Benchmarking No-Till Crop's Macro and Micronutrient Status

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Common Visual Symptoms of Macro and Micro Nutrient Deficiencies

- Causes: steady increases in corn (other crops) yields.
- Adverse weather conditions.
- Reduced fertilizer applications or deteriorated soil quality.

Iron deficiency in soybean

Sulfur deficiency

Value of Soil and Tissue Testing

- What do soil and tissue reports mean?

Nov 12, 2013

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IDENTIFICATION
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SOIL ANALYSIS REPORT

NEUTRAL AMMONIUM ACETATE (EXCHANGEABLE)

LAB NUMBER *259*	SAMPLE IDENTIFICATION	ORGANIC MATTER L.O.I.	PHOSPHORUS			POTASSIUM	MAGNESIUM	CALCIUM	SODIUM	pH		CATION EXCHANGE CAPACITY C.E.C.	PERCENT BASE SATURATION (COMPUTED)				
			P_1 (WEAK BRAY) 1:7	P_2 (STRONG BRAY) 1:7	OLSEN BICARBONATE P	K	Mg	Ca	Na	SOIL pH 1:1	BUFFER INDEX		% K	% Mg	% Ca	% H	% Na
		percent RATE	ppm RATE	ppm RATE	ppm RATE	ppm RATE	ppm RATE	ppm RATE	ppm RATE			meq/100g					
58677	1	2.1 L	28 H	35 M		156 M	215 M	2004 M	9	5.1	6.5	19.8	2.0	9.0	50.6	38.2	0.2
58678	2	1.8 L	24 H	27 M		184 H	218 H	1699 L	10	4.8	6.5	20.4	2.3	8.9	41.6	47.0	0.2
58679	3	2.7 M	36 VH	40 H		205 M	306 H	2584 M	8	5.2	6.3	24.4	2.2	10.5	53.0	34.2	0.1
58680	4	2.5 L	30 H	34 M		247 VH	319 VH	2490 M	10	5.3	6.5	22.9	2.8	11.6	54.4	31.0	0.2
58681	5	3.6 H	36 VH	47 H		228 M	391 H	2565 L	10	4.8	6.0	31.5	1.9	10.3	40.7	47.0	0.1
58682	6	2.9 M	28 H	33 M		194 M	322 H	2191 L	11	4.8	6.0	26.8	1.9	10.0	40.9	47.0	0.2
58683	7	2.1 L	40 VH	47 H		204 H	215 M	1848 L	10	5.0	6.5	19.7	2.7	9.1	46.9	41.1	0.2
58684	8	2.7 M	37 VH	50 H		194 H	221 H	1903 M	8	5.1	6.4	19.2	2.6	9.6	49.6	38.0	0.2
58685	9	3.0 M	26 H	35 M		187 M	343 VH	2251 L	10	5.1	6.2	23.6	2.0	12.1	47.7	38.0	0.2
58686	10	2.8 M	32 VH	42 H		220 H	465 VH	2825 M	15	5.5	6.4	25.1	2.2	15.4	56.3	25.8	0.3

Outline

- Soil and tissue testing for nutrient status: main approaches, benefits, and limitations.

- Iowa case-study: benchmarking crop nutrient status across the state.

- Increase the value of soil and tissue testing.

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Nutrient Sufficiency Concept

- A nutrient is in sufficient amount if additions of that nutrient does not produce (economic) yield response.

- Soil and tissue testing is based on empirical relationship (or correlation) between the amount of nutrient extracted by different chemicals from the soil or plant tissues and yield response to a specific nutrient.

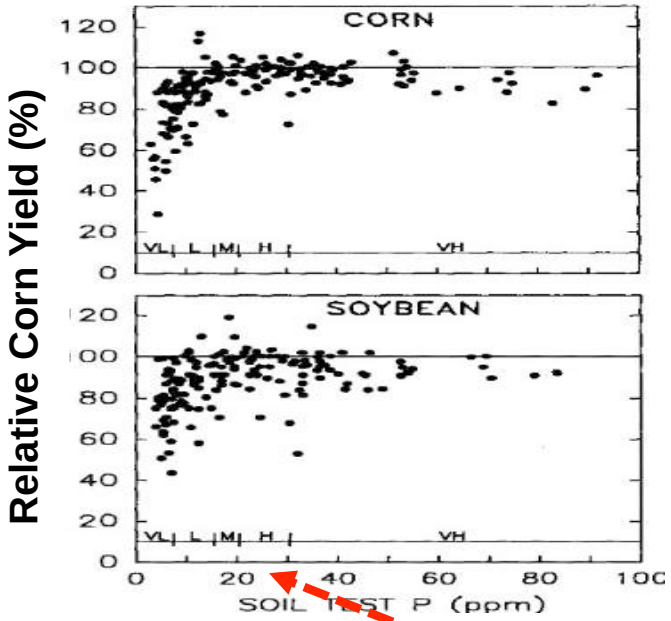
Sufficiency Level of Available Nutrient

- Critical Range or Critical Concentration below which economic and above no economic Yield Response (YR) to a nutrient is observed.

- Only one deficient nutrient at a time, other factors and nutrients should not be limited.

