N Response Functions for Today's Production Costs

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Motivation . . .

- High nitrogen fertilizer prices
- "Failure" of Mitscherlich function at farm level
- Large successful farms desire algorithms for making decisions
- Build on existing K-State recommendations

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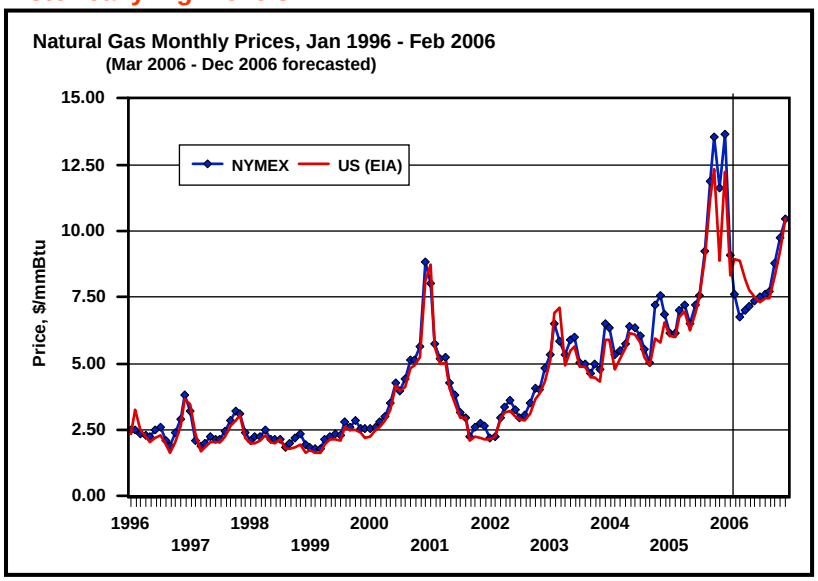
Natural gas prices have been falling, but they are still at historically high levels…



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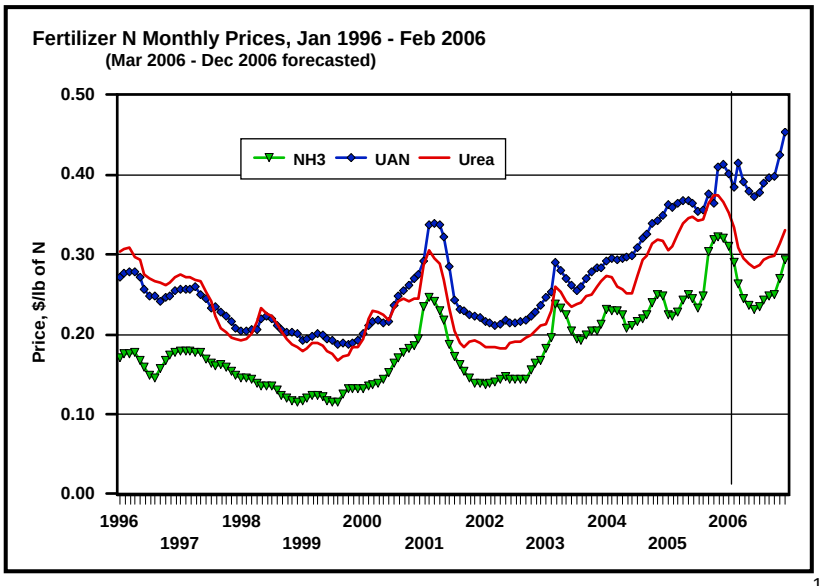
Based on 3/3/06 futures closing prices

Nitrogen fertilizer prices are at historically high levels…



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Based on 3/3/06 futures closing prices

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

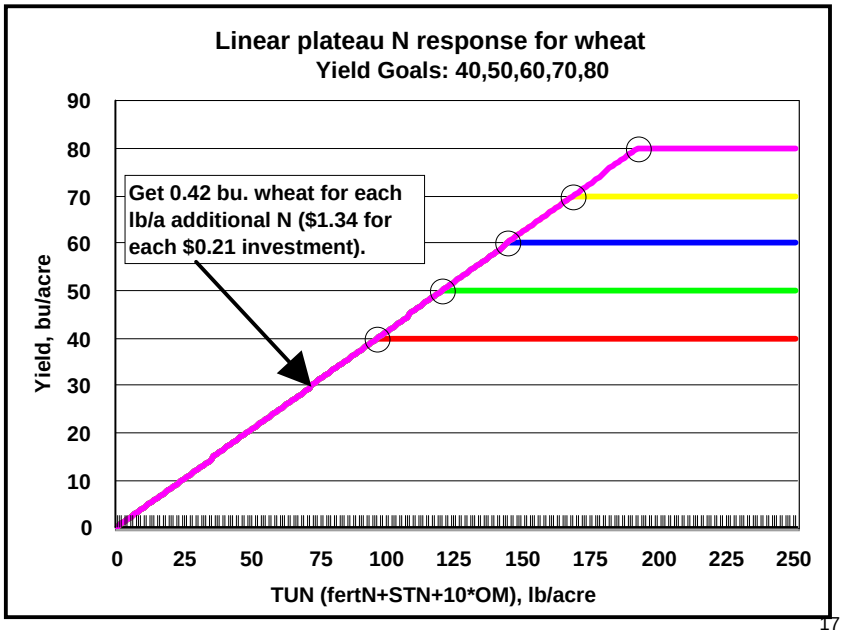
KSU nitrogen recommendations vs. N price

