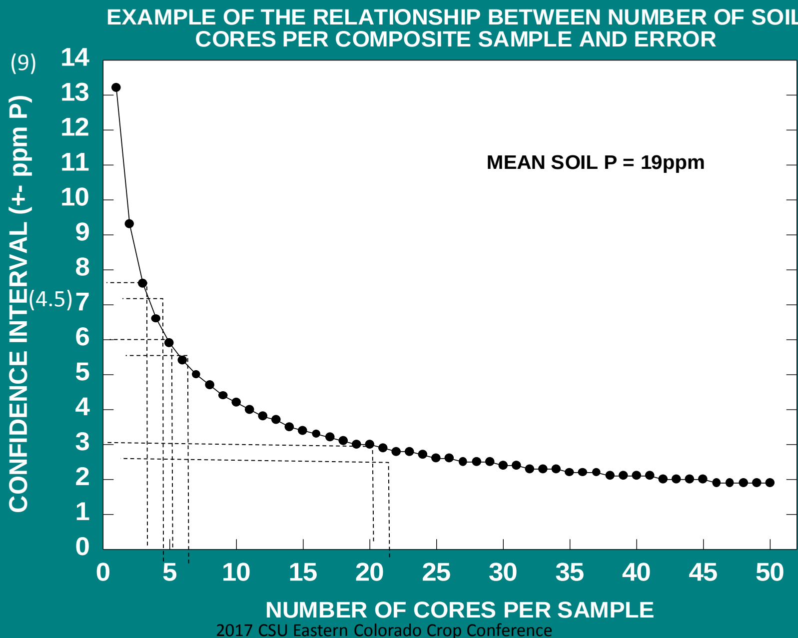
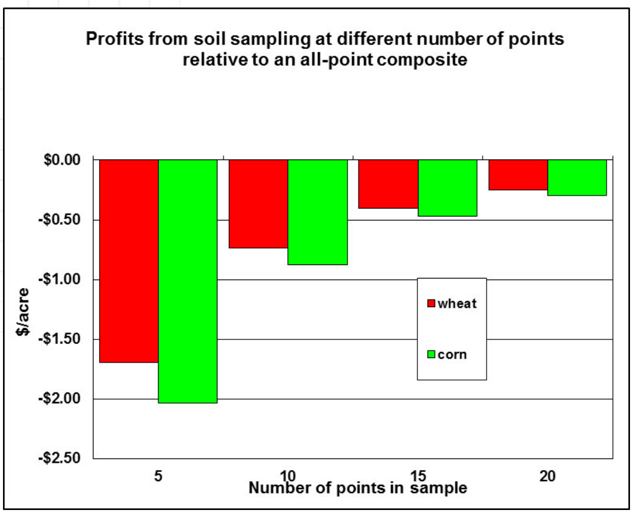


Economics of Accuracy



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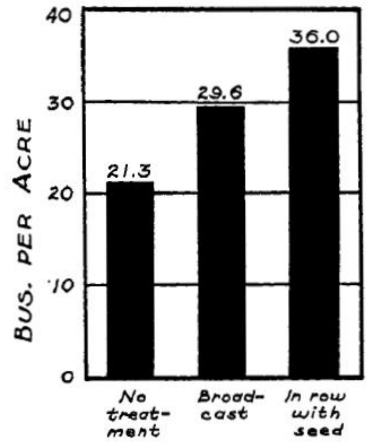
The Role of Soil Testing

- 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)

Phosphorus in Wheat

- Wheat is our most responsive crop to P
- A multitude of application and placement options
  - Broadcast spread
  - In-furrow mixed with seed or via air-cart
- Critical to early growth and development, crown health, and fall tiller initiation
- Even in high STP soils may see a starter response

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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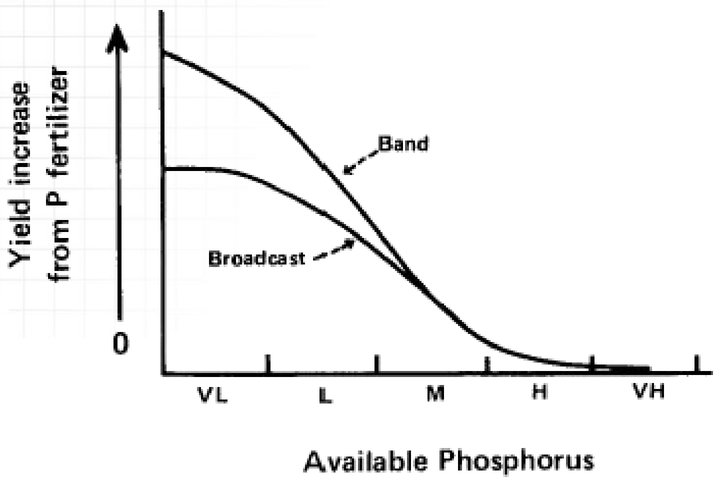
Soil test P and application method



Common generalized depiction of broadcast vs. band

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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
Proso Millet	cwt	0.69

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Planting Time N Applications

- Nitrogen, like P , enhances early tillering
- 15-30 pounds N in the fall at planting should be used when using a traditional topdress system.
  - Especially important when planting into wide C:N corn stalks, wheat stubble or cover crops. More if planting into sorghum.
- Having enough N available in the fall is especially important with sensor based topdress systems, since you topdress later.
  - If planning on Feekes 5 or later topdress consider increasing the fall N rate, especially if low nitrate ST in the surface soil.

