What to do About High Fertilizer Prices

Terry Kastens
tkastens@ksu.edu, 785-532-5855
Kevin Dhuyvetter
kcd@ksu.edu, 785-532-3527

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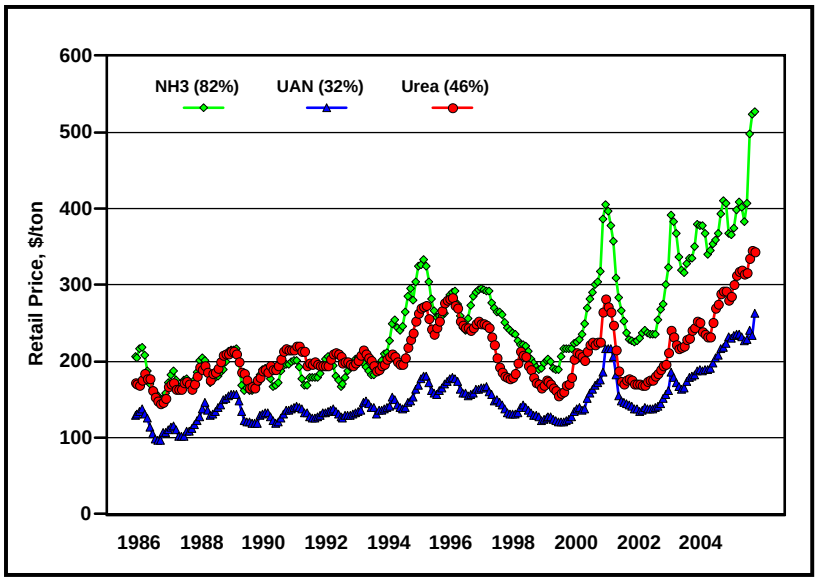
www.agmanager.info

Department of Agricultural Economics
Kansas State University
Winter 2005/06 meetings

Historical monthly nitrogen fertilizer prices, Corn Belt



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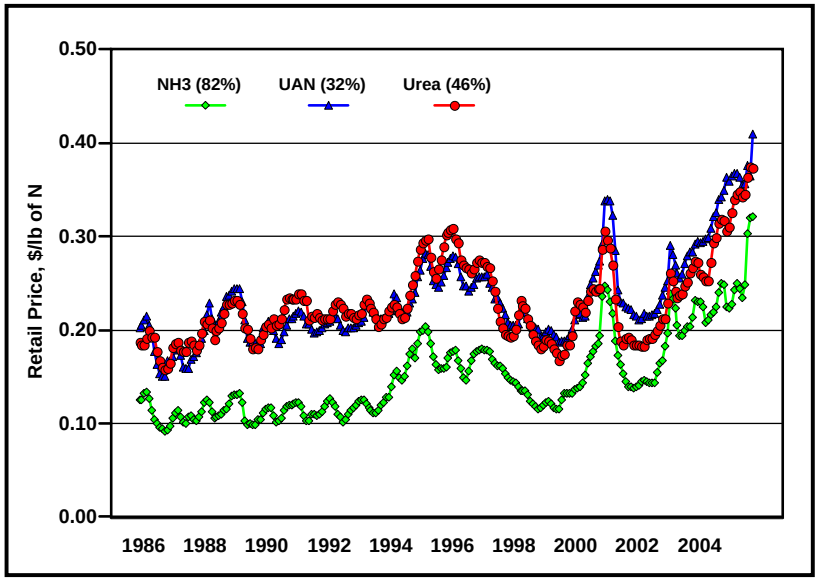
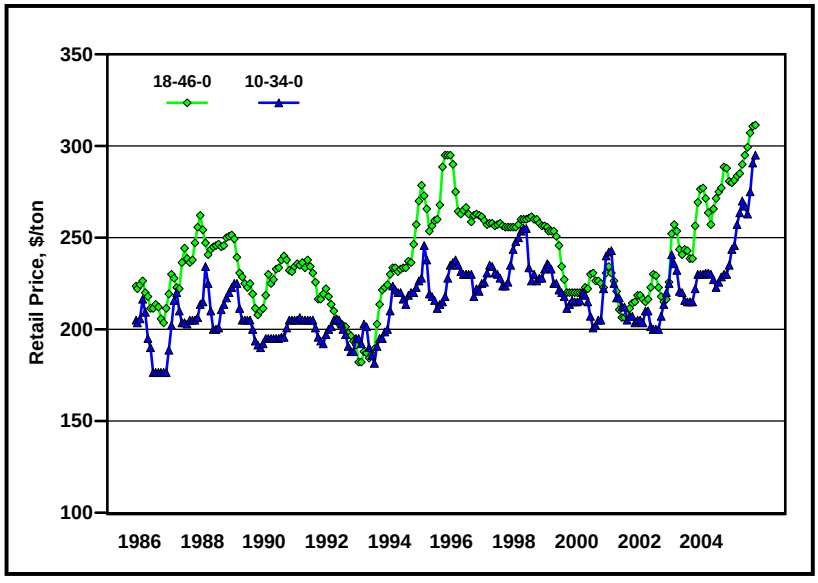
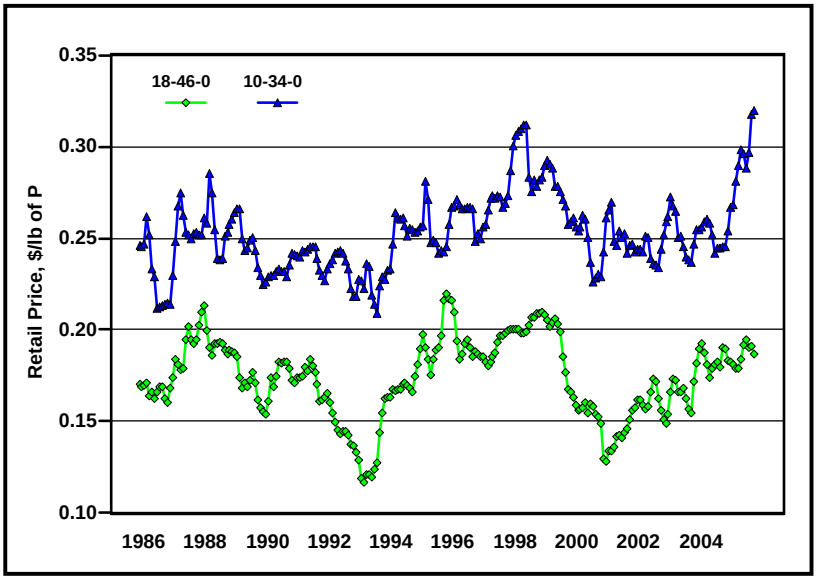