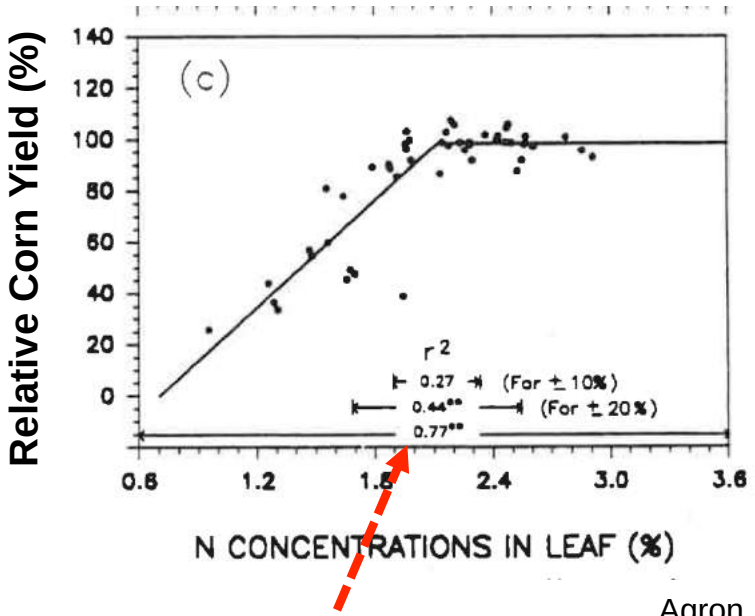
Sufficiency Level of Available Nutrient

Soil Phosphorous Test



J. Prod. Agr. 1992.5:148-152.

Corn Nitrogen Tissue Test



Agron. J. 1991. 4:525-531

Optimal Range or Critical Concentration

Sufficiency Level of Available Nutrient

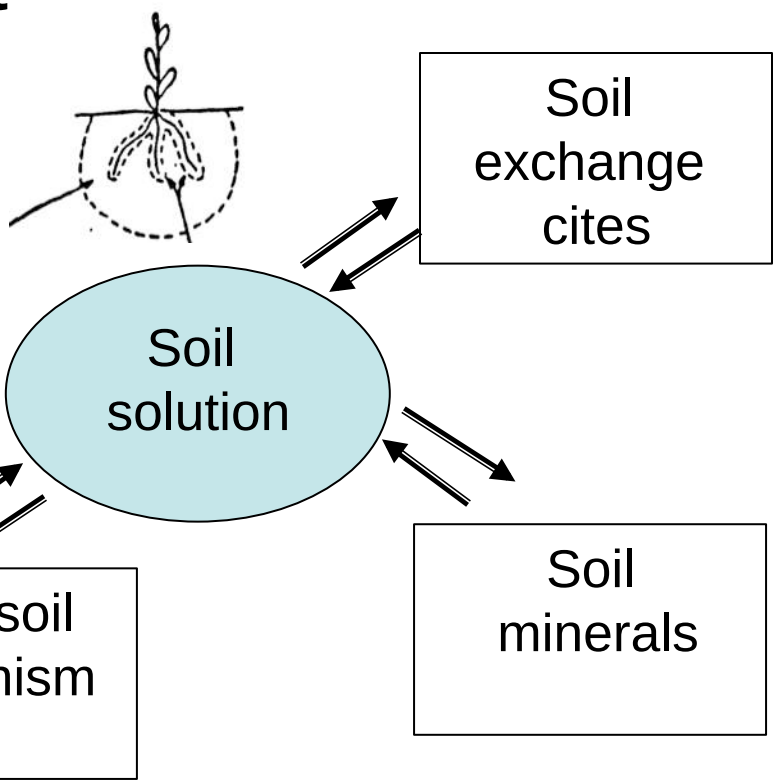
- Relative yields provide the index of sufficiency. Relative yield is the percentage of the maximum yield obtained when other nutrients and factors are not limited.

- The assumption is that soils with different CEC, SOM and other factors have similar relative yields from additions of the same nutrient.

Intensity vs Quantity of Soil Available Nutrient

- Intensity-nutrient concentration in the soil solution. This nutrient pool is taken by plants.

- Quantity-amount of nutrients released from the soil solid phase or SOM. Different chemicals extractant should mimic this release.



Sufficiency Level of Available Nutrient

- Based on the likelihood of (economic) yield response to a nutrient application (short-term profitability).

- Critical or optimal ranges are independent of other nutrients; this is good and bad.

- Tissue nutrient concentrations often widely vary with a crop stage, crop genetics, geography, yield levels or due nutrient concentration or dilution.

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Sufficiency Level Soil Testing plus Build-Up or Maintenance

- Based on the long-term profitability to applied fertilizers (P and K) and maintaining their optimal sufficiency levels.

- Needs to estimate yield and crop nutrient removal in (lb/ acre).

- Soil testing for build-up could be less frequent than for sufficiency level testing alone.

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Basic Cation Saturation Ratio Concept

- Based on “the ideal” basic cation exchange ratios”, Ca/Mg, Mg/K or Ca/K.
- Focused on the balance between nutrients.
- Often difficult or too expensive to reach “the ideal cation ratios”.
- Works better in highly weathered soils with low SOM and CEC.