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Starter Interaction

- Starter can reduce the negative impacts of late planting and less than optimal seeding rates
- Promotion of fall tillering (N effect)

Suggested Maximum Rates of Fertilizer to be Applied Directly With Wheat Seed

	Pounds N + K_2O (No urea or UAN)	
Row Spacing (inches)	Medium to Fine Textured Soils	Sandy or Dry Soils
15	16	11
10	24	17
6-8	30	21

Source: K-State Agronomy e-Update #256

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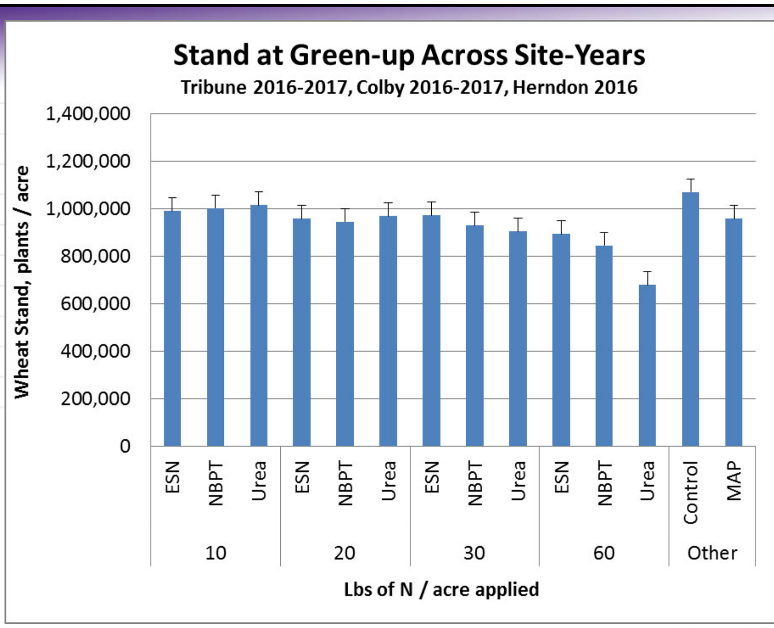

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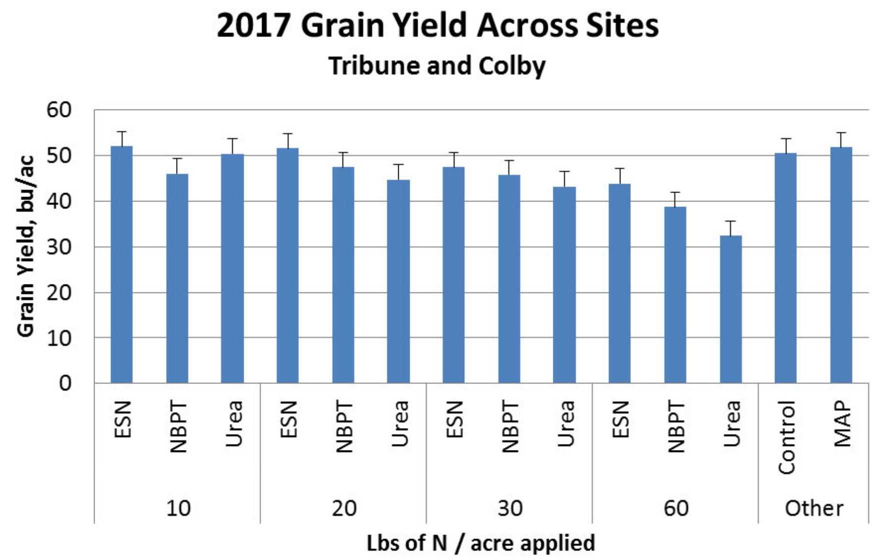

Wheat: timing of N application

N rate (lbs/acre)	Application time	Yield (bu/acre)
0	NA	46
60	Feekes 4-5	49
60	Feekes 6*	58
60	Feekes 9	48
LSD (0.1)		3

* Jointing

Tucker and Mengel, 2008

Application method of topdress N

N rate (lbs/acre)	Nitrogen Source	Application Method	Yield (bu/acre)
0	NA	NA	46
60	Dry urea	Broadcast	51
60	UAN	Sprayed	47
60	UAN	Streamer bars	56
LSD (0.1)			3

Tucker and Mengel, 2008

What about foliar N application?

- Usually recommended for application later in the season.
- Slow release N source and may be in combination with other nutrients.
- Just as effective as traditional N sources on a pound basis.
- Protein?

Wheat Protein

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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)

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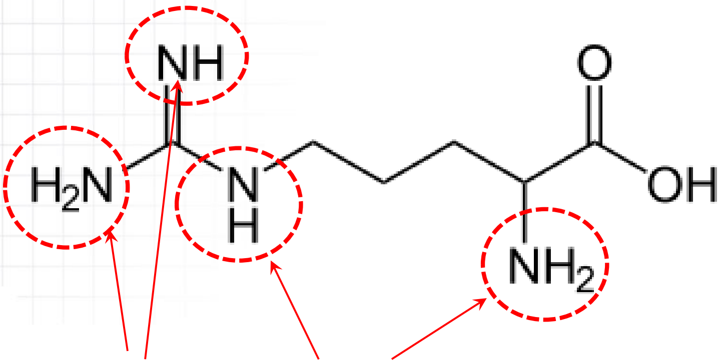
Amino acid arginine ($C_6H_{12}N_4O_2$)



Amino nitrogen N

32% by weight is N

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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

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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

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Plant Use of N

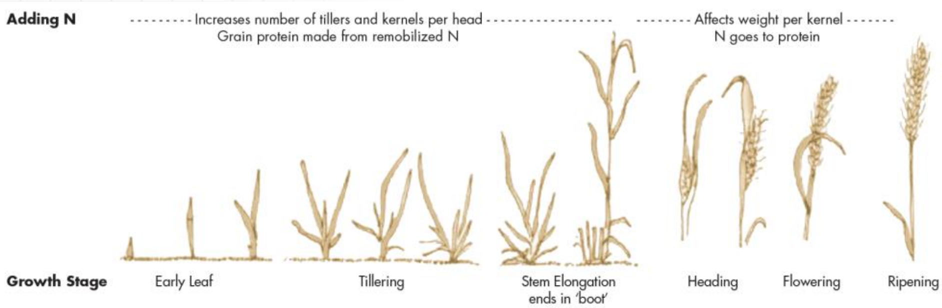

FIGURE 2. Approximate cereal growth stages and N application timing effects on yield and protein. This figure was modified from its original (4).

Jones et al., Montana State Univ. EB0206

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N supply effects on Grain Yield and Protein

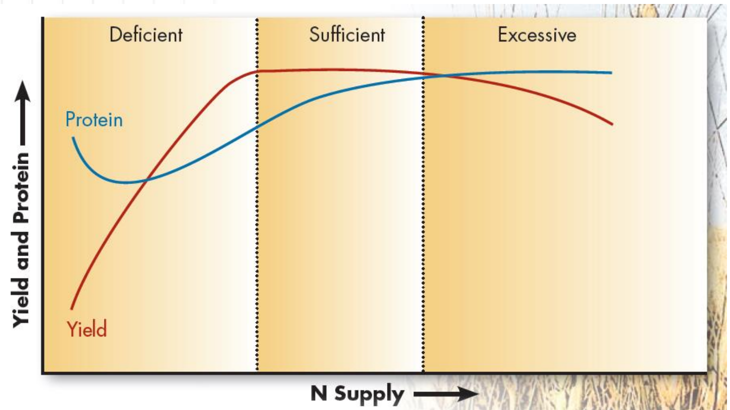
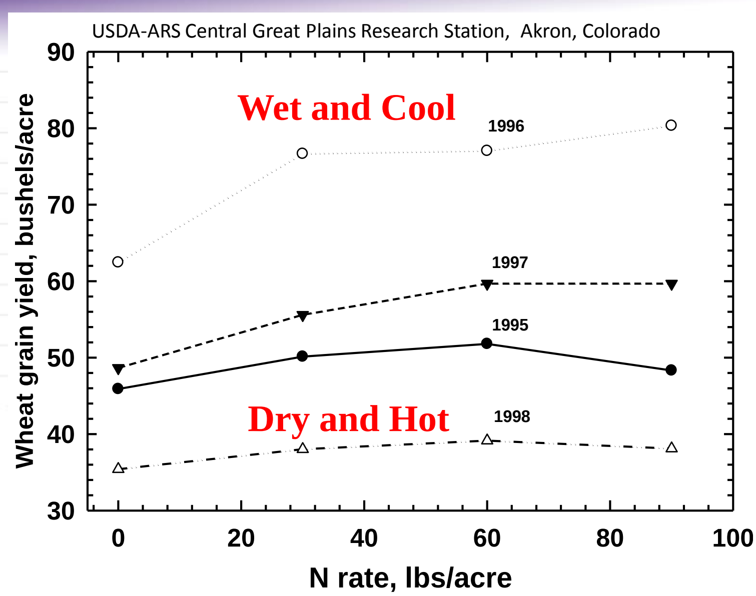
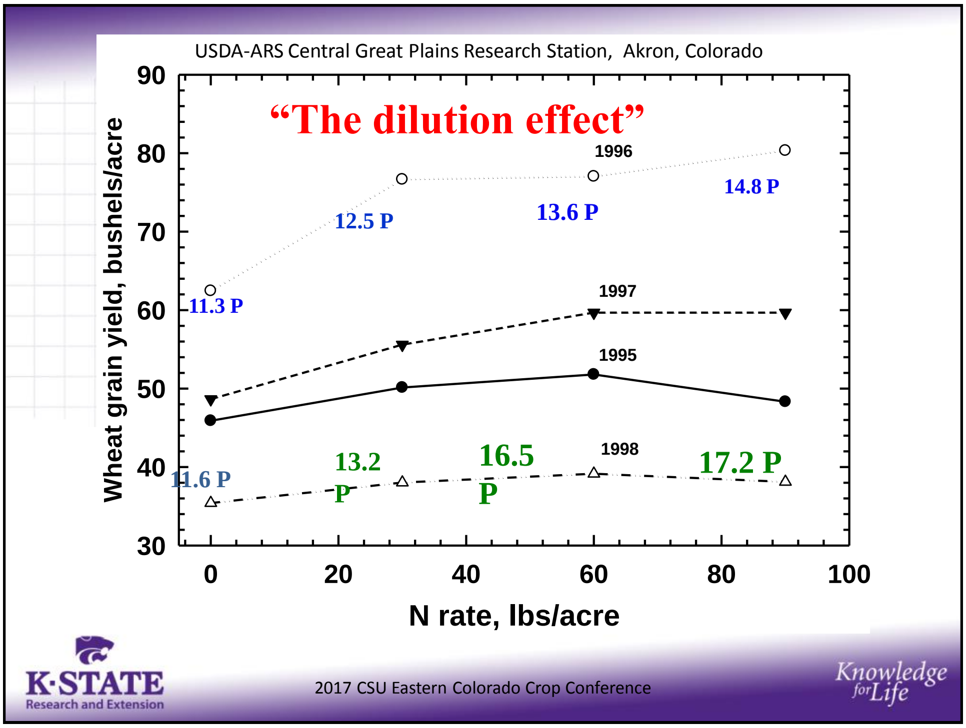


FIGURE 1. The response of wheat yield and grain protein to increasing N (1).

Jones et al., Montana State Univ. EB0206




USDA-ARS Central Great Plains Research Station, Akron, Colorado
"The dilution effect"
Wheat grain yield, bushels/acre
90
80
70
60
50
40
30
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
0
20
40
60
80
100
N rate, lbs/acre
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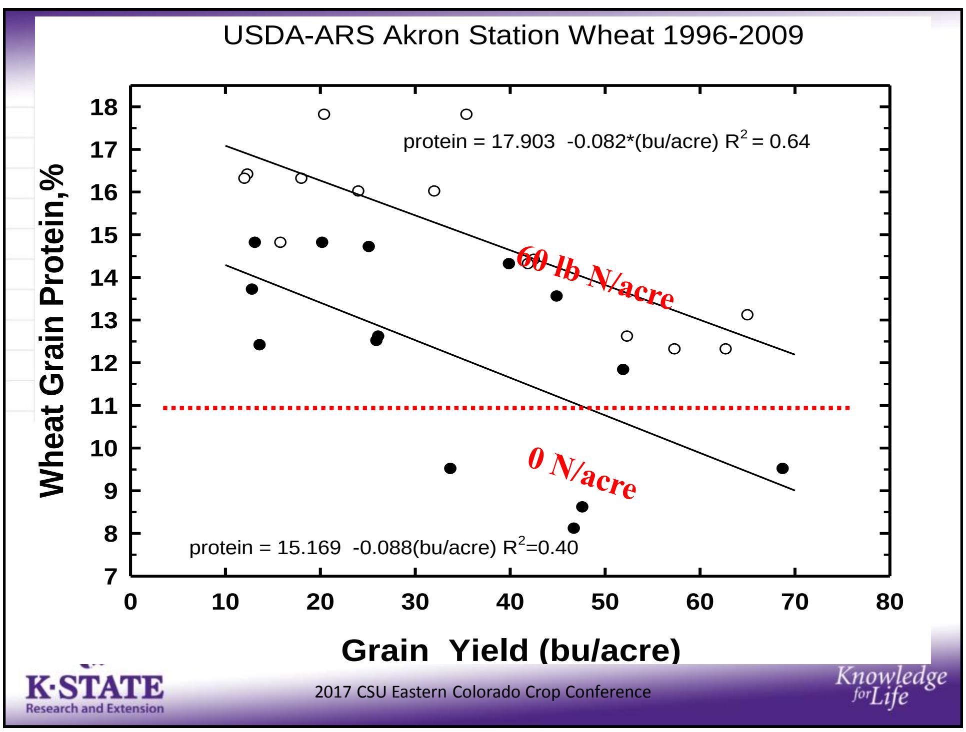
USDA-ARS Akron Station Wheat 1996-2009
Wheat Grain Protein,%
protein = 17.903 -0.082*(bu/acre) R2 = 0.64
60 lb N/acre
0 N/acre
protein = 15.169 -0.088(bu/acre) R2=0.40
18
17
16
15
14
13
12
11
10
9
8
7
0
10
20
30
40
50
60
70
80
Grain Yield (bu/acre)
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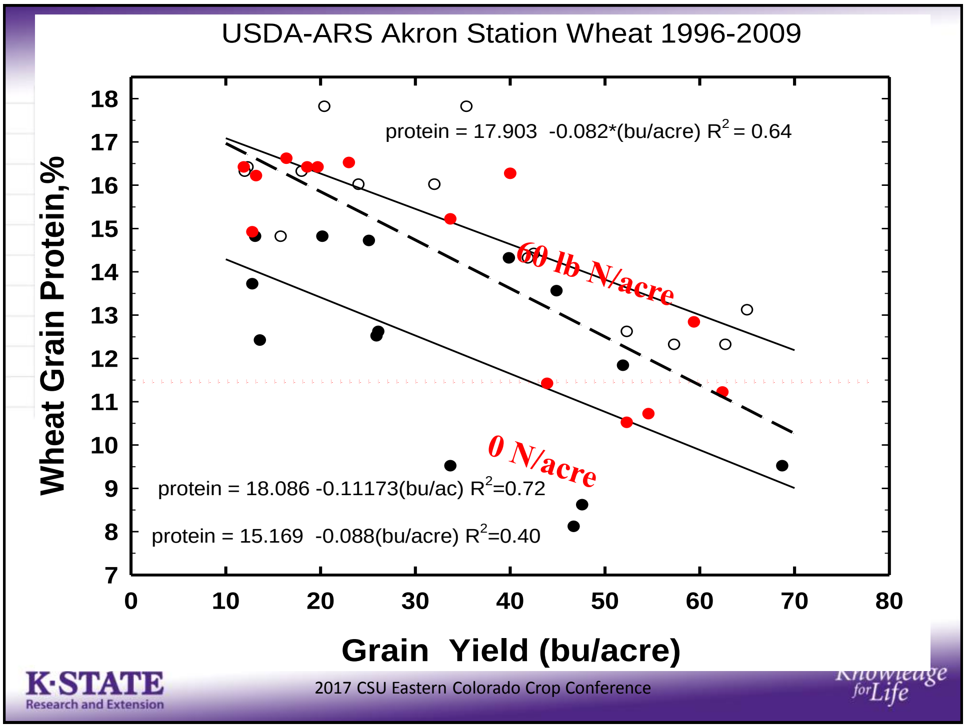
USDA-ARS Akron Station Wheat 1996-2009
Wheat Grain Protein,%
Grain Yield (bu/acre)
protein = 17.903 -0.082*(bu/acre) R² = 0.64
60 lb N/acre
0 N/acre
protein = 18.086 -0.11173(bu/ac) R²=0.72
protein = 15.169 -0.088(bu/acre) R²=0.40
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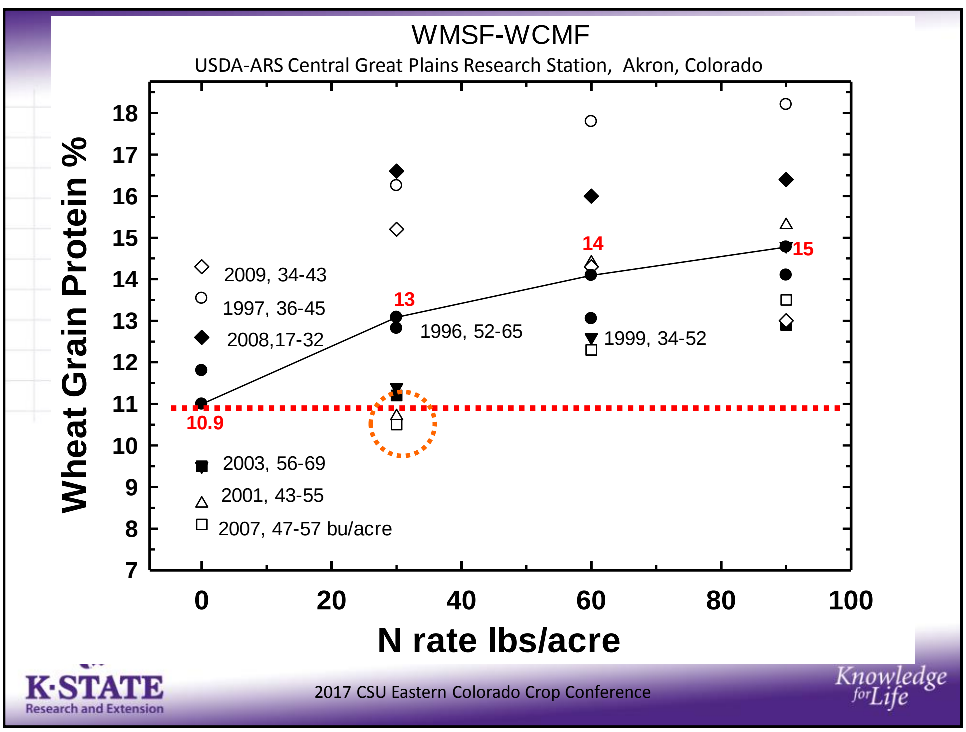
WMSF-WCMF
USDA-ARS Central Great Plains Research Station, Akron, Colorado
Wheat Grain Protein %
N rate lbs/acre
2009, 34-43
1997, 36-45
2008,17-32
1996, 52-65
1999, 34-52
2003, 56-69
2001, 43-55
2007, 47-57 bu/acre
10.9
13
14
15
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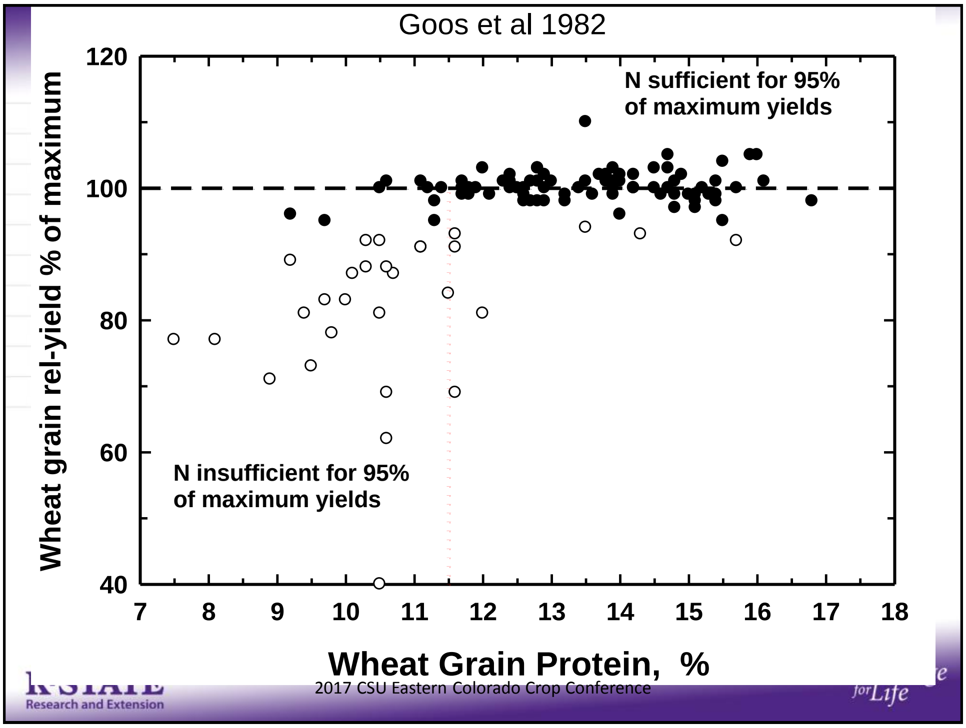
Goos et al 1982
Wheat grain rel-yield % of maximum
Wheat Grain Protein, %
N sufficient for 95%
of maximum yields
N insufficient for 95%
of maximum yields
120
100
80
60
40
7
8
9
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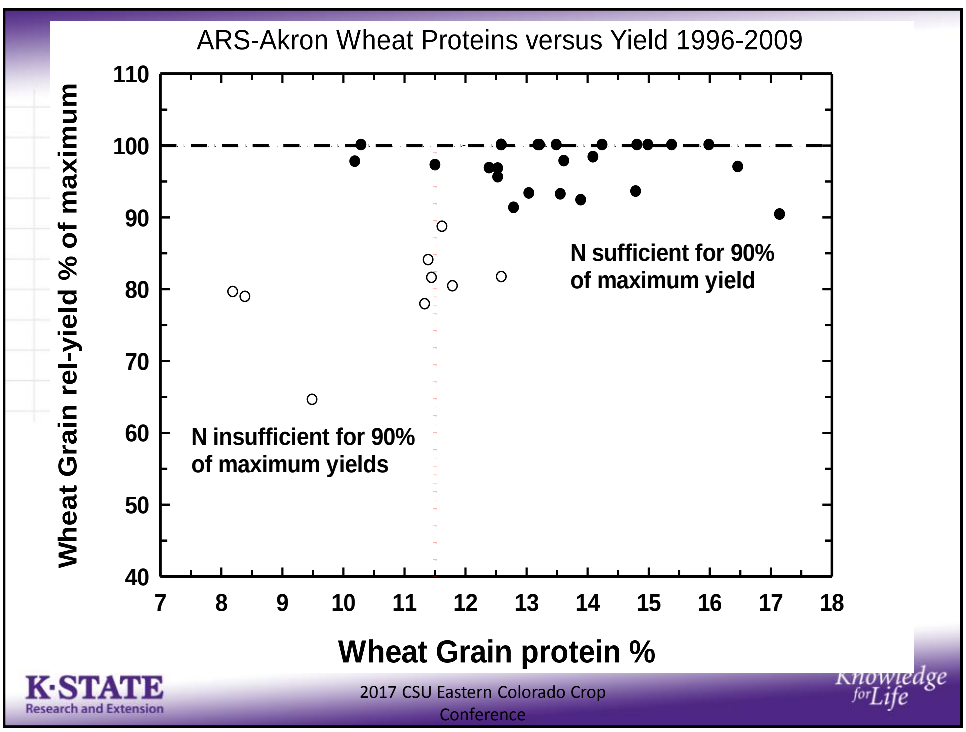
ARS-Akron Wheat Proteins versus Yield 1996-2009
Wheat Grain rel-yield % of maximum
Wheat Grain protein %
N sufficient for 90%
of maximum yield
N insufficient for 90%
of maximum yields
110
100
90
80
70
60
50
40
7
8
9
10
11
12
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17
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Increasing 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

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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

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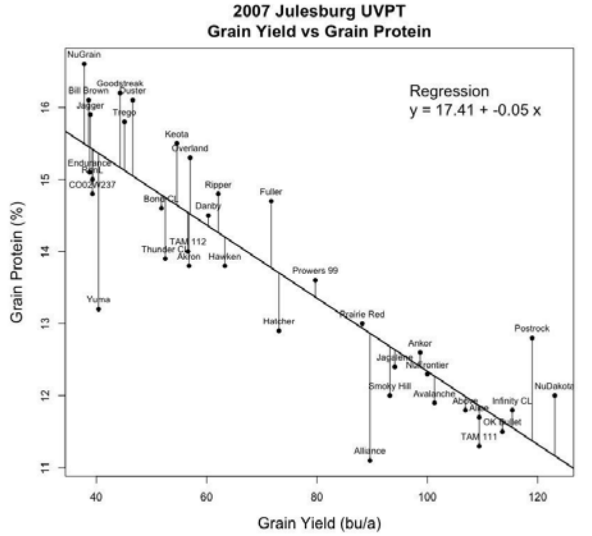
Grain Protein Deviation



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ramwheatdb.com/wheatvartab.php

Home Varieties Database What's New Links

Colorado Wheat Variety Database

Database Main Page | Wheat Variety Information | Single Location Trial Data | Multiple Location Trial Data | Head-to-Head Comparisons

Wheat Variety Summary

Switch to Form View

Variety	Kind*	Origin/Year	Heading	Height	Coleoptile	Straw	RWA	Leaf Rust	Stripe Rust	Wheat Streak	Test Weight	Protein	Milling	Baking
1863	--	KSU 2012	4	5	4	--	S	7	3	--	5	3	4	5
AP502 CL	CL1	Syngenta 2001	1	4	8	2	S	9	9	5	6	5	7	7
Above	CL1	CSU-TX 2001	2	4	9	3	S	9	8	5	7	6	4	6
Akron	--	CSU 1994	6	5	5	7	S	9	9	9	8	6	6	3
Ankor	--	CSU 2002	5	6	5	4	R*	9	8	9	5	6	5	4
Armour	--	Monsanto 2008	3	1	8	3	S	5	7	7	8	4	4	5
Avery	--	CSU 2015	6	7	5	7	S	8	7	3	4	7	4	3
Baca	--	CSU 1973	5	9	8	9	S	4	6	7	4	7	3	3
Bearpaw	--	MT 2011	9	3	3	3	S	--	7	--	5	5	6	5
Bill Brown	--	CSU 2007	5	4	2	4	R*	2	6	7	4	7	6	4
Billings	--	OK 2009	7	5	6	6	S	2	2	--	8	4	2	3
Bond CL	CL1	CSU 2004	4	7	5	5	R*	6	8	8	8	9	6	4
Brawl CL Plus	CL2	CSU 2011	2	6	9	3	S	6	5	7	4	1	4	3
Byrd	--	CSU 2011	4	6	6	7	S	8	7	2	4	7	3	3
CSU Blend13	--	CSU-MT 2004/2011	5	3	--	--	R*/S	--	--	--	5	7	4	5
Camelot	--	NE 2008	3	8	5	7	S	2	4	7	5	2	3	4
Cowboy	--	WY-CSU 2011	7	6	3	8	R*	7	7	6	7	7	4	6