Historical monthly phosphorus fertilizer prices…

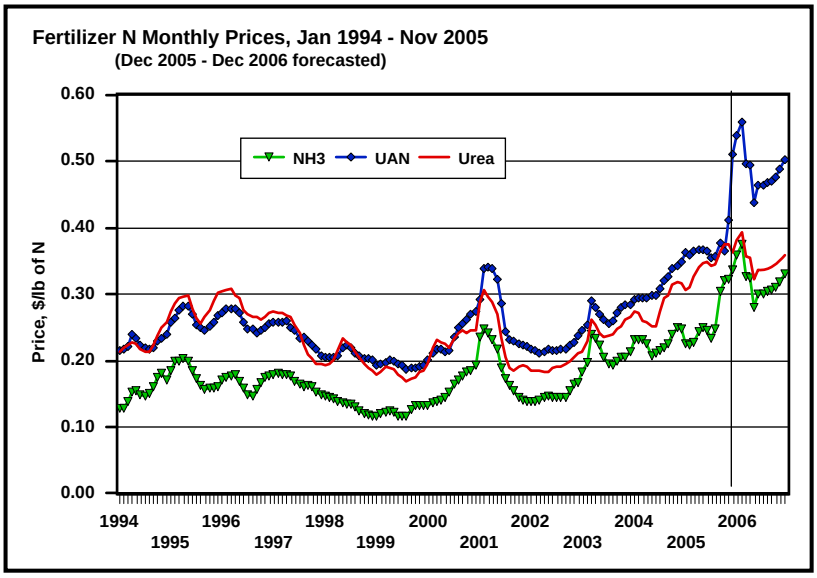


Historical monthly phosphorus fertilizer prices…



N is valued at simple average of NH3, urea, and UAN prices

Nitrogen fertilizer prices are at historically high levels…



Historical and forecasted fertilizer prices during principal fertilizing months…

Fertilizer Prices (Corn Belt)

Percent of total	40.0%	17.5%	17.5%	20.0%	5.0%	100.0%	
			Oct-May Fertilizer Price/lb*				Year-to-year
Year	NH3 (82%)	UAN (32%)	Urea (46%)	- P -	- K -	Wtd Avg	% change
2000	$0.136	$0.204	$0.205	$0.211	$0.148	$0.175	-----
2001	$0.217	$0.305	$0.272	$0.193	$0.148	$0.234	33.2%
2002	$0.141	$0.218	$0.187	$0.201	$0.144	$0.175	-25.3%
2003	$0.195	$0.253	$0.227	$0.209	$0.141	$0.211	20.7%
2004	$0.218	$0.290	$0.262	$0.214	$0.141	$0.234	10.8%
2005	$0.238	$0.356	$0.322	$0.223	$0.174	$0.267	14.4%
2006 (F)	$0.330	$0.476	$0.365	$0.224	$0.190	$0.333	24.8%
05 - Avg(00-04)	$0.057	$0.103	$0.092	$0.017	$0.029	$0.061	29.9%
06 - Avg(00-04)	$0.148	$0.222	$0.134	$0.019	$0.045	$0.128	62.1%
05 / Avg(00-04)	31.2%	40.4%	39.7%	8.3%	20.4%	29.9%	
06 / Avg(00-04)	81.7%	87.6%	58.2%	9.0%	31.4%	62.1%	

* Oct-Dec of previous year (P = average of 10-34-0 and 18-46-0, K = muriate of potash)
F = forecast

K-STATE Kansas State University
Department of Agronomy MF-2586 Nutrient Management
Soil Test Interpretations and Fertilizer Recommendations

KSU nitrogen recommendations…

Corn and grain sorghum

N rec = (Yield Goal x 1.6) – (%SOM x 20) – Profile N – Manure N – Other N Adjustments + Previous Crop Adjustments

Wheat

N rec = (Yield Goal x 2.4) – (%SOM x 10) – Profile N – Manure N – Other N Adjustments + Previous Crop Adjustments + Tillage Adjustments + Grazing Adjustments

Sunflowers

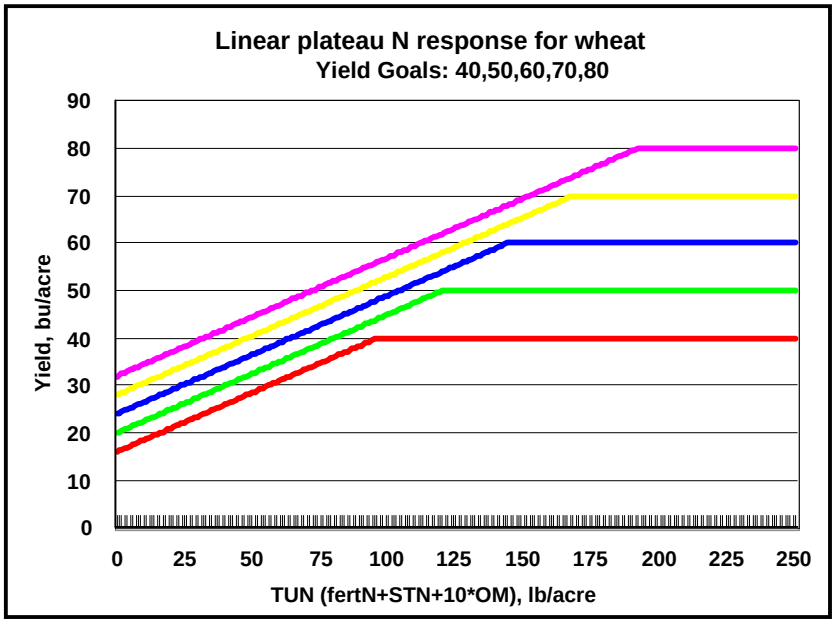
N rec = (Yield Goal x 0.075) – (%SOM x 20) – Profile N – Manure N – Other N Adjustments + Previous Crop Adjustments

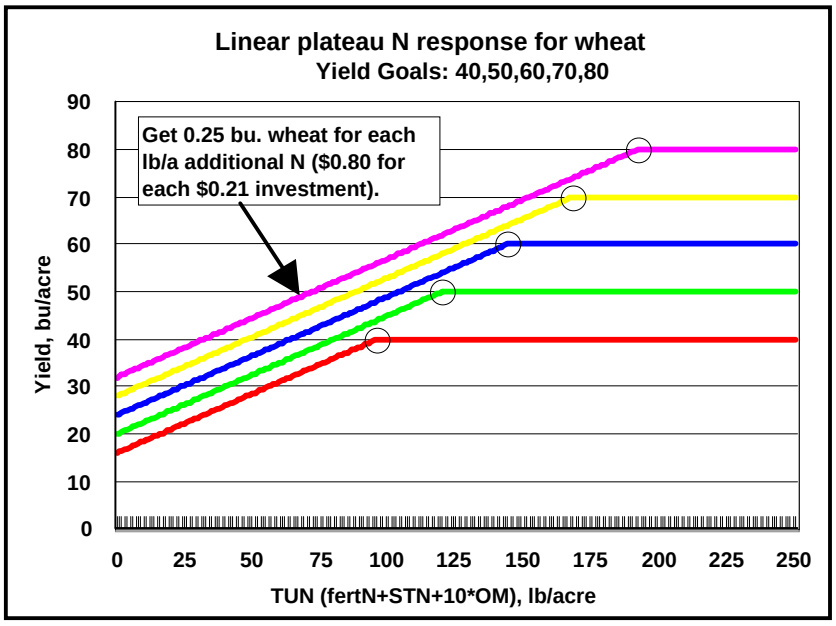
KSU nitrogen recommendations vs. N price

