

Fertilizer Economics: When to apply less

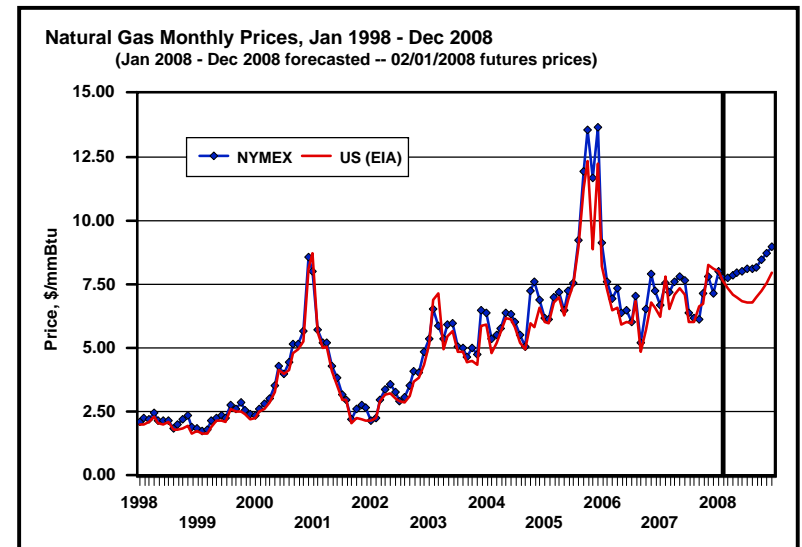
Kevin C. Dhuyvetter -- kcd@ksu.edu -- 785-532-3527
 Terry L. Kastens -- tkastens@ksu.edu -- 785-532-5866
 Department of Agricultural Economics
 Kansas State University



Presented at McPherson County Fertilizer School
 February 14, 2008
 4-H Building, McPherson, KS

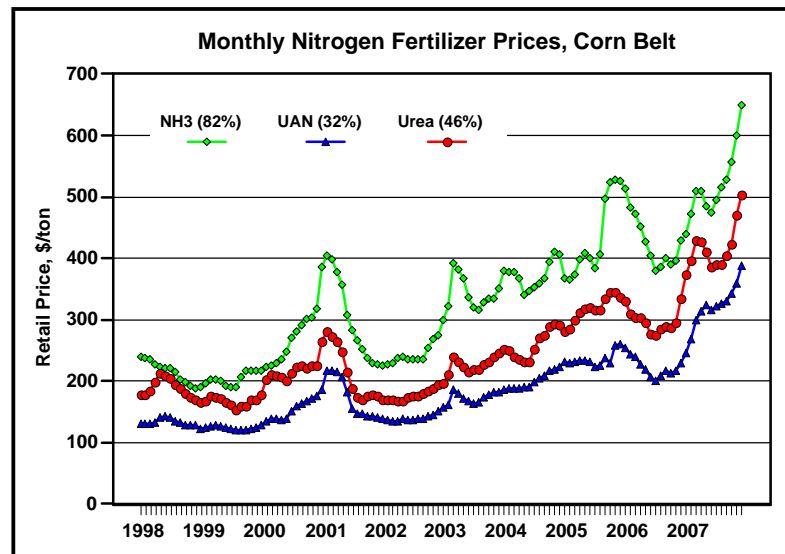


Natural gas prices are high by long-term standards, but relatively low price compared to crude oil...

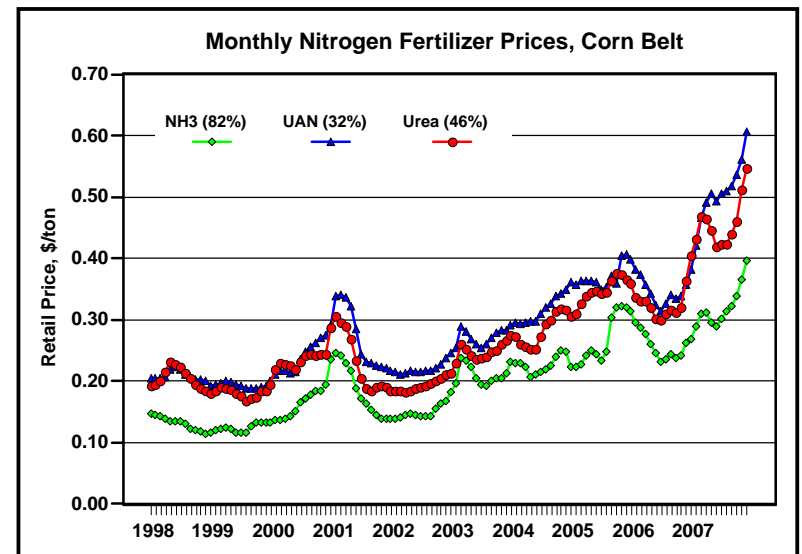


Futures-based forecast based on 2/01/08 closing futures prices

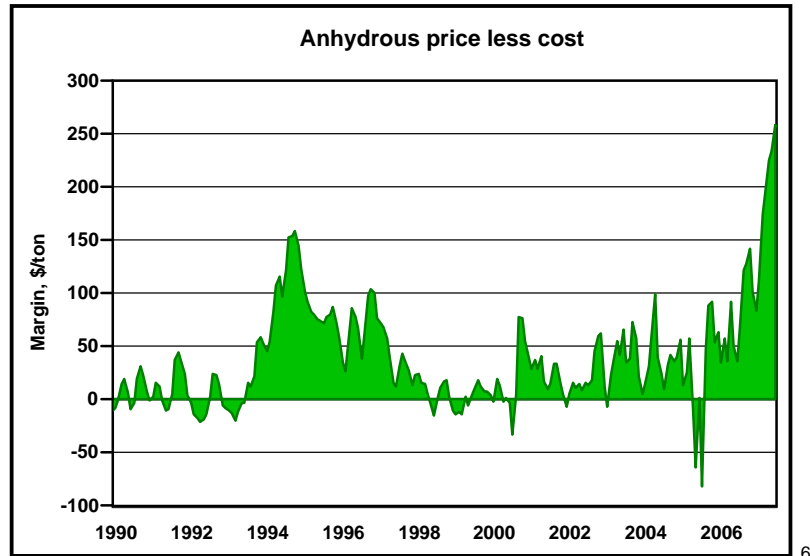
Nitrogen prices are at all time highs...



Nitrogen prices are at all time highs...

