Variable Rate (fertilizer) Economics

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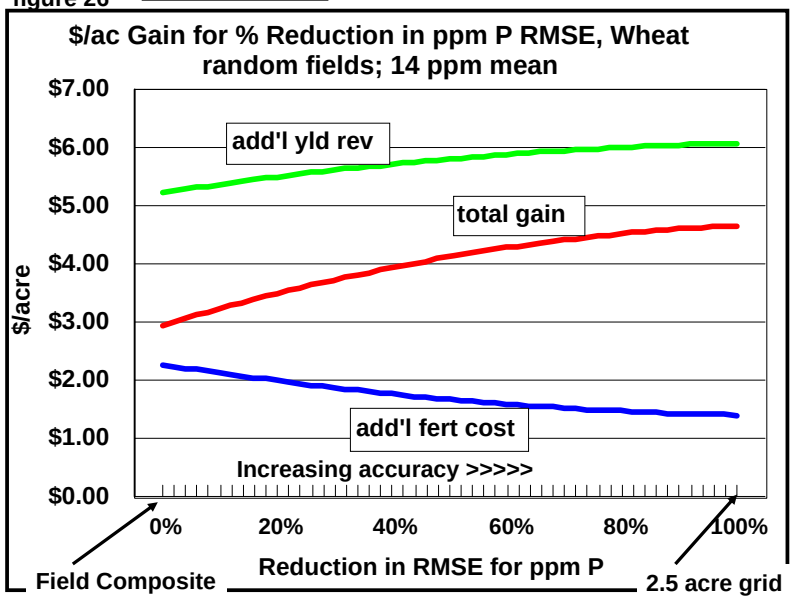
We have been involved for years

- Considerable amount of original research
  - But also reported on work of others
- Nutrients: N, P, K, Lime
- Scale: big fields and little fields (grid/zone mgt)
- We've argued with everyone
  - Agronomists
  - Engineers
  - Other economists
  - Farmers
  - Often ourselves (when no one else would argue with us)
- Many unexpected nuggets along the way . . .
- Motivation:
  - Others just aren't "getting it"
  - We're just not "getting it"

Oh, no. Another trip down memory lane.
. . . you got it.

figure 26 January 1999



Accuracy matters, but will it matter enough to overcome cost of acquisition?

January 2000

Conclusions

- basing fertilizer decisions on farm or site-specific data demands more complex response functions
- P-response function considerations
  - treat fertP and STP as substitutes
  - consider buildup over time
  - should consider dynamic models along with discounting
  - operator time horizon matters
  - in short horizons the steady-state path is not optimal
- site-specific P management for study farm
  - breakeven at best at the 2.5 acre scale
  - easy to justify at some scale

There is a scale at which VRA will pay, but perhaps not the one we envisioned.

August 2000

Crude Generalizations from FICPA

1. No current precision ag activities (typically agronomic ones) stand out as being extremely profitable
2. Despite years of research, returns to VRT N are likely to be small or non-existent
   - Will be a tagalong activity
   - Better yield goals would help
   - Sugar beets are an exception
   - Pollution concerns are an exception
3. Yield-goal research has died down
   - Are yield goals merely a holdover of old ways?

1 and 2 still true; 3 was not quite right – yield goals still quite important to N recommendations

August 2000

Crude Generalizations from FICPA

4. Remote sensing is the hot topic (64 studies)
   - Spatially dense, low cost per data point
   - Multiple images during the year
   - Non-invasive (don't have to go to field)
   - Notable profits haven't surfaced
   - Geo-rectification and registerin
5. Electrical soil conductivity se
   - Spatially dense, low cost per da
   - Gains are site-specific
   - Soil moisture influences

Maybe we can lower the cost of information to improve profitability of VRA?

- RS and EC measure everything

Remote sensing was really hot then and hasn't gone away (still building slowly)

EC interest really hot a few years ago, but not disappearing either

August 2000

Crude Generalizations from FICPA

6. Management zones are appealing but not especially successful
   - 4 successful, 4 not, 8 unsure
   - Thought to maximize the information acquired from a single soil sample
   - Rely on farmer intuition
   - Each factor needs different zone classifications, P-mgt, K-mgt, RS, EC, yield-based, and farmer-drawn zones are all different
   - Optimal zones become grids

Management zones, where they exist, are mostly intuitive – persist because of the lack of feasible alternatives (actually, they are losing ground)