- Recommendations do not explicitly include prices
- Mathematical relationship between expected yield and nitrogen (i.e., production function) is needed in order to adjust recommendations for prices
- Similar issues pertain to P & K recommendations (i.e., no way to adjust them for prices)
- We assume KSU had in mind these prices:
  - Wheat $3.20/bu
  - Corn $2.35/bu
  - fertN $0.21/lb N

Nitrogen production function…

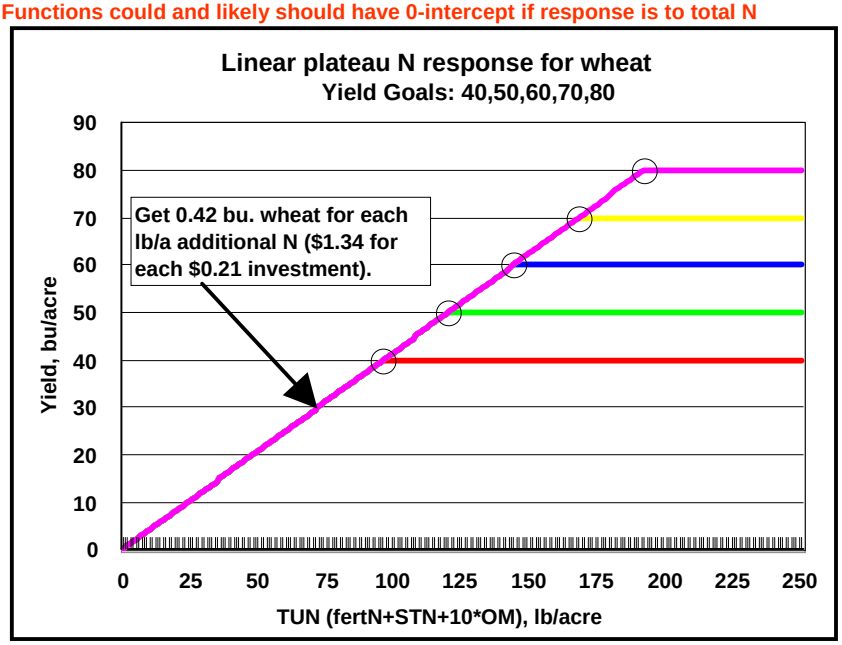
- In a limiting factor framework, it is generally believed that relationship between N and yield is linear for any given year and location (implies linear plateau production function)
- Linear plateau production function implies that optimal N will either be 0 or level where yield plateaus
- Average of multiple linear plateau production functions can be non-linear and this represents expectations of future N:yield relationship