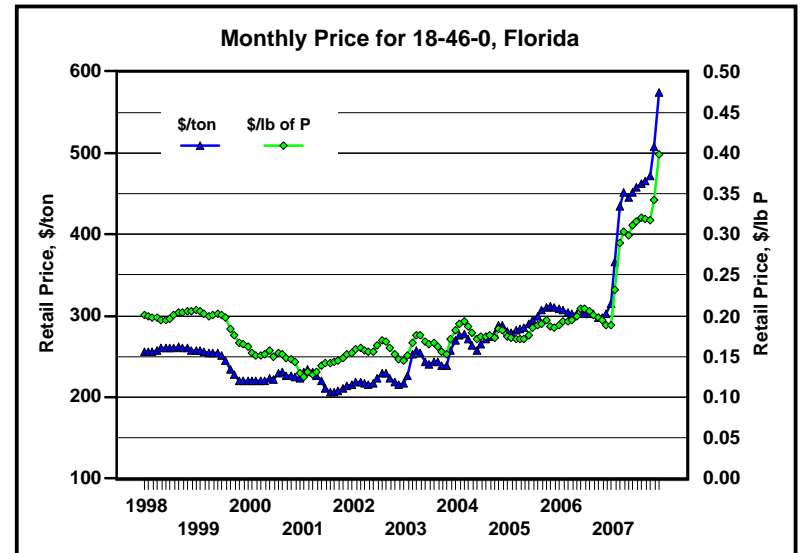


Margins in the nitrogen fertilizer industry are extremely positive in the current environment...



6

Phosphorus prices are at all time highs...



7

NYSE's best in 2007

Updated 3d 12h ago | Comment | Recommend 1

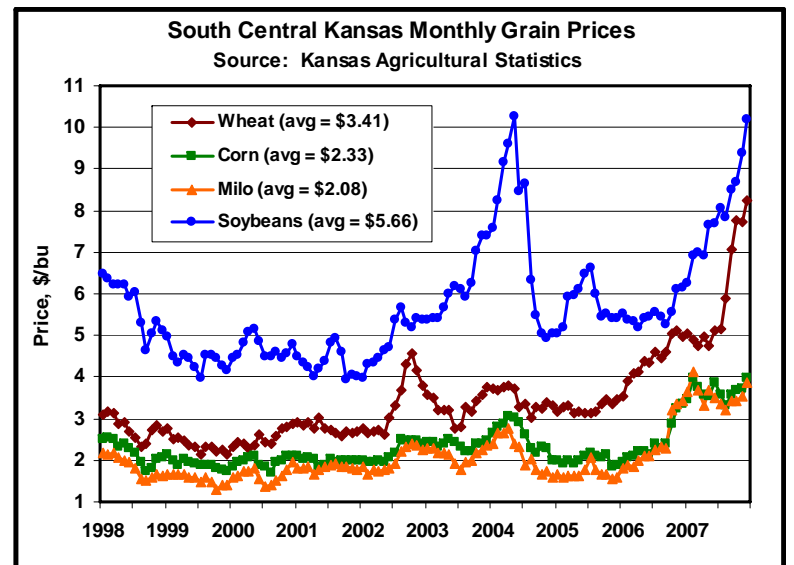
The best-performing stocks on the New York Stock Exchange for the year:

Company	2007 close	% gain
Mosaic	\$94.34	341.7%
CF Industries Holdings	\$110.06	329.3%
Terra Industries	\$47.76	298.7%
Mechel OAO	\$97.14	281.2%
China Southern Airlines	\$65.45	220.1%
PotashCorp	\$143.96	201.0%
Siderurgica Nacional	\$89.57	198.8%
Trina Solar	\$53.80	184.7%
Excel Maritime Carriers	\$40.19	175.1%
AK Steel Holding	\$46.24	173.6%
Owens Illinois	\$49.50	168.3%
Bally Technologies	\$49.72	166.2%
Vimpel-Communications	\$41.60	163.5%
Chipotle Mexican Grill	\$147.07	158.0%
GraTech International	\$17.75	156.5%
Calgon Carbon	\$15.89	156.3%
Suntech Power Holdings	\$82.32	142.1%
CNH Global	\$65.82	141.1%
New Oriental Edu&Tchnlgy	\$80.59	140.3%
National Oilwell Varco	\$73.46	140.1%
Yanzhou Coal Mining	\$97.06	139.4%
Jacobs Engineering	\$95.61	134.5%
Aegean Marine Petrol Netwk	\$38.39	134.1%
McDermott International	\$59.03	132.1%
Agrium	\$72.21	129.3%
Alpha Natural Resources	\$32.48	128.3%

Great year to be in the fertilizer business

8

But, grain prices are also at all time highs!



10

What do these high prices imply for fertilizer rates?

15



KSU nitrogen recommendations...

Corn and grain sorghum

$N \text{ rec} = (\text{Yield Goal} \times 1.6) - (\% \text{SOM} \times 20) - \text{Profile N} - \text{Manure N} - \text{Other N Adjustments}$
+ Previous Crop Adjustments

Wheat

$N \text{ rec} = (\text{Yield Goal} \times 2.4) - (\% \text{SOM} \times 10) - \text{Profile N} - \text{Manure N} - \text{Other N Adjustments}$
+ Previous Crop Adjustments + Tillage Adjustments + Grazing Adjustments

Sunflowers

$N \text{ rec} = (\text{Yield Goal} \times 0.075) - (\% \text{SOM} \times 20) - \text{Profile N} - \text{Manure N} - \text{Other N Adjustments}$
+ Previous Crop Adjustments

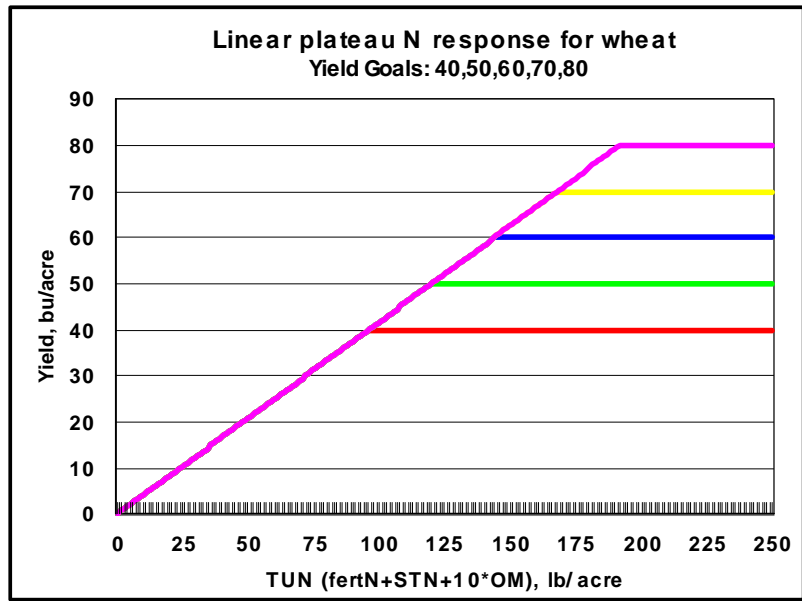
KSU nitrogen recommendations vs. N price