August 2000

Crude Generalizations from FICPA

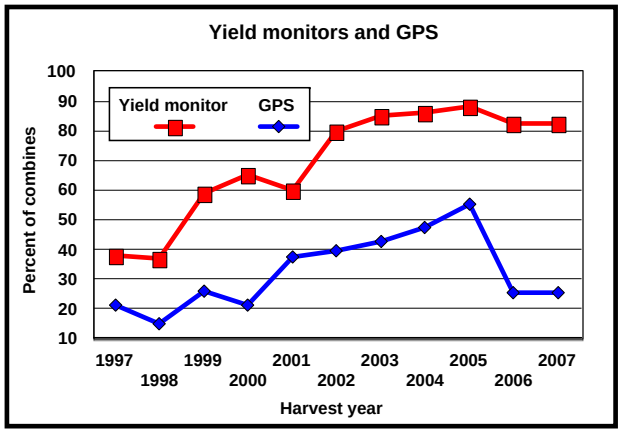
7. Grid sampling works but is too expensive
   - At some sufficiently small scale it works
   - At some sufficiently large scale it's profitable
   - Optimal cell size is site-specific
   - Despite attempts by research and business to discredit, it remains viable
     - At 2% of farms (1999), USDA deems most popular PA activity
8. Yield monitors & yield mapping here to stay
   - 55% (26% w/ mapping) of CHAMP combines (1999)
   - Adoption based on faith
   - Some frustration after multiple years

Is grid sampling growing? Probably slowly?

#8 likely still true today

An aside . . . a lot of yield monitors but not much mapping

CHAMP Program (custom harvesters)



- Members providing maps – 33.3%
  - For providers, this % of customers mapped – 6.6%

August 2000

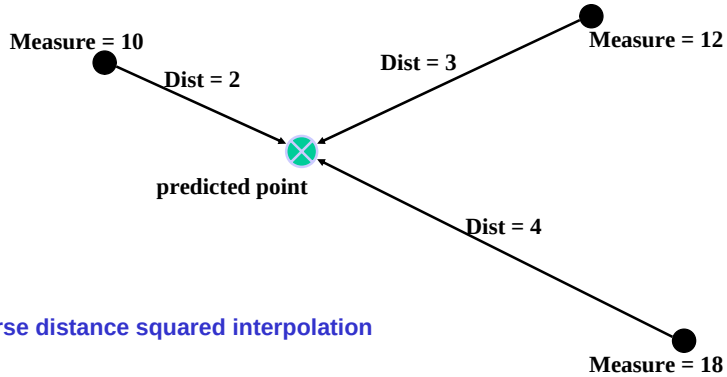
Crude Generalizations from FICPA

11. VRT lime is likely to be profitable
    - Yields turn down with excess pH
    - Kansas has a transition area where only some parts of a field gain from lime
12. VRT P is also likely to be profitable

- It is the capital investment characteristics of lime and P that make VRT potentially profitable. Information-gathering and VRT costs can be spread across years.

These probably were overstatements

September 2000

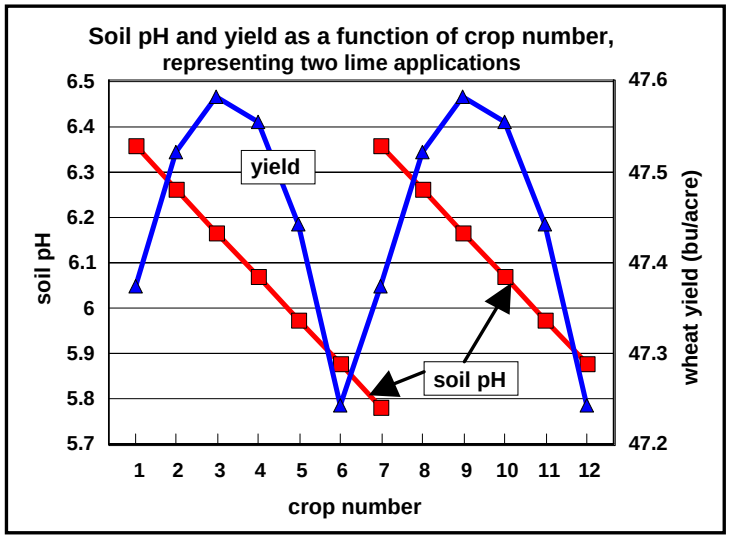


Inverse distance squared interpolation

$$\text{prediction} = \frac{\frac{1}{2^2}\times 10 + \frac{1}{3^2}\times 12 + \frac{1}{4^2}\times 18}{\frac{1}{2^2} + \frac{1}{3^2} + \frac{1}{4^2}} = 11.7$$

Along the way we spent considerable time both learning ourselves and training others how to do the math

January 2001



Some farms likely are managing lime/pH better than they did as a result of PA

Are they using VRA on lime? Well, maybe sort-of. . .