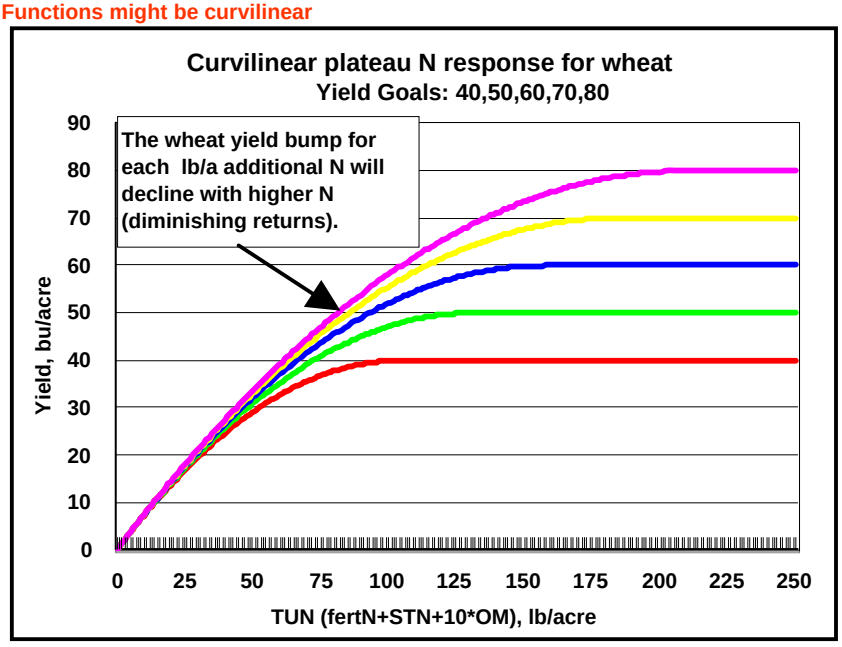


Price won't matter until fertN = $0.80/lb, then optimal is 0 lb/acre

Functions could and likely should have 0-intercept if response is to total N

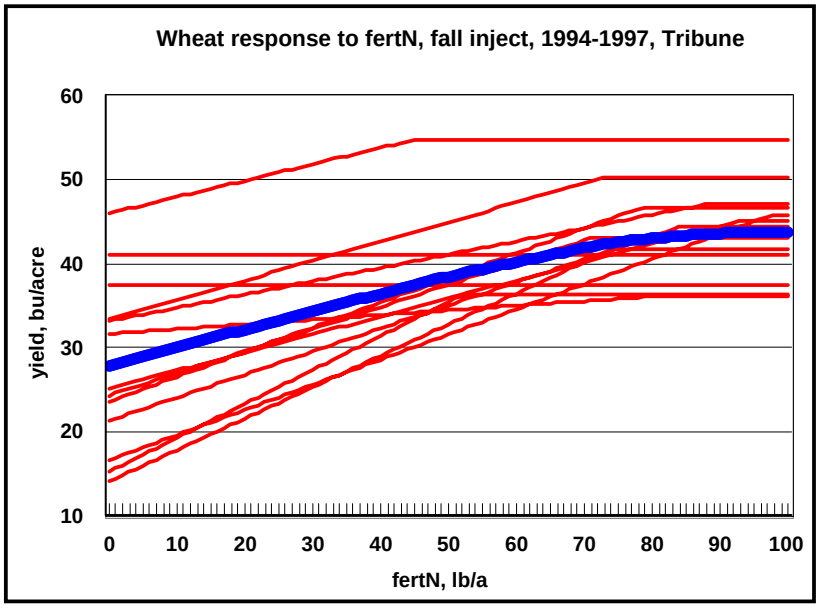


Functions might be curvilinear



Fertilizer N research in late 2005
Kastens, Dhuyvetter, Schlegel, and Dumler

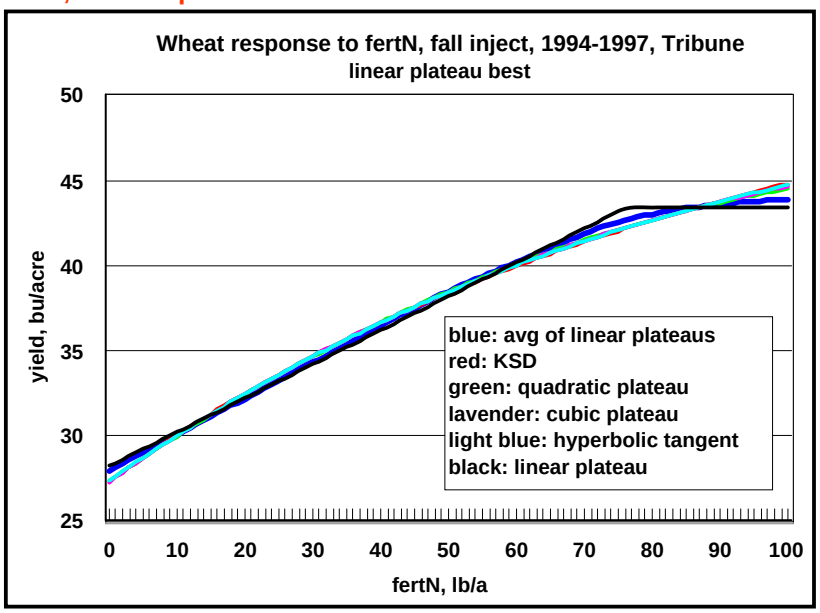
Average of linear plateaus can become non-linear…



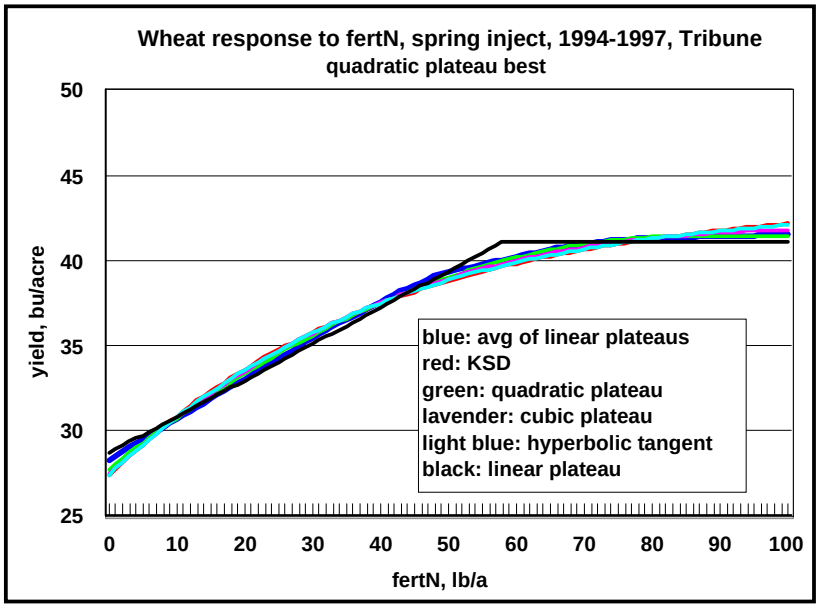
Functional form…

- Numerous functional forms could be used that would meet objectives. We considered:
  - Linear plateau, along with four different curvilinear forms
- Based on nitrogen fertilizer research studies from north central and western Kansas on wheat, corn, and milo, quadratic plateau model fit data better than alternatives most often
- Most non-linear models "look" very similar, but results (i.e., optimal N versus N price) do vary

Here, a linear plateau fit blue line the best



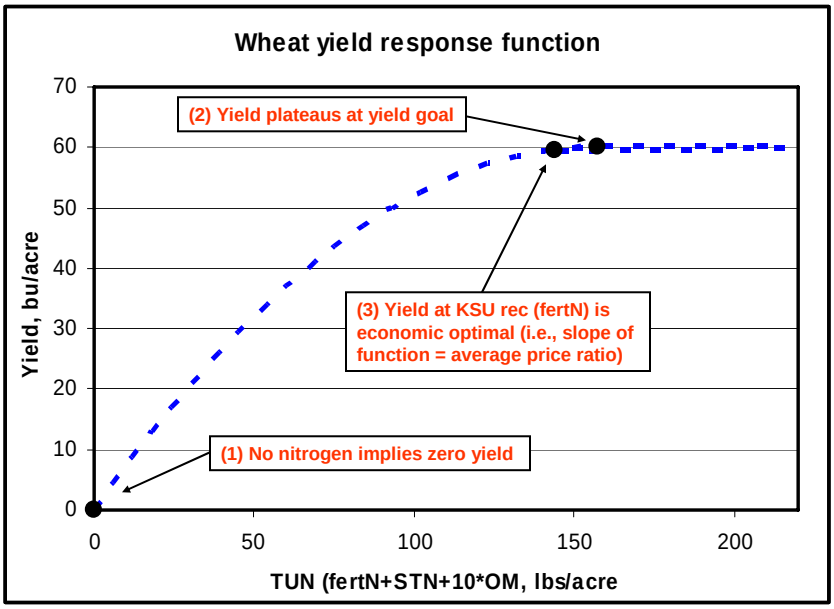
Here, a quadratic plateau fit blue line the best



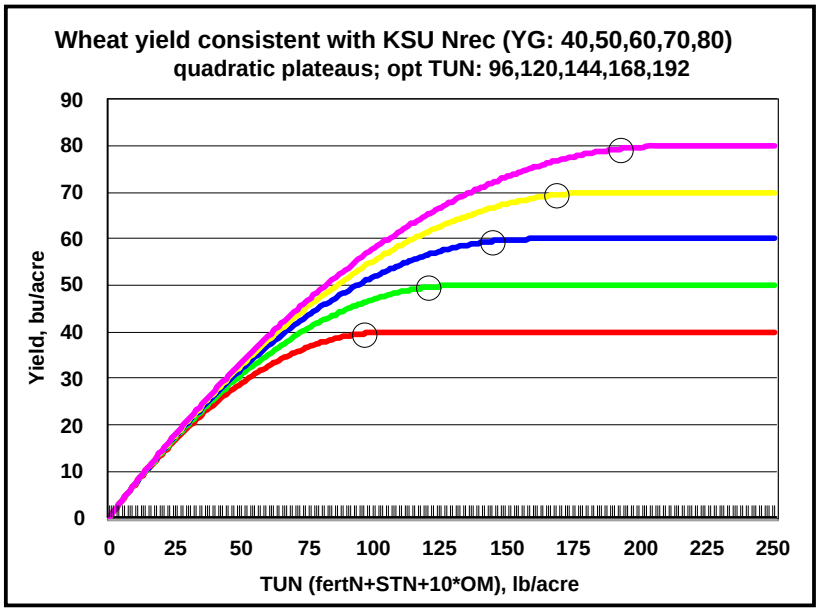
Nitrogen production function…

- Nice property of non-linear production function is that it implies diminishing marginal returns and thus prices matter
- Assumed functional form is quadratic plateau which allows diminishing returns – consistent with linear plateau in any given year
- Estimate model parameters such that
  - KSU Nrec is economic optimum at historical average prices
  - Yield plateau is equal to yield goal
  - Intercept goes through origin (i.e., 0 N equates to 0 yield)