- 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

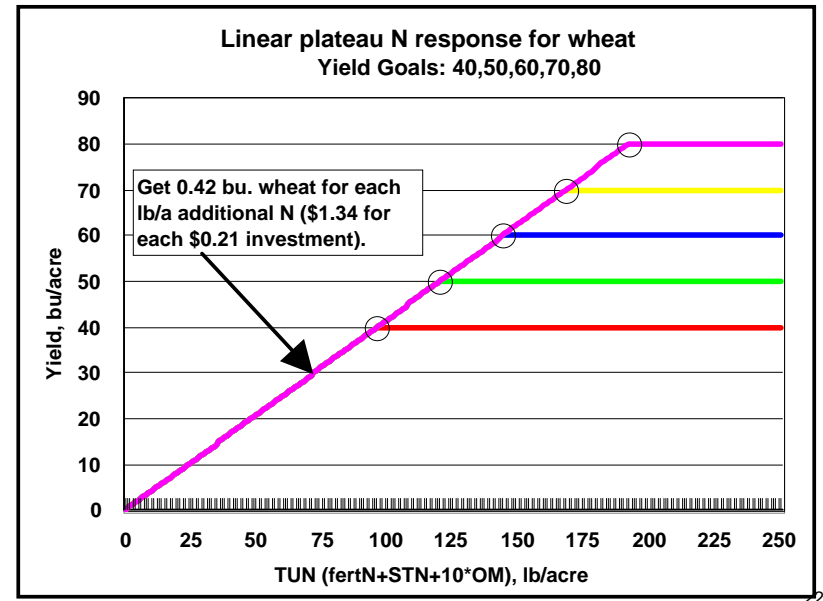
Nitrogen production function...

- 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

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

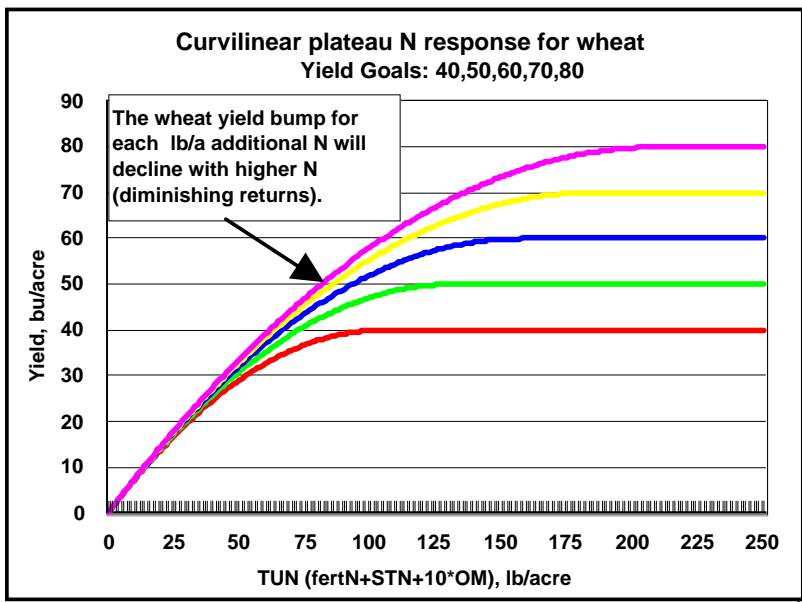


Functions could and likely should have 0-intercept if response is to total N

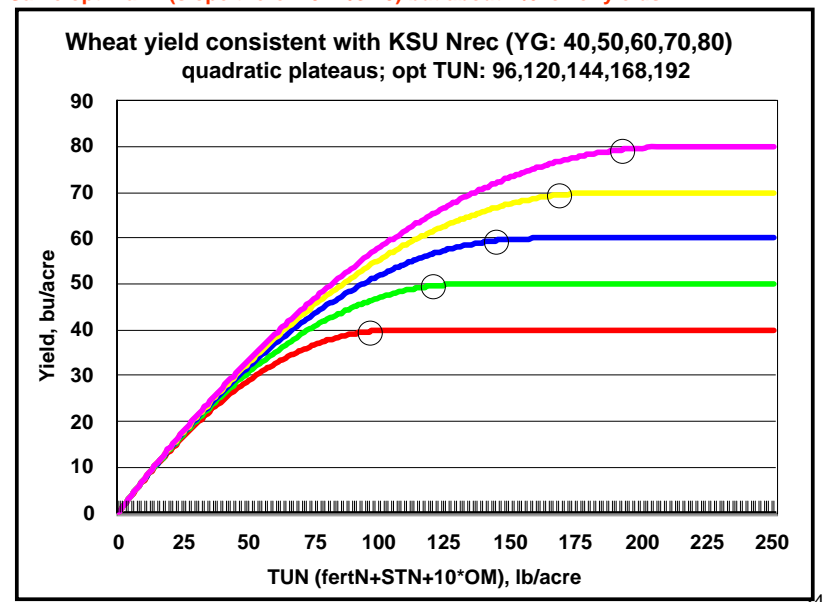


Price won't matter until fertN = \$1.34/lb, then optimal is 0 lb/acre

Functions might be curvilinear



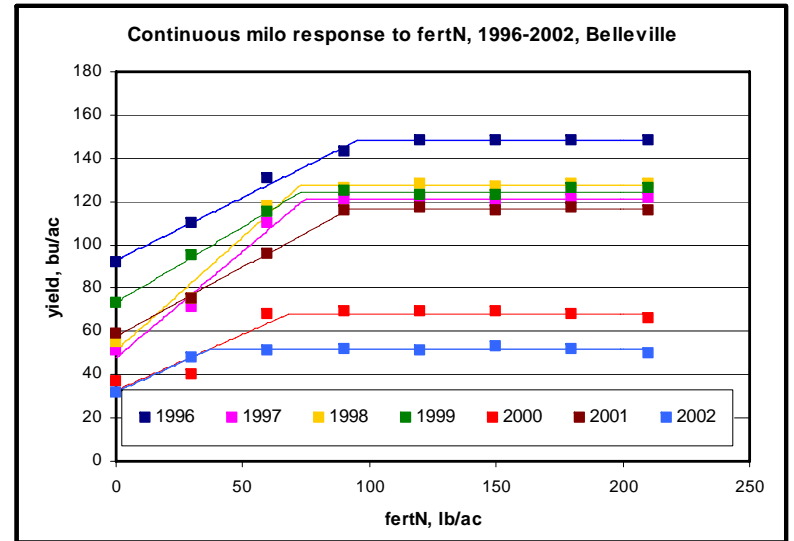
Same optimal N (slope there = 0.21/3.20) but about 1% lower yields



