Adjusting Irrigation and N Rates for High Energy and Fertilizer Costs

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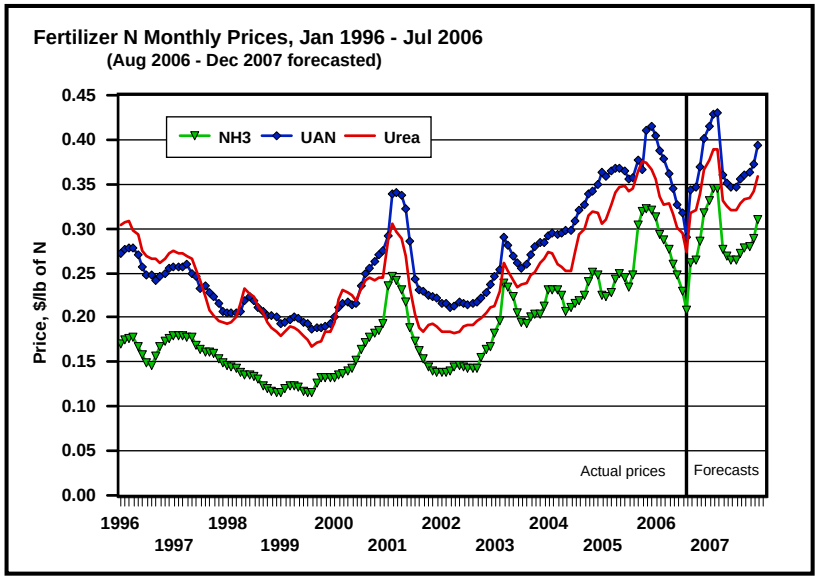
Historical and forecasted nitrogen prices, Corn Belt



Prices have been falling throughout 2006, unfortunately forecasts suggest prices could increase back to previous highs.

Forecasted N fertilizer prices are at historically high levels…

Nitrogen Fertilizer Prices, Corn Belt

	Nitrogen Source / Time Period							
	NH3 (82%)		UAN (32%)		Urea (46%)		Weighted	
Year	Oct-Dec	Feb-Apr	Oct-Dec	Feb-Apr	Oct-Dec	Feb-Apr	Average*	% chg
1999/00	$0.132	$0.138	$0.191	$0.215	$0.181	$0.226	$0.176	-----
2000/01	$0.187	$0.240	$0.269	$0.338	$0.243	$0.297	$0.256	45.5%
2001/02	$0.141	$0.141	$0.224	$0.213	$0.191	$0.184	$0.177	-31.0%
2002/03	$0.162	$0.223	$0.229	$0.275	$0.206	$0.248	$0.219	24.1%
2003/04	$0.207	$0.228	$0.282	$0.294	$0.259	$0.263	$0.251	14.3%
2004/05	$0.246	$0.231	$0.343	$0.364	$0.316	$0.325	$0.296	18.1%
2005/06	$0.321	$0.285	$0.396	$0.376	$0.372	$0.330	$0.341	15.0%
2006/07 F	$0.289	$0.322	$0.372	$0.406	$0.342	$0.369	$0.344	1.0%
06/07 - 05/06	($0.032)	$0.037	($0.024)	$0.030	($0.030)	$0.040	$0.003	1.0%
06/07 - Avg(99/04)	$0.123	$0.128	$0.190	$0.198	$0.126	$0.126	$0.128	59.4%

* Weighted average based on 40% NH3, 25% UAN, and 35% Urea split equally between Oct-Dec and Feb-Apr

F = forecast

Forecasted crop prices are at recent highs…

Harvest Crop Prices, Kansas^

Year	Wheat	Corn	Sorghum	Soybeans
2000	$2.59	$1.70	$1.68	$4.45
2001	$2.72	$1.90	$1.79	$4.11
2002	$3.14	$2.57	$2.46	$5.20
2003	$2.79	$2.14	$2.14	$6.87
2004	$3.41	$1.90	$1.72	$4.83
2005	$3.12	$1.71	$1.60	$5.30
2006 F	$4.75	$2.35	$2.40	$5.45
2007 F	$4.48	$2.92	$2.80	$6.07
2007 - 2006	($0.28)	$0.57	$0.39	$0.62
2007 - Avg(00/04)	$1.55	$0.88	$0.84	$0.97

^ Average of Colby, Scott City, Beloit, Hutchinson, Emporia, and Topeka

F = forecast (wheat in 2006 is an actual price) where 2006 forecasts are based on forward bids and 2007 forecasts are based on futures adjusted for basis).