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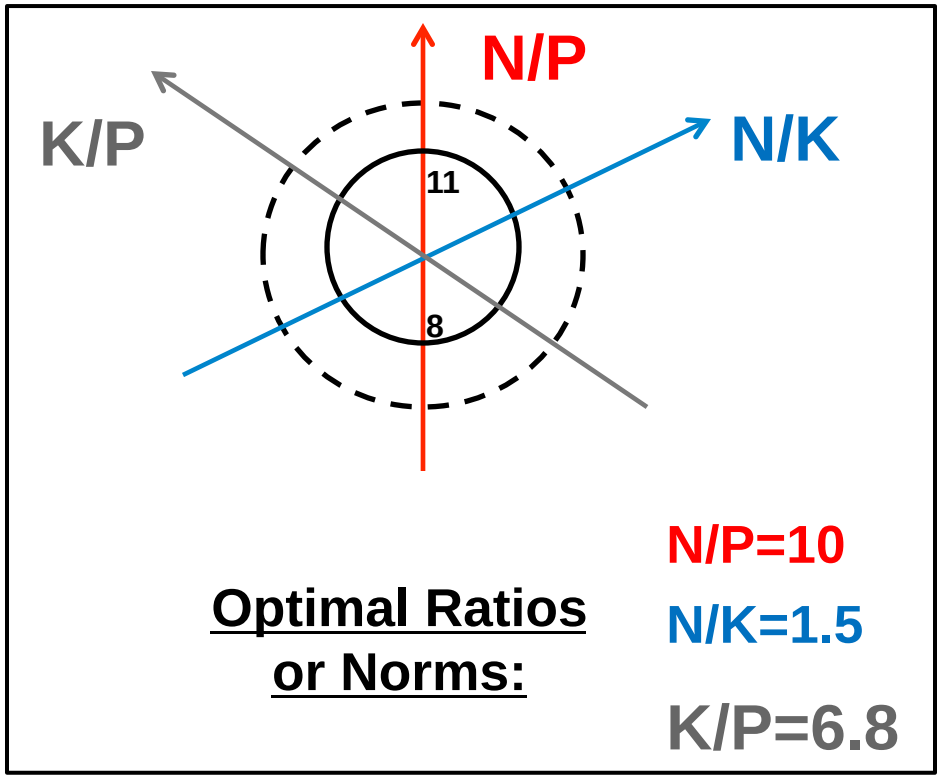
Diagnostic and Recommendation Integrated System (DRIS)

- Based on ratios of several nutrients.
- Nutrients are ranked by the degree of deficiency.
- Optimal ratios are located inside the inner circle.
- Optimal ratios are less effected by a crop stage.



Diagnostic and Recommendation Integrated System (DRIS)

- Focused on the balance and interactions between several nutrients.
- DRIS requires a lot of data to establish reliable norms and is/was computationally complex.
- Private companies and laboratories use some elements of DRIS.

Needs to Understand the Basics of Soil and Tissue Testing

- A recent surge in promoting the use of tissue testing by private industry.
- Many universities do not have well established calibration categories for soil and tissue tests for many micronutrients.
- Farmers and agronomists sometime need to make difficult management decisions.

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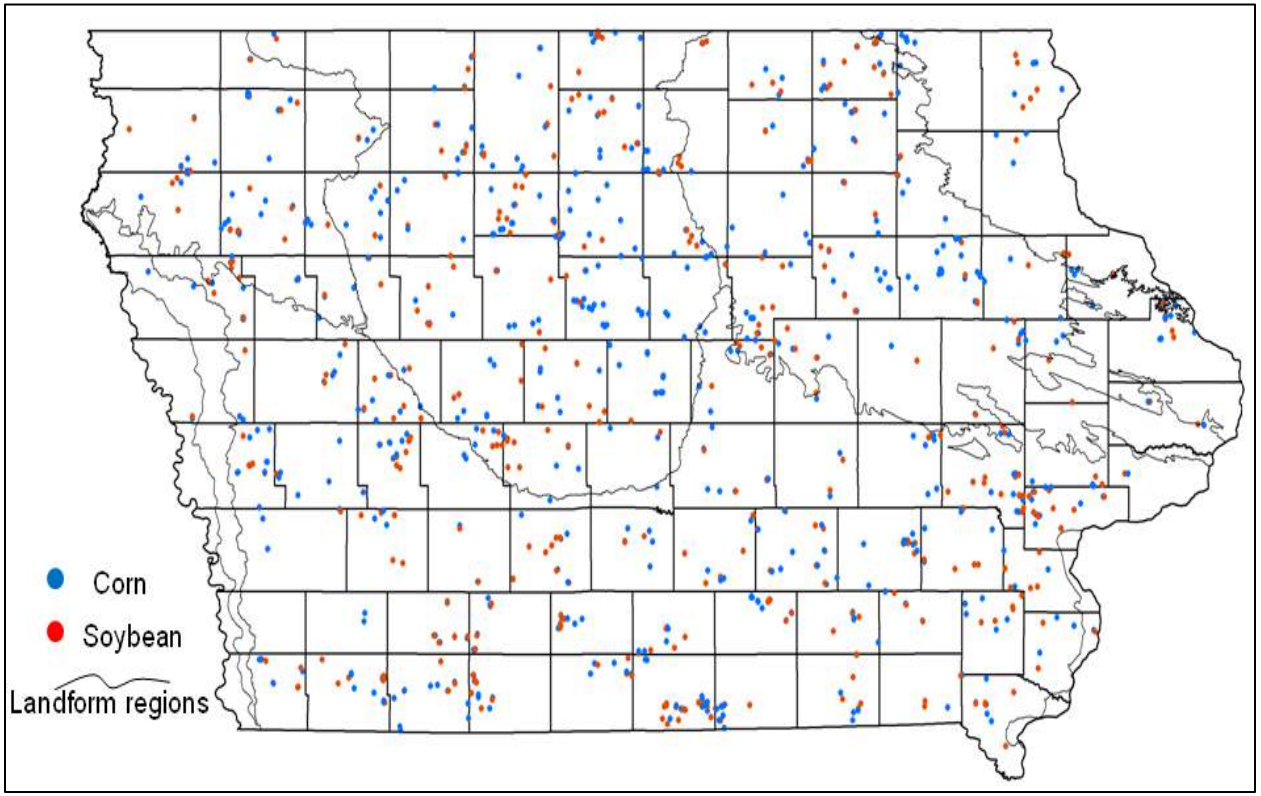
2011 Nutrient Benchmarking Survey