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

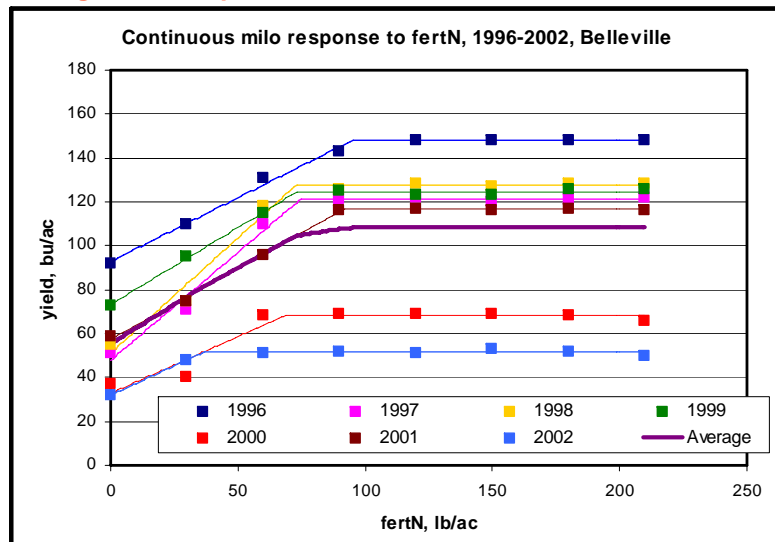


Yield response by year – linear plateau “fits” data quite well...

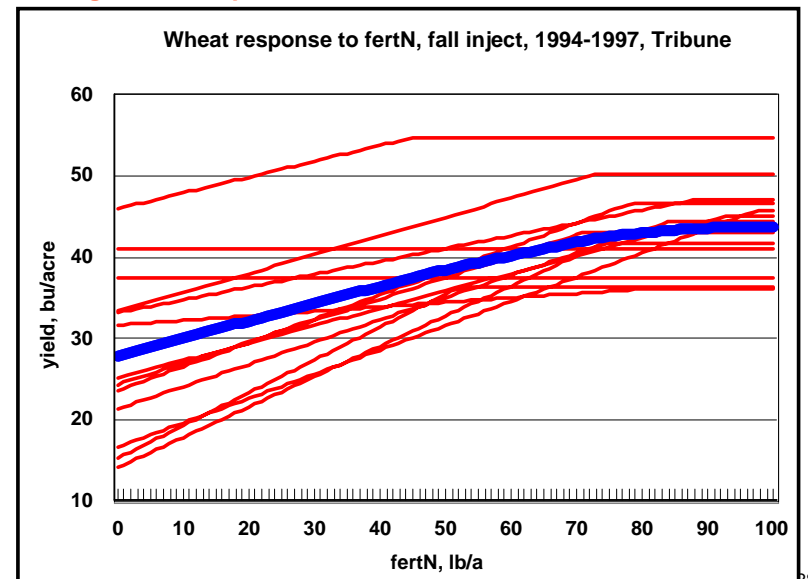


What would yield be for given fertN next year?

Average of linear plateaus can become non-linear...



Average of linear plateaus can become non-linear...

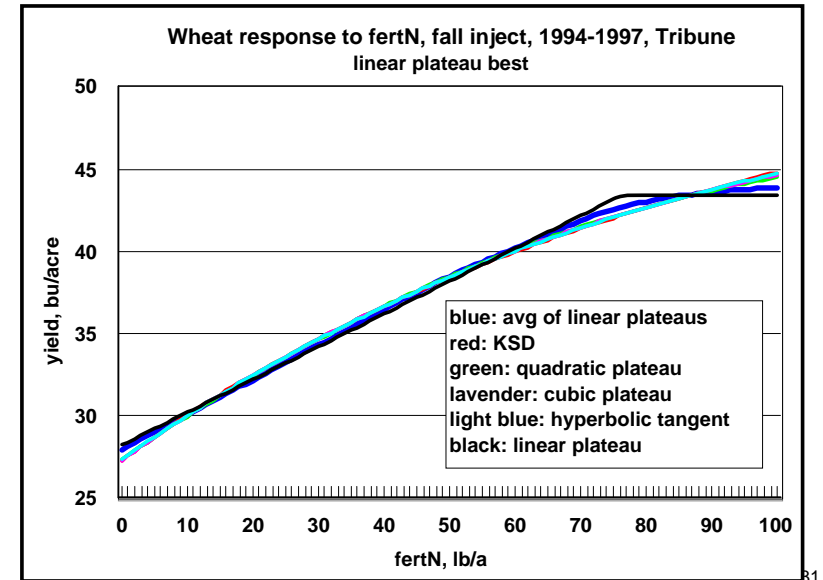


Blue line is NOT based on a mathematical function

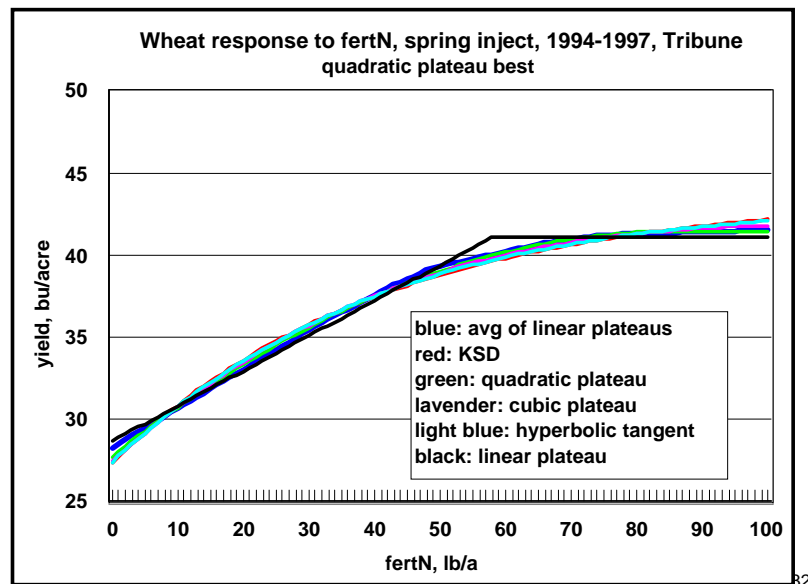
Functional form...