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

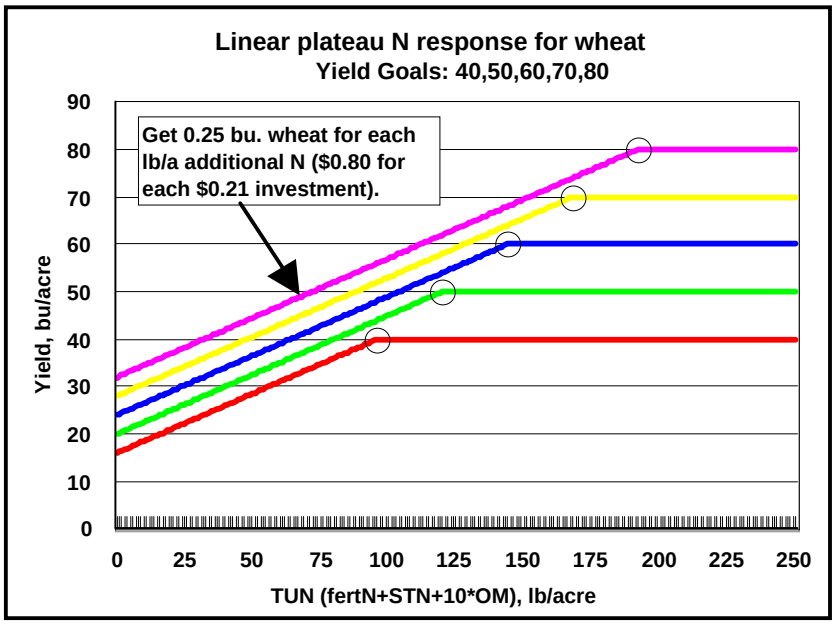
N rec = (Yield Goal x 0.075) – (%SOM x 20) – Profile N – Manure N – Other N Adjustments
+ Previous Crop Adjustments

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

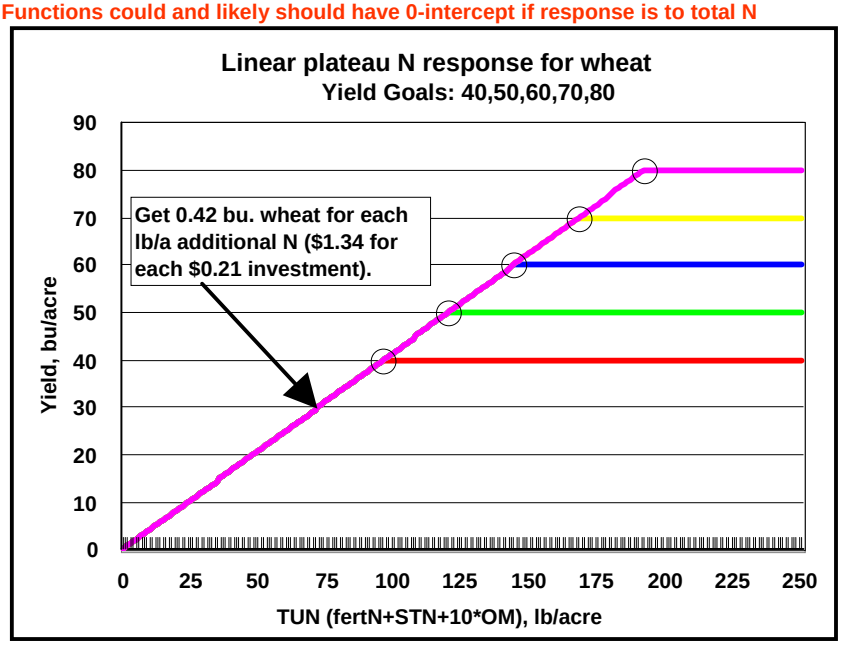
Nitrogen production function…

- 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



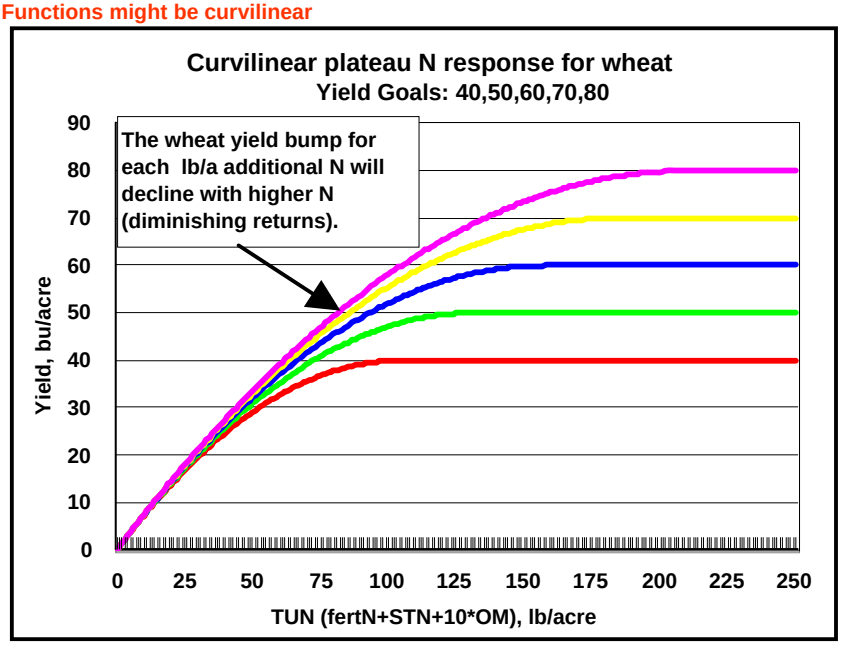
Price won't matter until fertN = $0.80/lb, then optimal is 0 lb/acre