August 2001

Problem #1

- Models behind university fertilizer recommendations are usually not explicit
  - What happens to yields at less or more than the recommended fertilizer rates?
  - What happens to profits?
- Difficult to assess expected profits for VRT/PA without an explicit yield/fertilizer relationship

So began a whole line of research that tried to get mathematical models for decision-making from agronomy understanding

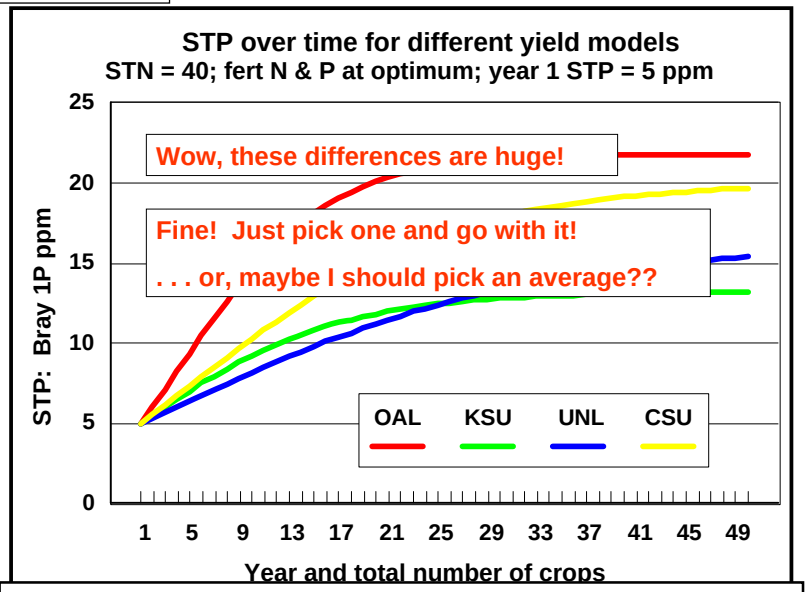
It wouldn't have happened without PA

Better field-scale decisions result

Yield models

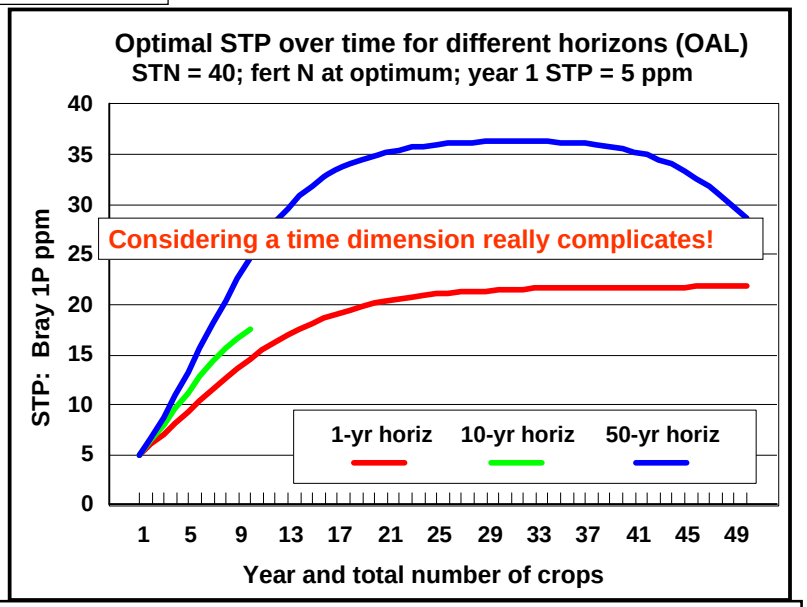
- We've always used yield models in our work
- Yield models are always questionable
- We have always striven for increased buy-in of agronomists and farmers
  - Try to do a better job incorporating what THEY believe
- But unexpected, hard-to-explain, results still routinely emanate from our work

Early 2002



Following different fertilizer recommendations over time will lead to different levels of soil fertility

Early 2002



Optimal fertilizer P decisions are different if one considers time horizon

December 2003

Managing Fertilizer Programs on Leased Land in the Eastern Corn Belt

Indiana Crop Advisor Conference
Indianapolis, Indiana
December 16-17, 2003

This work was keyed off of the Tri-State (MI, OH, IN) fertilizer recommendations

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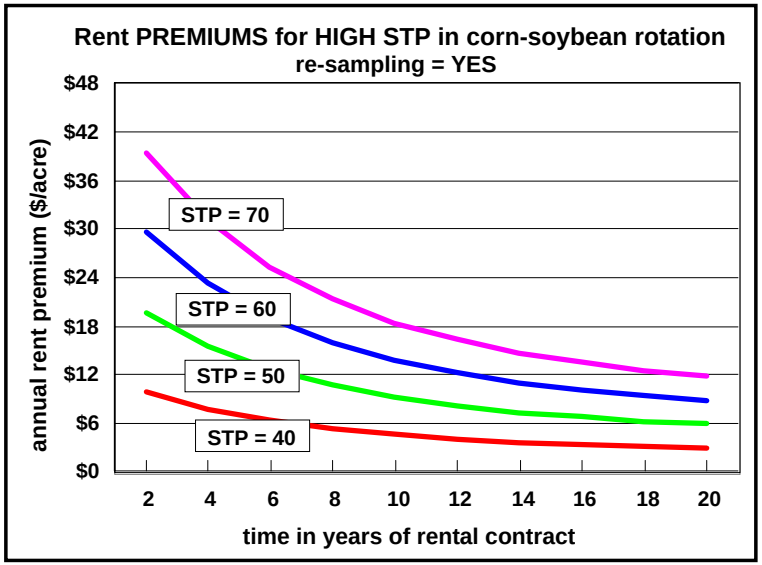
paper at www.agmanager.info