- Numerous functional forms could be used that would meet objectives. We considered:
 - Linear plateau, along with four different curvilinear forms
- Most non-linear models “look” very similar, but results (i.e., optimal N versus N price) do vary

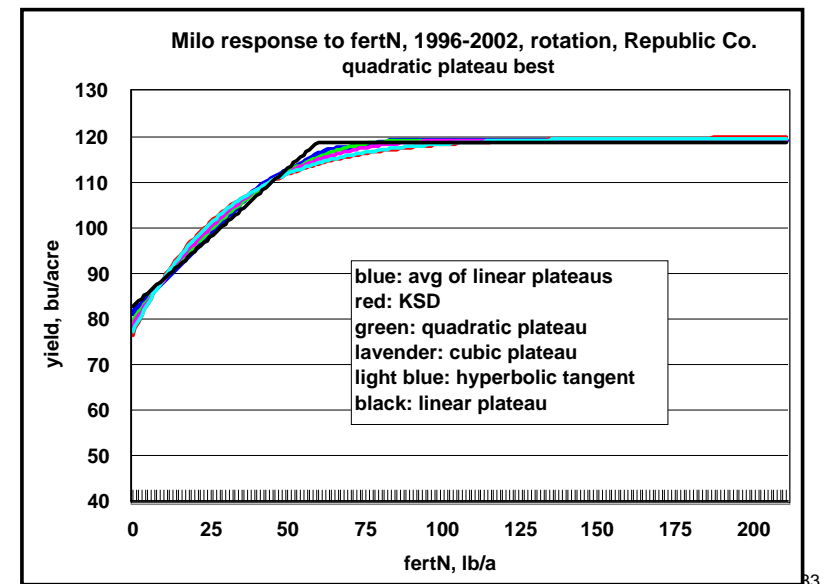
Here, a linear plateau fit blue line the best



Here, a quadratic plateau fit blue line the best



Here, a quadratic plateau fit blue line the best



Back to the Belleville milo data

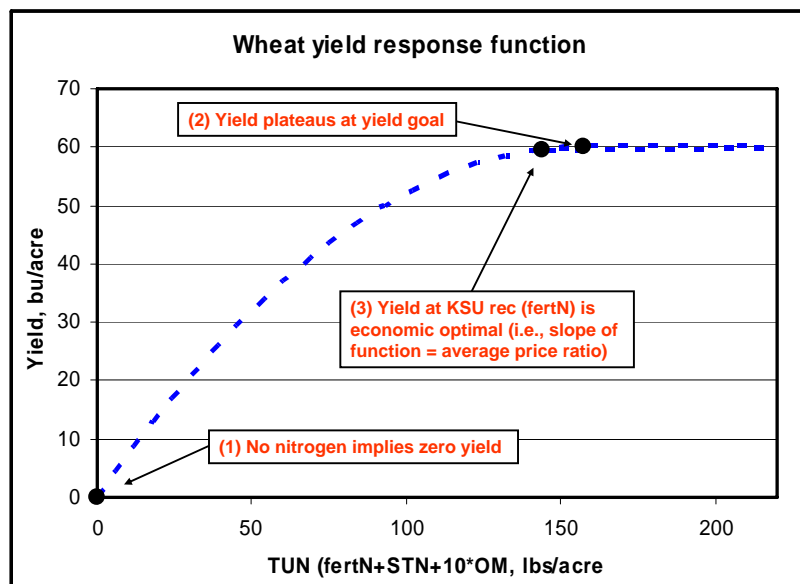
Functional form...

- 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**

Nitrogen production function...

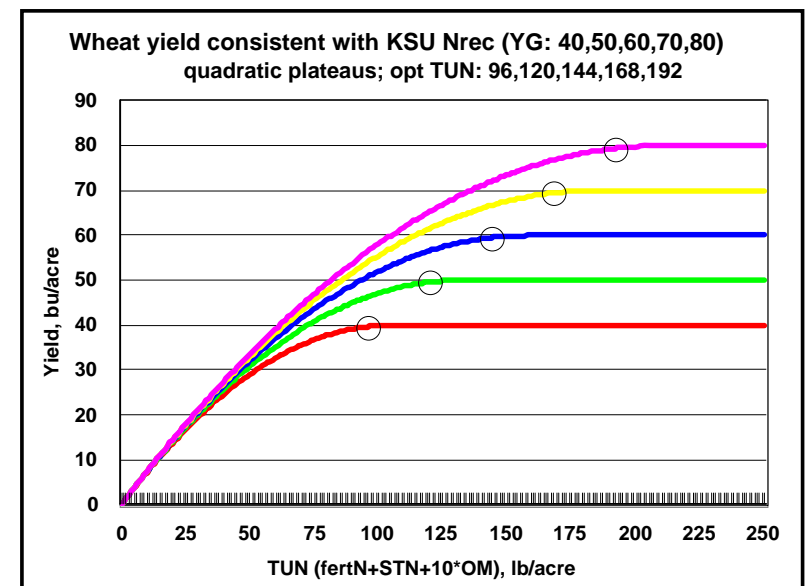
- Nice property of non-linear production function is that it implies diminishing marginal returns and thus prices matter
- Assumed functional form is quadratic plateau which allows diminishing returns – consistent with linear plateau in any given year
- Estimate model parameters such that
 - KSU Nrec 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...