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



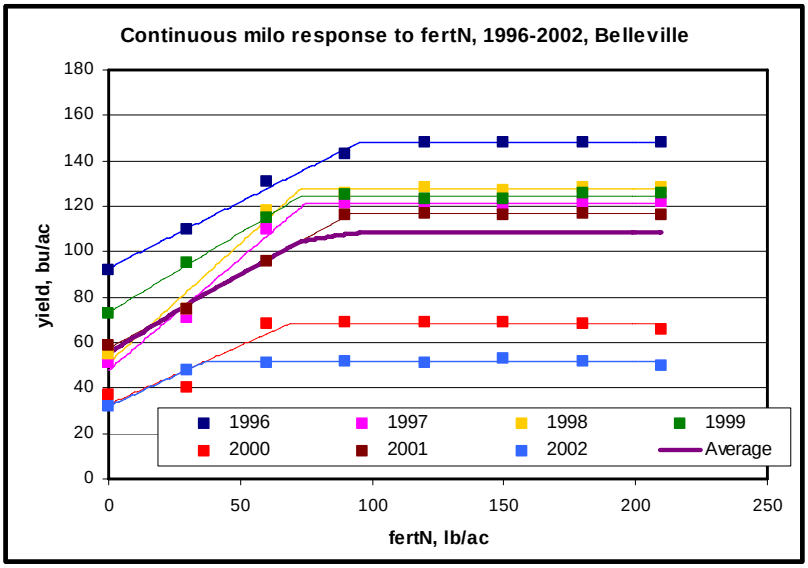
Price won't matter until fertN = $1.34/lb, then optimal is 0 lb/acre

Functions might be curvilinear



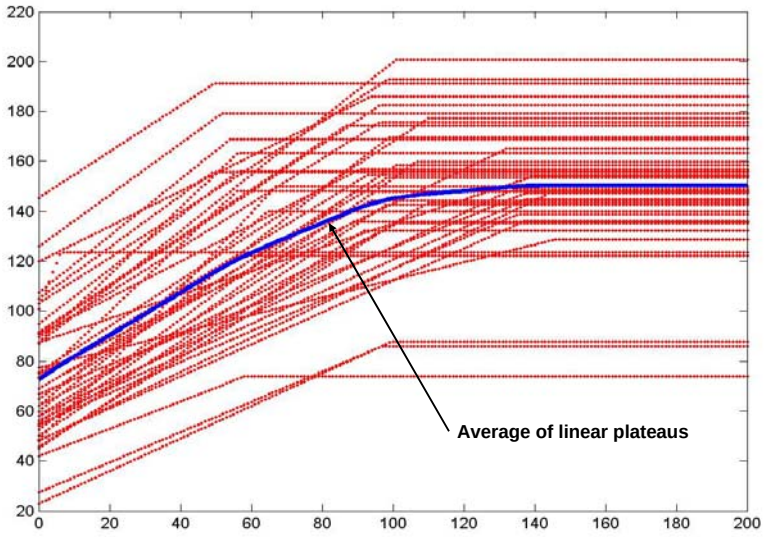
Fertilizer N research in late 2005
Kastens, Dhuyvetter, Schlegel, and Dumler

Yield response by year – linear plateau "fits" data quite well…



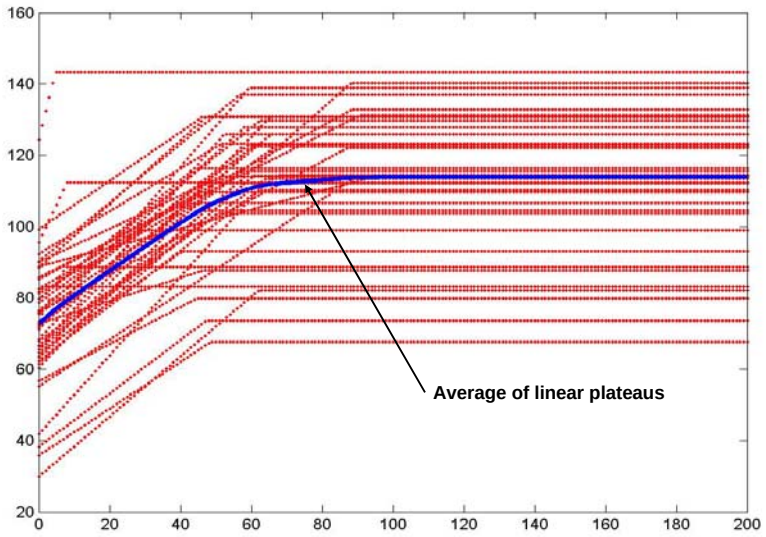
… average (expectation) of linear plateaus can become non-linear.

Tribune corn (1961-2004)



The more years included, the "smoother" the average of the linear plateaus becomes…

Tribune milo (1961-2004)



The more years included, the "smoother" the average of the linear plateaus becomes…