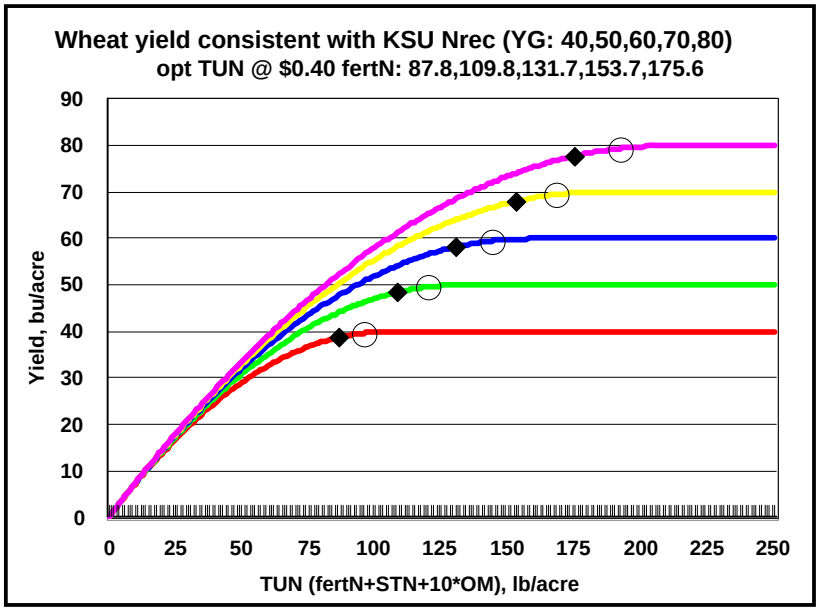
Defined points that allowed quadratic-plateau function to be defined…



Same optimal N (slope there = 0.21/3.20) but yields about 1% lower than plateau



Slope at diamonds is 0.40/3.20)



Adjustments to KSU Nrecs at various N prices

Nitrogen Recommendations for Wheat

Yield goal, bu/ac	40	50	60	70	80
KSU N rec, lbs/ac	46	70	94	118	142

N price	Price adjusted N rec, lbs/ac				
$0.25	44	68	91	115	139
$0.30	42	65	88	111	134
$0.35	40	62	85	107	130
$0.40	38	60	82	104	126
$0.45	36	57	78	100	121

N price	Price adjusted N rec reduction				
$0.25	3.7%	3.1%	2.8%	2.6%	2.4%
$0.30	8.4%	6.9%	6.2%	5.8%	5.5%
$0.35	13.1%	10.8%	9.6%	9.0%	8.5%
$0.40	17.8%	14.6%	13.1%	12.1%	11.5%
$0.45	22.5%	18.5%	16.5%	15.3%	14.6%

SOM=2.0; STN=30; Wheat price=$3.20

Adjustments to KSU Nrecs at various N prices

Nitrogen Recommendations for Corn

Yield goal, bu/ac	60	90	120	150	180
KSU N rec, lbs/ac	26	74	122	170	218

N price	Price adjusted N rec, lbs/ac				
$0.25	24	72	119	166	213
$0.30	23	69	115	161	208
$0.35	21	66	111	157	202
$0.40	19	63	107	152	196
$0.45	17	60	104	147	190

N price	Price adjusted N rec reduction				
$0.25	5.9%	3.1%	2.5%	2.3%	2.1%
$0.30	13.3%	7.0%	5.7%	5.1%	4.8%
$0.35	20.7%	10.9%	8.8%	7.9%	7.4%
$0.40	28.1%	14.8%	12.0%	10.7%	10.0%
$0.45	35.4%	18.7%	15.1%	13.6%	12.7%

SOM=2.0; STN=30; Corn price=$2.35

Adjustments to KSU Nrecs at various N prices

Nitrogen Recommendations for Grain Sorghum

Yield goal, bu/ac	50	75	100	125	150
KSU N rec, lbs/ac	10	50	90	130	170

N price	Price adjusted N rec, lbs/ac				
$0.25	9	48	87	127	166
$0.30	7	45	84	122	160
$0.35	5	42	80	117	155
$0.40	3	40	76	113	149
$0.45	1	37	73	108	144

N price	Price adjusted N rec reduction				
$0.25	13.5%	4.1%	3.0%	2.6%	2.4%
$0.30	31.9%	9.6%	7.1%	6.1%	5.6%
$0.35	50.2%	15.1%	11.2%	9.7%	8.9%
$0.40	68.6%	20.6%	15.2%	13.2%	12.1%
$0.45	87.0%	26.1%	19.3%	16.7%	15.3%

SOM=2.0; STN=30; Sorghum price=$2.10

Adjustments to KSU Nrecs at various N prices

Nitrogen Recommendations for Sunflowers

Yield goal, bu/ac	1,000	1,500	2,000	2,500	3,000
KSU N rec, lbs/ac	5	42.5	80	117.5	155

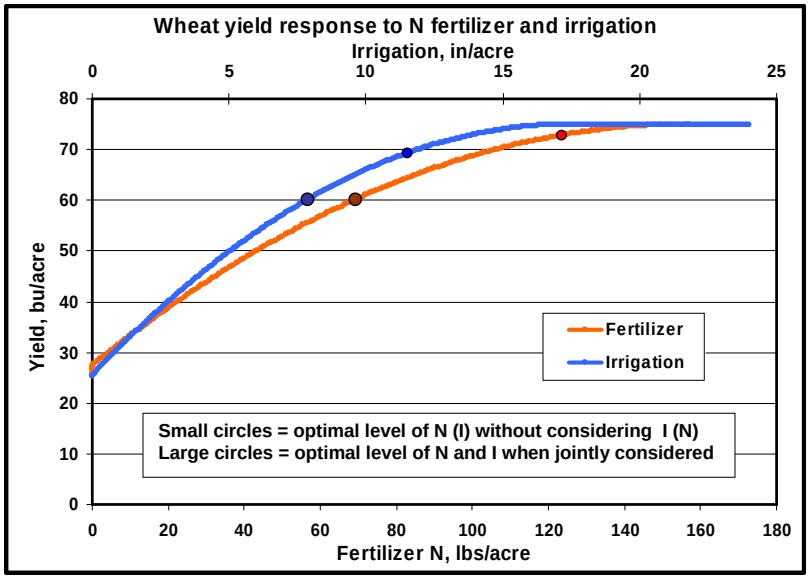
N price	Price adjusted N rec, lbs/ac				
$0.25	4	41	78	115	152
$0.30	3	39	75	111	148
$0.35	1	37	72	108	144
$0.40	0	35	70	105	140
$0.45	0	33	67	101	135