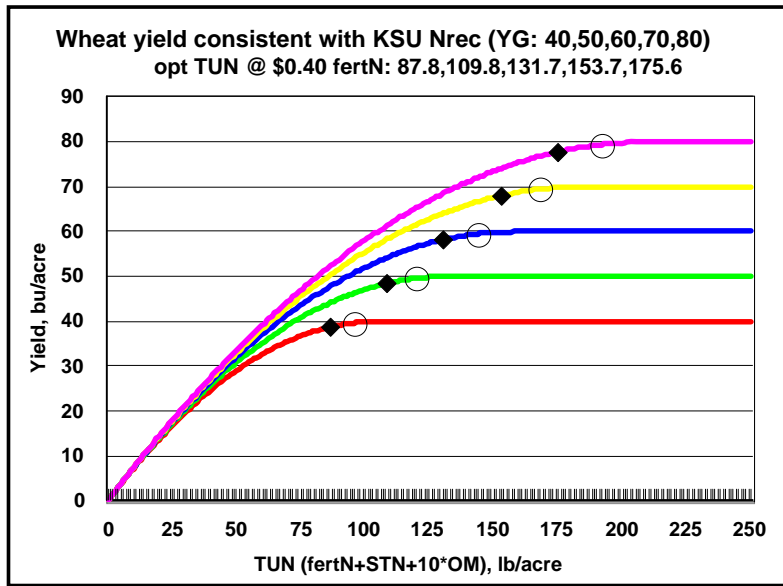
36

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



37

Slope at diamonds is 0.40/3.20



With more expensive N, you make more money by applying less

38

	Wheat	Corn	Sorghum	Soybean	Sunflower	Alfalfa
Yield goal (YG), bu/ac	50.0	120.0	100.0	36.0	1800.0	4.5
Enter 0 for dryland or 1 for irrigated	0	0	0	0	0	0
Annual rainfall	26.0	26.0	26.0	26.0	26.0	26.0
Organic matter (OM), %	2.00	2.00	2.00	2.00	2.00	2.00
Soil test nitrogen (STN), lbs/ac	10.0	10.0	10.0	10.0	10.0	10.0
Other N adjustments, lbs/ac	0.0	0.0	0.0	0.0	0.0	0.0
Nitrogen fertilizer cost, \$/lb	\$0.500	\$0.500	\$0.500	\$0.500	\$0.500	\$0.500
Irrigation energy cost, \$/inch	\$3.00	\$3.00	\$3.00	\$3.00	\$3.00	\$3.00
KSU recommended nitrogen, lbs/ac	90.0	142.0	110.0	0.0	85.0	---
Econ Optimum fertN, lbs/ac	92.2	139.1	108.5	0.0	83.0	---
Econ Optimum Irrigation Amount, in	0.0	0.0	0.0	0.0	0.0	---
Yield at optimal N and I, bu/ac	49.8	119.0	99.0			
INCOME PER ACRE						
A. Yield per acre	49.8	119.0	99.0	32.4	1,787.3	4.1
B. Price per unit	\$9.50	\$4.75	\$4.50	\$10.00	\$0.2400	\$85.00
C. Net government payments	\$15.00	\$15.00	\$15.00	\$15.00	\$15.00	\$15.00
D. Indemnity payments	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
E. Miscellaneous income	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
F. Returns/acre ((A x B) + C + D + E)	\$487.73	\$580.25	\$460.71	\$339.00	\$443.95	\$359.25

Adjustments to KSU Nrecs at various wheat and N prices

Nitrogen Recommendations for Wheat										
		Wheat price, \$/bu				Wheat price, \$/bu				
Yield goal, bu/ac		45				60				
KSU N rec, lbs/ac*		78				114				
N price \$/lb		Price adjusted N rec, lbs/ac				Price adjusted N rec, lbs/ac				
		\$2.50	\$3.00	\$3.50	\$4.00	\$4.50	\$2.50	\$3.00	\$3.50	\$4.00
\$0.40	63	67	70	73	74	94	100	104	107	109
\$0.45	60	65	68	71	73	90	97	101	104	107
\$0.50	57	62	66	69	71	86	93	96	102	105
\$0.55	54	60	64	67	69	82	90	95	99	102
\$0.60	51	57	62	65	67	78	86	92	97	100
N price		Price adjusted N rec reduction				Price adjusted N rec reduction				
\$0.40	18.8%	13.5%	9.7%	6.8%	4.6%	17.1%	12.3%	8.8%	6.2%	4.2%
\$0.45	22.8%	16.8%	12.5%	9.3%	6.8%	20.8%	15.3%	11.4%	8.5%	6.2%
\$0.50	26.7%	20.1%	15.4%	11.8%	9.1%	24.4%	18.3%	14.0%	10.8%	8.3%
\$0.55	30.7%	23.4%	18.2%	14.3%	11.3%	28.0%	21.4%	16.6%	13.0%	10.3%
\$0.60	34.7%	26.7%	21.1%	16.8%	13.5%	31.7%	24.4%	19.2%	15.3%	12.3%

Soil organic matter (SOM)=2.0; Soil test nitrogen (STN)=10; Other N adjustment=0
* Based on formulas reported in Soil Test Interpretations and Fertilizer Recommendations (MF-2586)

Adjustments to KSU Nrecs at various wheat and N prices

Nitrogen Recommendations for Wheat										
Yield goal, bu/ac					60					
KSU N rec, lbs/ac*					114					
N price \$/lb	Wheat price, \$/bu				Wheat price, \$/bu					
	\$8.00	\$8.50	\$9.00	\$9.50	\$8.00	\$8.50	\$9.00	\$9.50	\$10.00	
	Price adjusted N rec, lbs/ac				Price adjusted N rec, lbs/ac					
\$0.40	80	81	81	82	82	117	118	118	119	119
\$0.45	79	80	80	81	81	116	117	117	118	118
\$0.50	78	79	80	80	80	115	115	116	117	117
\$0.55	78	78	79	79	80	113	114	115	116	116
\$0.60	77	77	78	78	79	112	113	114	115	115
N price	Price adjusted N rec reduction				Price adjusted N rec reduction					
\$0.40	-3.1%	-3.7%	-4.2%	-4.7%	-5.1%	-2.8%	-3.4%	-3.8%	-4.3%	-4.7%
\$0.45	-1.9%	-2.5%	-3.1%	-3.6%	-4.1%	-1.7%	-2.3%	-2.8%	-3.3%	-3.7%
\$0.50	-0.6%	-1.4%	-2.0%	-2.6%	-3.1%	-0.6%	-1.2%	-1.8%	-2.4%	-2.8%
\$0.55	0.6%	-0.2%	-0.9%	-1.5%	-2.1%	0.6%	-0.2%	-0.8%	-1.4%	-1.9%
\$0.60	1.9%	1.0%	0.2%	-0.5%	-1.1%	1.7%	0.9%	0.2%	-0.4%	-1.0%

Soil organic matter (SOM)=2.0; Soil test nitrogen (STN)=10; Other N adjustment=0
 * Based on formulas reported in *Soil Test Interpretations and Fertilizer Recommendations* (MF-2586)

42

Adjustments to KSU Nrecs at various corn and N prices

Nitrogen Recommendations for Corn										
Yield goal, bu/ac					125					
KSU N rec, lbs/ac*					150					
N price \$/lb	Corn price, \$/bu				Corn price, \$/bu					
	\$3.25	\$3.75	\$4.25	\$4.75	\$5.25	\$3.25	\$3.75	\$4.25	\$4.75	\$5.25
	Price adjusted N rec, lbs/ac				Price adjusted N rec, lbs/ac					
\$0.40	66	68	69	71	71	144	147	149	151	152
\$0.45	64	67	68	69	70	141	144	147	149	151
\$0.50	63	65	67	68	69	138	142	145	147	149
\$0.55	61	64	65	67	68	135	139	142	145	147
\$0.60	59	62	64	66	67	132	137	140	143	145
N price	Price adjusted N rec reduction				Price adjusted N rec reduction					
\$0.40	5.4%	2.8%	0.8%	-0.8%	-2.1%	4.2%	2.2%	0.6%	-0.6%	-1.7%
\$0.45	7.9%	4.9%	2.7%	0.9%	-0.6%	6.2%	3.8%	2.1%	0.7%	-0.5%
\$0.50	10.4%	7.1%	4.6%	2.6%	0.9%	8.1%	5.5%	3.5%	2.0%	0.7%
\$0.55	12.9%	9.2%	6.5%	4.3%	2.5%	10.0%	7.2%	5.0%	3.3%	1.9%
\$0.60	15.4%	11.4%	8.4%	6.0%	4.0%	11.9%	8.9%	6.5%	4.6%	3.1%