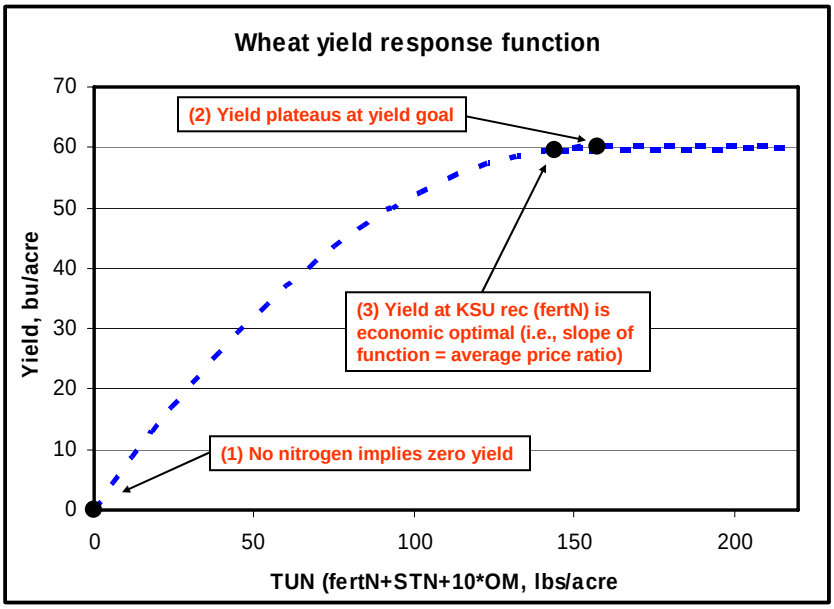
Functional form…

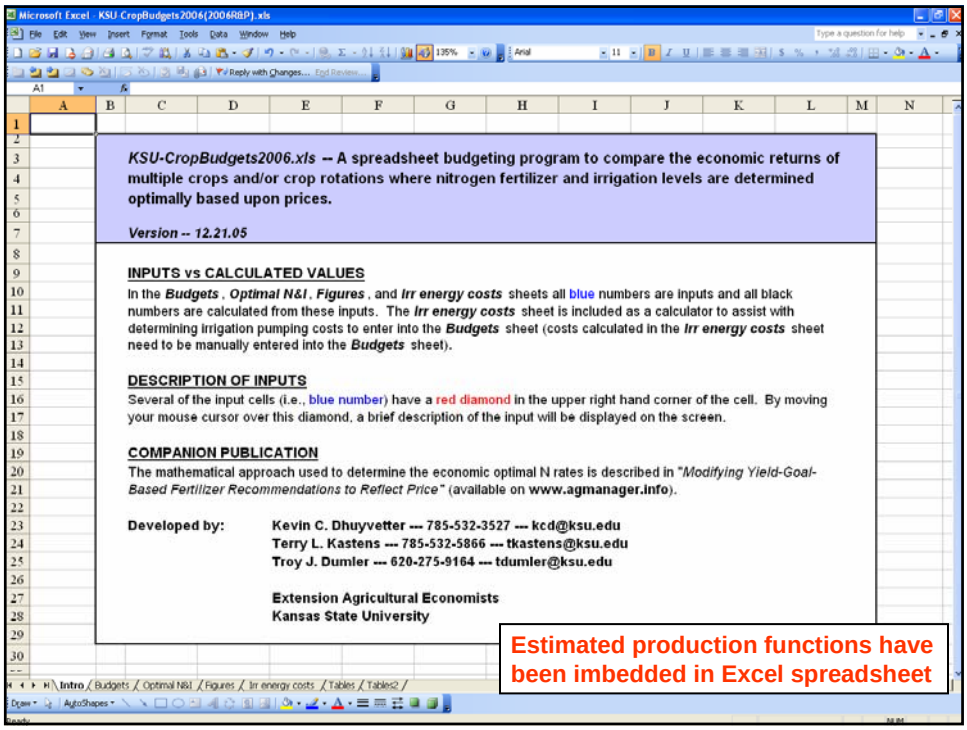
- Numerous functional forms could be used that would meet objectives. We considered:
  - Linear plateau, along with four different curvilinear forms
- Based on nitrogen fertilizer research studies from north central and western Kansas on wheat, corn, and milo, quadratic plateau model fit data better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