- 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

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



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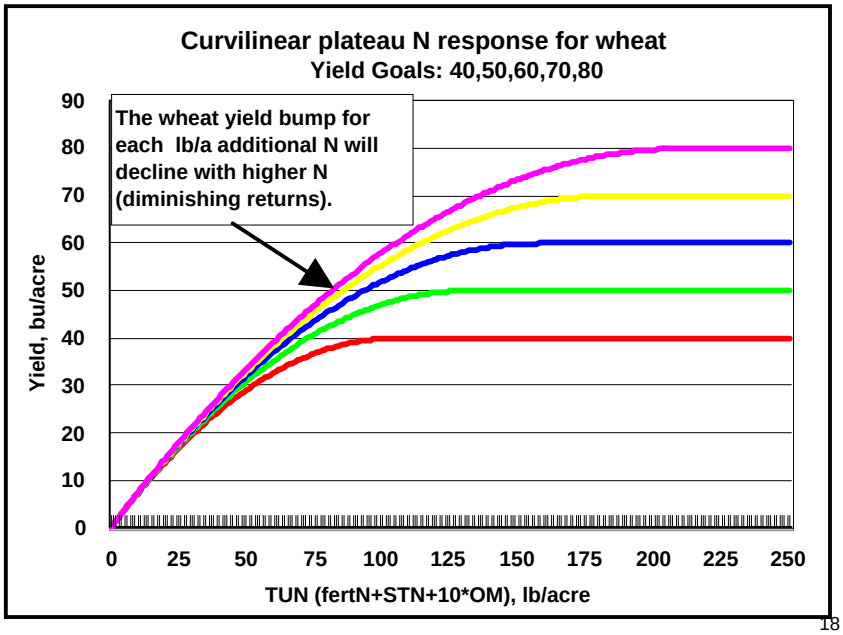
Functions might be curvilinear



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

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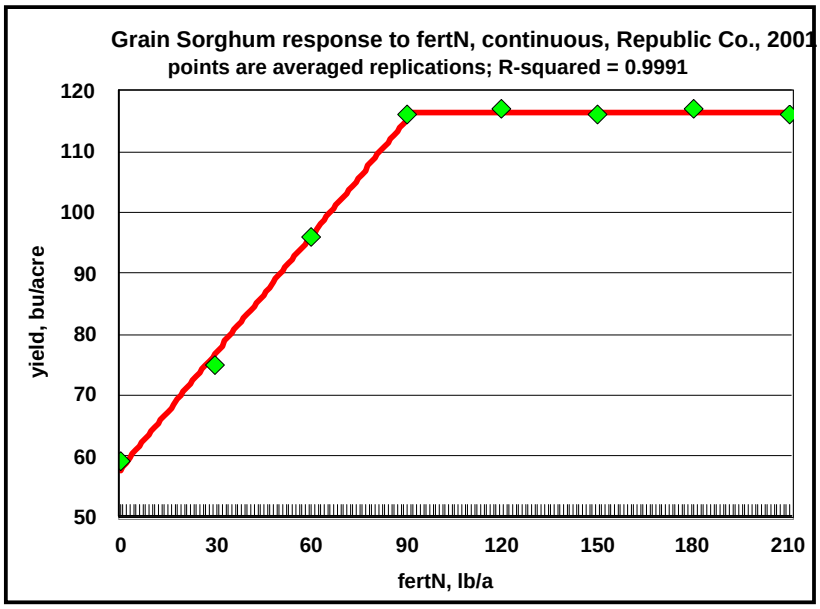

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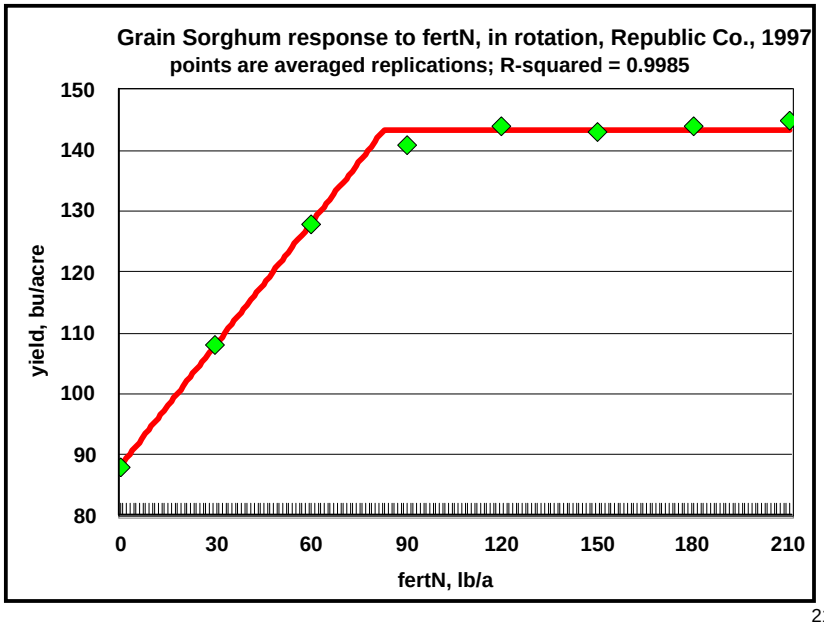
Some site-years were fit very well by a linear plateau function



