Lime Application and Soil pH

Crop Opportunity Update
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pH

- Degree of acidity or alkalinity (0-14 scale)
  - $pH = -\log [H^+]$
  - Each unit of pH change = 10X change in H^+
- Impacts soil chemistry and biological properties
  - Influences root uptake of nutrients and toxins
  - Impacts activity of soil microorganisms
  - Alters activity of plant pathogens
- Soil pH change is a complex phenomenon!!!
  - Depends on both site and management factors

Background

- Using ammonium based N fertilizers in crop production has been shown to acidify soils via:
  - removal of base cations such as Ca^{2+} and Mg^{2+} through crop harvest
  - N fertilizer application and N transformation(nitrification), a process that releases H^{+} into the soil
  - NO_3^- not taken up by the growing crop (leach to deeper soil layers taking Ca^{2+} and Mg^{2+})
- Recommendations of the optimal level of N to apply based on "yield goal"
  - typically ignore the cost of lime created by N fertilization

N fertilizers and cost of lime?

Nitrogen source	Composition	Lime required ($lb\ CaCO_3/lb\ N$)
Anhydrous ammonia	82-0-0	1.8
Urea	46-0-0	1.8
Ammonium nitrate	34-0-0	1.8
Ammonium sulfate	21-0-0-24	5.4
Monoammonium phosphate	10-52-0	5.4
Diammonium phosphate	18-46-0	3.6
Triple super phosphate	0-46-0	0.0

Adapted from Havlin et al., 1999

Nitrogen Source	Pound of Aglime per Pound of N
Ammonium Sulfate	7
Ammonium Phosphates	7
Anhydrous Ammonia	4
Urea	4
28% Solution	4
Ammonium Nitrate	4

Approximate amount. Adapted from Modern Corn Production.

Iowa State University

Effect of N Application on Soil pH

lb N/acre/year	Soil pH
0	6.1
40	6.1
80	6.0
120	6.0
160	5.8
200	5.7

Ammonium Nitrate applied each year for 5 years, 7 in. incorporation. Plano silt loam soil.

Walsh, 1965. Fert. & Lime Conf. UW-Madison.