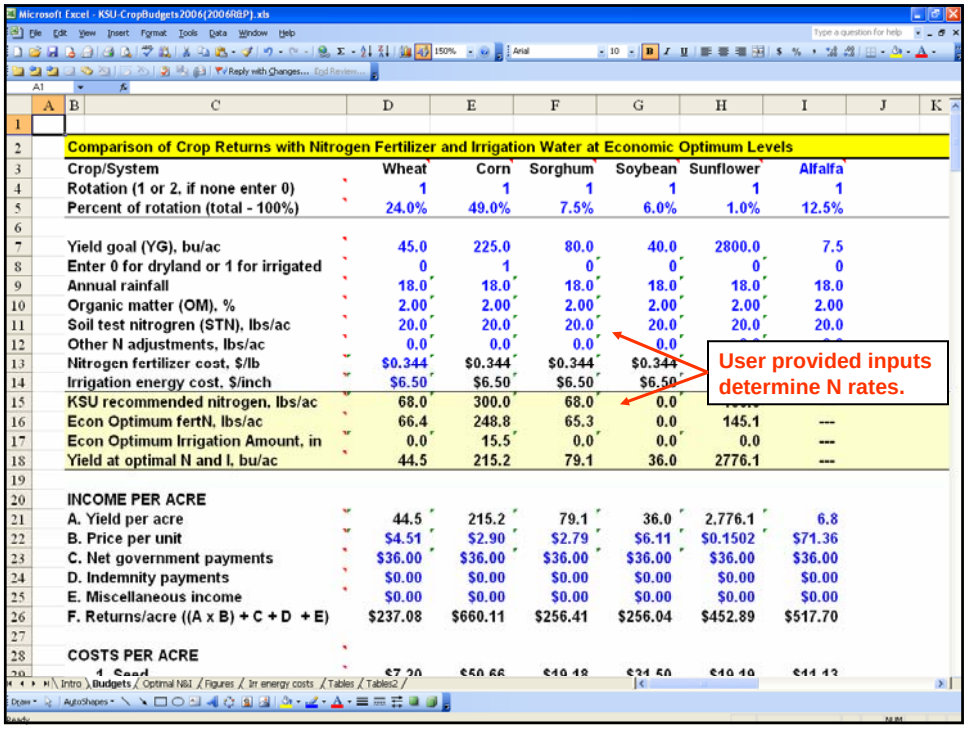
Nitrogen production function…

- 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…







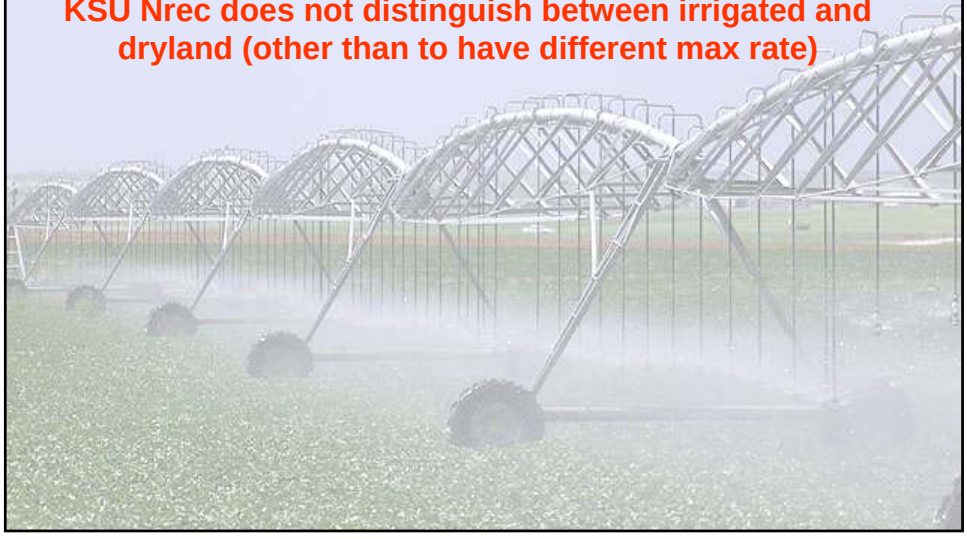
Comparison of Crop Returns with Nitrogen Fertilizer and Irrigation Water at Economic Optimum Levels

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%)	24.0%	49.0%	7.5%	6.0%	1.0%	12.5%
Yield goal (YG), bu/ac	45.0	225.0	80.0	40.0	2800.0	7.5
Enter 0 for dryland or 1 for irrigated	0	1	0	0	0	0
Annual rainfall	18.0	18.0	18.0	18.0	18.0	18.0
Organic matter (OM), %	2.00	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	20.0
Other N adjustments, lbs/ac	0.0	0.0	0.0	0.0		
Nitrogen fertilizer cost, $/lb	$0.344	$0.344	$0.344	$0.344		
Irrigation energy cost, $/inch	$6.50	$6.50	$6.50	$6.50		
KSU recommended nitrogen, lbs/ac	68.0	300.0	68.0	0.0		
Econ Optimum fertN, lbs/ac	66.4	248.8	65.3	0.0	145.1	---
Econ Optimum Irrigation Amount, in	0.0	15.5	0.0	0.0	0.0	---
Yield at optimal N and I, bu/ac	44.5	215.2	79.1	36.0	2776.1	---
INCOME PER ACRE						
A. Yield per acre	44.5	215.2	79.1	36.0	2,776.1	6.8
B. Price per unit	$4.51	$2.90	$2.79	$6.11	$0.1502	$71.36
C. Net government payments	$36.00	$36.00	$36.00	$36.00	$36.00	$36.00
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)	$237.08	$660.11	$256.41	$256.04	$452.89	$517.70
COSTS PER ACRE						

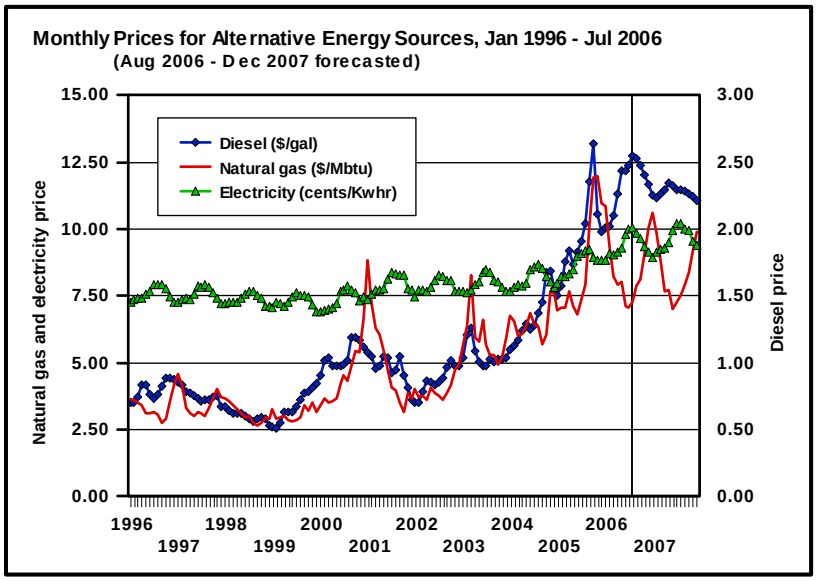
User provided inputs determine N rates.

What about N rates under irrigation?