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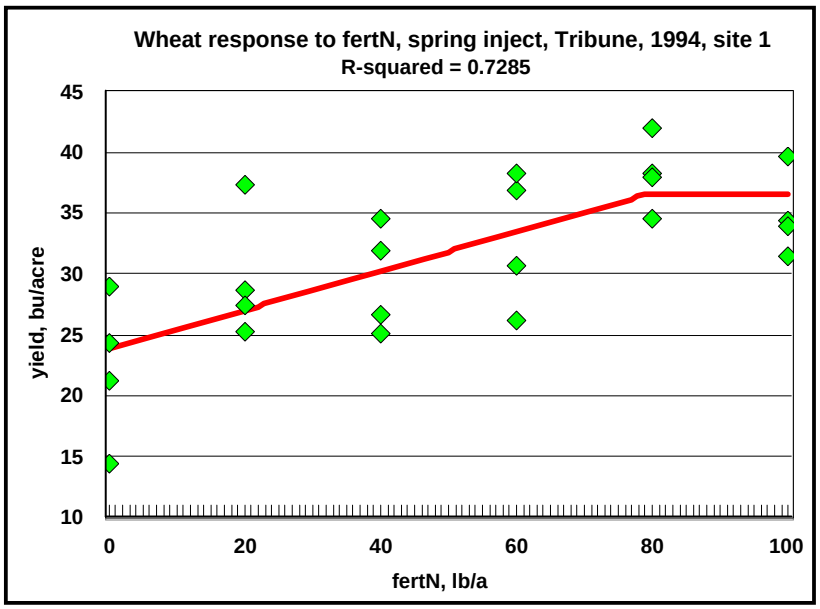
Some site-years were fit very well by a linear plateau function



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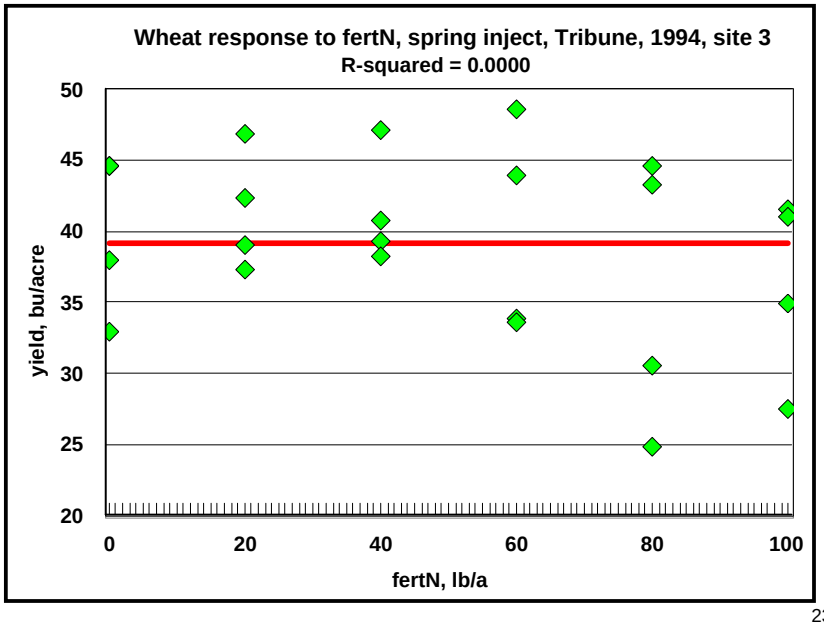
Some site-years were fit reasonably well by a linear plateau function



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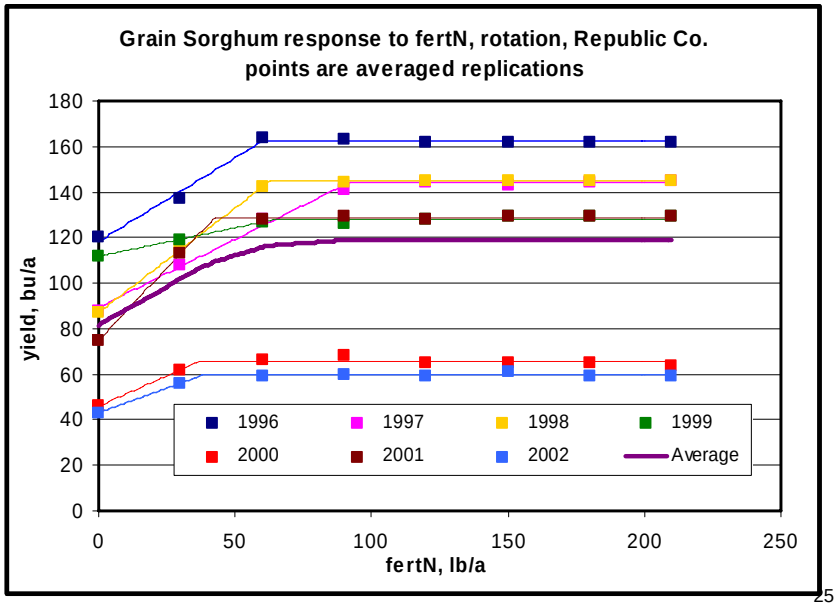
A few site-years were fit terribly by a linear plateau function