- 505 corn and 376 soybean fields were sampled across Iowa by farmers and agronomists.



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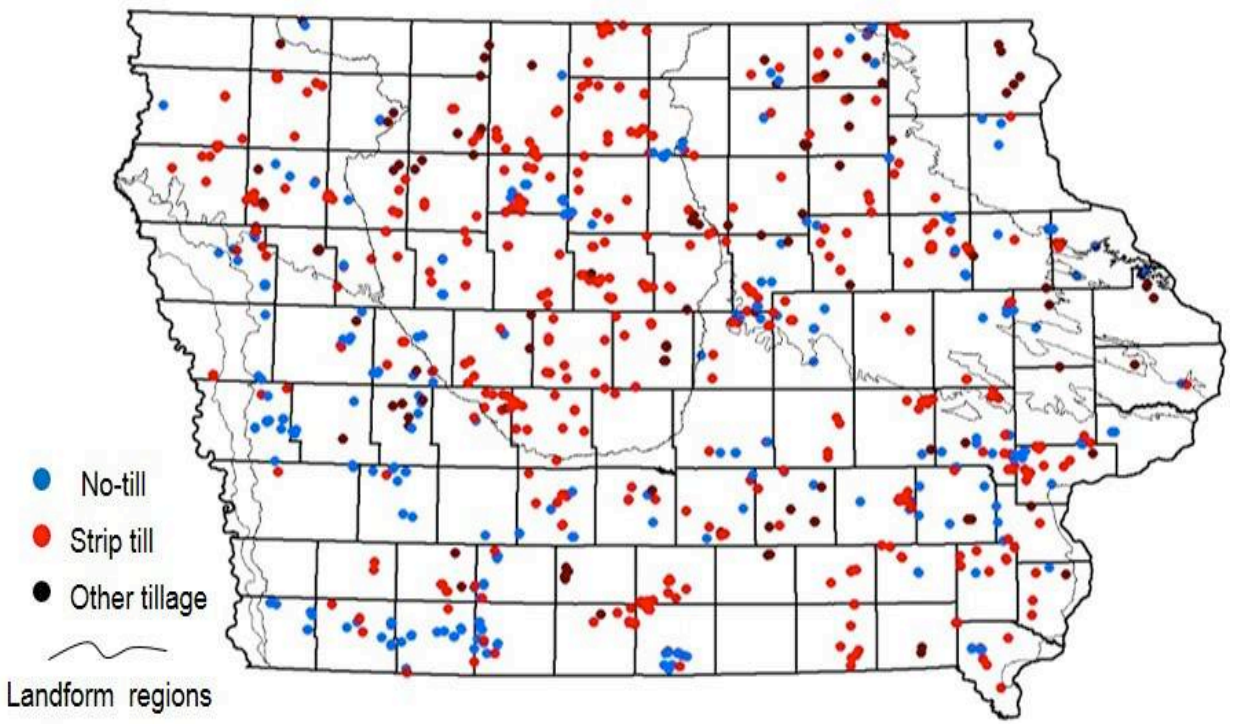
Nutrient Benchmarking Survey in Iowa

- Farmers identified 108 corn and 151 soybean fields as no-till.