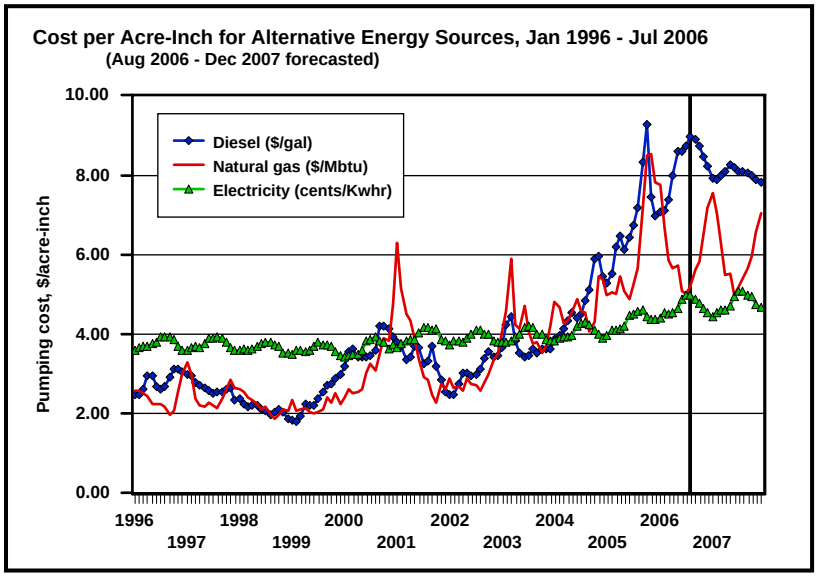
KSU Nrec does not distinguish between irrigated and dryland (other than to have different max rate)



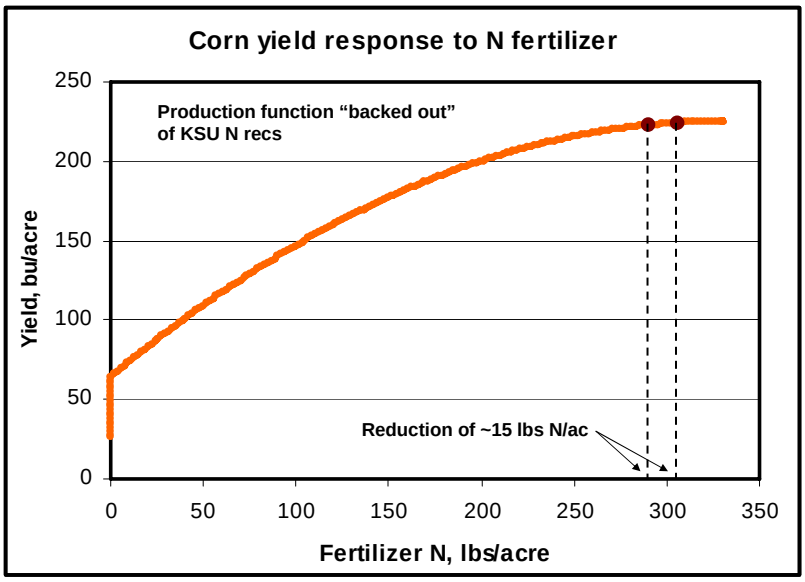
Historical and forecasted energy prices



Rising energy prices imply irrigation pumping costs have been increasing significantly…

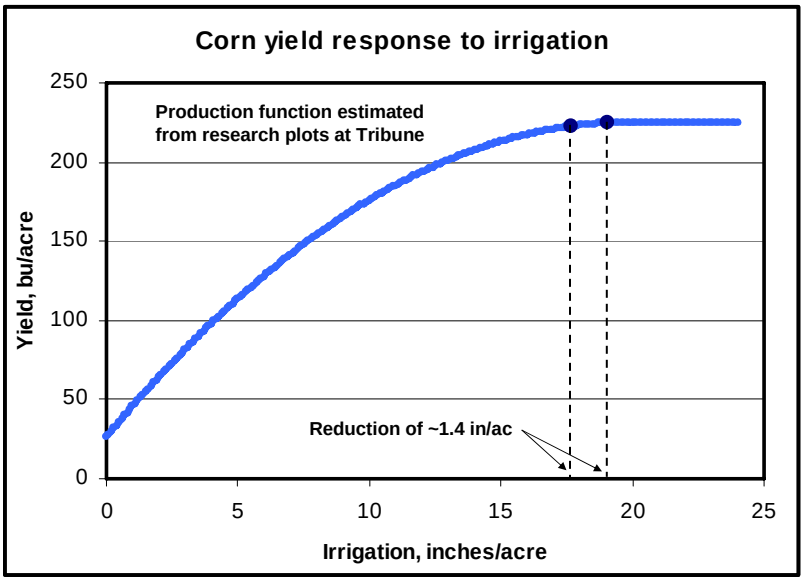


At projected corn prices, change in optimal N is relatively small due to higher N price…