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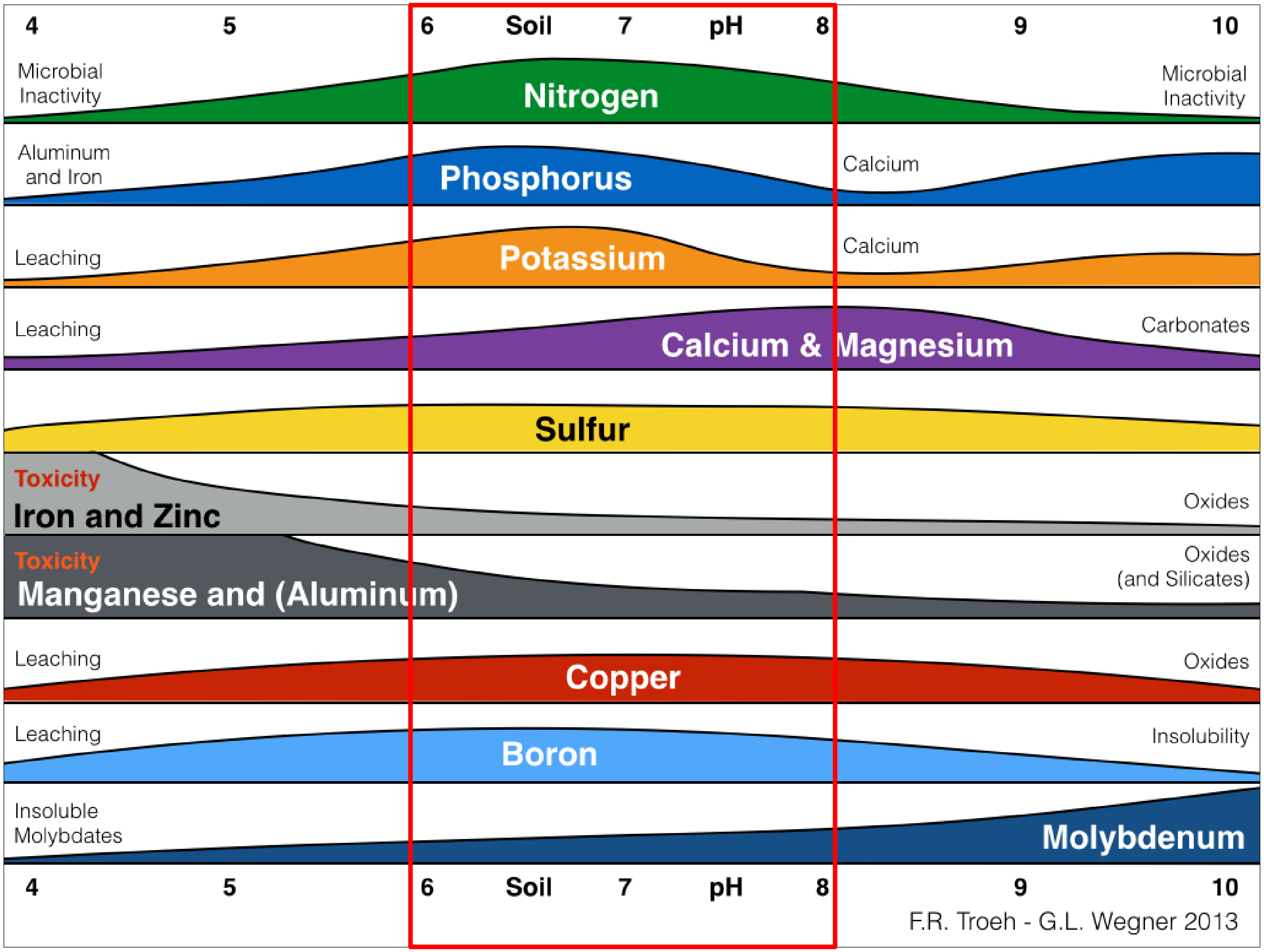
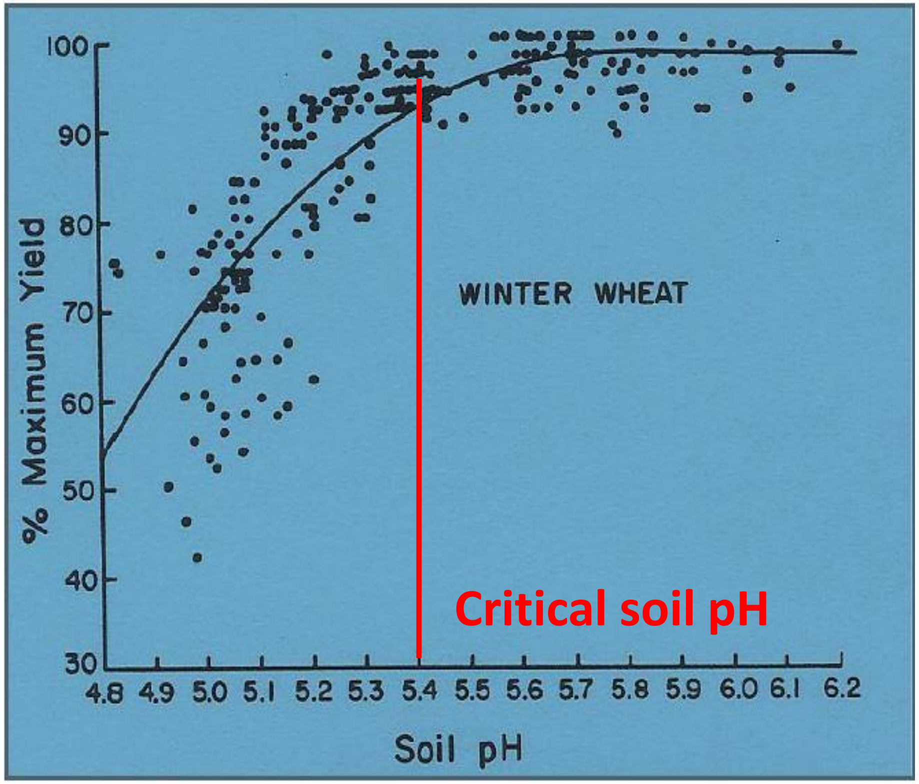
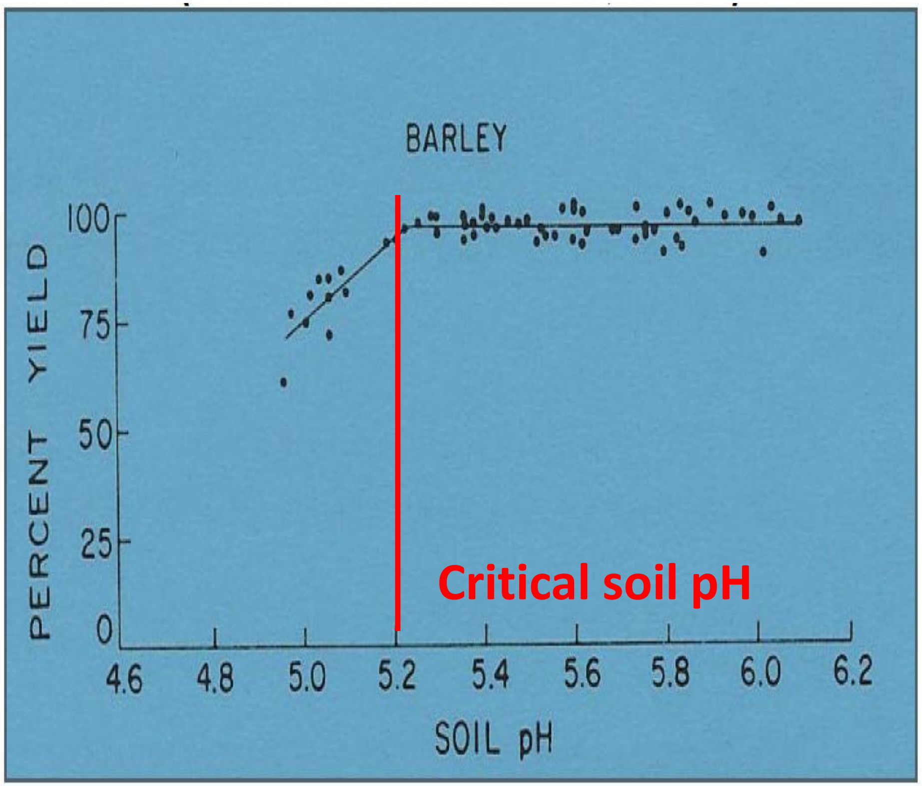
Nutrient availability/pH relationship



Critical pH for yield reductions





(Mahler and McDole, 1987, results of 5 year study)