December 2003

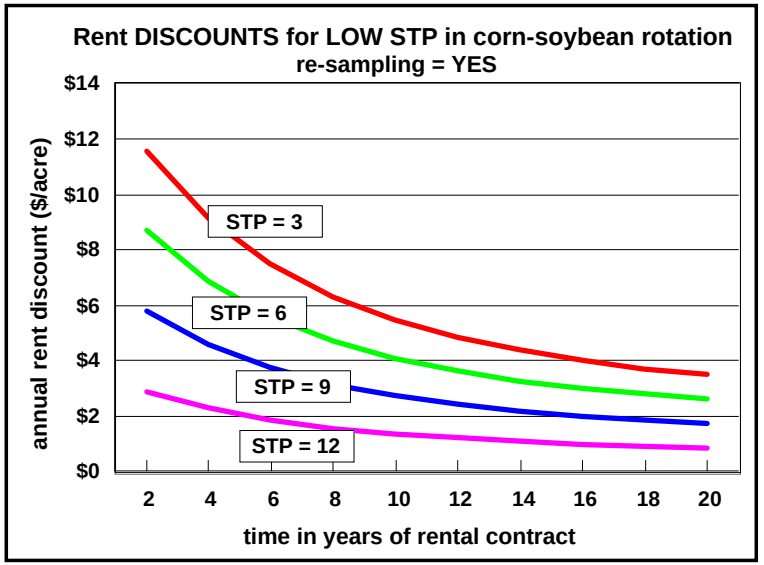
High STP case



An aside: 50% higher phosphate prices would increase all premiums 50%

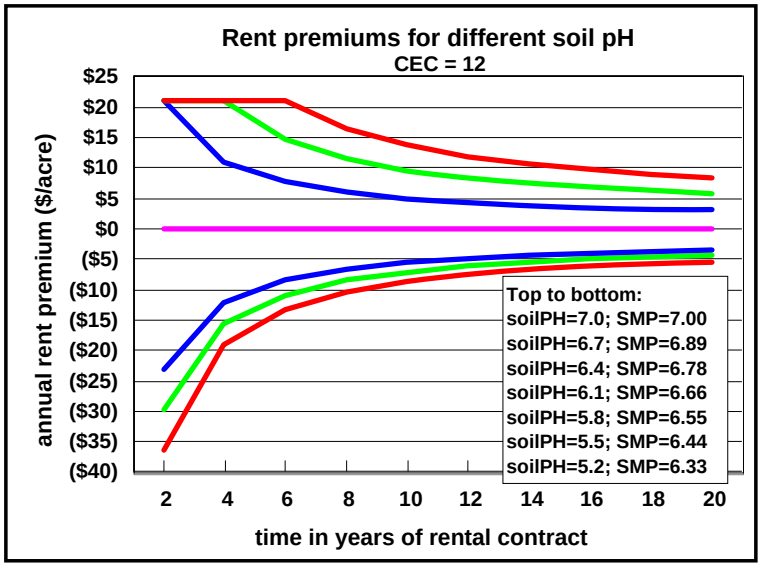
December 2003

Low STP case



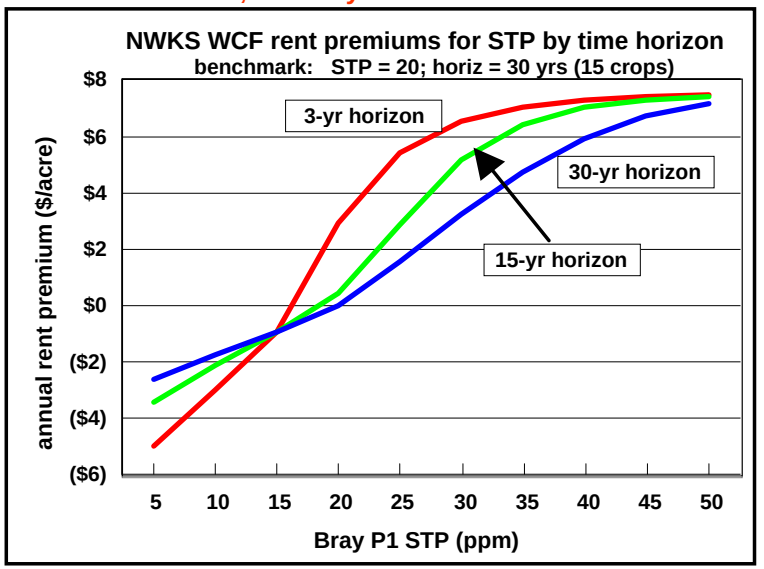
December 2003

High and low soil pH



December 2003

In KS, we likely would believe this



December 2004

Herbicide VRA (Rider et al.)