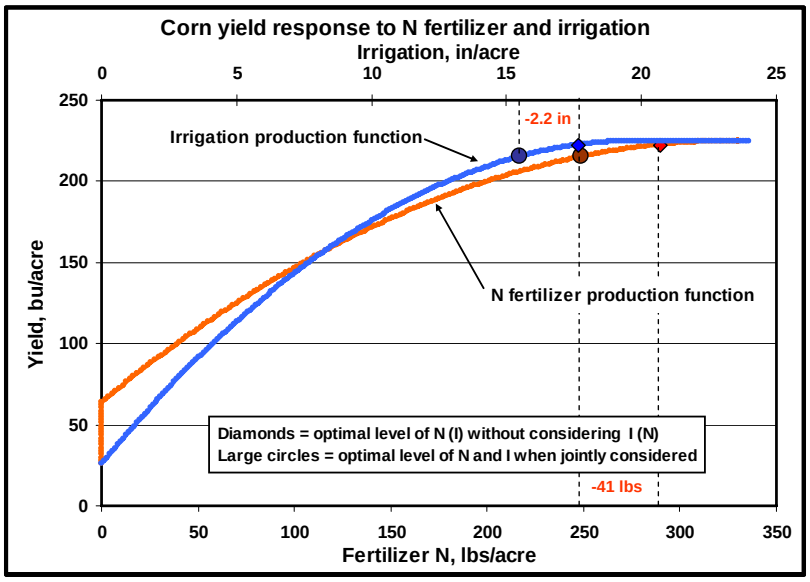
Corn $2.90/bu; N cost = $0.21/lb vs. $0.344/lb

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



Corn $2.90/bu; irrigation cost = $2.50/in vs. $6.50/in

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



Corn $2.90/bu; N $0.344/lb, irrigation cost = $6.50/in

Adjustments to KSU Nrecs at various corn and N prices

Nitrogen Recommendations for Irrigated Corn

Yield goal, bu/ac			225					225		
KSU N rec, lbs/ac*			300					300		
Irrigation pumping cost, $/ac-in			$2.50					$6.50		
N price	Corn price, $/bu					Corn price, $/bu				
$/lb	$2.00	$2.30	$2.60	$2.90	$3.20	$2.00	$2.30	$2.60	$2.90	$3.20
	Price adjusted N rec, lbs/ac					Price adjusted N rec, lbs/ac				
$0.20	273	280	286	291	295	236	249	258	265	271
$0.25	265	273	280	286	289	229	241	253	260	267
$0.30	256	265	273	280	284	219	234	245	254	262
$0.35	249	258	267	273	278	212	227	240	249	256
$0.40	240	251	260	267	273	203	219	232	243	251
N price										
	Price adjusted N rec reduction					Price adjusted N rec reduction				
$0.20	9.1%	6.6%	4.8%	2.9%	1.7%	21.4%	17.1%	14.0%	11.5%	9.7%
$0.25	11.5%	9.1%	6.6%	4.8%	3.5%	23.8%	19.5%	15.8%	13.4%	10.9%
$0.30	14.6%	11.5%	9.1%	6.6%	5.4%	26.9%	22.0%	18.3%	15.2%	12.8%
$0.35	17.1%	14.0%	10.9%	9.1%	7.2%	29.3%	24.4%	20.1%	17.1%	14.6%
$0.40	20.1%	16.4%	13.4%	10.9%	9.1%	32.4%	26.9%	22.6%	18.9%	16.4%

Soil organic matter (SOM)=2.0; Soil test nitrogen (STN)=20; Other N adjustment=0

* Based on formulas reported in *Soil Test Interpretations and Fertilizer Recommendations* (MF-2586)

Adjustments to KSU Nrecs at various corn and N prices*

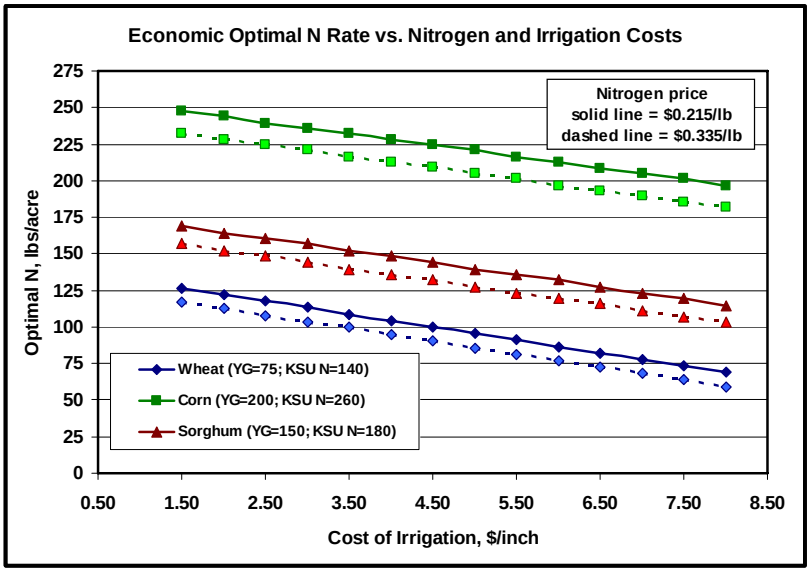
Nitrogen Recommendations for Corn

Yield goal, bu/ac			175					225		
KSU N rec, lbs/ac*			220					300		
N price	Corn price, $/bu					Corn price, $/bu				
$/lb	$2.00	$2.30	$2.60	$2.90	$3.20	$2.00	$2.30	$2.60	$2.90	$3.20
	Price adjusted N rec, lbs/ac					Price adjusted N rec, lbs/ac				
$0.20	217	221	223	225	227	296	301	304	307	309
$0.25	211	215	218	221	223	288	293	298	301	304
$0.30	204	209	213	216	219	279	286	291	295	299
$0.35	197	203	208	212	215	271	279	285	289	293
$0.40	191	198	203	207	211	263	271	278	284	288
N price										
	Price adjusted N rec reduction					Price adjusted N rec reduction				
$0.20	1.3%	-0.3%	-1.5%	-2.4%	-3.2%	1.2%	-0.3%	-1.4%	-2.3%	-3.0%
$0.25	4.3%	2.3%	0.8%	-0.4%	-1.3%	4.0%	2.2%	0.8%	-0.4%	-1.3%
$0.30	7.3%	4.9%	3.1%	1.7%	0.5%	6.8%	4.6%	2.9%	1.6%	0.5%
$0.35	10.2%	7.5%	5.4%	3.7%	2.4%	9.7%	7.1%	5.1%	3.5%	2.3%
$0.40	13.2%	10.1%	7.7%	5.8%	4.3%	12.5%	9.5%	7.3%	5.5%	4.0%