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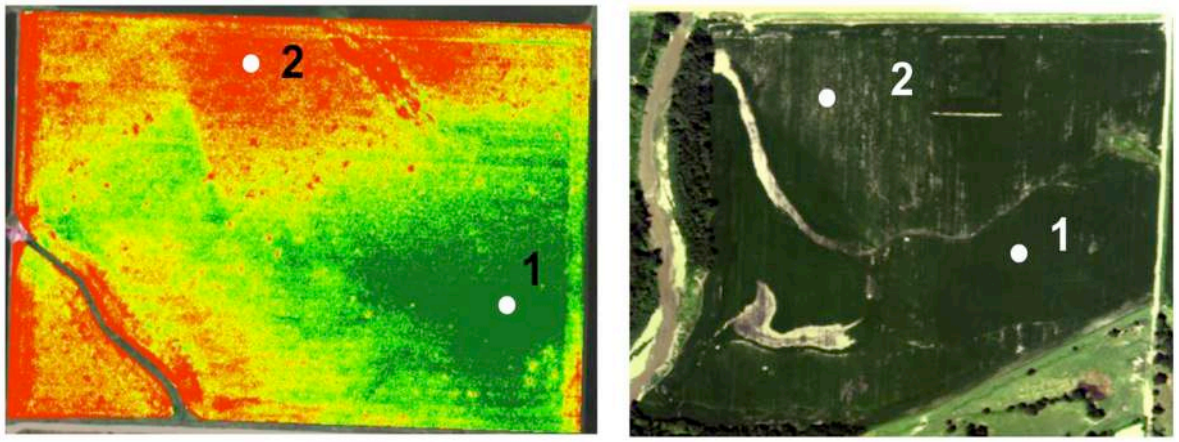
Soil and Corn and Soybean Tissue Sampling

- "Target Good"-1 area with higher yield potential.
- "Target Bad"-2" within an area with potential stress crop.



Late July or Early August NDVI (left) and color (right) images of the corn and soybean canopy.

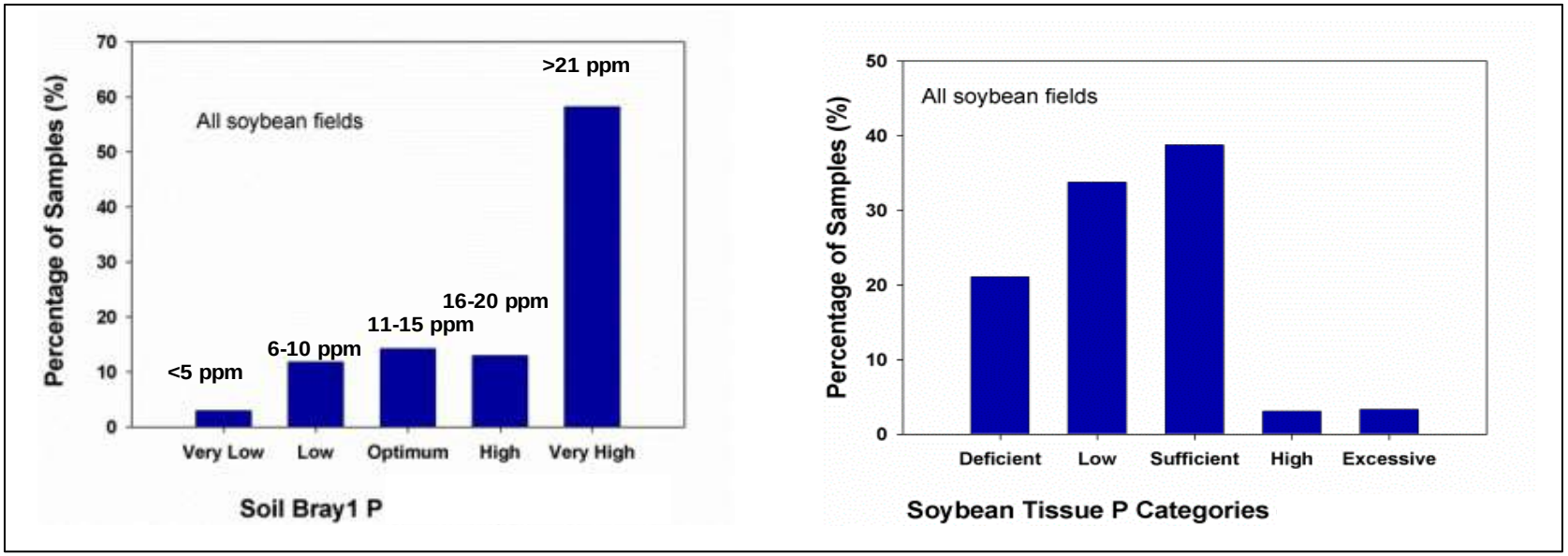
Farmers and Agronomists Collected Samples

- Corn at R3-R4 stage.
- Soybean at R4-R5 stage.

Soil and Tissue Tests

- SOM and pH.
- Macronutrients: N, P, K and S.
- Micronutrients: zinc (Zn), copper (Cu), manganese (Mn), iron (Fe), and boron (B).
- A commercial lab analyzed the samples and provided nutrient sufficiency categories.

Agreement between Soil and Tissue Test Categories for Soybean



- Soil P test suggested ~ 70% samples were optimal why tissue test suggested only ~10% were optimal.