Fit of linear plateau to site-year trials:

- **Based on:**
  - 18 nitrogen fertilizer research studies from north central and western Kansas on wheat, corn, and grain sorghum
  - Involving 259 site-year fits of linear plateau
- **Average R-squared was 0.75**
- **We assumed that a site-year trial can be generalized as a linear plateau**
  - If you knew at fertilizing time the upcoming year's response to fertN, fertilizer price would be more-or-less irrelevant

Average of linear plateaus can become non-linear…



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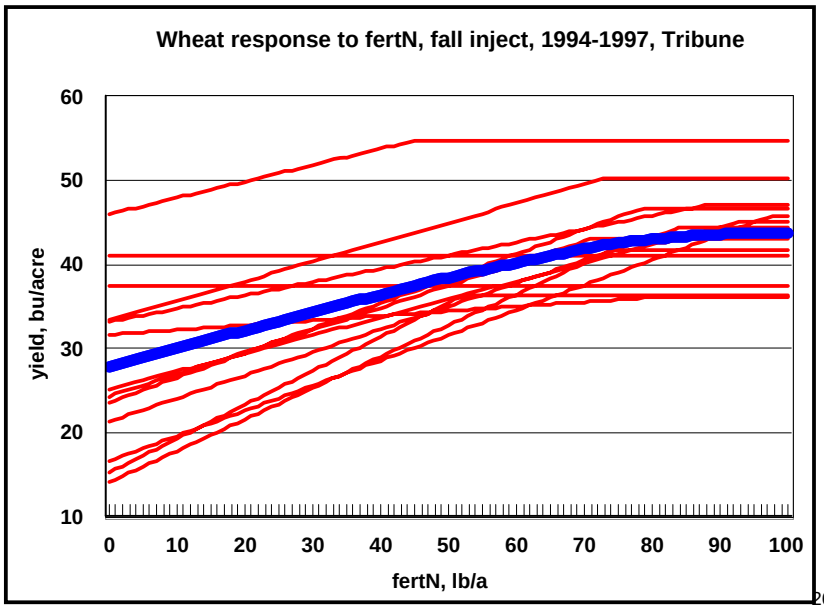
Average of linear plateaus can become non-linear…



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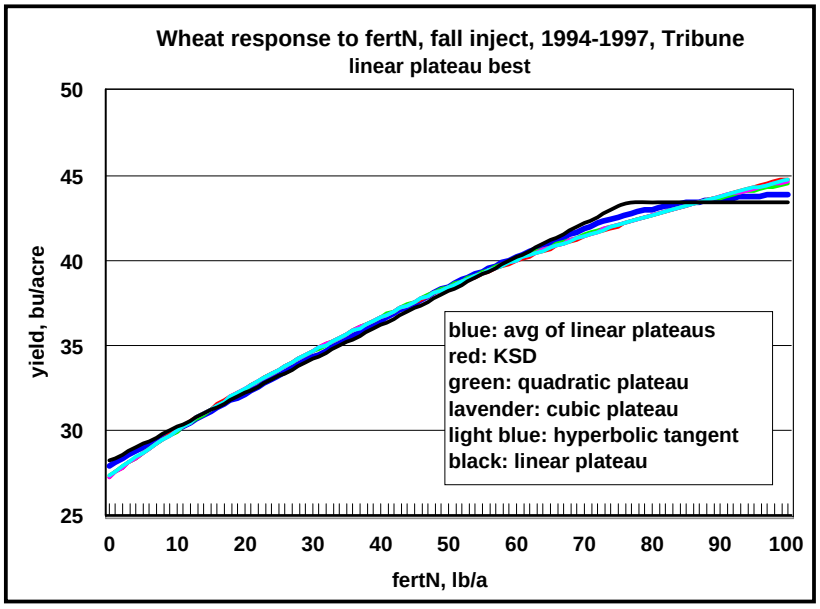
Functional form…

- Numerous functional forms could be used that would meet our objective of fitting the blue line. We considered:
  - Linear plateau
  - Quadratic plateau
  - Mitscherlich (KSD)
  - Cubic plateau
  - Hyperbolic tangent