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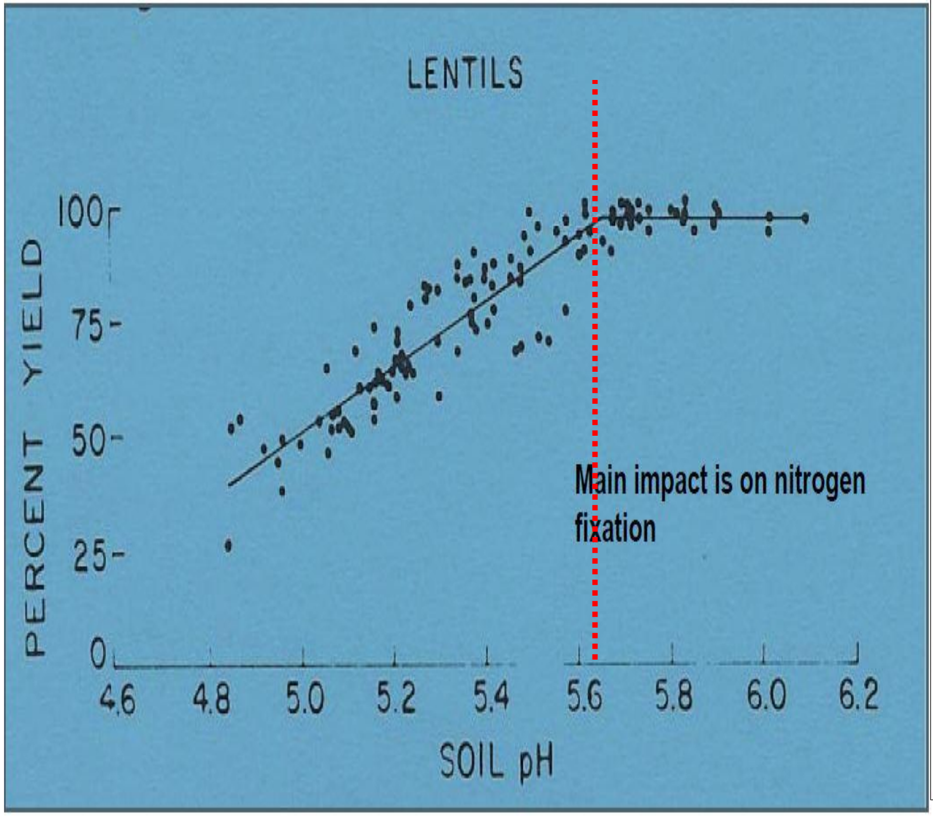
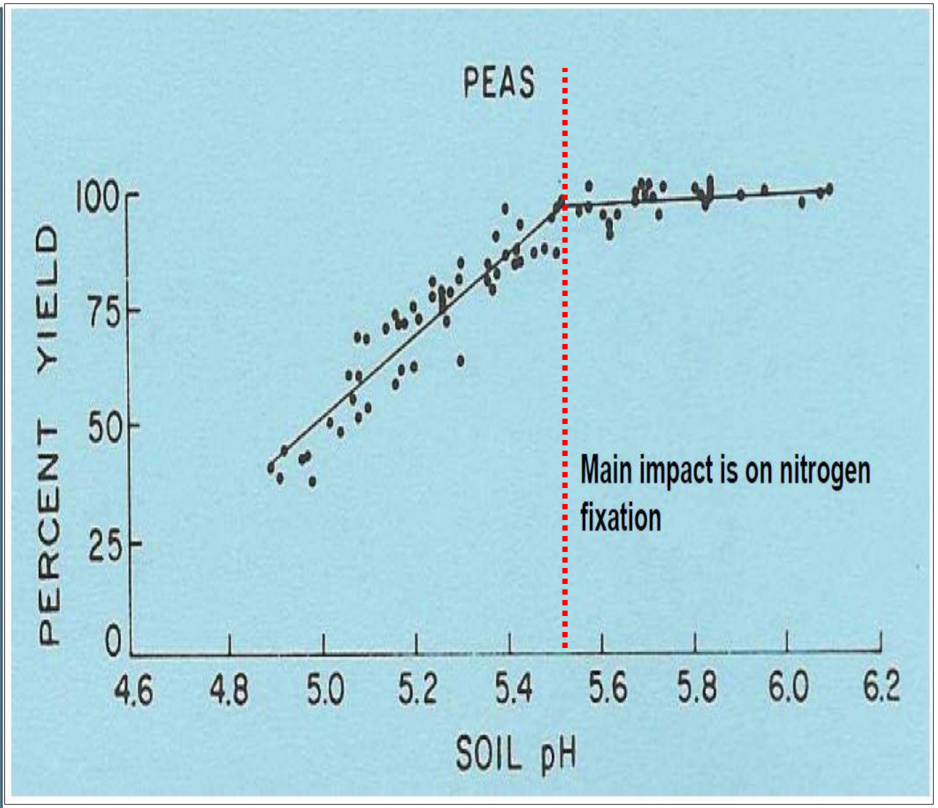




(Mahler and McDole, 1987, results of 5 year study)