Soil organic matter (SOM)=2.0; Soil test nitrogen (STN)=20; Other N adjustment=0
* Based on formulas reported in *Soil Test Interpretations and Fertilizer Recommendations* (MF-2586)

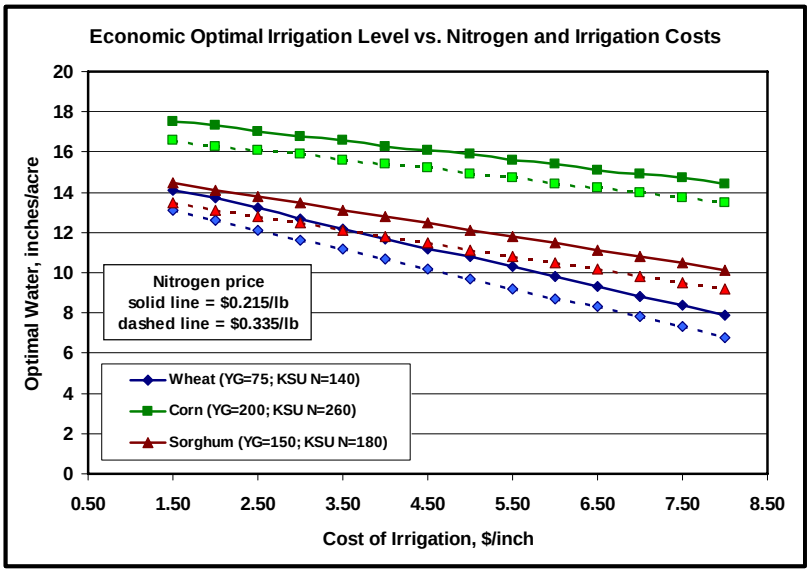
*** Optimal rates do not consider irrigation pumping costs**

Optimal N rate…



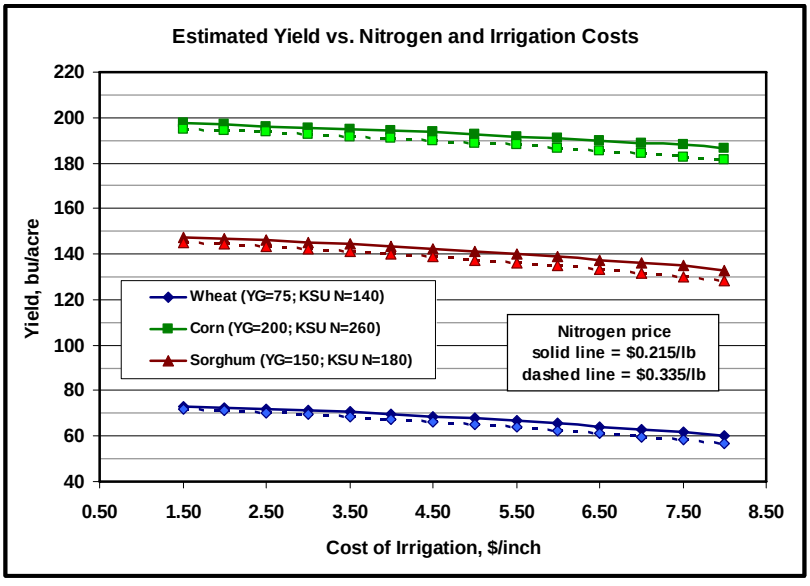
Increase in NUE = 29.6%, 14.3%, 21.7% for wheat, corn, and sorghum, respectively. ($3/ac-in & $0.215/lb N prices ➔ $6/ac-in & $0.335/lb N)

Optimal irrigation rate…



Increase in IWUE = 28.0%, 11.2%, 19.3% for wheat, corn, and sorghum, respectively.
($3/ac-in & $0.215/lb N prices ➔ $6/ac-in & $0.335/lb N)

Estimated yield…



Summary …

- In order to adjust fertN (irrigation) rates in response to prices, a mathematical relationship between N (water) and yield is needed.
- Quadratic-plateau function allows diminishing returns, but is also consistent with linear plateau within any site-year. A quadratic-plateau function can be "backed out" of KSU N recs.
- Even with N prices at historical highs, economic optimal N rates for 2007 dryland crops are only slightly less (2-5%) than KSU N recs due to strong crop prices. However, optimal N rates for irrigated fields are considerably lower than KSU N recs (10-20%) due to high pumping costs as well as high N prices.
- Nitrogen fertilizer and irrigation production functions have been estimated and imbedded within the *KSU-CropBudgets2006.xls* spreadsheet that allow producers to determine optimal N rates for their own farms/fields.