Here, a linear plateau fit blue line the best



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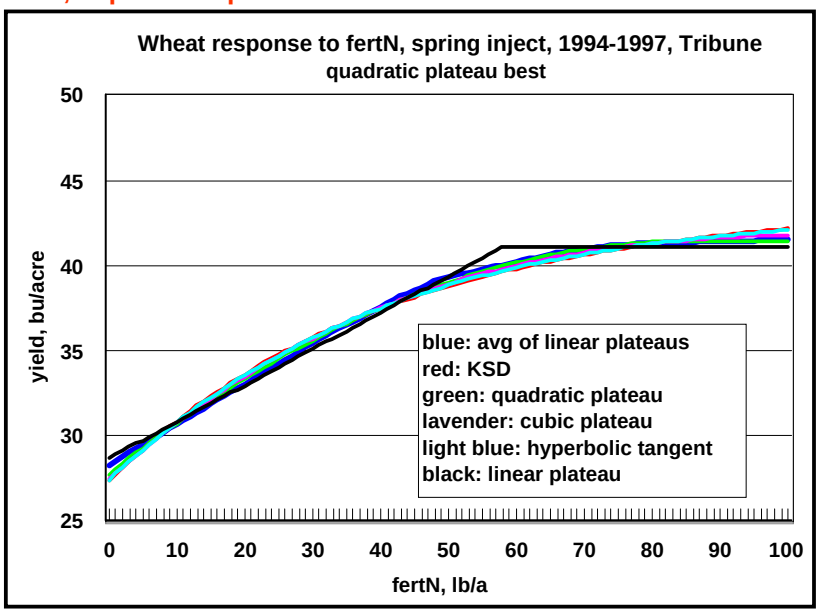
Here, a quadratic plateau fit blue line the best



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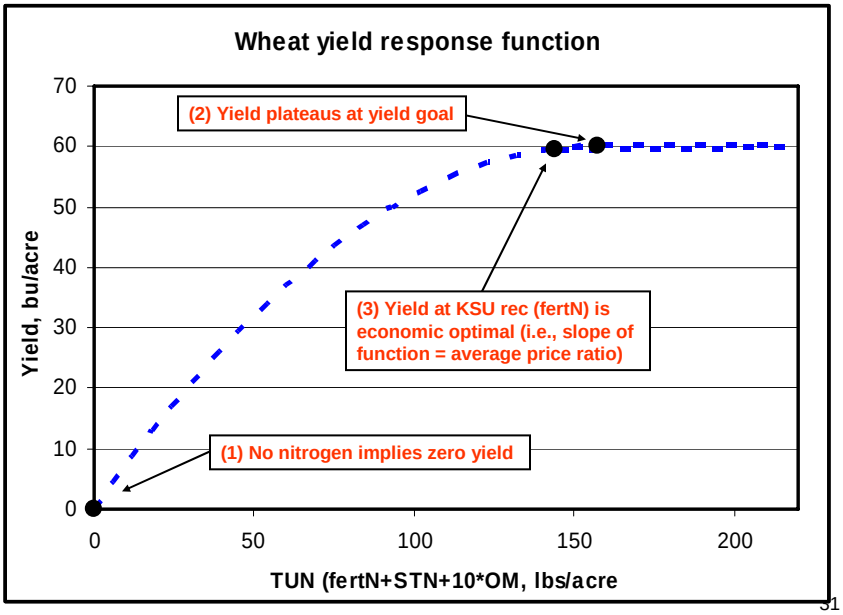
Nitrogen production function…

- **Across the 18 N research studies, the quadratic plateau model fit the data better than alternatives most often**
  - diminishing marginal returns ➔ prices matter
  - consistent with linear plateau in any given year
- **Estimate model parameters such that**
  - KSU Nrec is economic optimum at historical prices
  - Yield plateau is equal to yield goal
  - Intercept goes through origin (i.e., 0 N ➔ 0 yield)

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



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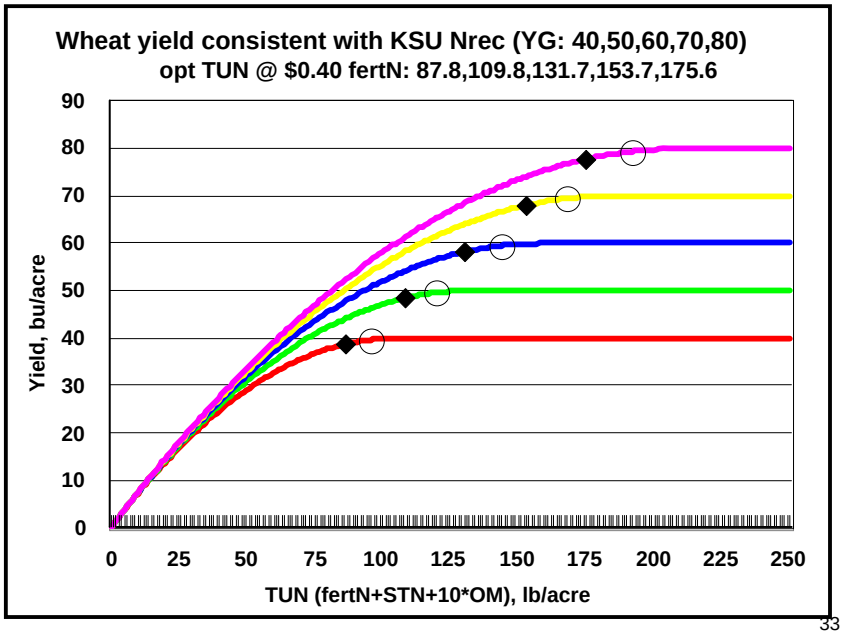
Slope at diamonds is 0.40/3.20