Summary of Critical pH

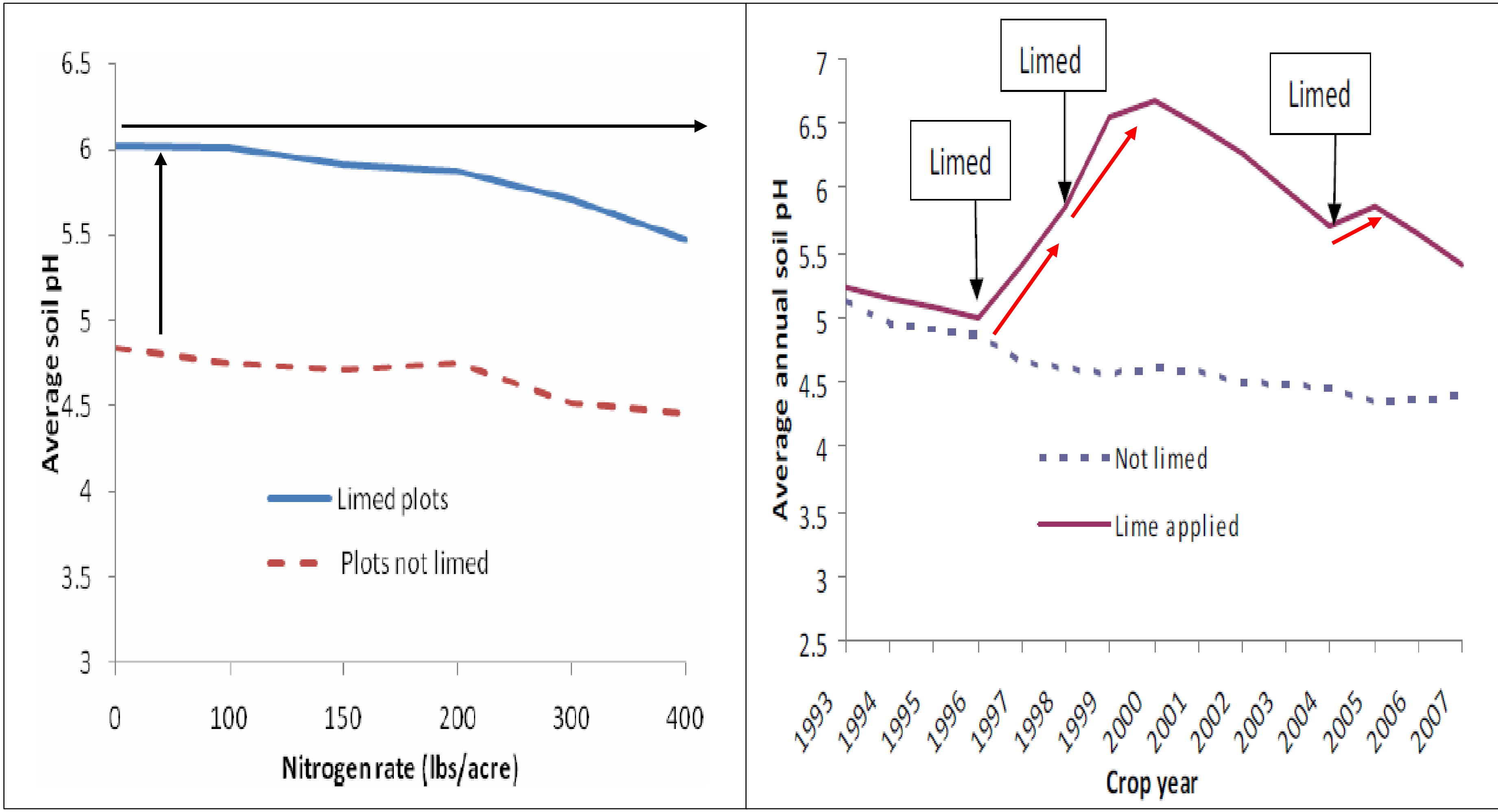
Crop	Critical pH
Winter and Spring Cereals	5.2 to 5.4
Grain Legumes	5.5 to 5.6
Lentils	*5.6*
Peas	*5.5*
Canola (winter)	5.5 to 5.8
Alfalfa	5.7
(Mahler and McDole, 1987; Brown et al., 2009; Lofton et al., 2010)	

Management solutions -liming

- Neutralizes toxic elements: Al, Mn, H
- Improves overall nutrient availability
- Increases microbial activity
- Increases the percentage of non-acid cations(Ca, Mg, K, Na)
- Improves Ca, Mg availability

- Magnitude and duration depends on:
  - initial soil pH
  - fertilizer additions and
  - crops grown

Soil pH vs N rate & time



Why this study?

- Traditional Aglime sources are required in excess of over 1000 lbs/ac to achieve any desirable soil pH change
  - benefits of liming come at a significant cost to the farmer
- SuperCal 98G has influenced soil pH at rates as low as 400 lbs/ac to give comparable yield
- Soil amendment benefits for up to five successive years

Objectives

The objectives of this study were to demonstrate:

- the effects of application of SuperCal 98 on soil pH
- whether SuperCal 98 application can provide economic return to producers

Study Site

Study site: Scott
Study year: 2015

Scott, SK
(**Dark Brown**
Soil Zone)

Experimental Setup

- Experimental Design
  - Split-plot in RCBD with four replications
  - Main plot (crop) and Sub-plot (lime)
- Seeding rate: 300 (wheat) and 150 (canola) seeds/m^2
- Fertilizer and lime application
  - Urea and AS applied mid-row, MAP seed-placed according to soil test recommendation
  - Lime (0-700 lbs/ac) applied in seed-row, 7 days to seeding
- Plot size: 2 x 10 m

Plots Layout

Canola						
PLOT	401	402	403	404	405	406
TRT	1	4	5	2	3	6
PLOT	301	302	303	304	305	306
TRT	4	6	1	2	3	5
PLOT	201	202	203	204	205	206
TRT	4	5	6	3	1	2
PLOT	101	102	103	104	105	106
TRT	1	2	3	4	5	6

Wheat						
PLOT	407	408	409	410	411	412
TRT	11	7	12	8	10	9
PLOT	307	308	309	310	311	312
TRT	12	9	7	10	11	8
PLOT	207	208	209	210	211	212
TRT	8	7	11	9	12	10
PLOT	107	108	109	110	111	112
TRT	7	8	9	10	11	12