- Estimated profit
  - average margin between site-specific and uniform full label rate application
    - $22.33/ac from the quadratic models
    - $17.95/ac from the Mitscherlich models
  - average margin between site-specific and uniform optimal rate application
    - $1.96/ac from the quadratic models
    - $2.08/ac from the Mitscherlich models

Benefits there but insufficient to cover costs of information gathering

Ever more believable yield models

- We're motivated by
  - "The models we're using don't seem to work right"
- Maybe we should quit arguing about whose fertilizer recommendations are most correct and simply start with some particular research-based fertilizer recommendations, e.g., KSU's, and take them as a given.
- What must the researchers believe about yield response given their recommendations?
- Can we get to this point?
  - "If you accept KSU's fertilizer recommendations, it pretty much follows that you have to believe what we're telling you now."

March 2006

N Response Functions for Today's Production Costs

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Alan J. Schlegel – agronomist, KSU
Troy J. Dumler – ag economist, KSU

Sometimes outside forces motivate our work.

Work started in fall of 2005, in the face of high fertilizer prices and low crop prices.

We all were making ad hoc suggested rate cutbacks at the time.

Presented at:
Great Plains Soil Fertility Conference
March 7-8, 2006, Denver, Colorado

March 2006

K-STATE Kansas State University
Department of Agronomy

Soil Test Interpretations and Fertilizer Recommendations

MF-2586 Nutrient Management

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

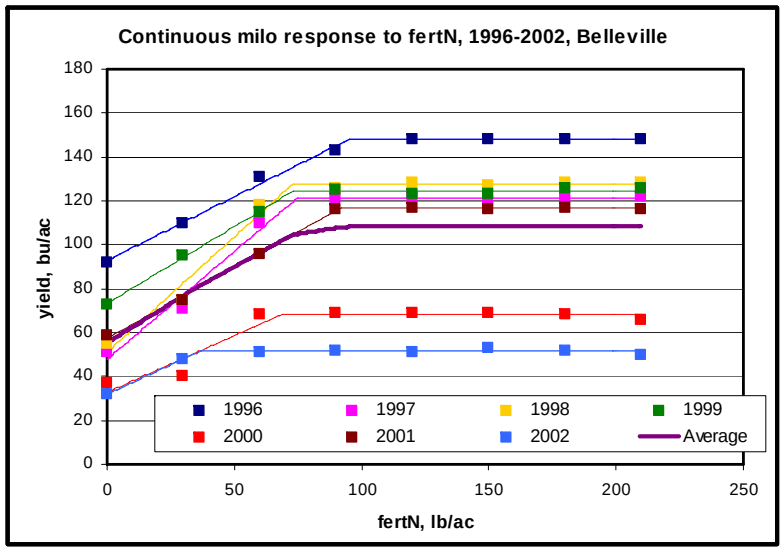
March 2006

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 $3.22/bu
  - Corn $2.35/bu
  - fertN $0.21/lb N (fertP, used later, $0.24/lb P2O5)