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Agreement between Soil and Tissue Test Categories for Soybean

	Below/Above Optimal Category		Agreement
	Soil test	Tissue test	
Phosphorous	**15/71**	**55/6**	very poor
Potassium	**29/47**	**85/3**	poor
Sulfur	**95/2**	**46/4**	very poor
Zinc	**13/-**	**62/-**	very poor
Copper	**18/46**	**87/1**	very poor
Manganese	**57/21**	**32/33**	poor
Boron	**72/5**	**60/7**	poor

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Agreement between Soil and Tissue Test Categories for Corn

	Below/Above Optimal Range		Agreement
	Soil test	Tissue test	
Phosphorous	10/66	38/18	poor
Potassium	28/45	46/28	poor
Sulfur	91/2	46/4	poor
Zinc	11/-	91/-	very poor
Copper	18/47	46/11	very poor
Manganese	55/24	66/12	poor
Boron	70/6	66/11	poor

Why Soil and Tissue Tests Categories Disagree

- The good agreement should not be always expected because different tests work in different conditions.

- For example for corn, soil S test is considered less reliable than tissue S test.

- Knowledge of the likelihood of yield response to a nutrient is needed.

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Odds to Test in a Lower Test Category for "Target Bad" Samples in Corn

- "Target Bad" sampling areas were 1.9 times more likely to test in the lower Zn and Cu soil test categories than "Target Good" sampling areas.

	Soil test	Tissue test
Nitrogen	-	**1.7:1**
Phosphorous	1:1	**1.5:1**
Potassium	1:1	1:1
Sulfur	1:1	**1.7:1**
Zinc	**1.9:1**	1:1
Copper	**1.8:1**	1:1
Manganese	1:1	**1.5:1**
Boron	**1:1**	1:1

Odds to Test in a Lower Test Category for "Target Bad" Samples in Corn

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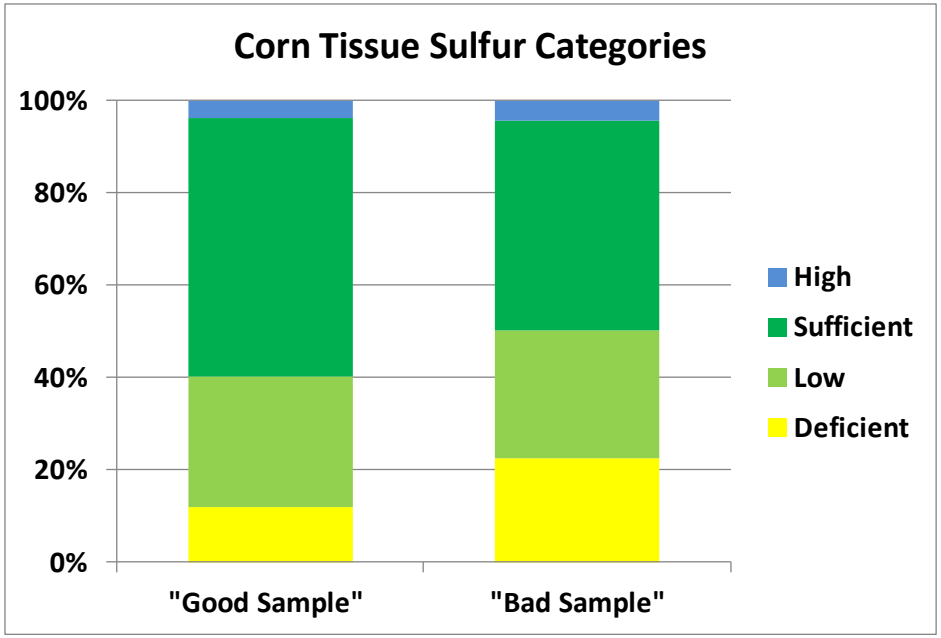

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Odds to Test in a Lower Test Category for "Target Bad" Samples for Soybean

- "Target Bad" sampling areas were 1.7 times more likely to test in the lower Mn soil test category than "Target Good" sampling areas.

	Soil test	Tissue test
Nitrogen	-	1:1
Phosphorous	1:1	1:1
Potassium	1:1	1:1
Sulfur	1:1	1:1
Zinc	1:1	1:1
Copper	1:1	1:1
Manganese	**1.7:1**	1:1
Boron	**1**	1:1

Why Differences Between Corn and Soybean?

- Based corn tissue sampling, “Target Bad” areas were about 1.5 times more likely to have a lower nutrient status for N, P, S, and Mn.

- Unlike in corn, visual appearance of soybean or plant biomass may not be a good indicator of soybean nutrient status.