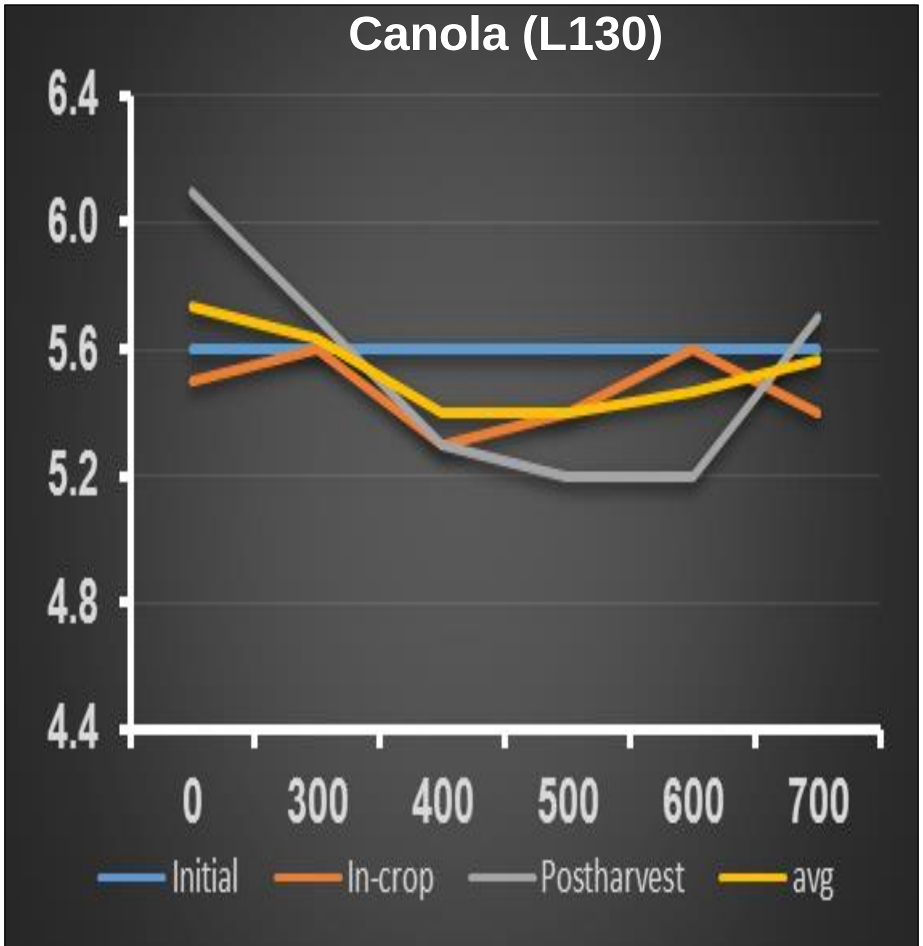
Data & Analysis

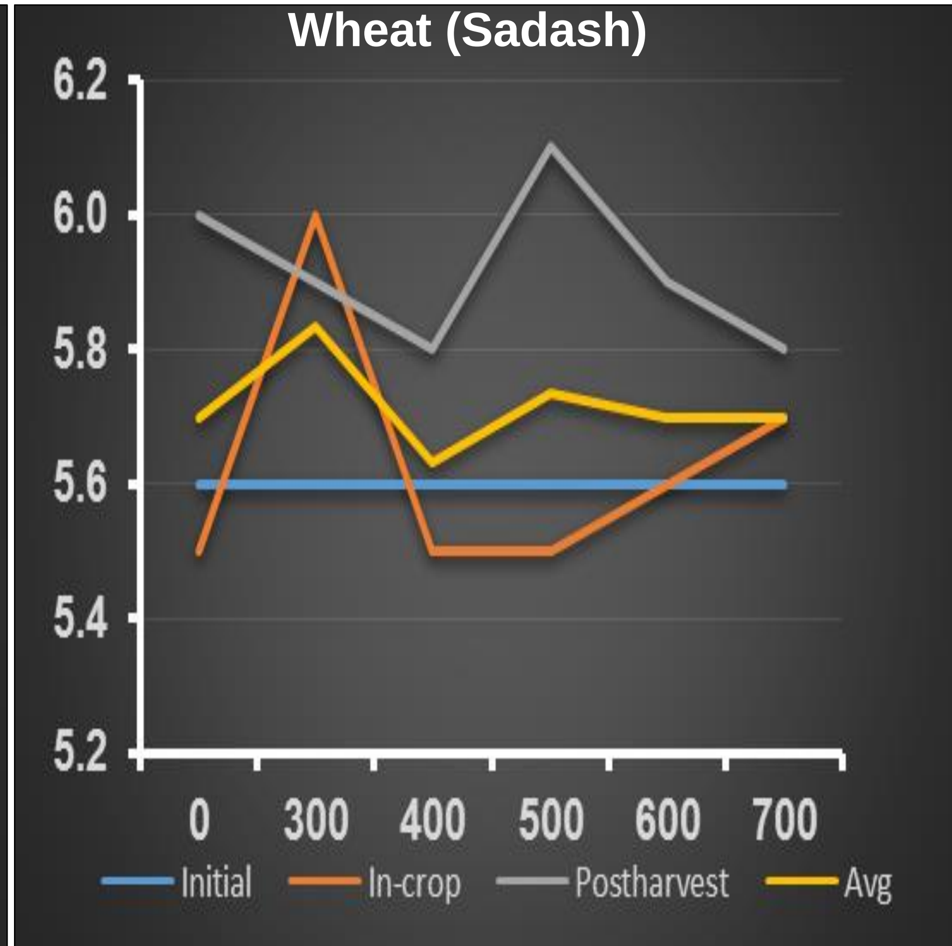
- Data was collected on
  - Plant density
  - NDVI
  - Yield
  - Soil pH (Initial, In-crop and Postharvest)
- Data was analysed using PROC MIXED in SAS 9.3

Preliminary Results

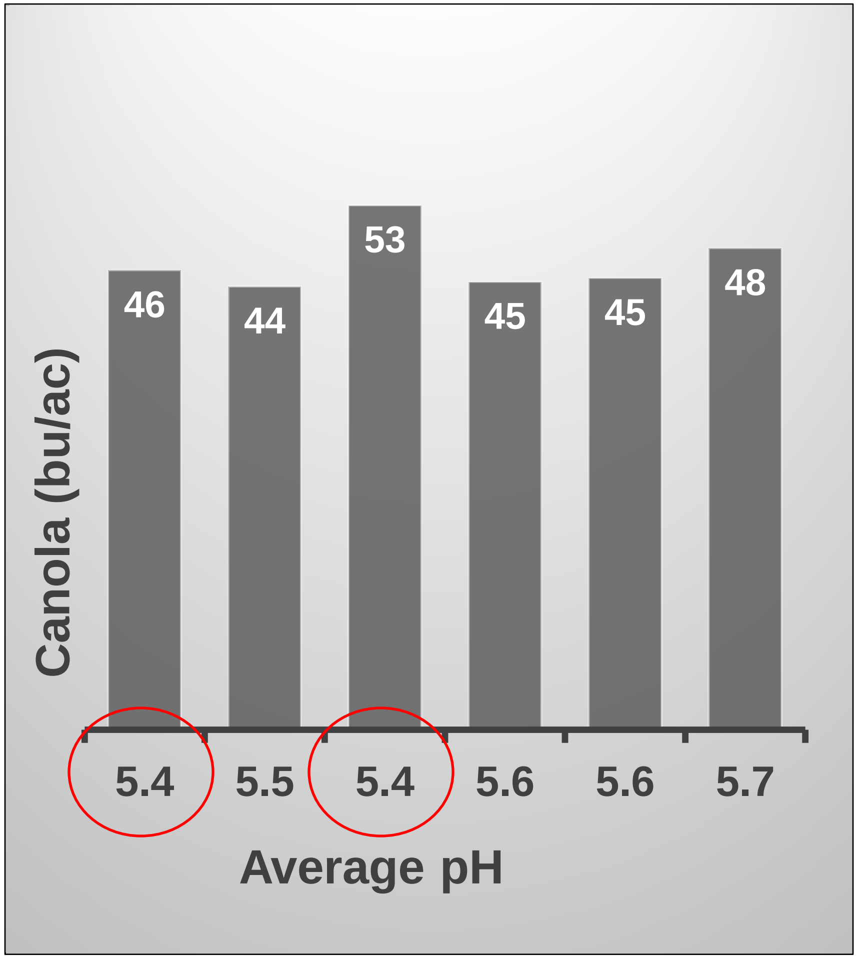
- Plant density, NDVI (4 leaf stage) and yield were all not affected by lime rate and crop type
- NDVI (prior to bolting) was affected by crop but not lime rate (canola > wheat)
  - crop physiology, four leaf stage vs bolting

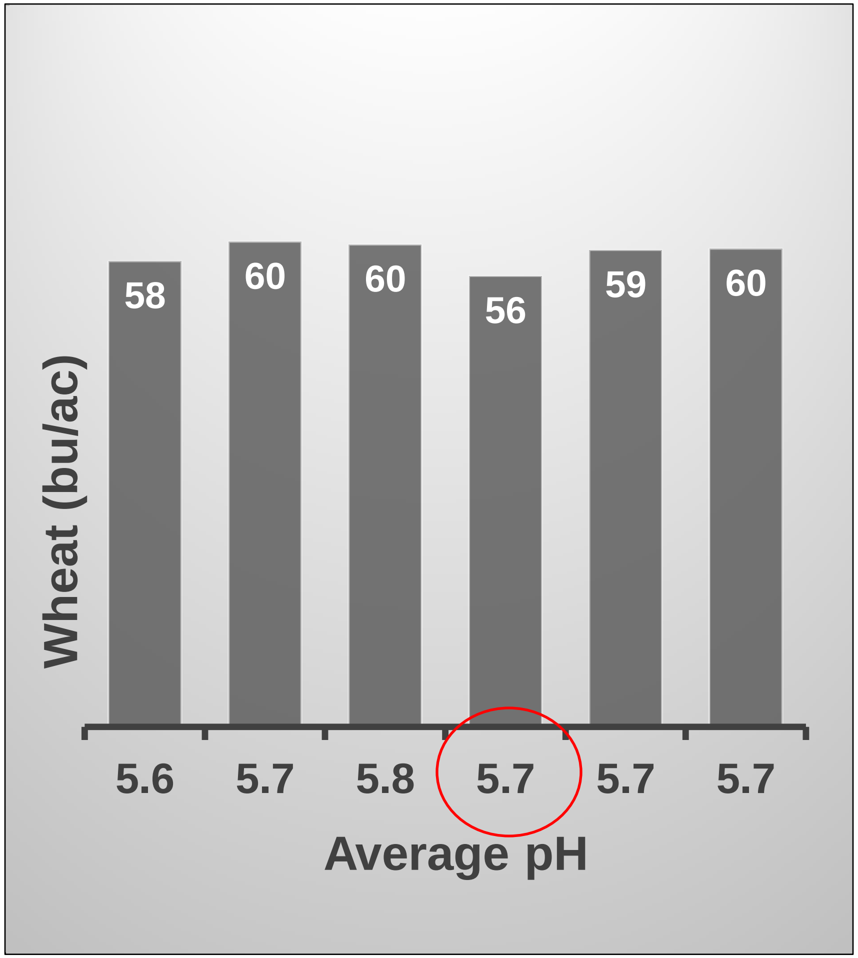
Lime (lbs/ac) vs soil pH



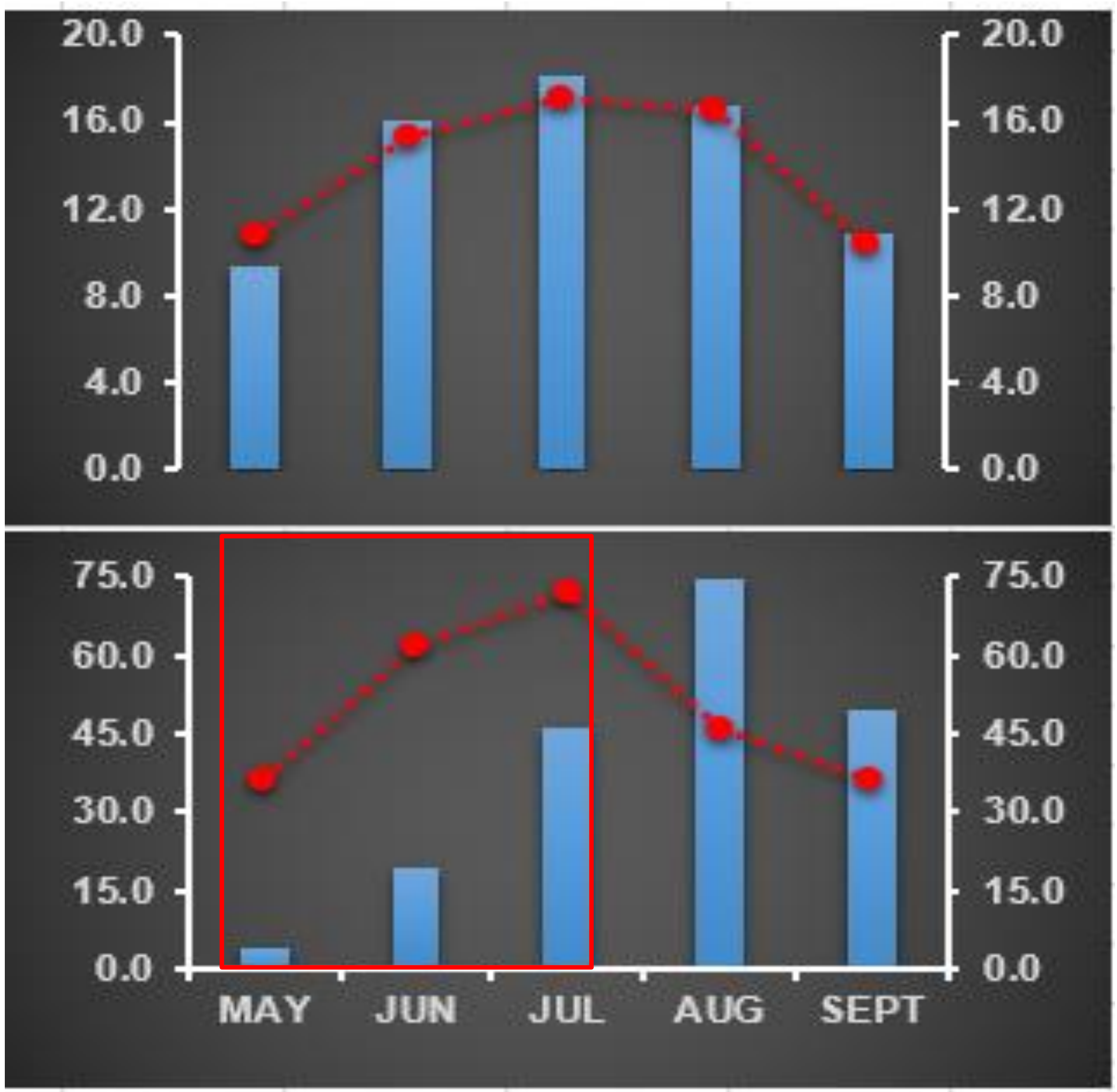


Soil pH vs Yield





Weather Conditions



Back to reality: Economics??

NET Gain ($/ac)

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Liming rate (lbs/ac)	*0*	*300*	*400*	*500*	*600*	*700*
Yield (bu/ac)	46	44	53	45	45	48
Price ($/bu)	10.16	10.16	10.16	10.16	10.16	10.16
Gross Income ($/ac)	*467.36*	*447.04*	*538.48*	*457.20*	*457.20*	*487.68*
Seed cost ($/ac)	56.00	56.00	56.00	56.00	56.00	56.00
Fertilizer cost ($/ac)	78.68	78.68	78.68	78.68	78.68	78.68
Cost of lime ($/ac)	0.00	759.00	1012.00	1265.00	1518.00	1771.00
Total Cost ($/ac)	134.68	893.68	1146.68	1399.68	1652.68	1905.68
NET Gain ($/ac)	***332.68***	***-446.64***	***-608.20***	***-942.48***	***-1195.48***	***-1418.00***

Liming rate (lbs/ac)	*0*	*300*	*400*	*500*	*600*	*700*
Yield (bu/ac)	58	60	60	56	59	60
Price ($/bu)	5.36	5.36	5.36	5.36	5.36	5.36