March 2006

Site-year response is linear but average appears curvilinear



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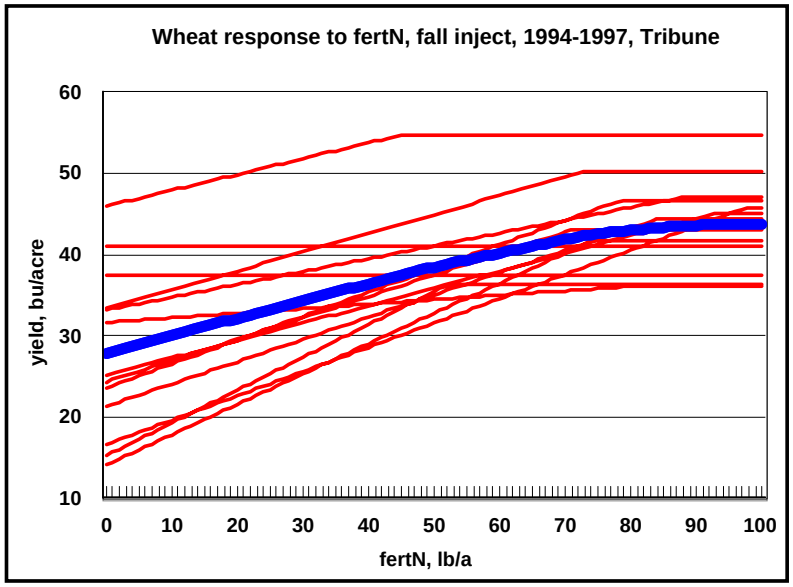
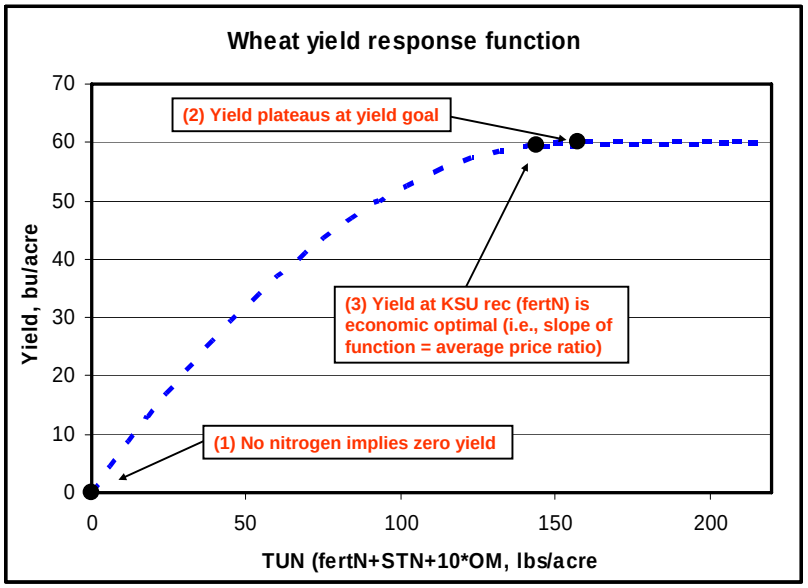


March 2006

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



March 2006

- We believe we got to the point of "if you believe KSU's fertilizer recommendations you have to believe our price-dependent profit-maximizing rates"
- Everything was embedded in an Excel spreadsheet so that users could determine optimal fertilizer N rates based on fertilizer N prices and crop prices
- We could use the spreadsheet to recommend some "typical" percentage cutbacks on fertilizer – dealers had been requesting such info throughout 2005

March 2006

Adjustments to KSU Nrecs at various wheat and N prices

Nitrogen Recommendations for Wheat

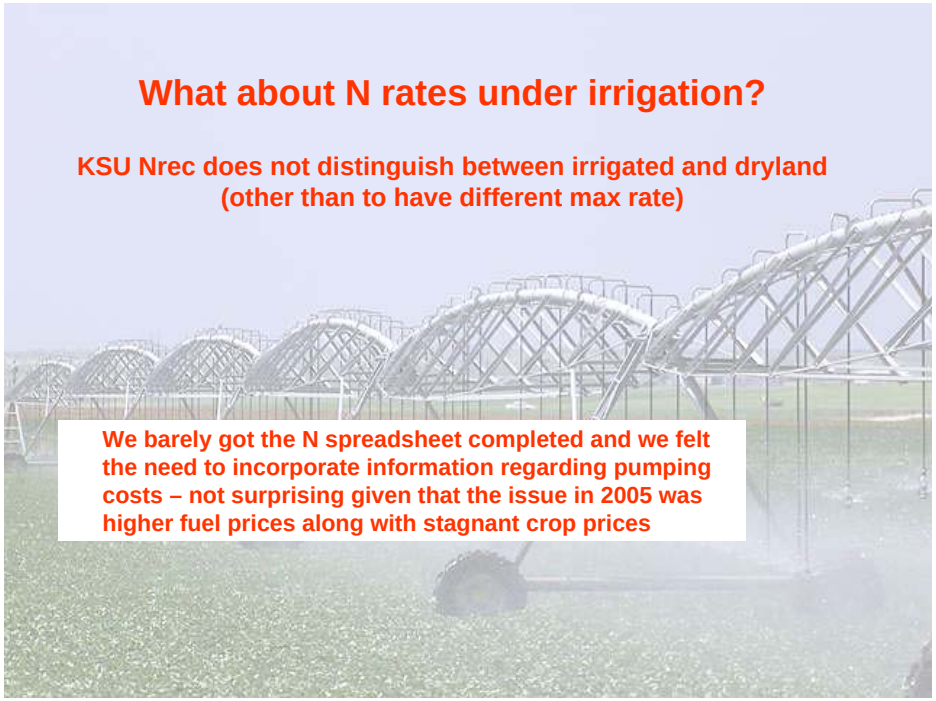
Yield goal, bu/ac			45					60		
KSU N rec, lbs/ac*			78					114		
N price	Wheat price, $/bu					Wheat price, $/bu				
$/lb	$2.50	$3.00	$3.50	$4.00	$4.50	$2.50	$3.00	$3.50	$4.00	$4.50
	Price adjusted N rec, lbs/ac					Price adjusted N rec, lbs/ac				
$0.40	63	67	70	73	74	94	100	104	107	109
$0.45	60	65	68	71	73	90	97	101	104	107
$0.50	57	62	66	69	71	86	93	98	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)

We were able to suggest more rigorously determined cutbacks at the time

What about N rates under irrigation?

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

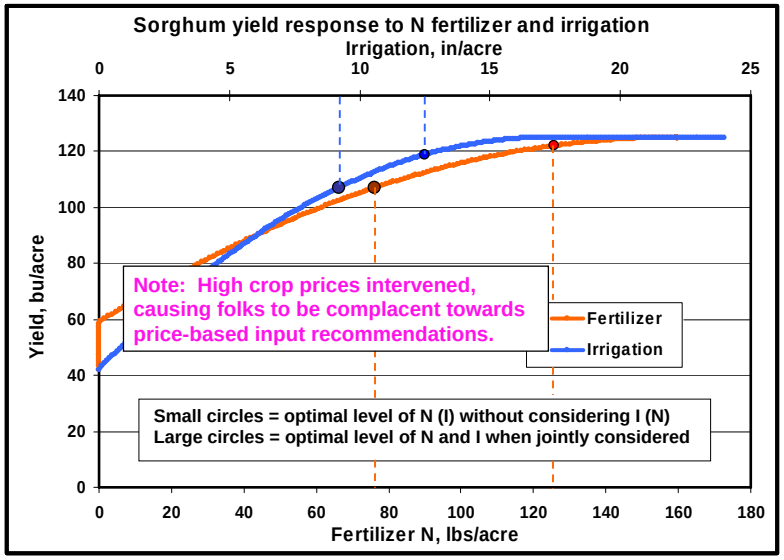


We barely got the N spreadsheet completed and we felt the need to incorporate information regarding pumping costs – not surprising given that the issue in 2005 was higher fuel prices along with stagnant crop prices

- **KSU N recs don't distinguish between irrigators and non-irrigators, which means:**
  - **Recommended N rates assume water is not limiting yield (or that producer picks a reduced yield goal based on water cost)**
- **With high pumping cost and high N prices and low crop prices, our spreadsheet recommended large cutbacks in both N and irrigation water**

March 2006

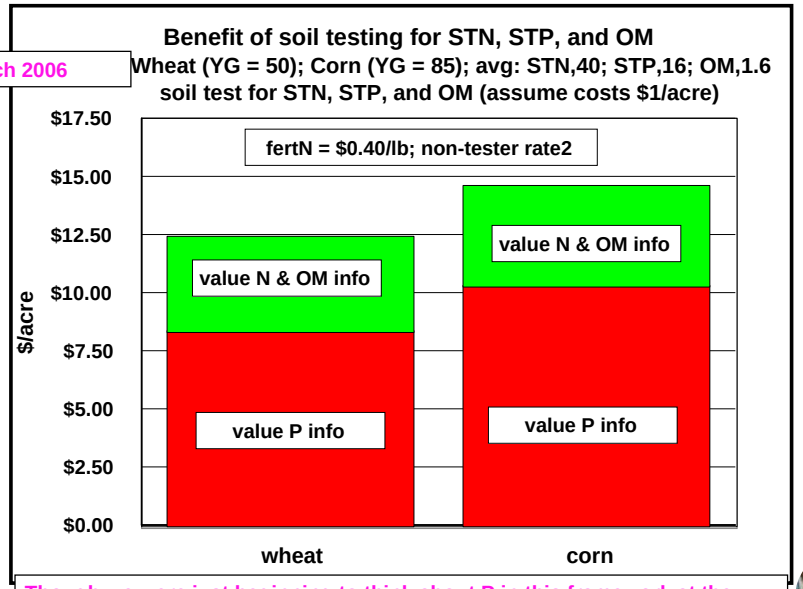
When considering irrigation and N together, optimal values decrease significantly…



Sorghum price = $2.10/bu, N price = $0.40/lb, irrigation cost = $6.50/inch

P information more valuable than N information

March 2006



Though we were just beginning to think about P in this framework at the time, some interesting output regarding the benefit to soil testing arose.

Fall 2008

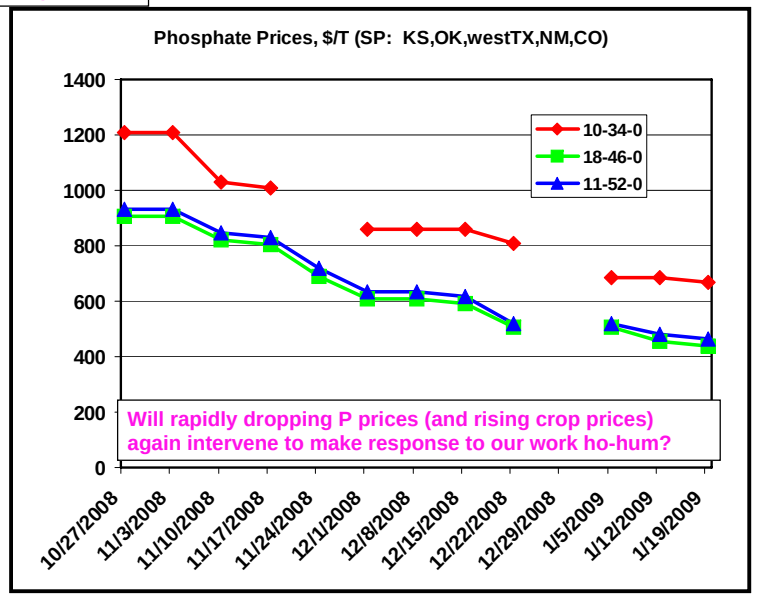
Late summer early Fall 2008 …

- Very high fertilizer prices and not just N
- Falling crop prices
- Producers asking about price-based adjustments again, especially related to high P prices ($1.20/lb P2O5??)

- And so we adjust the decision spreadsheet again . . . this time incorporating P
  - Use MF-2586 sufficiency P recs

- Very large cutbacks in P were suggested in October

January 2009



2007-2008

- We've showed over and over again the economic benefits to GPS technologies
  - Autoguidance
  - Boom and section control
    - VRA can be on or off

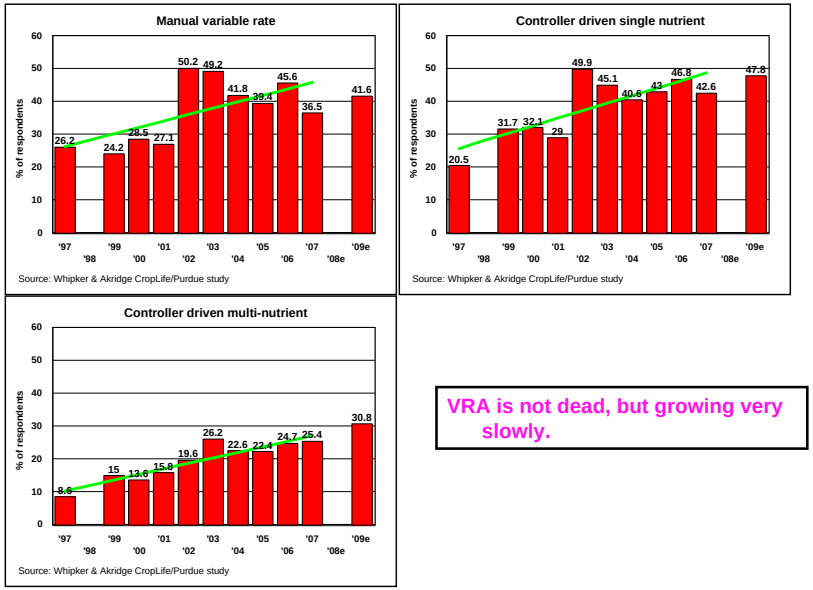
- Yield monitors here to stay

- Investment in much of the yield and input data collection stuff, and rate controlling stuff, is easily justified outside the world of traditional VRA

We've daydreamed about and researched many aspects of VRA over the years.

So, what are our thoughts today?

Percent of service providers offering services



VRA is not dead, but growing very slowly.

VRA Economics

- Yield response function
  - In a 1-year story, problem is pretty much licked
- VRA equipment cost – no big deal any more
- So, a couple of hurdles are gone

- Soil test thinking
  - Soil tests generally pay at some spatial scale
  - Soil tests are still expensive at a small scale
  - Infrequent small-scale tests sort of work for some nutrients
  - Basing N rates on soil tests a big problem, let alone VRA
  - So, at best small profit if depend upon small-scale soil tests
  - No cheap (and accurate) soil test proxies

- Will we be able to get past soil test thinking?
  - Can we charge ahead, chasing some new idea, relegating analysis to a monitoring role rather than a determining one?

The Time Dimension

- Soils are alive and change over time
- Does fertilizer impact yield or does it impact soil fertility, which in turn impacts yield?
- We've thought some about P and soil pH over time, but have only daydreamed about N in this context

- Continuous no-till: many time-dimension facets
  - Changes in soil structure that can modify yield goals?
  - Increases in soil organic matter, which might greatly buffer the impact of annual decisions around fertilizer
    - Quantity and timing of fertilizer becomes less important?
  - With no-till, can we simply use grain-removal based fertilizer rates, ensuring "correct" rates only when averaged across time? Might that work for N, as well as P?

    . . . tune in to tonight's discussion group

Questions ???

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