N price	Price adjusted N rec reduction				
$0.25	21.7%	3.8%	2.7%	2.3%	2.1%
$0.30	48.8%	8.6%	6.1%	5.2%	4.7%
$0.35	76.0%	13.4%	9.5%	8.1%	7.4%
$0.40	100.0%	18.2%	12.9%	11.0%	10.0%
$0.45	100.0%	23.0%	16.3%	13.9%	12.6%

SOM=2.0; STN=30; Sunflower price=$0.12

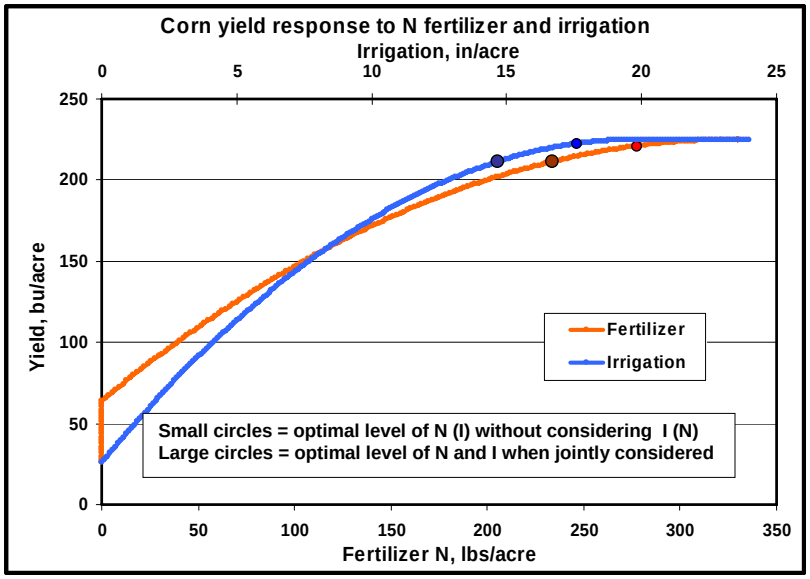
Extensions to research:
1) irrigation
2) phosphorus

When considering irrigation and N together, optimal values decrease significantly…



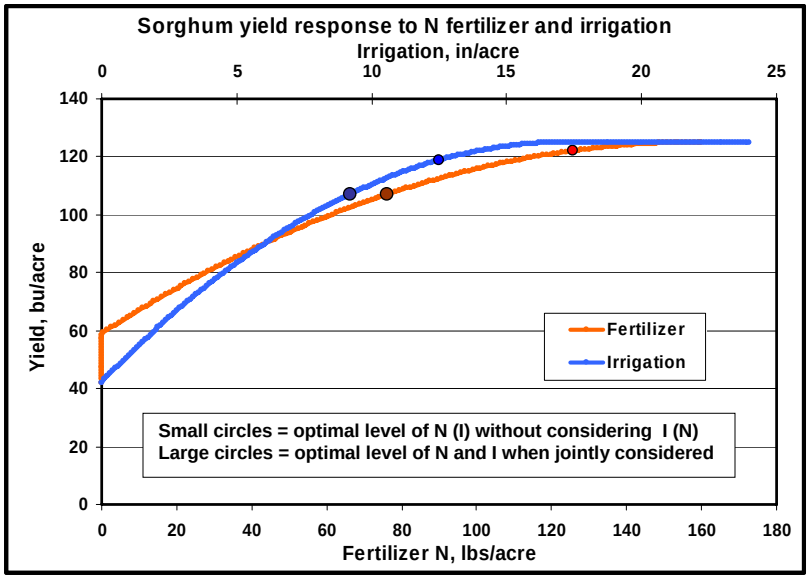
Wheat $3.20/bu; N $0.40/lb (base $0.21), irrigation cost = $6.50/inch (base $3.10)

When considering irrigation and N together, optimal values decrease significantly…



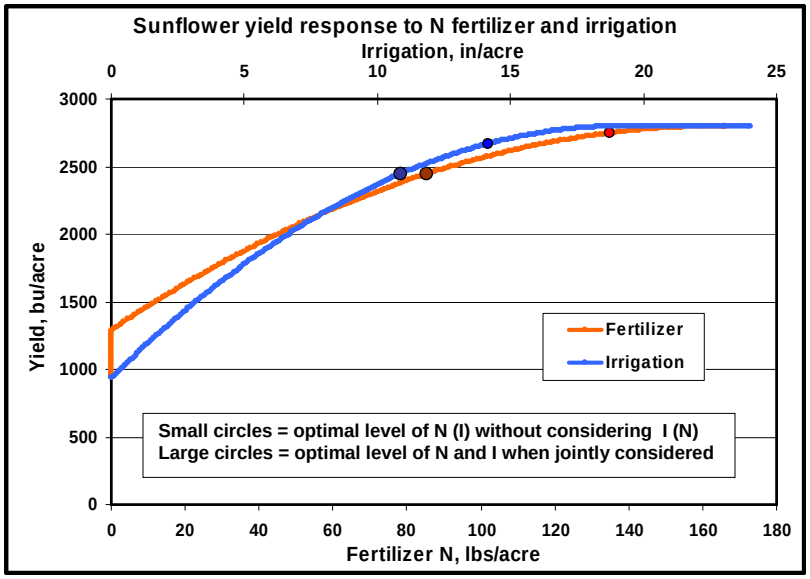
Corn $2.35/bu; N $0.40/lb (base $0.21), irrigation cost = $6.50/inch (base $3.10)

When considering irrigation and N together, optimal values decrease significantly…