Gross Income ($/ac)	*310.88*	*321.60*	*321.60*	*300.16*	*316.24*	*321.60*
Seed cost ($/ac)	23.25	23.25	23.25	23.25	23.25	23.25
Fertilizer cost ($/ac)	71.63	71.63	71.63	71.63	71.63	71.63
Cost of lime ($/ac)	0.00	759.00	1012.00	1265.00	1518.00	1771.00
Total Cost ($/ac)	94.88	853.88	1106.88	1359.88	1612.88	1865.88
NET Gain ($/ac)	***216.00***	***-532.28***	***-785.28***	***-1059.72***	***-1296.64***	***-1544.28***

Reasons

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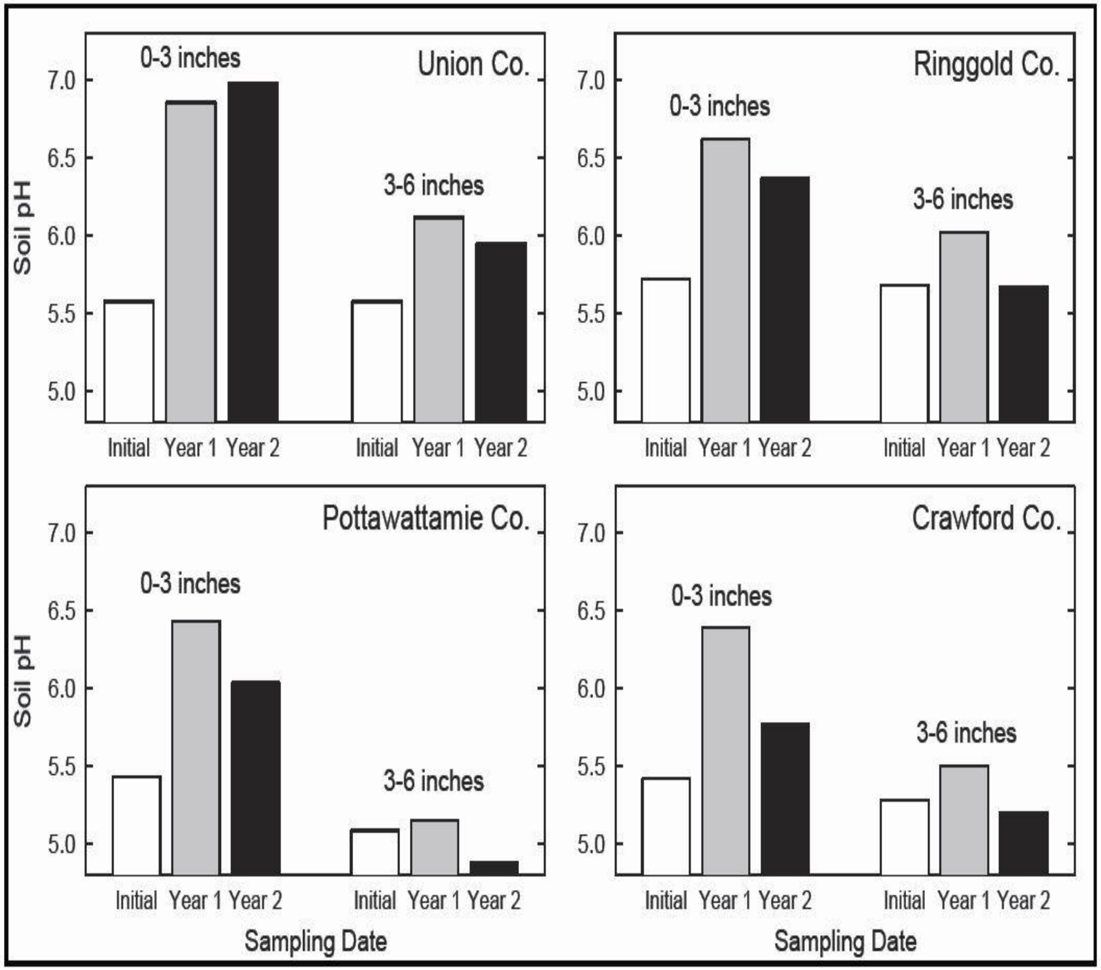
- From an economic perspective, liming is a *capital investment* rather than an operating input because of its long-term effect
- 2015 growing conditions (low moisture)
- Critical pH for the crops
  - Cereals: 5.2 to 5.6 compared to (5.5 to 6.5??)
  - Canola: 5.5 to 5.8 compared to (*5.2 to 5.8??*)
- Economic model: lime is necessary to increase pH to reach maximum yield
  - Subsequent applications are done to maintain that level based on cost of lime