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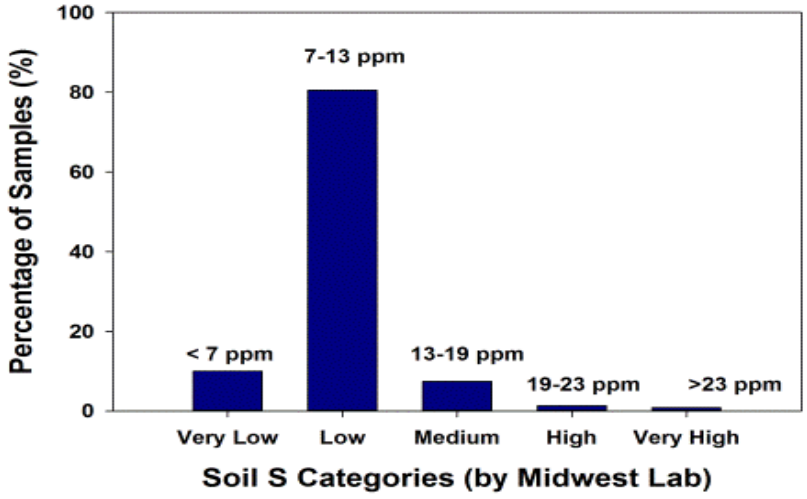
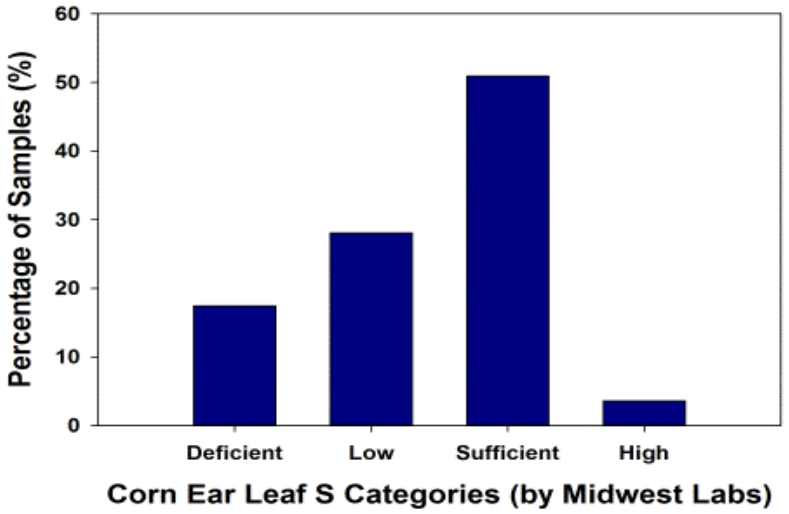
Diagnosing Corn Sulfur Status

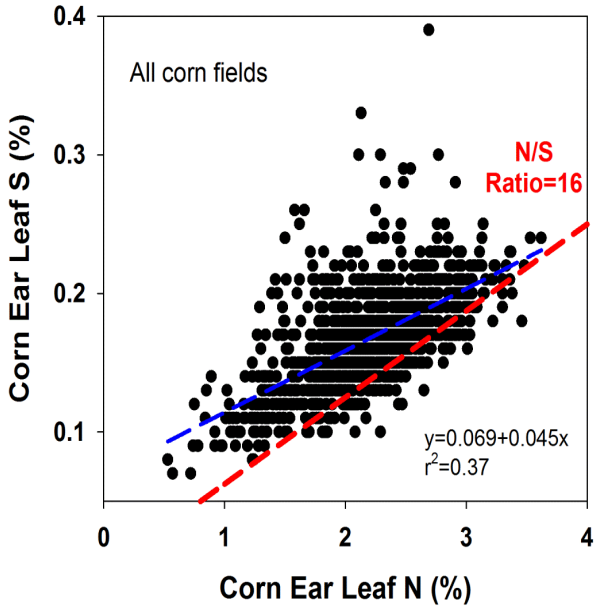


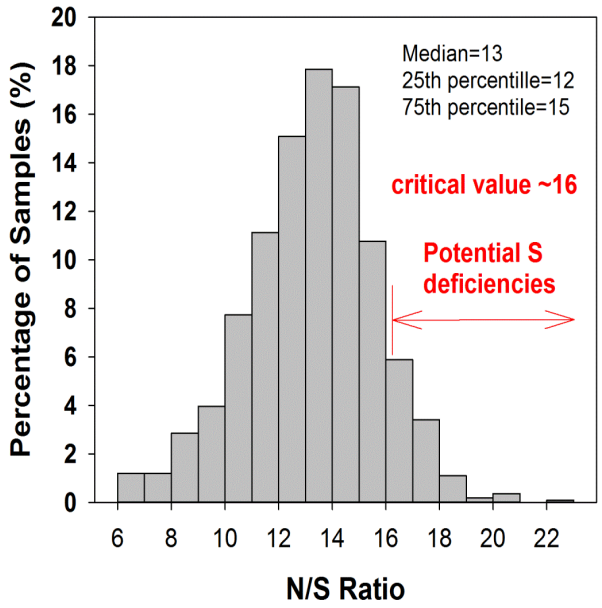


- About 40% of corn tissue samples would be considered in Low and Deficient Categories.

Diagnosing Corn Sulfur Deficiencies using N/S Ratio

- Corn tissue S positively correlated with tissue N content.
- A critical N/S ratios is considered 12-16.
- About 25% tissue samples had N/S ratio >16 and could be considered deficient.





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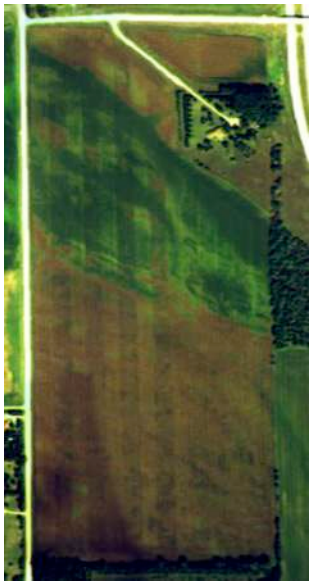
Corn Yield Response to Gypsum

Bremer Co.