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CSU Variety Database Protein Ratings

Variety	Protein Score
Avery	7
Brawl CL Plus	1
Byrd	7
Hatcher	8
Langin	6
SY Monument	5
TAM111	3
WB-Grainfield	6

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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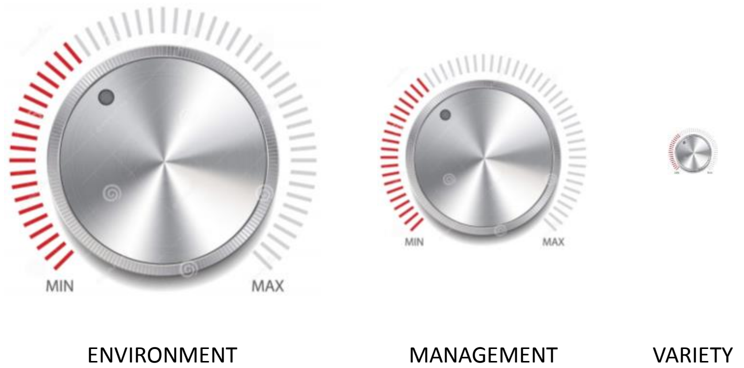
Protein Control Module



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?

Questions?

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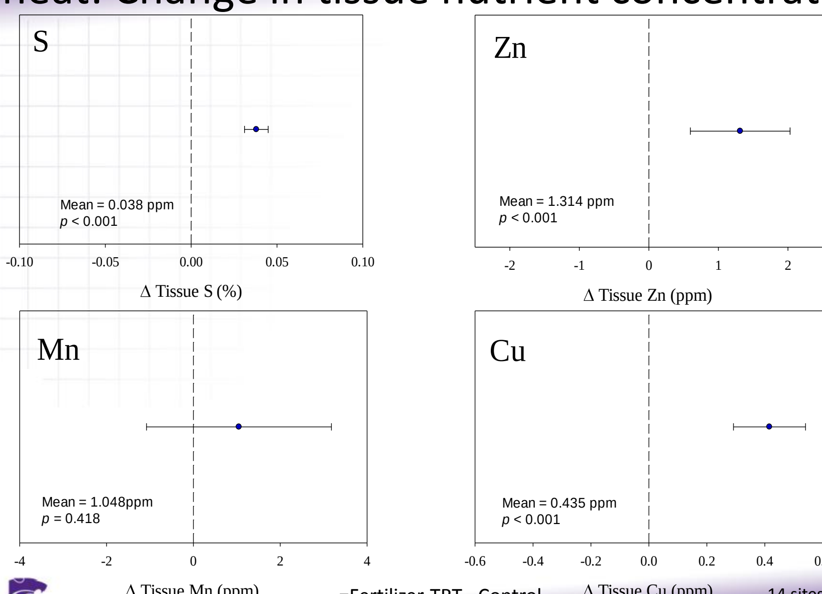
Wheat: Change in tissue nutrient concentration



=Fertilizer TRT - Control

14 sites, 4 reps

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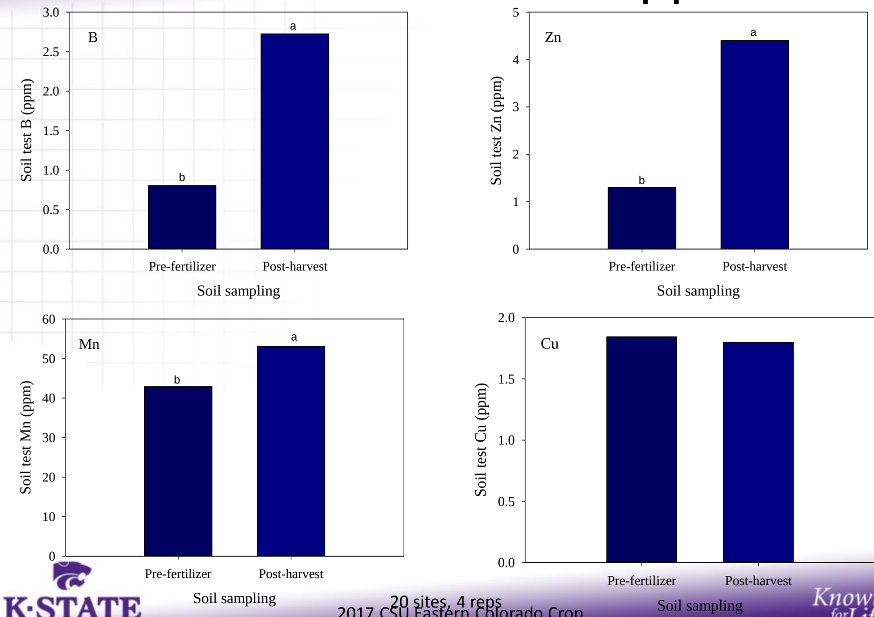
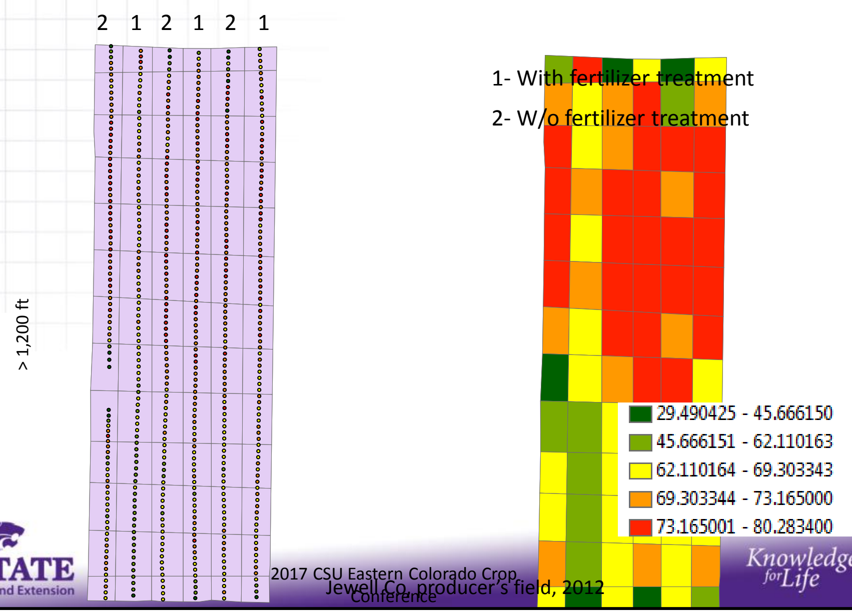
Soil test with fertilizer application



20 sites, 4 reps

On-farm strip trials



Jewell Co. producer's field, 2012

Plant sampling and analysis

- Any plant stress (drought, heat, soil compaction etc) can have a serious impact on nutrient uptake and plant tissue nutrient concentrations.
- A low value in the plant doesn't always mean the nutrient is low in the soil and the plant will respond to fertilizer.
- Tissue data interpretation can be more challenging for some nutrients.

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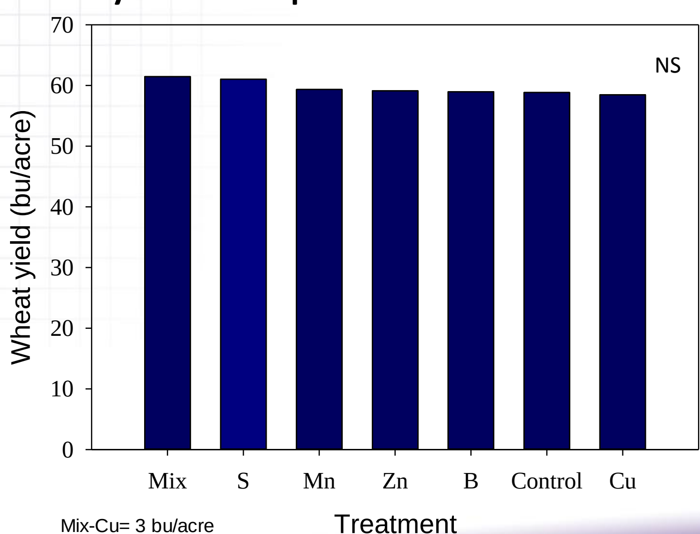
Wheat yield response across locations



Mix-Cu= 3 bu/acre

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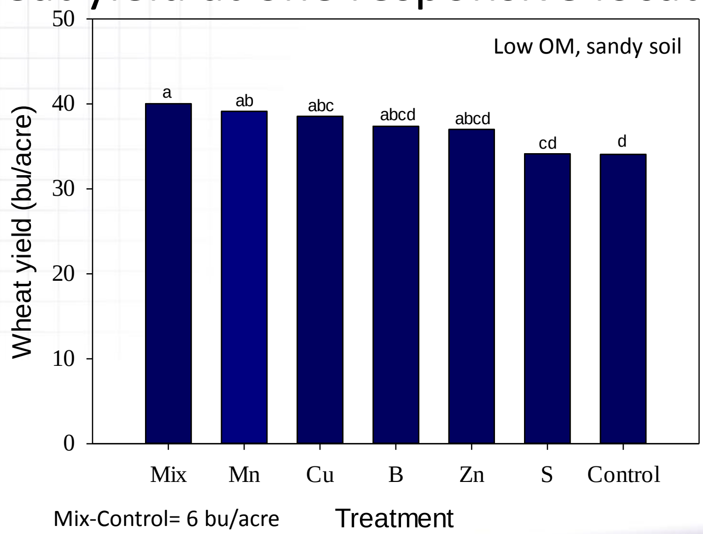
Wheat yield at one responsive location



Mix-Control= 6 bu/acre

Summary

- Soil applied Cu, Zn and B fertilizer generated significant increase in tissue concentrations.
  - Tissue S and Mn response different for wheat and soybean.
- The responsive wheat site showed the highest yield with the “mix” treatment.
- Post harvest soil analysis showed significant increase of soil test Zn, B, Mn with fertilizer application. Average increase in soil S.

Summary

- Potential response at sites with sandy soil with low OM.
- Soil test methods (DTPA vs Mehlich-3) correlate well for Zn.
- Significant variability within-field for soil test micros.
  - Starter or variable rate micros?

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Correlation-calibration for micros?

- Response is uncommon and highly variable.
- Lab analysis methods (for soil and tissue) should be evaluated.
- Poor correlation between soil and tissue values with current test methods.
- Tissue analysis show high variability (many factors influencing concentration?)

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Tissue analysis

- Combination of soil + tissue analysis useful for diagnostic purpose.
- Tissue test for some secondary and micros are good and currently used (sulfur, chloride).
- Can be useful as "quality control" and monitoring purpose.

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