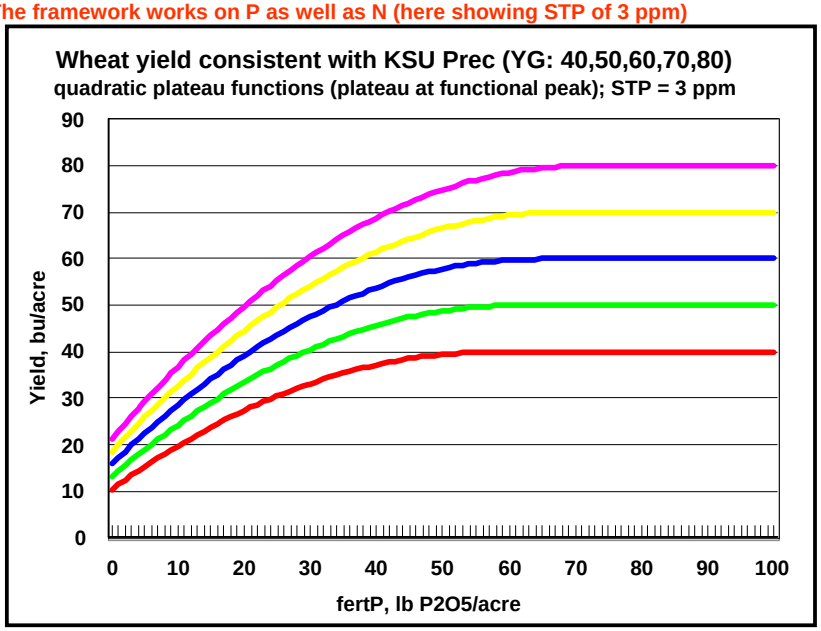
Milo $2.10/bu; N $0.40/lb (base $0.21), irrigation cost = $6.50/inch (base $3.10)

When considering irrigation and N together, optimal values decrease significantly…



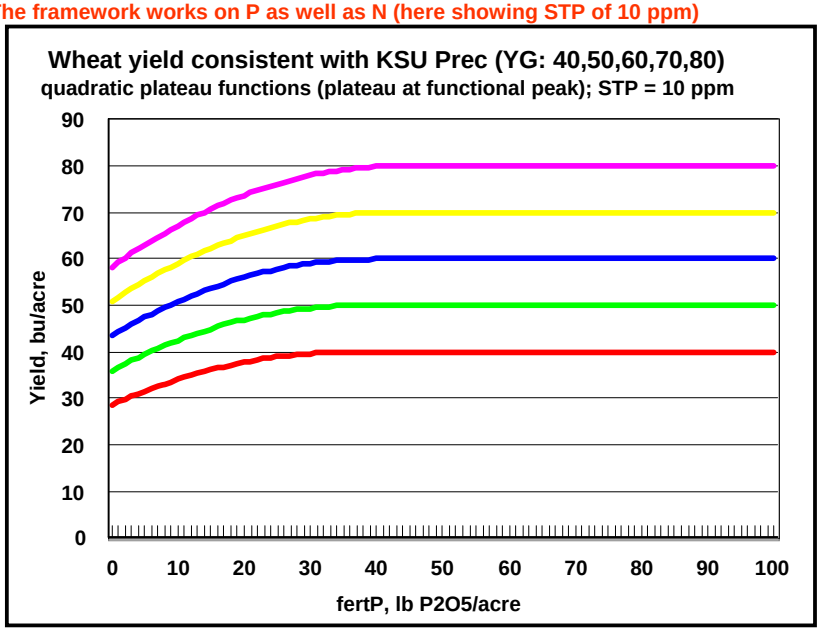
Sunflower $0.12/lb; N $0.40/lb (base $0.21), irrigation cost = $6.50/inch (base $3.10)

The framework works on P as well as N (here showing STP of 3 ppm)



Now can't do a P-encompassing x-axis however

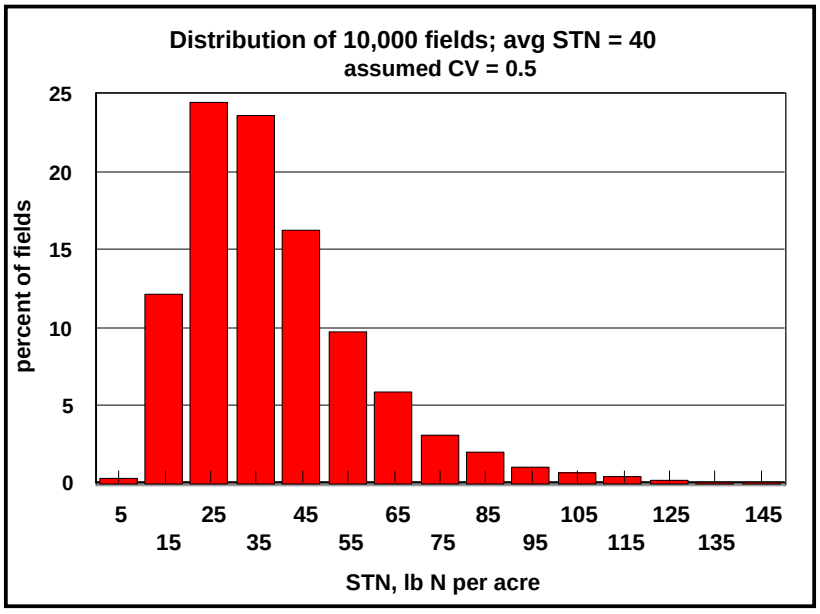
The framework works on P as well as N (here showing STP of 10 ppm)



Soil testing considerations

- **If STN varies but the variation is unknown it will be more profitable to apply more fertN than KSU or model recommends**
  - **because 1 lb/a above optimal rate will lose less money than a deficiency of 1 lb/a**
    - **Effect can be large in terms of fertN rate, perhaps 10-20 lb/a difference**
  - **How much STN variation is assumed in a single soil sample?**
    - **Do KSU Nrecs already assume this?**
  - **Not an issue if STN is 0, like in the east**
    - **Means KSU must assume stability of STN**

Assume considerable variation of soil tests across fields



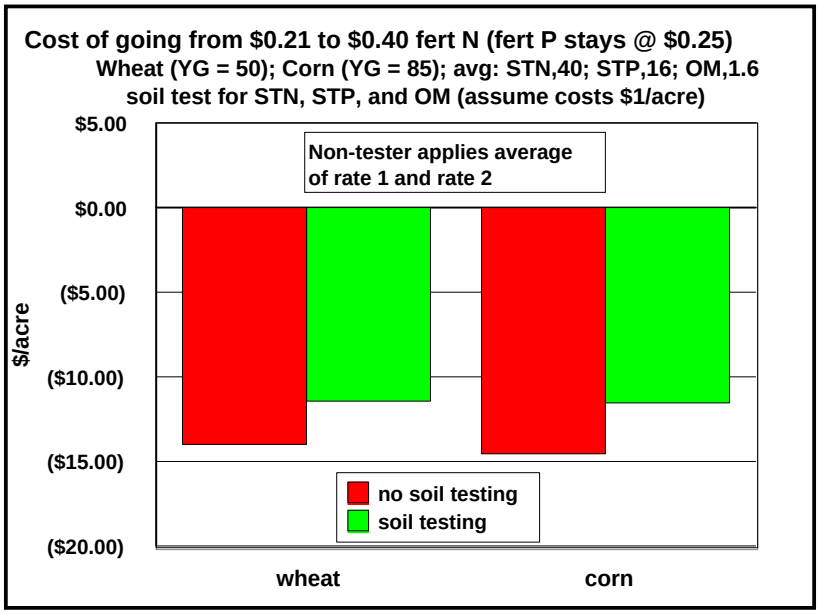
Manager who doesn't soil test: assumptions