Soil organic matter (SOM)=2.0; Soil test nitrogen (STN)=10; Other N adjustment=0
 * Based on formulas reported in *Soil Test Interpretations and Fertilizer Recommendations* (MF-2586)

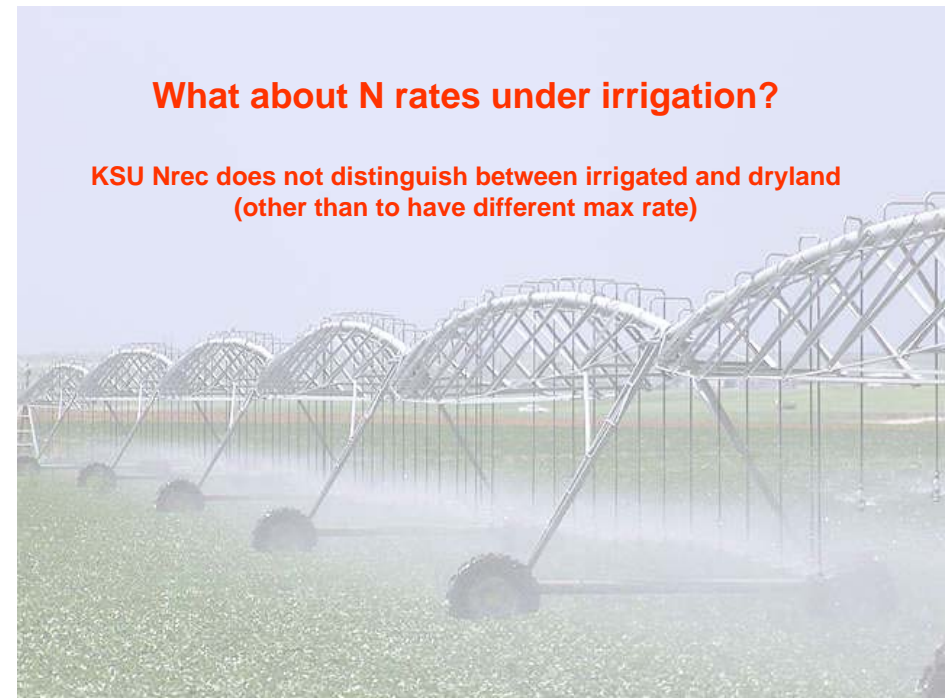
43

Adjustments to KSU Nrecs at various sorghum and N prices

Nitrogen Recommendations for Grain Sorghum										
Yield goal, bu/ac					120					
KSU N rec, lbs/ac*					142					
N price \$/lb	Grain sorghum price, \$/bu				Grain sorghum price, \$/bu					
	\$3.00	\$3.50	\$4.00	\$4.50	\$5.00	\$3.00	\$3.50	\$4.00	\$4.50	\$5.00
	Price adjusted N rec, lbs/ac				Price adjusted N rec, lbs/ac					
\$0.40	74	76	78	80	81	136	140	142	144	146
\$0.45	72	75	77	78	79	133	137	140	142	144
\$0.50	70	73	75	77	78	130	134	138	140	142
\$0.55	68	71	74	75	77	127	132	135	138	140
\$0.60	66	69	72	74	76	124	129	133	136	139
N price	Price adjusted N rec reduction				Price adjusted N rec reduction					
\$0.40	5.0%	2.0%	-0.2%	-2.0%	-3.4%	4.1%	1.7%	-0.2%	-1.7%	-2.8%
\$0.45	7.7%	4.3%	1.7%	-0.2%	-1.8%	6.3%	3.5%	1.4%	-0.2%	-1.5%
\$0.50	10.3%	6.5%	3.7%	1.5%	-0.2%	8.5%	5.4%	3.1%	1.2%	-0.2%
\$0.55	12.9%	8.8%	5.7%	3.3%	1.3%	10.7%	7.2%	4.7%	2.7%	1.1%
\$0.60	15.6%	11.1%	7.7%	5.0%	2.9%	12.8%	9.1%	6.3%	4.1%	2.4%

Soil organic matter (SOM)=2.0; Soil test nitrogen (STN)=10; Other N adjustment=0
 * Based on formulas reported in *Soil Test Interpretations and Fertilizer Recommendations* (MF-2586)

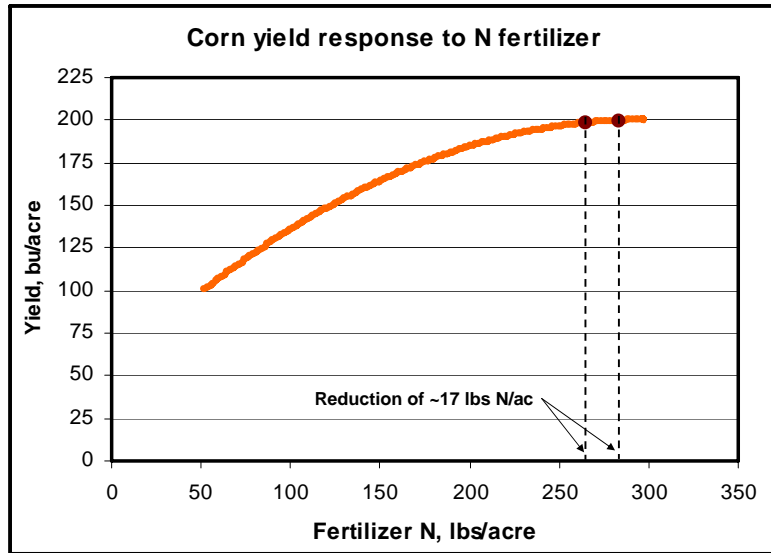
44



What about N rates under irrigation?