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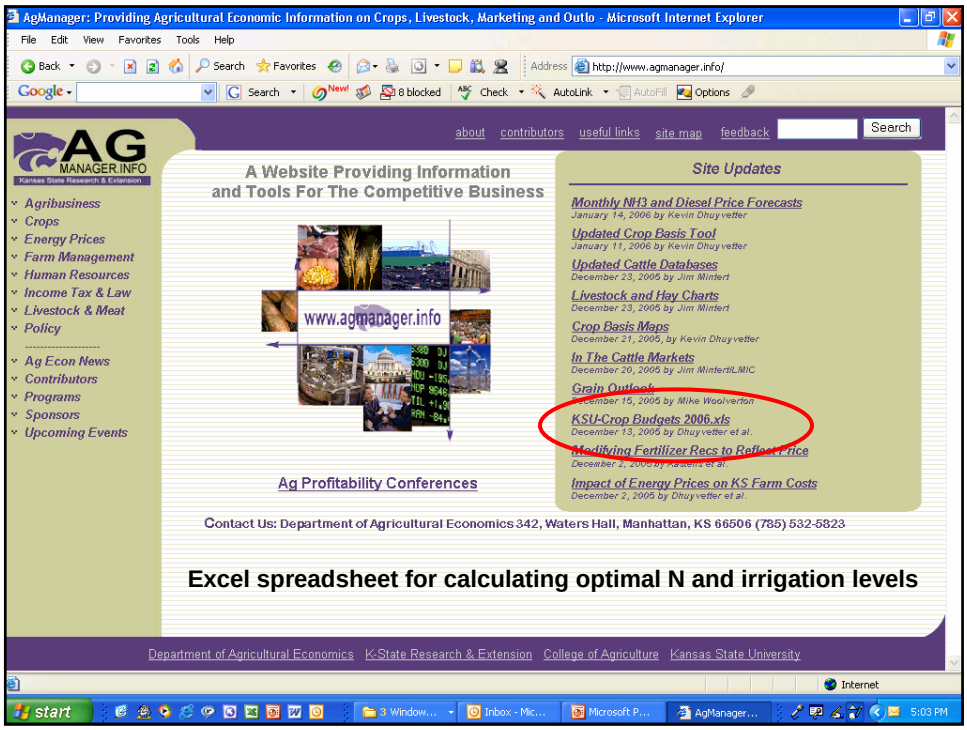

Dryland optimal fertilizer N values – Long-run (LR) N and crop prices

Comparison of Crop Returns with Nitrogen Fertilizer and Irrigation Water at Economic Optimum Levels					
Crop/System	Wheat	Corn	Sorghum	Soybean	Sunflower
Rotation (1 or 2, if none enter 0)	1	1	1	1	1
Percent of rotation (total - 100%)	75.0%	3.0%	10.0%	12.0%	0.0%
Yield Goal (YG), bu/ac	48.0	80.0	60.0	22.0	1200.0
Enter 0 for Dryland or 1 for Irrigated	0	0	0	0	0
Annual rainfall	28.0	28.0	28.0	28.0	28.0
Organic matter (OM), %	2.00	2.00	2.00	2.00	2.00
Soil test nitrogren (STN), lbs/ac	20.0	20.0	20.0	20.0	20.0
Other N adjustments, lbs/ac	0.0	0.0	0.0	0.0	0.0
Nitrogen fertilizer cost, $/lb	$0.212	$0.212	$0.212	$0.212	$0.212
Irrigation energy cost, $/inch	$2.220	$2.220	$2.220	$2.220	$2.220
KSU recommended nitrogen, lbs/ac	75.2	68.0	36.0	0.0	30.0
Econ Optimum fertN, lbs/ac	74.1	66.2	34.8	0.0	29.3
Econ Optimum Irrigation Amount, in	0.0	0.0	0.0	0.0	0.0
Yield at optimal N and I, bu/ac	47.6	79.3	59.4	21.3	1192.7
B. Price per unit	$2.93	$2.03	$1.85	$4.96	$0.110

Optimal rates are very close to KSU recommendations because prices are similar to long-term averages

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Dryland optimal fertilizer N values – Current N and crop prices

Comparison of Crop Returns with Nitrogen Fertilizer and Irrigation Water at Economic Optimum Levels					
Crop/System	Wheat	Corn	Sorghum	Soybean	Sunflower
Rotation (1 or 2, if none enter 0)	1	1	1	1	1
Percent of rotation (total - 100%)	75.0%	3.0%	10.0%	12.0%	0.0%
Yield Goal (YG), bu/ac	48.0	80.0	60.0	22.0	1200.0
Enter 0 for Dryland or 1 for Irrigated	0	0	0	0	0
Annual rainfall	28.0	28.0	28.0	28.0	28.0
Organic matter (OM), %	2.00	2.00	2.00	2.00	2.00
Soil test nitrogren (STN), lbs/ac	20.0	20.0	20.0	20.0	20.0
Other N adjustments, lbs/ac	0.0	0.0	0.0	0.0	0.0
Nitrogen fertilizer cost, $/lb	$0.332	$0.332	$0.332	$0.332	$0.332
Irrigation energy cost, $/inch	$2.220	$2.220	$2.220	$2.220	$2.220
KSU recommended nitrogen, lbs/ac	75.2	68.0	36.0	0.0	30.0
Econ Optimum fertN, lbs/ac	72.7	61.8	31.1	0.0	26.5
Econ Optimum Irrigation Amount, in	0.0	0.0	0.0	0.0	0.0
Yield at optimal N and I, bu/ac	47.5	78.8	58.9	21.3	1186.2
B. Price per unit	$4.12	$2.35	$2.14	$5.60	$0.125