Corn and soybean vs Liming



- pH change was only visible after the year of application
  - 0 - 6 inch
  - Aglime @ 3 ton ECCE/ac

Lime application (3 ton ECCE/acre) on soil pH for two different depths for four no-till trials one and two years after liming

Is it still worth an Investment??

Nitrogen source	Composition	Lime required ($lb\ CaCO_3/lb\ N$)
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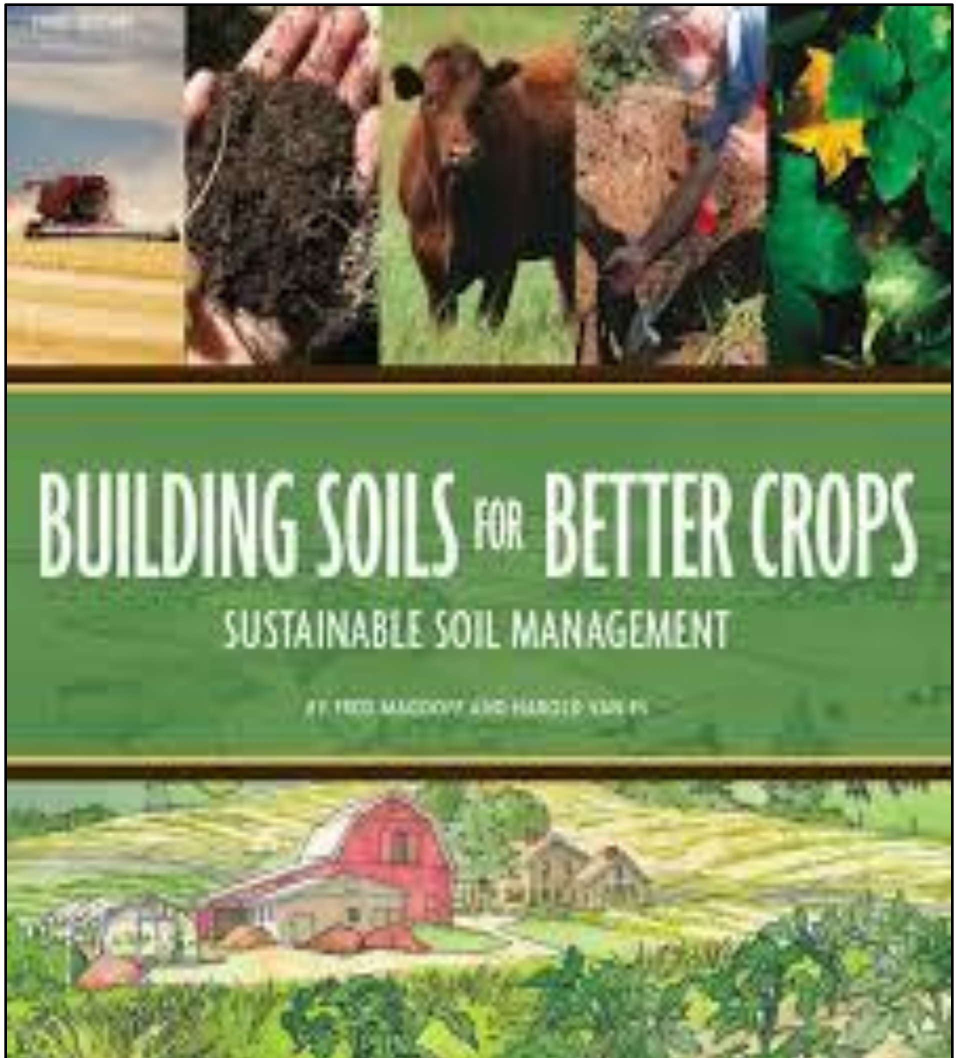
Iowa State University

Preliminary conclusions!!!

- Crops vary in their response to soil pH
  - respond to lime applications only if pH levels are limiting crop performance
  - subsequent applications are done to maintain that level based on cost of lime
- Liming is a *capital investment* rather than an operating input
- Lime application affects soil pH and yield over time

Take Home Message



- Liming is a *capital investment* rather than an operating input
- Each lb. of fertilizer applied has a corresponding lime cost
- Effects of lime on pH change depends on so many variables!!
- Producers should be aware rather than worry!!!

For more information visit:

www.warc.ca

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