**KSU Nrec does not distinguish between irrigated and dryland
(other than to have different max rate)**

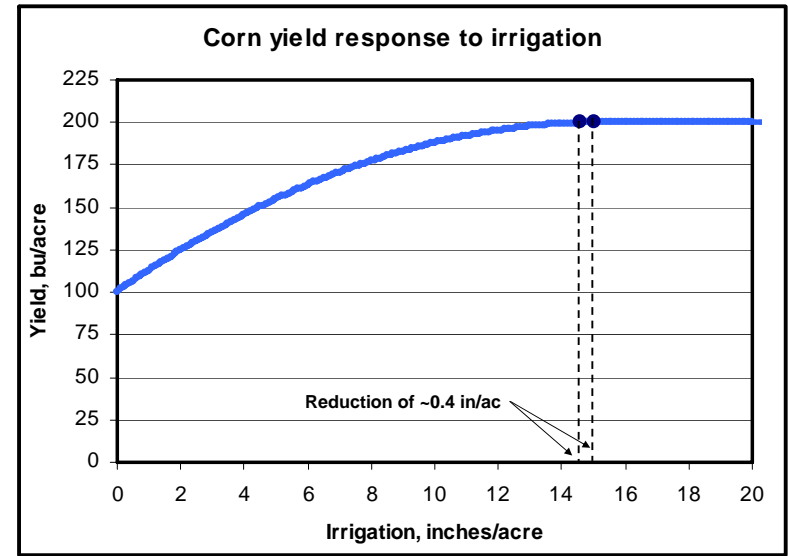
At projected corn prices, change in optimal N is relatively small due to higher N price...



Corn \$4.75/bu; N cost = \$0.21/lb vs. \$0.50/lb

46

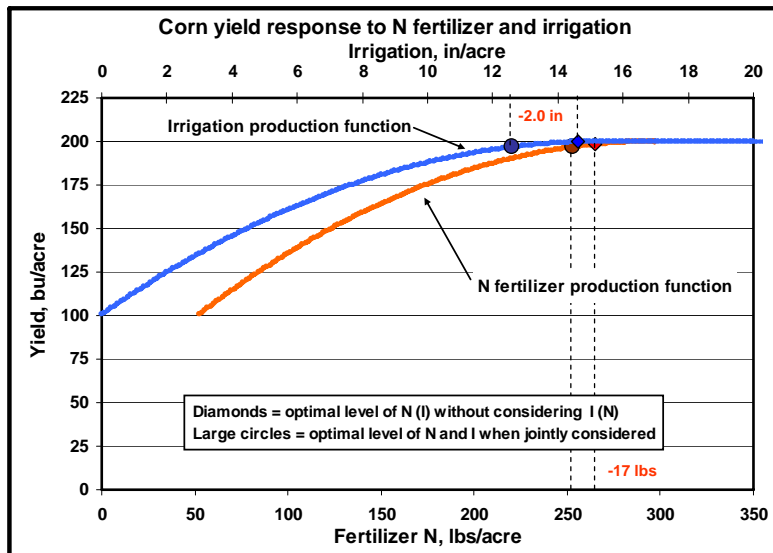
At projected corn prices, change in optimal water is relatively small due to higher pumping costs price...



Corn \$4.75/bu; irrigation cost = \$1.50/in vs. \$3.00/in

47

When considering irrigation and N together, optimal values decrease further...



Corn \$4.75/bu; N \$0.50/lb, irrigation cost = \$3.00/in

48

Microsoft Excel - KSU-CropBudgets2008

Comparison of Crop Returns with Nitrogen Fertilizer and Irrigation Water at Economic Optimum Levels						
Crop/System	Wheat	Corn	Sorghum	Soybean	Sunflower	Alfalfa
Rotation (1 or 2, if none enter 0)	1	1	1	1	1	1
Percent of rotation (total - 100%)	50.0%	10.0%	20.0%	20.0%	0.0%	0.0%
Yield goal (YG), bu/ac	50.0	200.0	100.0	36.0	1800.0	4.5
Enter 0 for dryland or 1 for irrigated	0	1	0	0	0	0
Annual rainfall	26.0	26.0	26.0	26.0	26.0	26.0
Organic matter (OM), %	2.00	2.00	2.00	2.00	2.00	2.00
Soil test nitrogen (STN), lbs/ac	10.0	10.0	10.0	10.0	10.0	10.0
Other N adjustments, lbs/ac	0.0	0.0	0.0	0.0	0.0	0.0
Nitrogen fertilizer cost, \$/lb	\$0.500	\$0.500	\$0.500	\$0.500	\$0.500	\$0.500
Irrigation energy cost, \$/inch	\$3.00	\$3.00	\$3.00	\$3.00	\$3.00	\$3.00
KSU recommended nitrogen, lbs/ac	90.0	270.0	110.0	0.0	85.0	---
Econ Optimum fertN, lbs/ac	92.2	253.1	108.5	0.0	83.0	---
Econ Optimum Irrigation Amount, in	0.0	12.6	0.0	0.0	0.0	---
Yield at optimal N and I, bu/ac	49.8	196.8				
INCOME PER ACRE						
A. Yield per acre	49.8	196.8				
B. Price per unit	\$9.50	\$4.75				
C. Net government payments	\$15.00	\$15.00				
D. Indemnity payments	\$0.00	\$0.00				
E. Miscellaneous income	\$0.00	\$0.00				
F. Returns/acre ((A x B) + C + D + E)	\$487.73	\$949.87				

If irrigation energy cost (i.e., the \$3.00/inch) were ignored, the economic optimal fertN rate would be 265.9 lbs/ac.

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
- Even with N prices near historical highs, economic optimal N rates for 2008 dryland crops are nearly identical to KSU N recs due to strong crop prices

50

Summary ...

- Optimal N rates for irrigated fields is slightly lower than KSU N recs (5-10%) due to high pumping costs as well as high N prices
- Nitrogen fertilizer and irrigation production functions have been estimated and embedded within the *KSU-CropBudgets2006.xls* spreadsheet that allow producers to determine optimal N rates for their own farms/fields
- Fertilizer prices are high so good management regarding soil fertility program is critical, but this does not necessarily mean reducing fertilizer rates

51



The screenshot shows a web browser window displaying the AgManager website. The browser's address bar shows the URL www.agmanager.info. The website header includes the AgManager logo and navigation links such as "About", "Contributors", "Useful links", "Site map", and "Feedback". A search bar is also present. The main content area features a central graphic with the text "A Website Providing Information and Tools For The Competitive Business" and "www.agmanager.info". Below this graphic, the text "Questions?" is displayed above the MAST logo. On the right side of the page, there is a "Site Updates" section listing various articles and reports with their dates and authors, including "Crop Insurance Price History", "Current Grain Outlook Newsletter", "Grain Outlook Radio Program", "World Grain Supply and Demand Estimates (IWASDE)", "Crop Basis Maps", "Updated Crop Basis Tool", "Kansas Grain Price Spread-Transportation Returns", "In The Cattle Markets", "Livestock Outlook Radio Program", "Futures-Based Price Forecasts for Diesel Fuel", "Livestock and Hay Charts", "KAMA Monthly Newsletter", "Economics of Bio-Energy Growth in Kansas", "Cropland Leasing Principles and Legal Issues in Kansas", "Farmland Values and Rental Rates in Northwest Kansas", "Grain Outlook Presentation - Ag Profitability conference", and "Insurance Workshop Video".