Optimal rates vary crop by crop due to N/crop price relationship

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Modifying KSU nitrogen recommendations based upon prices…

Nitrogen Recommendations for Corn

Yield goal, bu/ac	60	90	120	150	180
KSU N rec, lbs/ac	36	84	132	180	228

N price	Price adjusted N rec, lbs/ac				
$0.25	35	82	129	176	224
$0.30	33	79	125	172	218
$0.35	31	76	121	167	212
$0.40	29	73	118	162	206
$0.45	27	70	114	157	201

N price	Price adjusted N rec reduction				
$0.25	4.1%	2.6%	2.2%	2.0%	1.9%
$0.30	9.4%	6.0%	5.1%	4.7%	4.4%
$0.35	14.7%	9.4%	8.0%	7.3%	6.9%
$0.40	20.0%	12.8%	10.9%	10.0%	9.5%
$0.45	25.2%	16.2%	13.8%	12.6%	12.0%

SOM=2.0; STN=20; Corn price=$2.37

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Extensions to research: Irrigation

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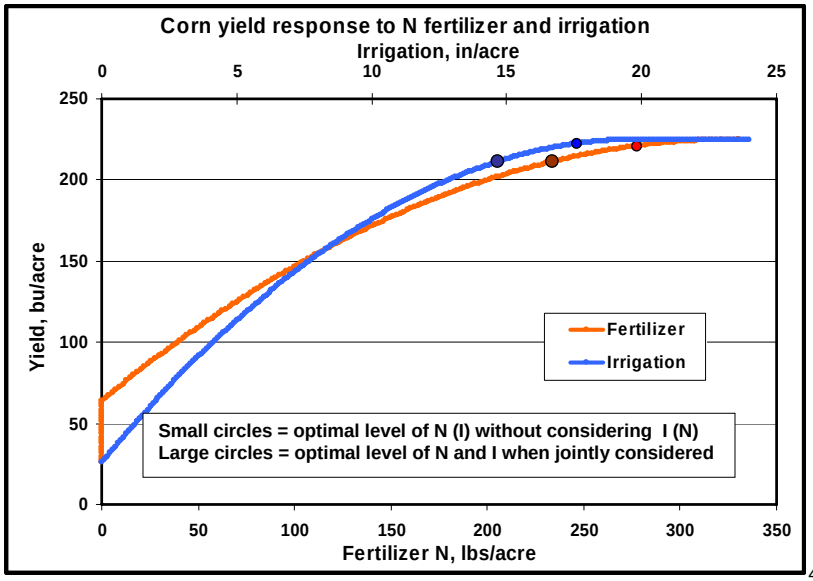
When considering irrigation and N together, optimal values decrease significantly…



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Corn price = $2.35/bu, N price = $0.40/lb, irrigation cost = $6.50/inch

Irrigated optimal fertilizer N values @ $0.21/lb N & $3.10/in

Comparison of Crop Returns with Nitrogen Fertilizer and Irrigation Water at Economic Optimum Levels					
Crop/System	Wheat	Corn	Sorghum	Soybean	Sunflower
Rotation (1 or 2, if none enter 0)	1	1	1	1	1
Percent of rotation (total - 100%)	24.0%	49.0%	7.5%	6.0%	1.0%
Yield Goal (YG), bu/ac	75.0	225.0	125.0	65.0	2800.0
Enter 0 for Dryland or 1 for Irrigated	1	1	1	1	1
Annual rainfall	18.0	18.0	18.0	18.0	18.0
Organic matter (OM), %	2.00	2.00	2.00	2.00	2.00
Soil test nitrogren (STN), lbs/ac	20.0	20.0	20.0	20.0	20.0
Other N adjustments, lbs/ac	0.0	0.0	0.0	0.0	0.0
Nitrogen fertilizer cost, $/lb	$0.21	$0.21	$0.21	$0.21	$0.21
Irrigation energy cost, $/inch	$3.10	$3.10	$3.10	$3.10	$3.10
KSU recommended nitrogen, lbs/ac	140.0	300.0	140.0	0.0	150.0
Econ Optimum fertN, lbs/ac	112.3	278.3	113.5	0.0	124.6
Econ Optimum Irrigation Amount, in	12.6	17.1	12.8	16.6	15.0
Yield at optimal N and I, bu/ac	71.1	221.0	119.5	58.5	2706.4

Optimal rates are below KSU recommendations because of irrigation

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Irrigated optimal fertilizer N values @ $0.40/lb N & $3.10/in