- **Application style: uniform rate across all fields in farm**
- **Application rate:**
  1. **Manager has a "feel" for typical or average STN on farm, perhaps from occasional random field sampling; applies this STN to KSU Nrec formula or model**
  2. **Manager has a "feel" for the uniform rate applied to his farm that would have maximized profits over space and time**

Across 10,000 simulated fields we:

- **Represent rate 1 by plugging the single 10,000-field average, for each of STN, STP, and OM into the model**
- **Represent rate 2 by finding the uniform rate that maximizes total profit across all fields**
  - **Notice that this rate could not be formally known by non-tester**
- **Represent soil-tester by applying each field's unique rate coming from model**
  - **No consideration of sub-field variability and possible impact on optimal rates**

Assume $5.00/acre N application charge can be foregone if 0 N rate best



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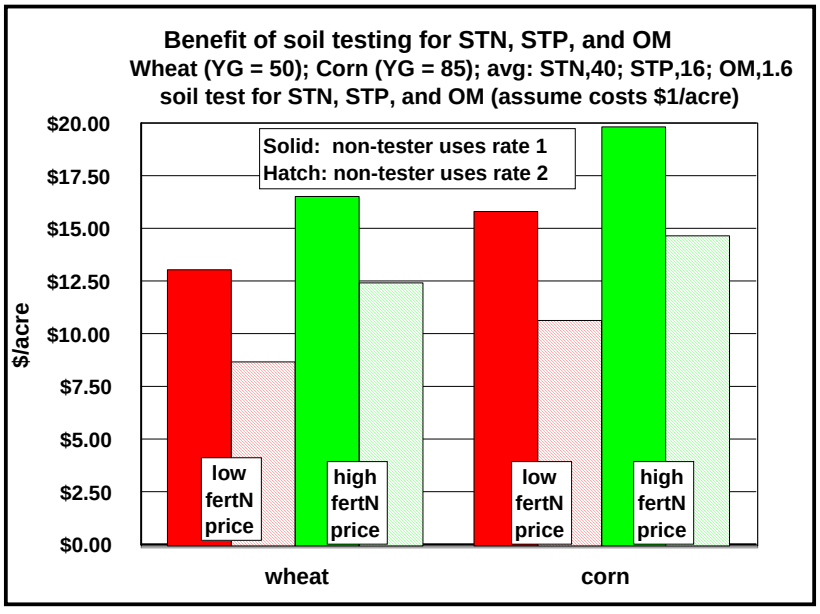
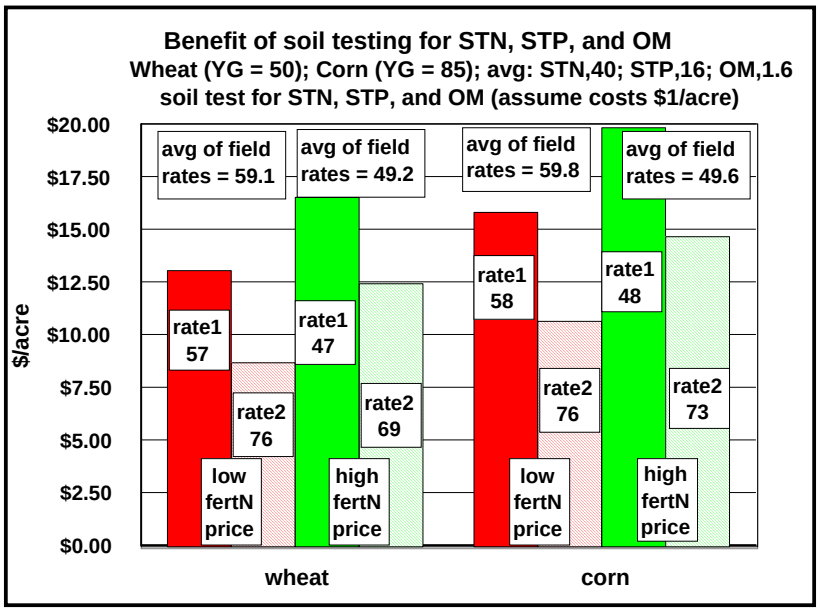
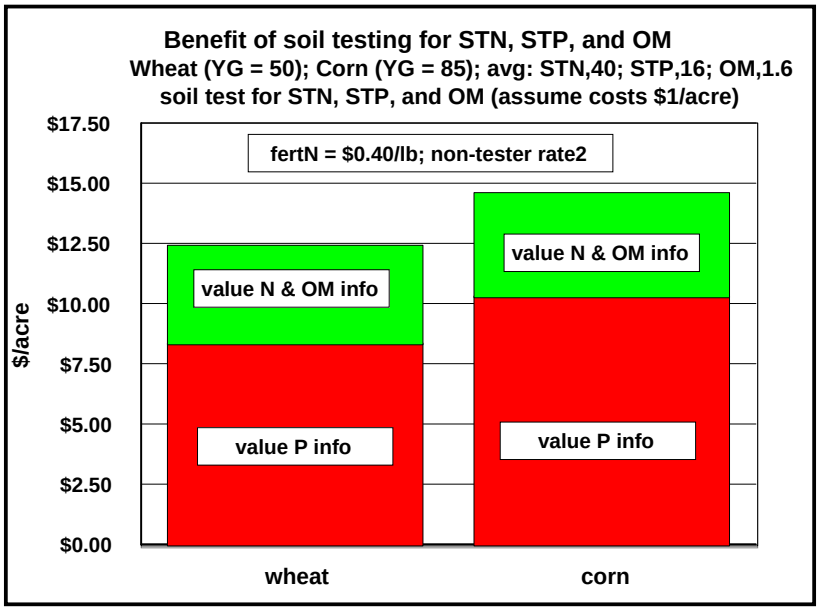




P information more valuable than N information



Eastern KS might skip STN test if STN = 0; but still may benefit from P info

Summary …

- In order to determine how to adjust fertN rates in response to prices, a mathematical relationship between N and yield is needed
- A quadratic-plateau function can be "backed out" of KSU N recs
- Quadratic-plateau function allows diminishing returns, but is also consistent with linear plateau within any site-year
- Nitrogen prices of $0.35-$0.40/lb lead to reductions in KSU N recs of 10-30% (significantly higher if irrigation costs are simultaneously considered)
- Soil sampling pays!
  - As long as you don't represent too much variation with a single soil sample