8 bu/acre
Rarely Flooded Loam



Bremer Co.

9 bu/acre
Rarely Flooded Loam and Sandy Loam

Black Hawk Co.

2 bu/acre
Loamy Fine Sand

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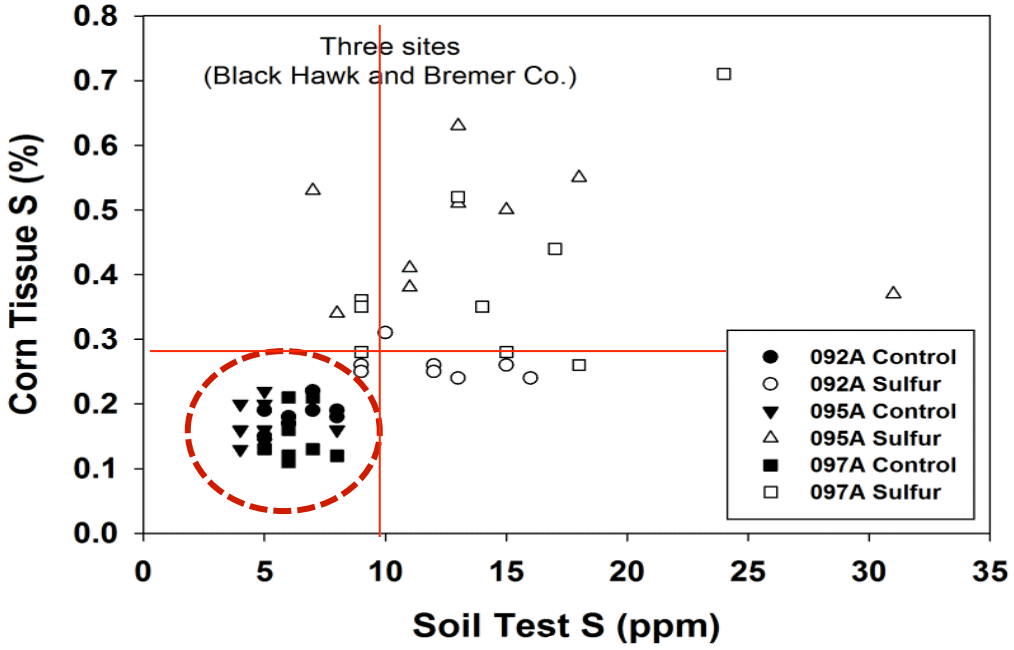
On-Farm Replicated Strip Trials with Gypsum

- Both soil and tissue S test correctly identified S stress within 3 corn fields in northeastern Iowa in 2011.



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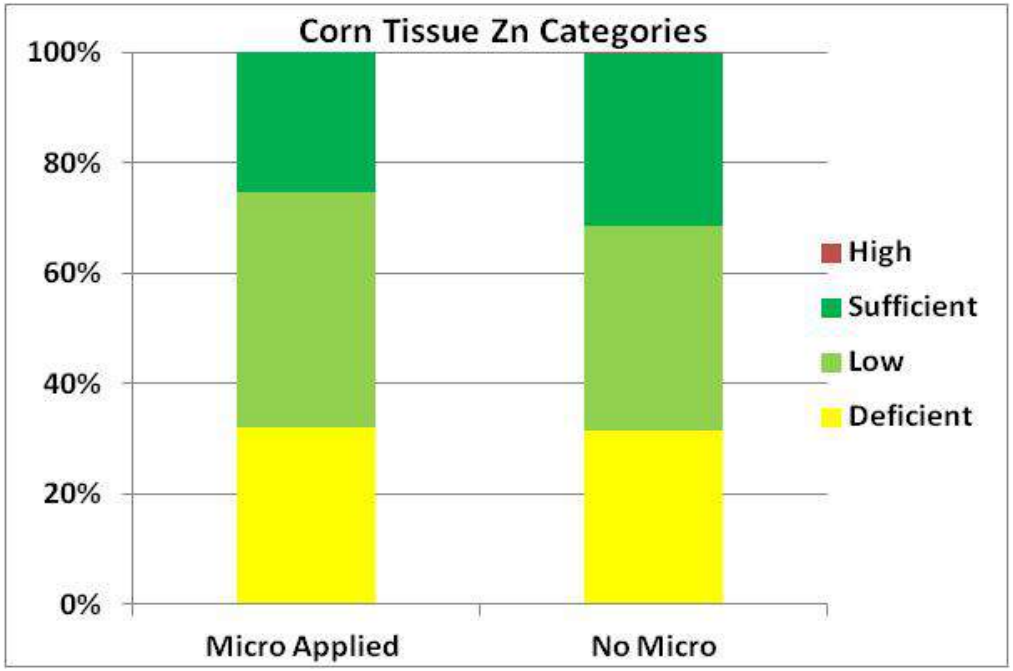
Effect of Micro Nutrient Applications on Corn Zn Status

- 110 corn fields received micro and S applications.
- The effect of micro applications was minimal on corn Zn tissue status.



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Factors Than Caused to Test in a Higher Corn Tissue Nutrient Status

- Manure history.
- