Soil Testing 101

David Dunn

Supervisor, Soils Testing Lab

University of Missouri-Delta Center

dunnd@missouri.edu


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Reasons for Soil Testing:

- Maximize yields by proper soil fertility conditions
- Minimize input costs
- Limit adverse environment impacts

Manage Nutrients with Soil Testing

- Soil analysis is science based and removes “guess work”.
- Fertilizer is expensive. Soil tests provide information on appropriate levels of nutrients needed.
- Soil testing results have been calibrated by experiments to gauge crop response for many years.

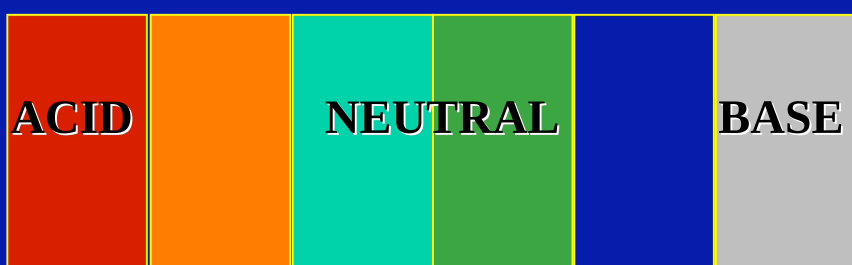
pH and Liming

pH: power of Hydrogen

- pH = negative log of H^+ concentration
  - Lower pH indicates greater H+ levels
- pH 7.0+ Micro nutrient availability
- pH 6.0-5.0 N, P, & K availability
- pH 5.0- Mn & Al toxicity

“Water” vs “Salt” pH

- Water pH
  - Measure in 1:1 slurry with distilled water
  - World standard



- Salt pH
  - Measure in i:1 slurry with 0.01M $CaCl_2$ solution
  - Missouri, S. Africa, & N. Ireland
  - More stable during year Less sensitive to soil fertility conditions
  - 0.5 units less that water pH

pH, Buffer pH, & Lime requirement

- **pH**
  - Measure of active acidity: Is there a problem?
- **Buffer pH**
  - Measure of reserve acidity:
- **Lime requirement**
  - Combination of both pH and Buffer pH
  - Based on crops to be grown
  - Sands<Silt loams<Gumbo

Salt pH Requirements of Major Crops

Cotton	6.1-6.5
Corn	6.1-6.5
Soybean	6.1-6.5
Rice	5.6-6.0
Alfalfa	6.6-7.0
Fescue	5.6-6.0
Burmudagrass	5.6-6.0

ENM-Effective Neutralizing Material

- **Amount of acidity that will be neutralized in 3 years**
- **Calculated based on:**
  - **Chemical composition**
    - **Limestone = 100% CCE**
    - **Dolomite = 109% CCE**
  - **Fineness of grind**
    - **> 8 mesh=0%; 8-40 mesh=25%; 40-60=60%; <60=100%**
- **ENM/ton=** $\frac{\%CCE}{100} \times \frac{\text{fineness factor}}{100} \times 800$

White Lime,
Red Lime
& Ca/Mg Soil Ratios

Role of Ca & Mg in plants

- Ca
  - Vegetative growth
    - Cell walls
    - Stiffening of stems
- Mg
  - Chlorophyll
  - Energy transfer
    - Storage in seeds

Ca/Mg removal by crops

Crop	Ca grain	Mg grain
Corn	0.02	0.06
Soybean	0.20	0.23
Rice	0.04	0.05
Sorghum	0.07	0.08
Cotton	3.00	4.00

Ca/Mg removal by crops

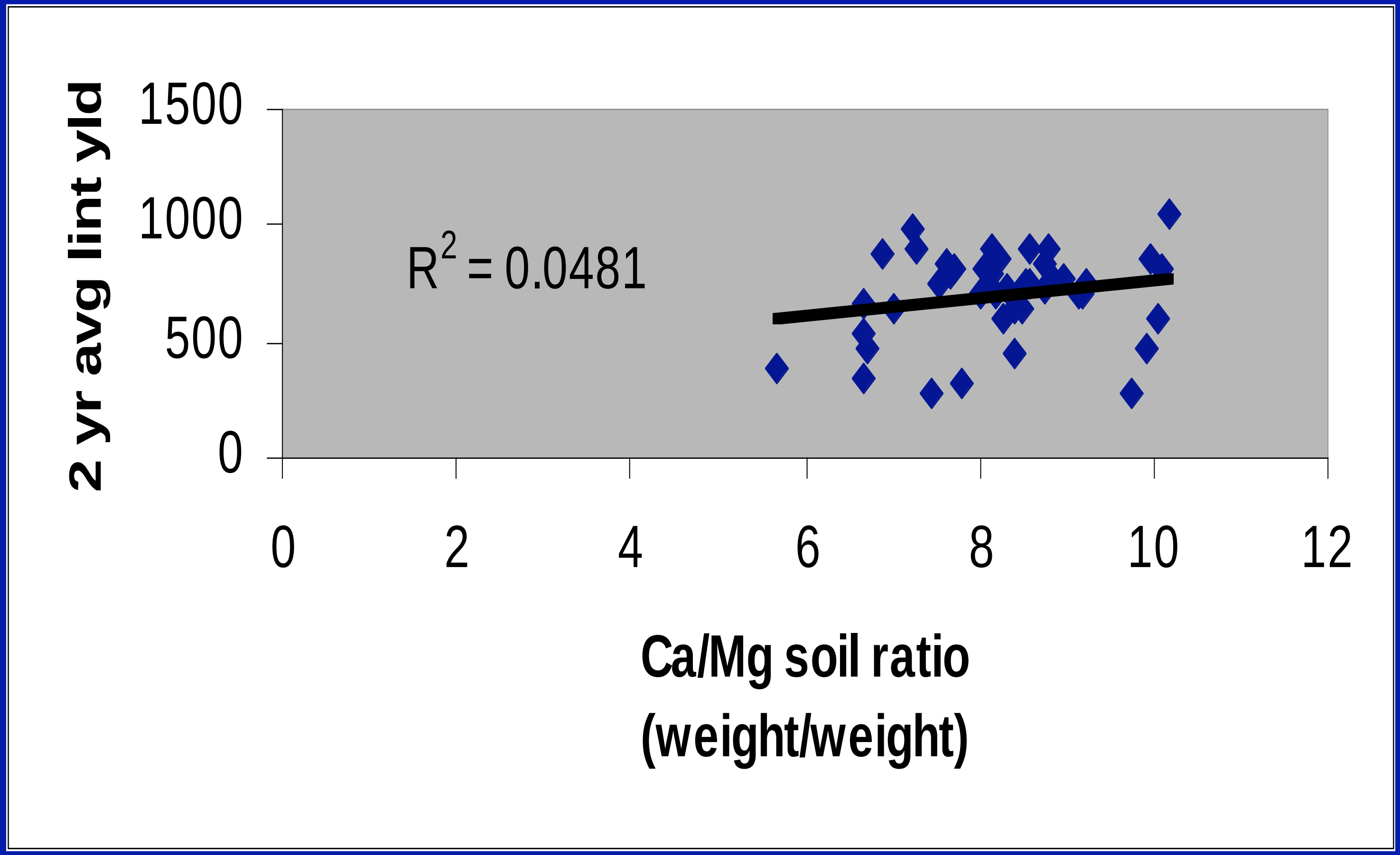
Crop	Ca grain	Mg grain	Ca stover	Mg stover
Corn	0.02	0.06	0.19	0.14
Soybean	0.20	0.23	1.5	0.22
Rice	0.04	0.05	0.12	0.06
Sorghum	0.07	0.08	0.31	0.15
Cotton	3.00	4.00	25.0	8.00

Ca/Mg removal by crops

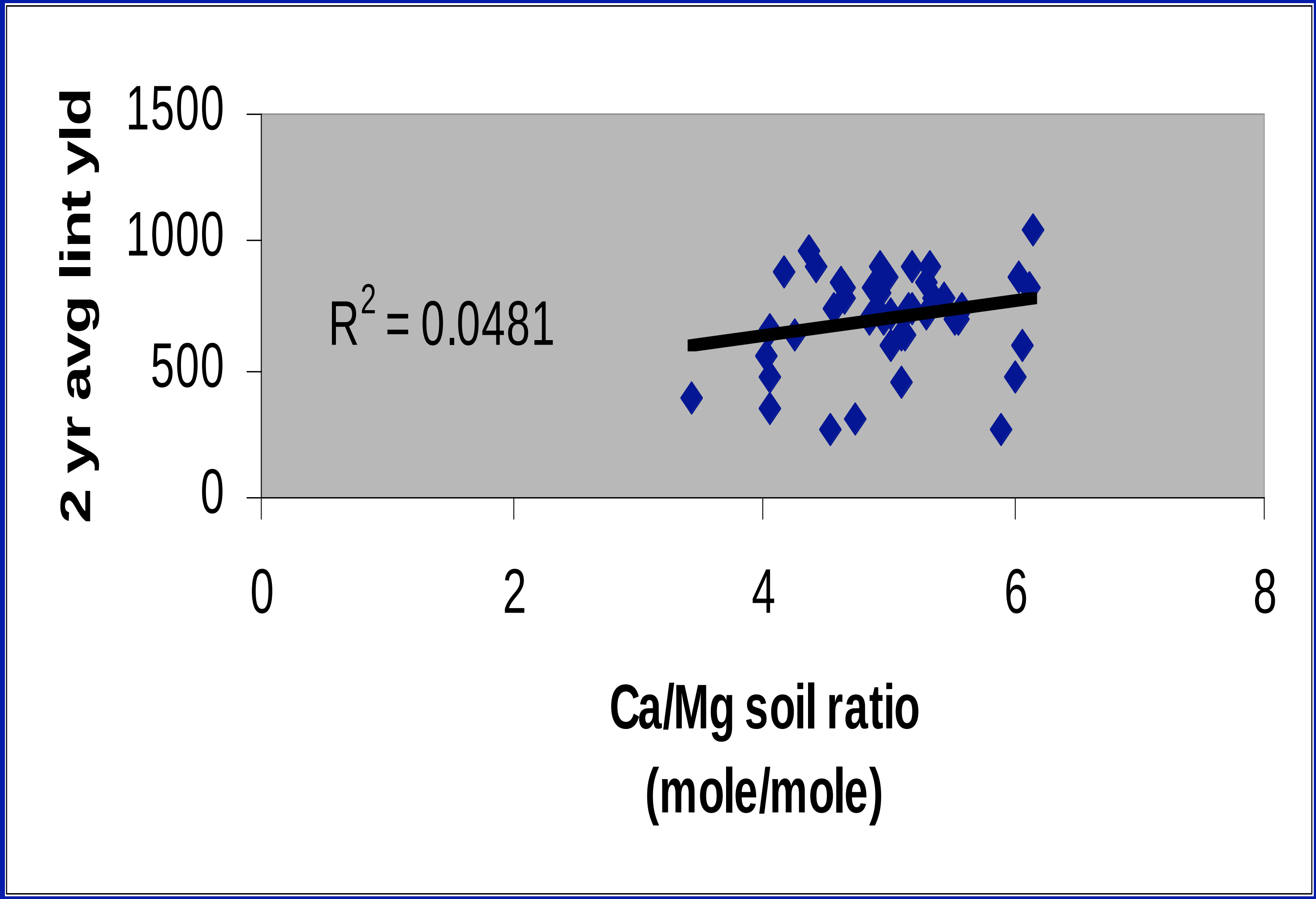
Crop	Ca grain	Mg grain	Ca stover	Mg stover
Corn	0.02	0.06	0.19	0.14
Soybean	0.20	0.23	1.5	0.22
Rice	0.04	0.05	0.12	0.06
Sorghum	0.07	0.08	0.31	0.15
Cotton	3.0	4.0	25.0	8.0
Alfalfa			28	5.0
Fescue			10	4.5
Burmuda			10	5.0

Ca/Mg supply by lime

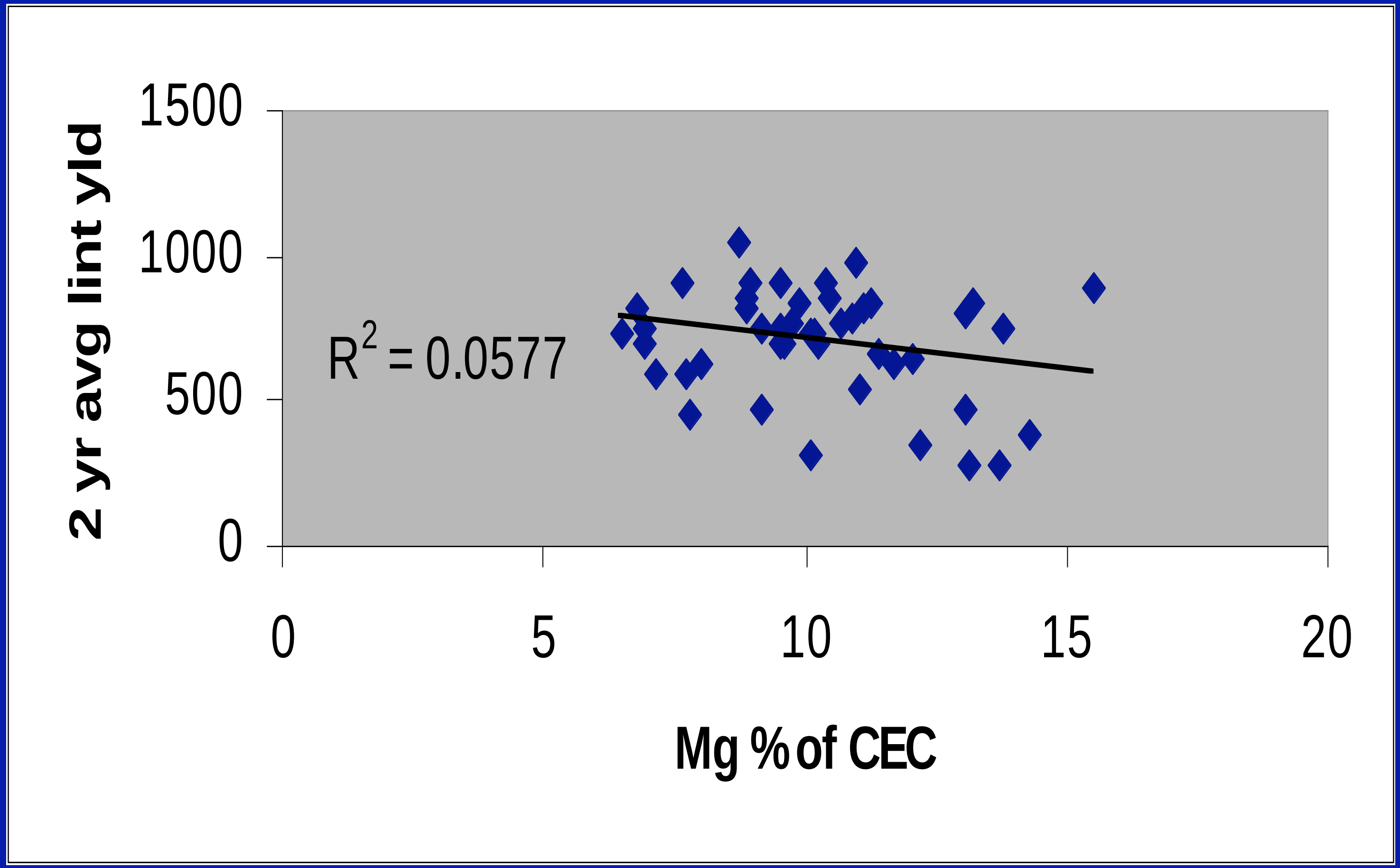
- **White lime**
  - $CaCO_3$
  - 40% Ca
    - 800 lb Ca/t
- **Red lime**
  - $CaMgCO_3$
  - 22% Ca
    - 440 lb Ca/t
  - 13% Mg
    - 260 lb Mg/t



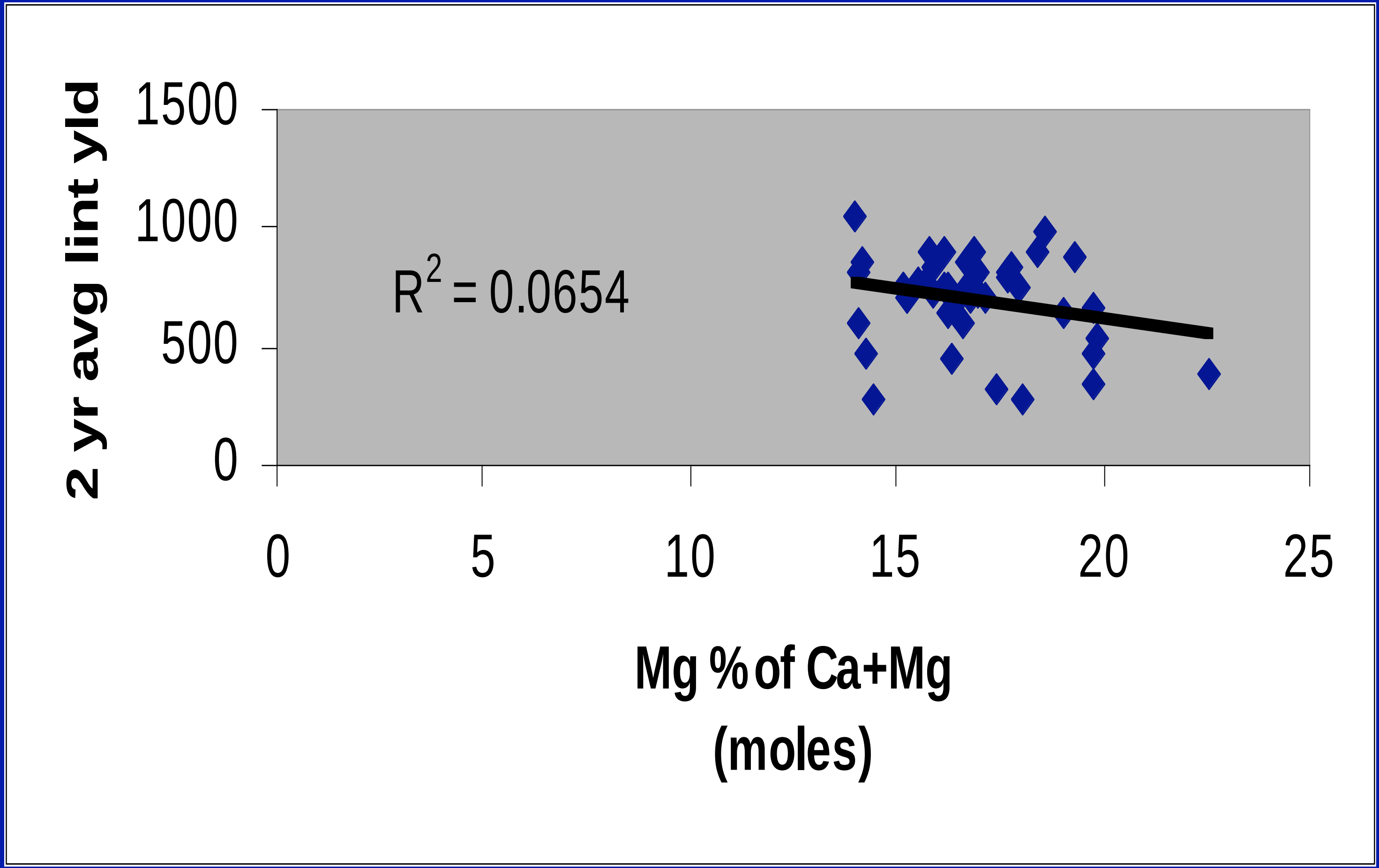
2 year average lint yields and Ca/Mg (weight/weight) soil ratio for a 45 acre production field in Hornersville, MO.



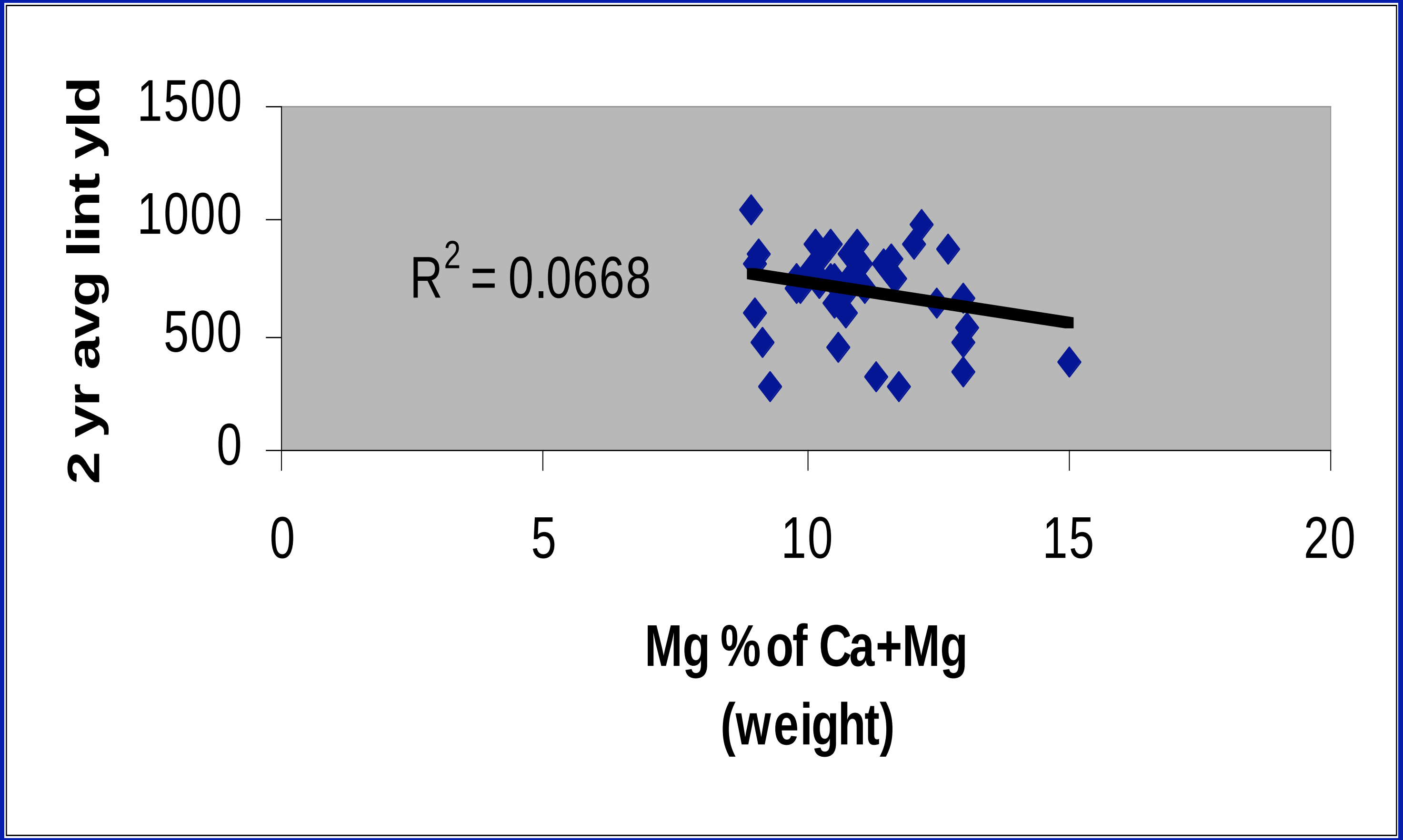
2 year average lint yields and Ca/Mg (mole/mole) soil ratios for a 45 acre production field in Hornersville, MO.



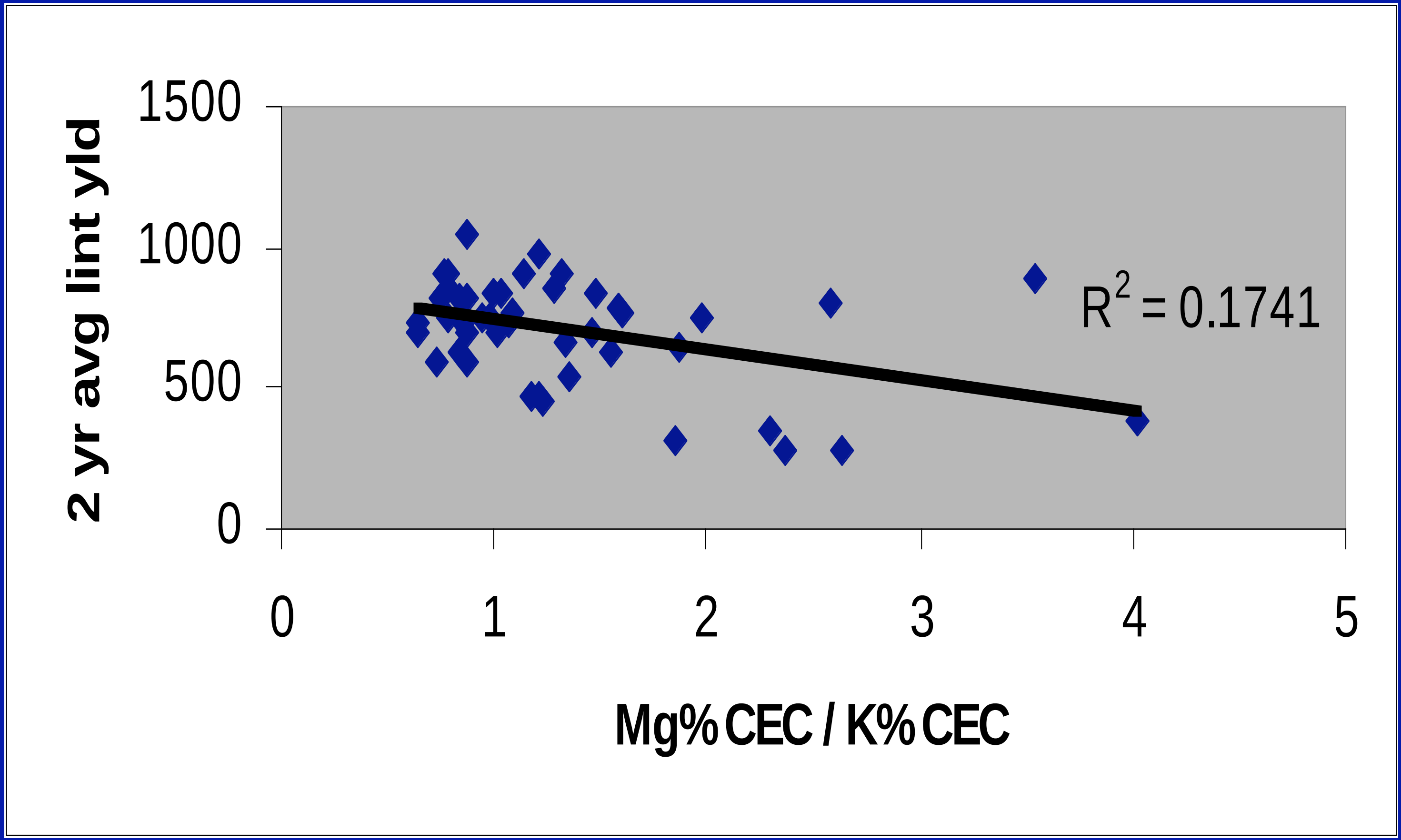
2 year average lint yields and Mg % of CEC for a 45 acre production field in Hornersville, MO.



2 year average lint yields and Mg as a % of Mg + Ca calculated on a molar basis for a 45 acre production field in Hornersville, MO.



2 year average lint yields and Mg as a % of Mg + Ca calculated on a weight basis for a 45 acre production field in Hornersville, MO.



2 year average lint yields and ratio of Mg % of CEC to K % CEC calculated on a weight basis for a 45 acre production field in Hornersville, MO.

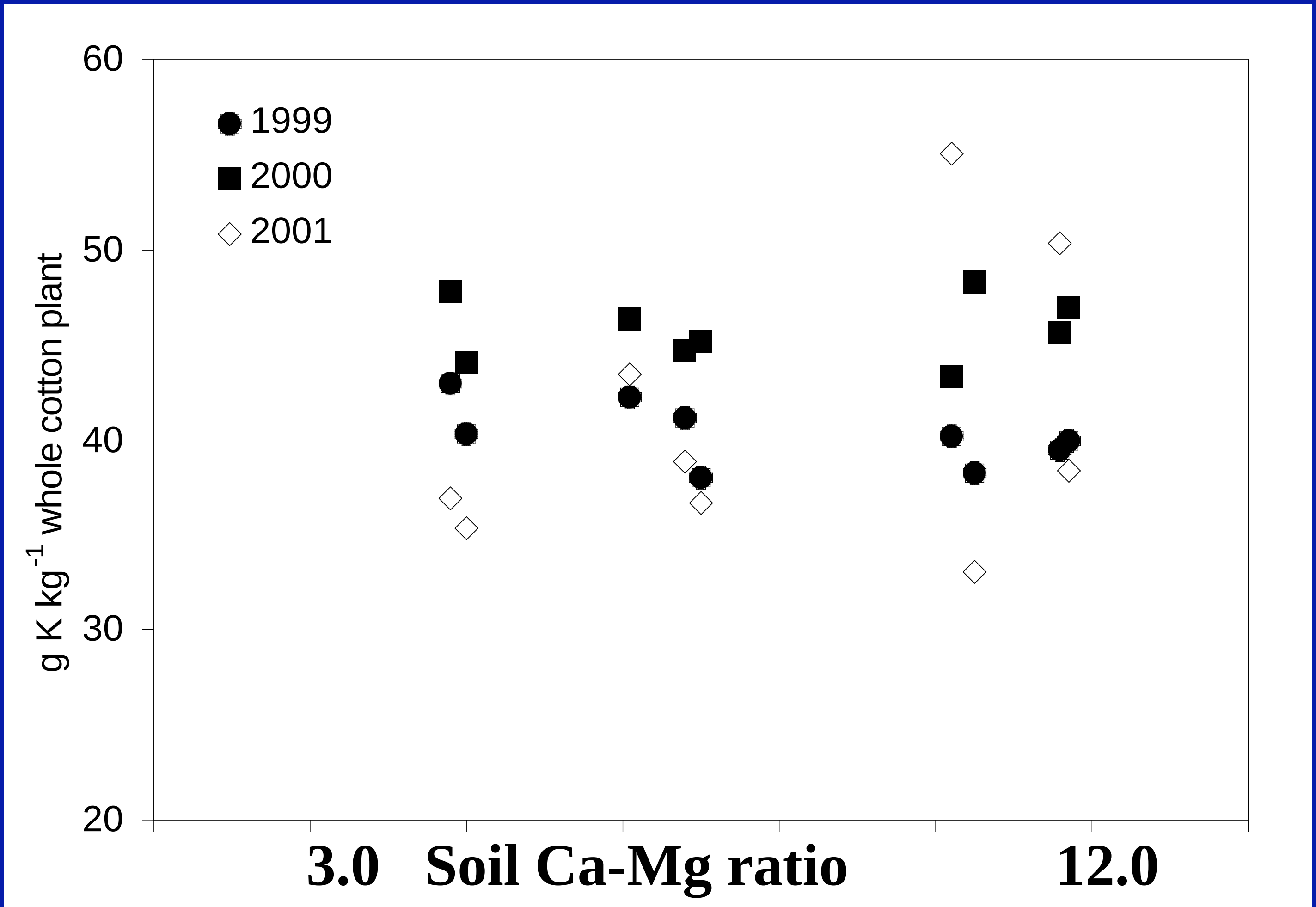
Experimental Design

- Gypsum ($CaSO_4$) & Epsom Salt ($MgSO_4$) used to produce a range of soil Ca/Mg ratios.
- Randomized and replicated complete block.
- Plant tissue samples collected at first square, first bloom, and first open boll growth stages.
- Harvested for lint yield, lint graded for fiber properties.
- Soil samples collected after harvest.

Treatments and Ca/Mg Soil Ratios

Material	Ton/a	Ca/Mg
$CaSO_4$	5.6	11.7
$CaSO_4$	3.7	11.6
$CaSO_4$	1.7	10.5
Control	0.0	10.2
$MgSO_4$	1.7	7.5
$MgSO_4$	3.7	7.0
$MgSO_4$	5.6	4.0
$MgSO_4$	7.4	3.8

Ca-Mg Ratios and K Uptake at First Square



Ca/Mg Soil Ratios & 3-year Average Cotton Lint Yields

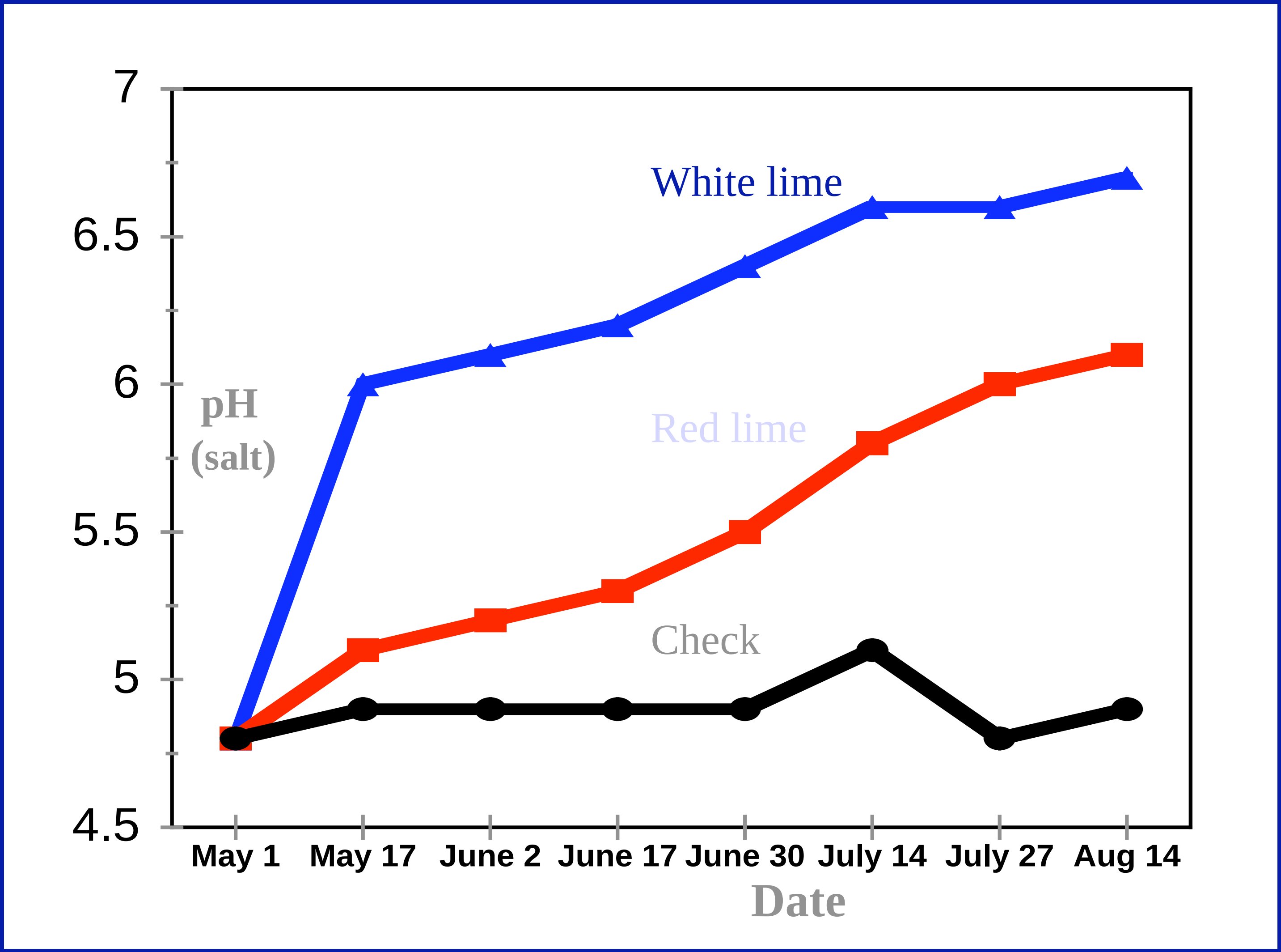
Ca/Mg soil ratio	Cotton lint yield (lb/a)
11.7	897
11.6	821
10.5	902
10.2	868
7.5	789
7.0	840
4.0	889
3.8	878
$LDS_{(0.05)}$	NS

The Real Question
Red (Dolomotic) or
White (Calcitic) Lime?

2000 Study:
Compares Red and White Lime at
Same Effective Rates

Treatments

1) Check
2) White lime @ 2.2 ton/acre
    1,100 ENM/a / 510 ENM/ton = 2.2 ton/a
3) Red lime @ 1.8 ton/acre, 11.6% Mg
    1,100 ENM/a / 620 ENM/ton = 1.8 ton/a
    11.6% Mg x 2,000 x 1.8 = 418 lbs Mg/a
4) White lime @ 2.2 ton+418 lbs Mg/acre



Average pH(salt) values for lime test 2000

Cotton Lint Yields

	2000	2001	2002	Average
Check	663 a	829 b	682 a	725 b
White lime	809 a	937 ab	713 a	820 a
Red lime	847 a	934 ab	729 a	838 a
White+Mg	722 a	983 a	683 a	796 a

Conclusions:

- Ca/Mg soil ratios, however calculated, were poorly correlated to cotton lint yields
- Altering Ca/ Mg soil ratios did not significantly effect cotton lint yields.
- White lime increased soil pH faster than red lime. This may be due to greater solubility for white lime.
- Lime, white or red, significantly increased cotton lint yields.

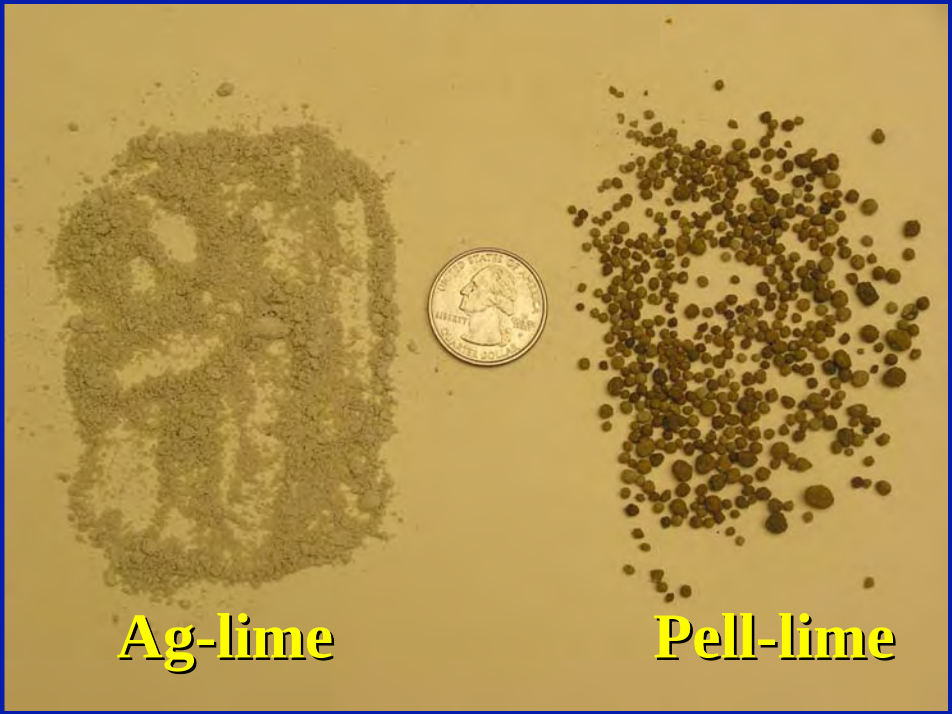
What about Gypsum ($CaSO_4$)?

- For Sharkey Clay soil: 1&2 ton rates
- Increased saturated hydrologic conductivity
- Decreased bulk density
- Numerically increased yields
- Cost: $40/ton

How about Pelletized Lime?

Pelletized lime: As Advertised

- Made from finely ground lime
- Easy to handle
- Relatively expensive
- Reacts quickly with soil
- Use at lower rates than ag-lime
- May be blended with fertilizers



Pelletized lime: as Delivered

- Made from finely ground lime, formed into a pellet
- Follow the instructions on the bag?

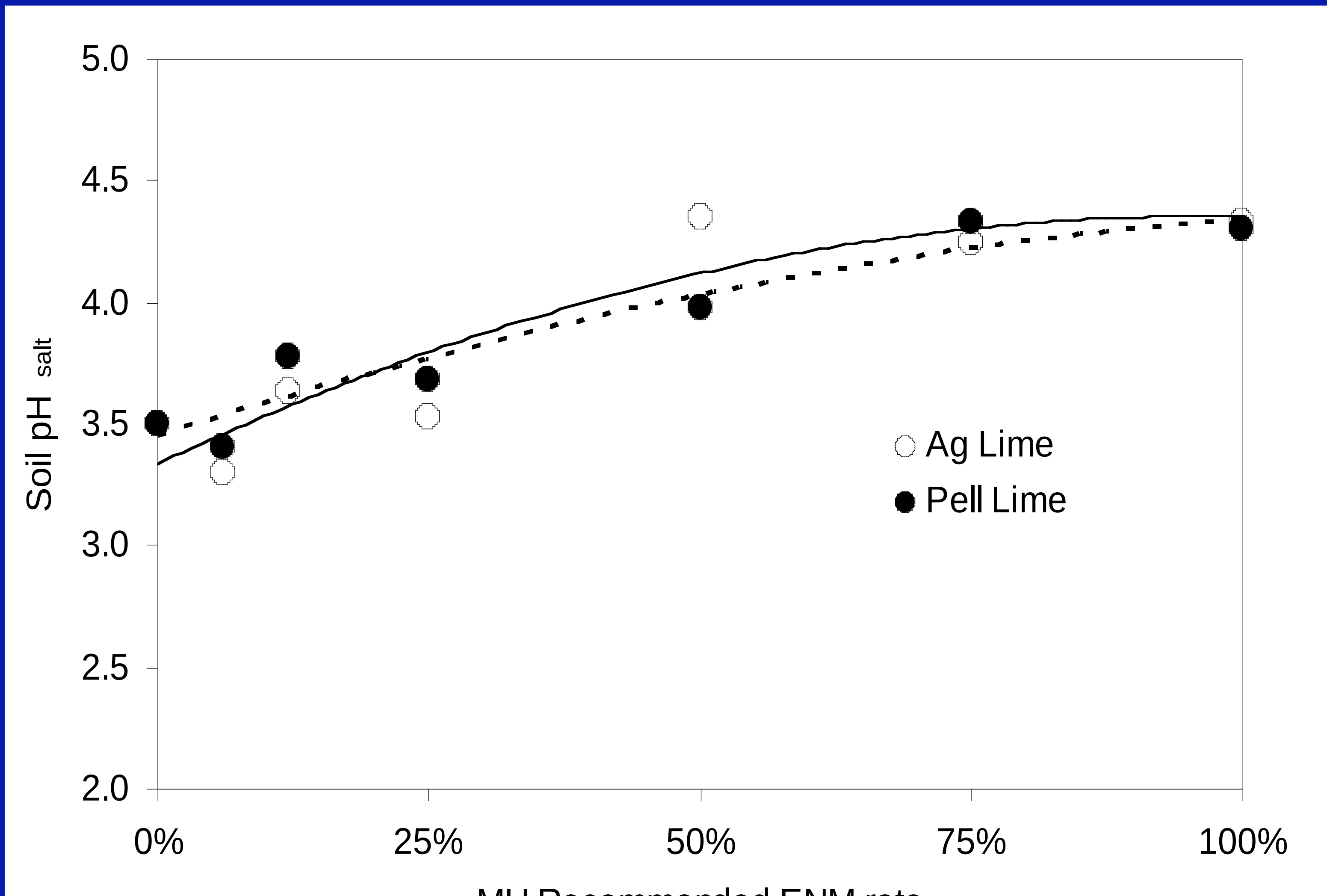
Ag-lime and Pell-lime compared at equivalent effective rates

- Soybean field acidified by adding 1 ton elemental sulfur, pH = 3.5
- Each product compared at same effective rate, MU recommendation was 1209 ENM/a
  - Ag-lime = 2.4 ton/a
  - Pell-lime =1.7 ton/a

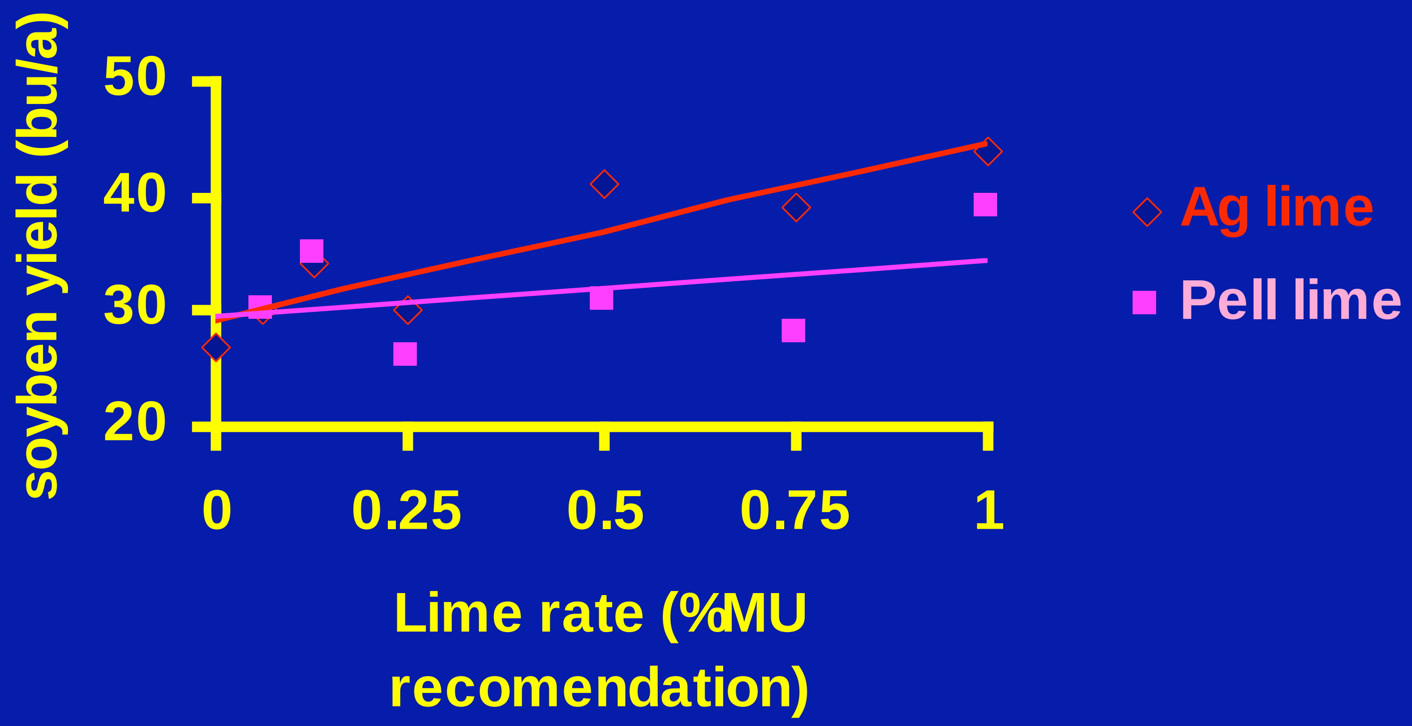
Ag-lime and Pell-lime compared at equivalent effective rates

- Soybean field acidified by adding 1 ton elemental sulfur, pH = 3.5
- Each product compared at same effective rate, MU recommendation was 1209 ENM/a
  - Ag-lime = 2.4 ton/a $43
  - Pell-lime =1.7 ton/a $187

pH at Harvest for Ag-lime and Pell-lime Treatments



Soybean Yields for Lime Rates



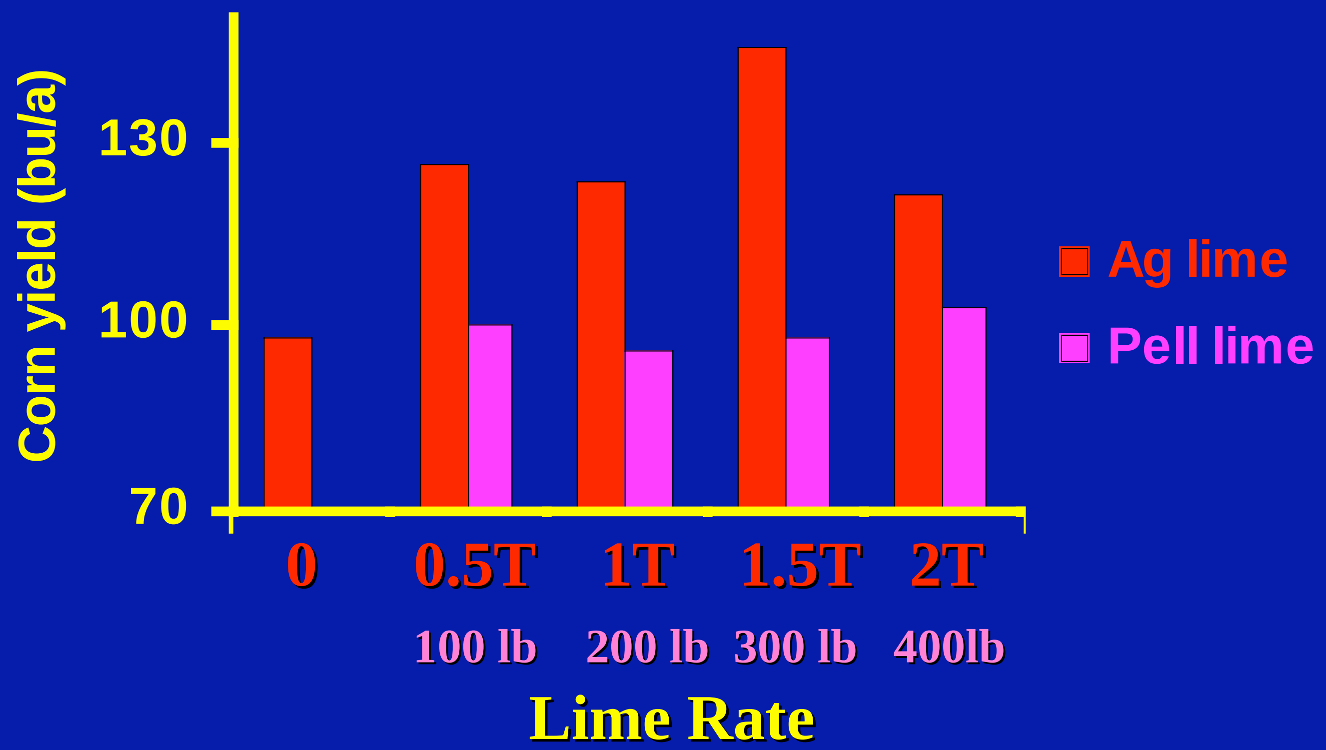
Pell-lime banded at low rates

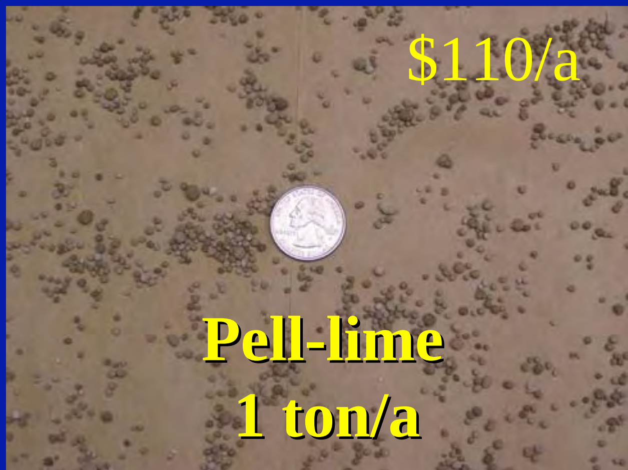
Pell lime rate	Yields (bu/a) In furrow	dribble
0 lb	--------27--------	
4 lb	27	26
8 lb	19	26
12 lb	28	31
16 lb	31	31

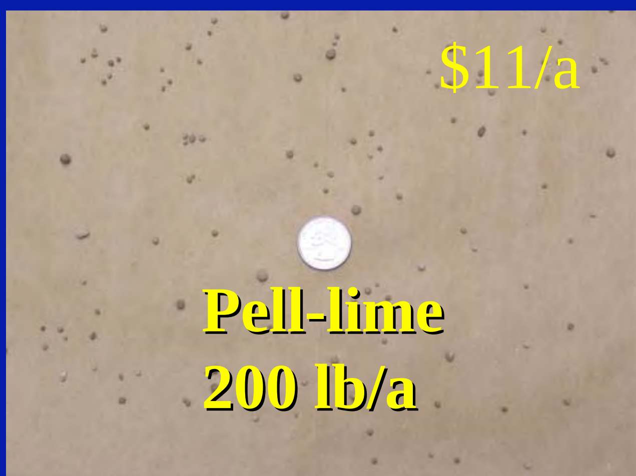
Pell-lime as a rescue treatment

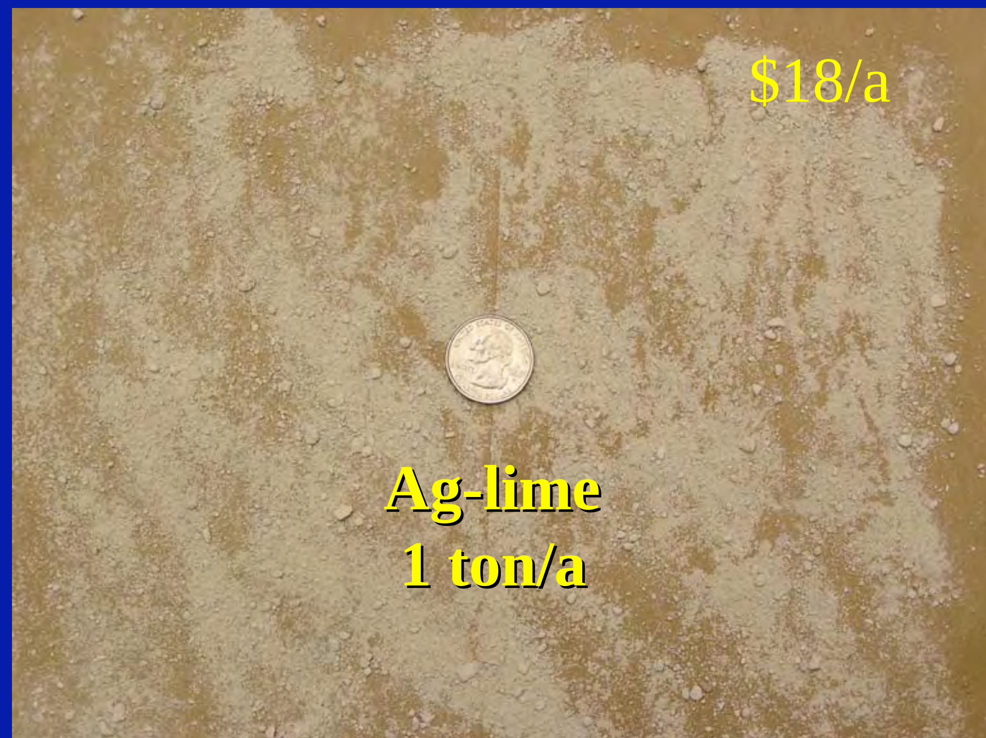
- Low pH 4.9, discovered after corn was planted.
- Compare "price equivalent" rates of ag-lime & pell-lime. 1 ton ag-lime = 200 lb pell-lime
- Surface applied & incorporated with normal weed control tillage

Ag and Pell Lime Rescue Rates for Corn




$110/a
Pell-lime
1 ton/a


$11/a
Pell-lime
200 lb/a


$18/a
Ag-lime
1 ton/a

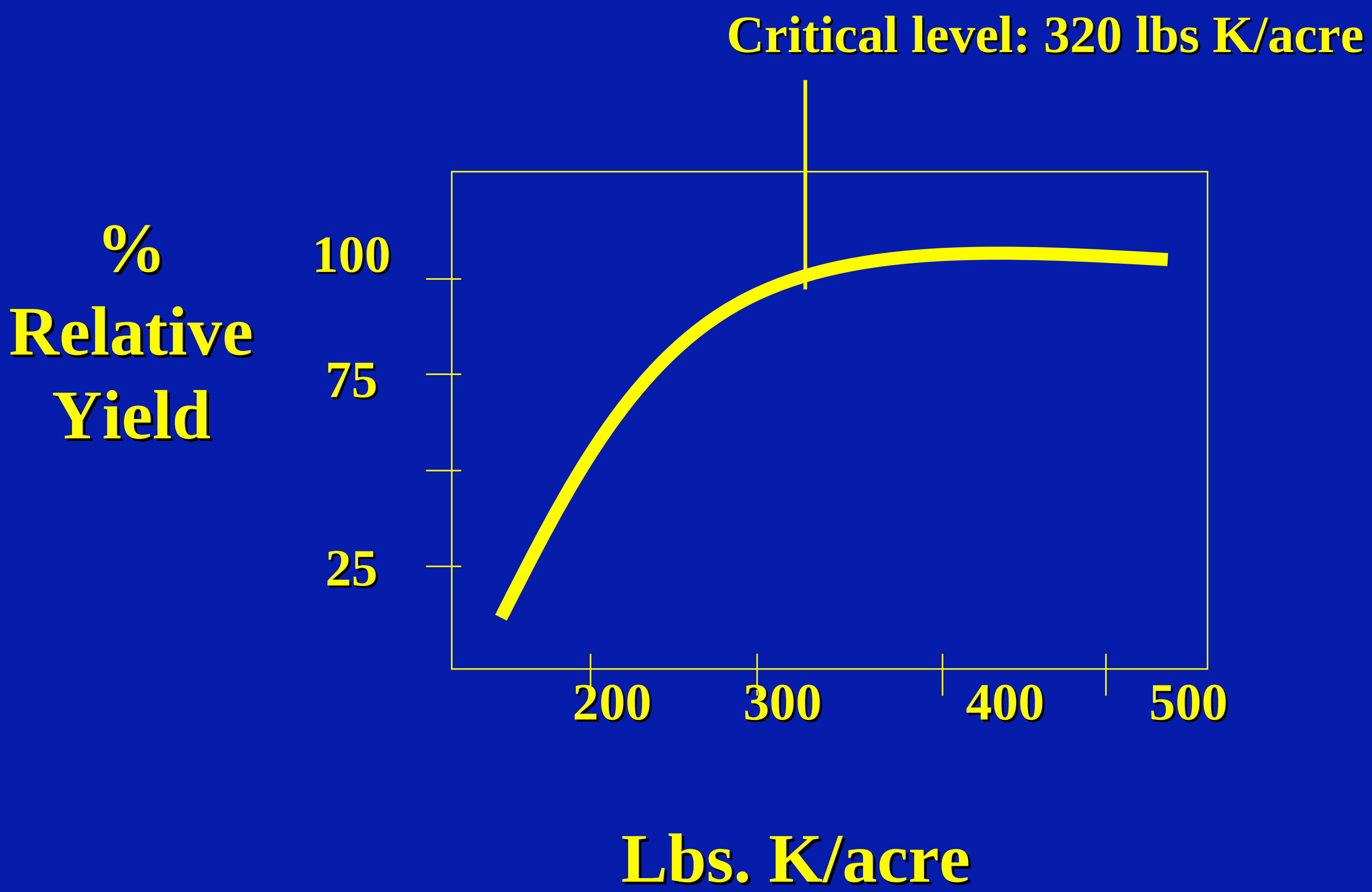
Pelletized Lime Conclusions:

- As effective as Ag lime at same ENM application rates
- Not a "quick fix"
- Follow the instructions on the bag
- Cost an issue

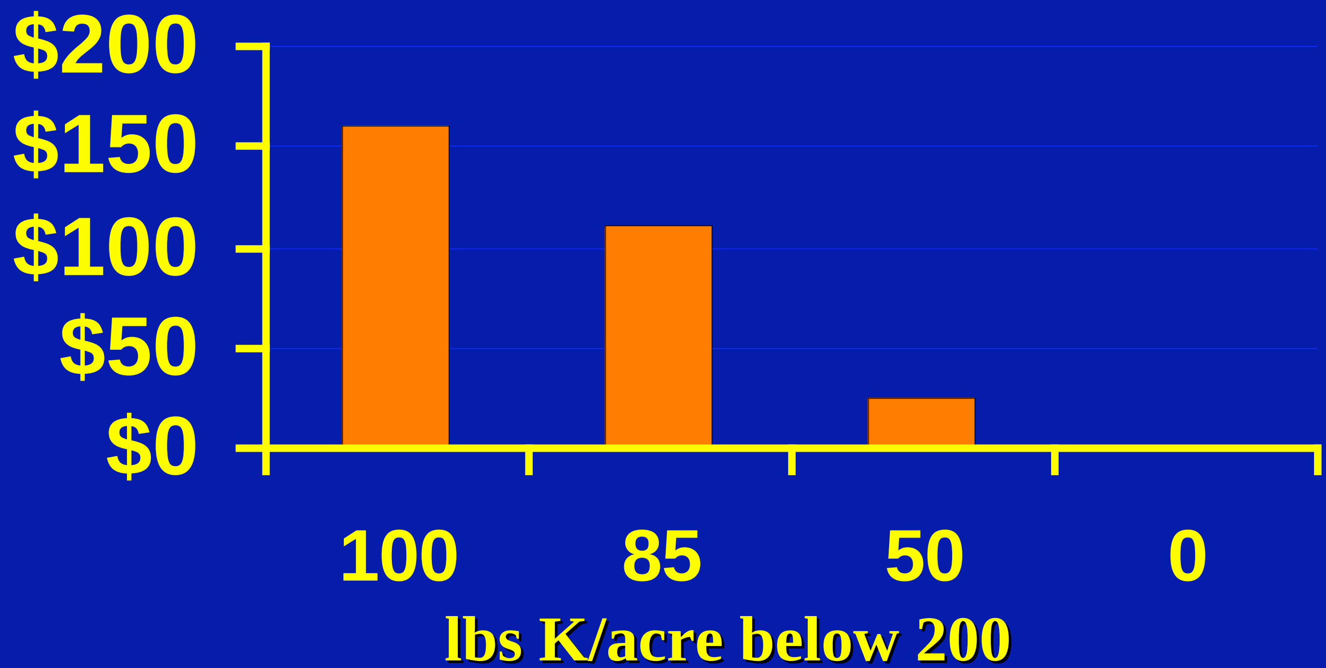
All Soil Test Recommendations for P & K Include:

- Critical Level
  - Yield loss below this level
- Crop removal
  - How much goes out with the crop
- Build-up
  - Extra added to keep soil testing above target level.
- Rotation?

Critical Level



The cost of being below the critical level for K:



Based on $5.00/bu rice

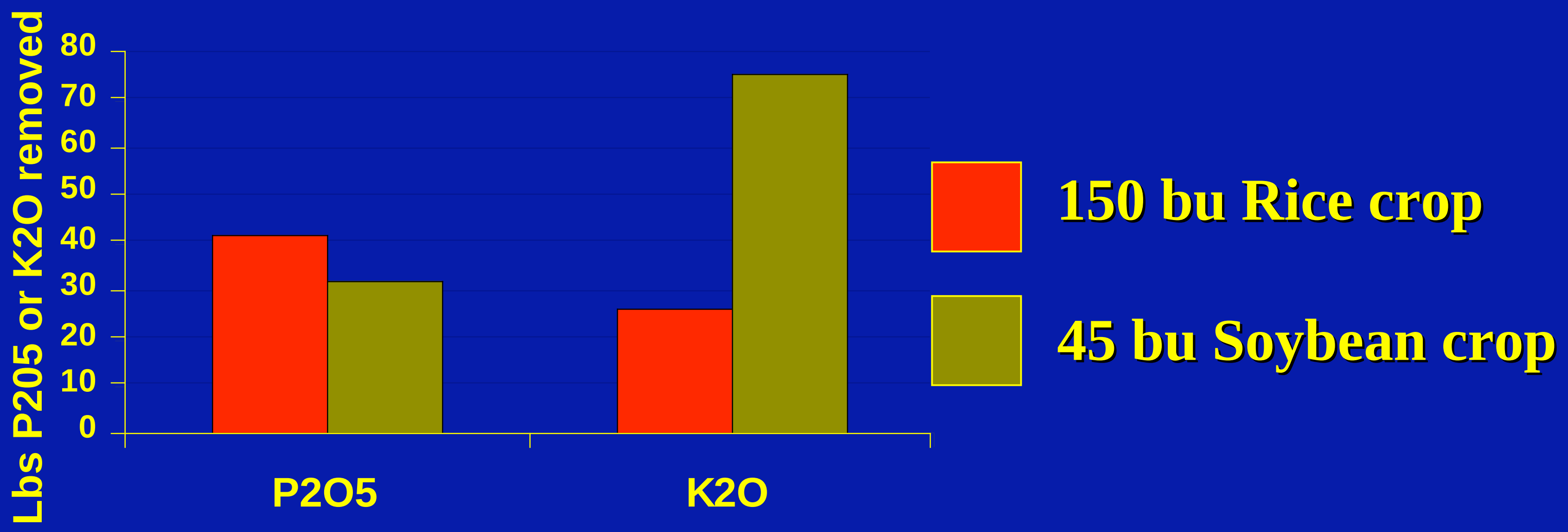
MU critical levels for crops

- P
  - Row crops except for rice: 45 lbs/a by Bray 1
  - Rice: 35 lbs/a by Bray 1
- K
  - Row crops except for rice: 220 + (5XCEC) lbs/a by Ammonium acetate
  - Rice: 125 + (5XCEC) lbs/a by Ammonium acetate

Crop removal for row crops in lbs for 1 bu/a

Crop	P_2O_5	K_2O	S
Corn	0.35	0.25	0.07
Cotton (1 bale)	20.0	16.0	4.5
Rice	0.28	0.17	0.04
Sorghum	0.40	0.25	0.09
Soybeans	0.90	1.50	0.20
Wheat	0.60	0.40	0.10

Grain Removal: Rice & Soybeans



Build Up:

- Fertilizer added above target level + crop removal to keep soils testing in optimum range
- Select from 1-8 years
  - 1 year, add more in a good year?
  - 8 year, limit inputs in bad years?
- MU default is 8 years, A&L is 4

Weighing options

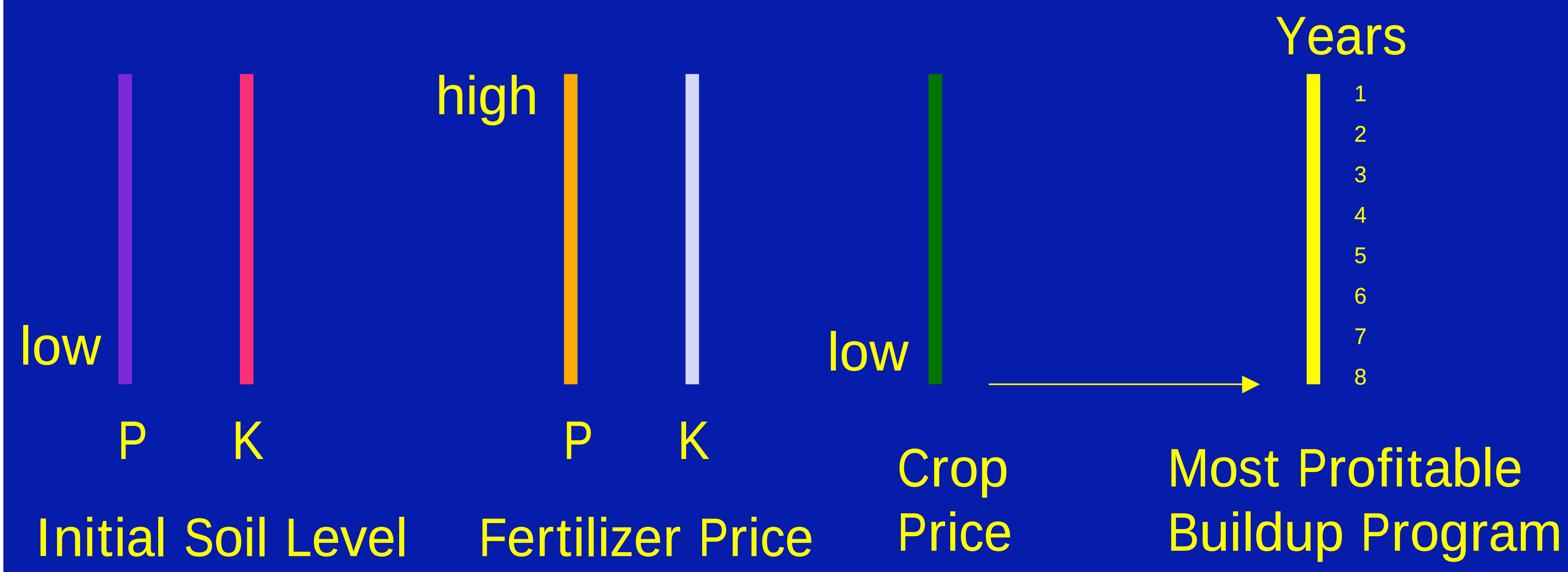
- 1 or 3-year buildup

  Puts strain on cash flow

- 8-year buildup

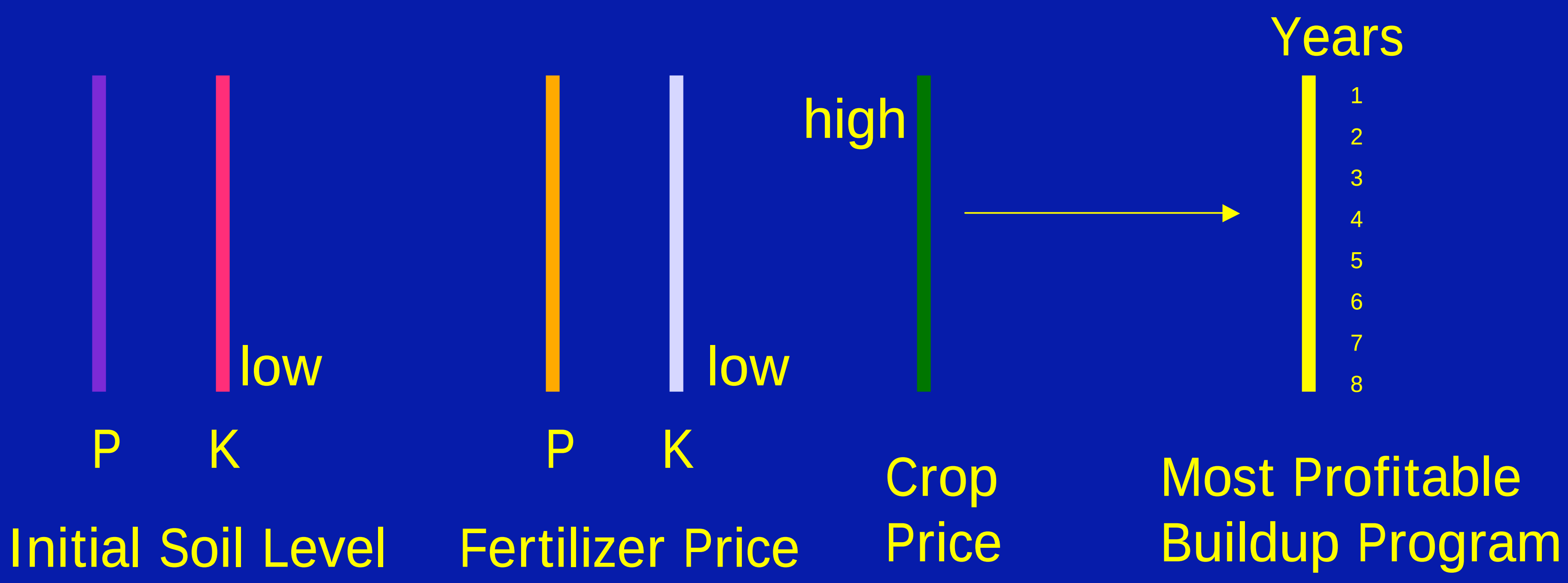
  Short-term yield lose?

Emerging Model



Example: Fescue

High value crop



Example: Rice

Rice yields 3-year average

PK Buildup Rice target	2004-6 bu/acre
N only	149
1-year	162
4-year	163
8-year	163

Soybean yields: 3-year average

PK Buildup Soy target	2004-6 bu/acre
No fertilizer	44
1-year	56
4-year	51
8-year	50

Fescue yields: 3-year cumulative

PK Buildup	2004-6 ton/acre
No fertilizer	3.1
N only ($89)	4.3
1-year ($289)	6.6
4-year ($256)	6.4
8-year ($197)	6.1

Soil Test Values

	Hay		Pasture	
	P	K	P	K
Check	9	198	10	207
1 year	48	252	51	311
4 year	27	210	29	241
8 year	15	228	15	235

Picking a soil lab: All labs produce good test results

- Turn around time
- Recommendations
  - Can you ask for different crops and yields?
  - Are they field verified?
- Costs
- **Pick a lab and stick with it!**

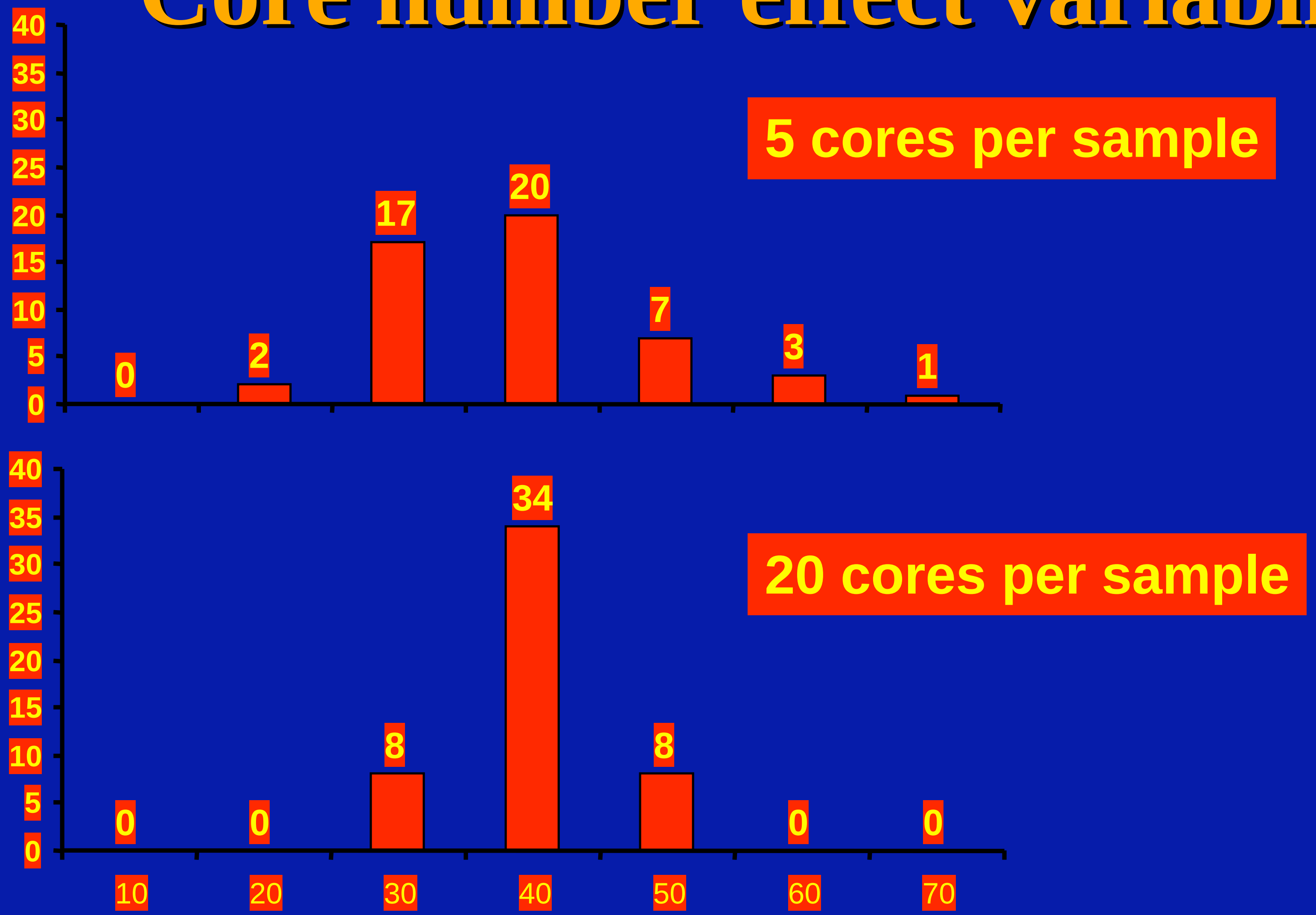
When to Sample

- Try to sample the same time of the year
- pH
  - pH lower in summer
- K
  - Wet soil tend to have higher K value
  - Plant uptake may lower P & K values during peak growing season.

Get a Representative Sample

- A soil test recommendation cannot be any better than the sample given!
- If cost is an issue, better to caricaturize one area and extrapolate than to collect an average sample of both.

Core number effect variability

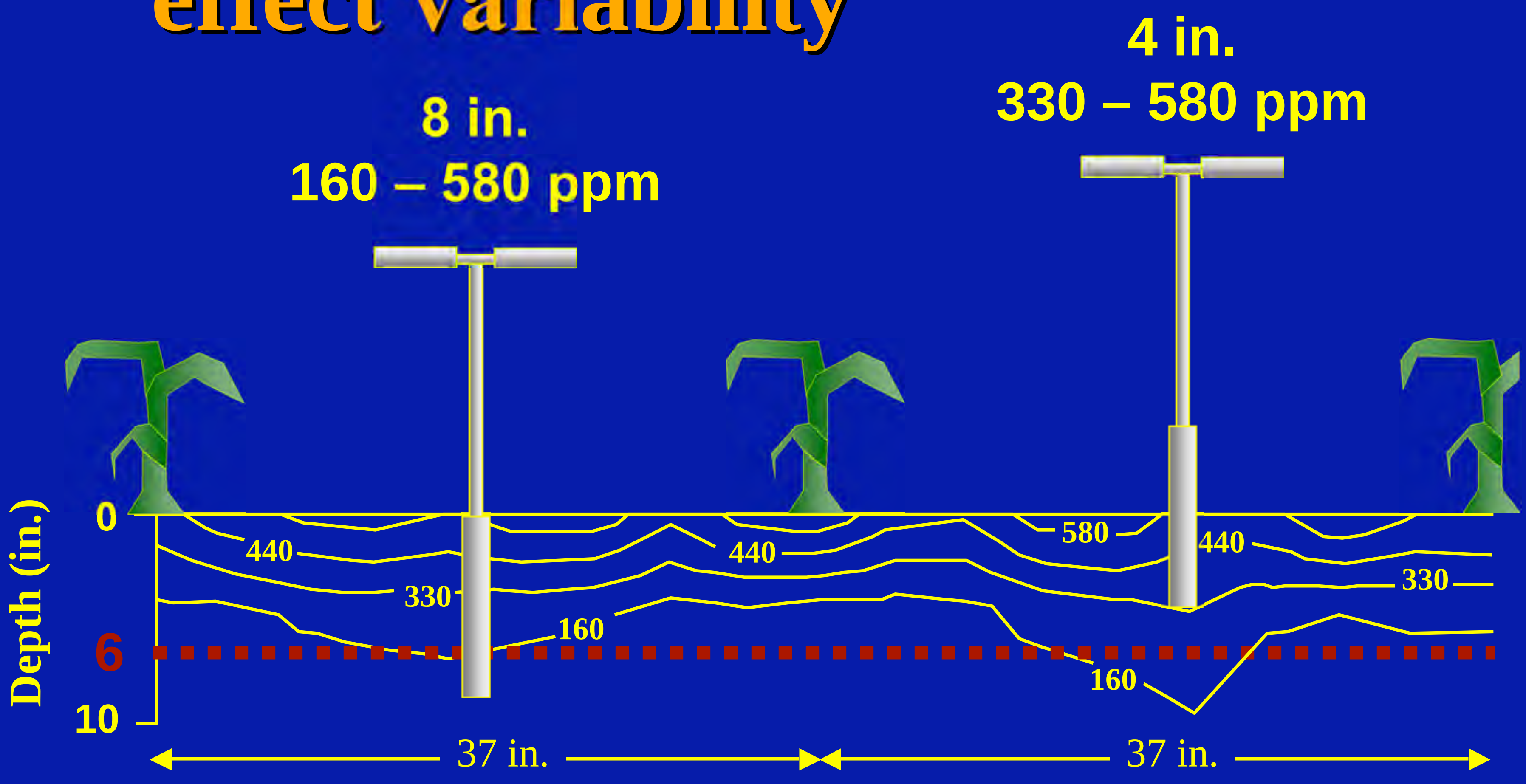


Implication of required core number

Get a good average for your fields

- Fourteen sub-samples make a statistically reproducible "composite"
- Sample across the whole area
- Sample to tillage and rooting depth
- Avoid noticeably different spots

Depth and location of core effect variability



Robbins and Voss, 1991 (IA)

Remember:

In our history, some of our most highly trained people have been the ones taking soil samples