Comparison of Crop Returns with Nitrogen Fertilizer and Irrigation Water at Economic Optimum Levels					
Crop/System	Wheat	Corn	Sorghum	Soybean	Sunflower
Rotation (1 or 2, if none enter 0)	1	1	1	1	1
Percent of rotation (total - 100%)	24.0%	49.0%	7.5%	6.0%	1.0%
Yield Goal (YG), bu/ac	75.0	225.0	125.0	65.0	2800.0
Enter 0 for Dryland or 1 for Irrigated	1	1	1	1	1
Annual rainfall	18.0	18.0	18.0	18.0	18.0
Organic matter (OM), %	2.00	2.00	2.00	2.00	2.00
Soil test nitrogren (STN), lbs/ac	20.0	20.0	20.0	20.0	20.0
Other N adjustments, lbs/ac	0.0	0.0	0.0	0.0	0.0
Nitrogen fertilizer cost, $/lb	$0.40	$0.40	$0.40	$0.40	$0.40
Irrigation energy cost, $/inch	$3.10	$3.10	$3.10	$3.10	$3.10
KSU recommended nitrogen, lbs/ac	140.0	300.0	140.0	0.0	150.0
Econ Optimum fertN, lbs/ac	96.7	250.7	95.9	0.0	110.3
Econ Optimum Irrigation Amount, in	10.9	15.6	11.1	16.6	13.5
Yield at optimal N and I, bu/ac	68.0	215.6	114.5	58.5	2630.3

Optimal rates decrease 10-20% at high N price

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Irrigated optimal fertilizer N values @ $0.40/lb N & $6.50/in

Comparison of Crop Returns with Nitrogen Fertilizer and Irrigation Water at Economic Optimum Levels					
Crop/System	Wheat	Corn	Sorghum	Soybean	Sunflower
Rotation (1 or 2, if none enter 0)	1	1	1	1	1
Percent of rotation (total - 100%)	24.0%	49.0%	7.5%	6.0%	1.0%
Yield Goal (YG), bu/ac	75.0	225.0	125.0	65.0	2800.0
Enter 0 for Dryland or 1 for Irrigated	1	1	1	1	1
Annual rainfall	18.0	18.0	18.0	18.0	18.0
Organic matter (OM), %	2.00	2.00	2.00	2.00	2.00
Soil test nitrogren (STN), lbs/ac	20.0	20.0	20.0	20.0	20.0
Other N adjustments, lbs/ac	0.0	0.0	0.0	0.0	0.0
Nitrogen fertilizer cost, $/lb	$0.40	$0.40	$0.40	$0.40	$0.40
Irrigation energy cost, $/inch	$6.50	$6.50	$6.50	$6.50	$6.50
KSU recommended nitrogen, lbs/ac	140.0	300.0	140.0	0.0	150.0
Econ Optimum fertN, lbs/ac	66.5	224.9	66.9	0.0	82.7
Econ Optimum Irrigation Amount, in	7.6	14.2	8.3	15.2	10.6
Yield at optimal N and I, bu/ac	59.2	208.6	102.7	58.5	2419.5

At high N and irrigation costs, optimal rates decrease significantly

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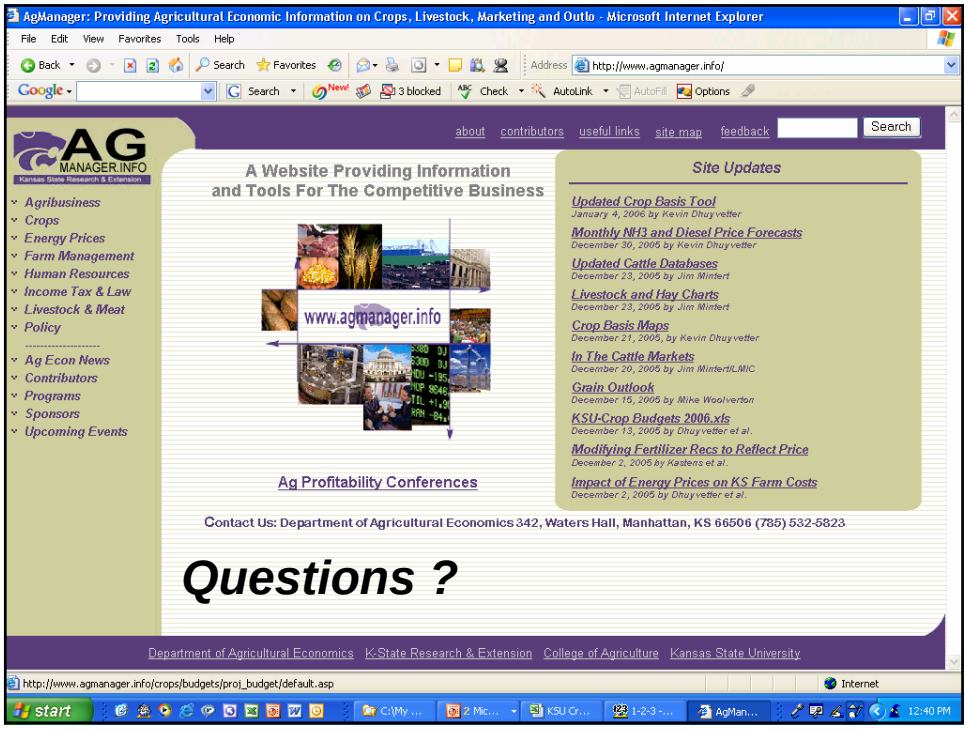
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Grain Outlook
December 15, 2005 by Mike Woolverton
KSU-Crop Budgets 2006.xls
December 13, 2005 by Dhuyvetter et al.
Modifying Fertilizer Recs to Reflect Price
December 2, 2005 by Kastens et al.
Impact of Energy Prices on KS Farm Costs
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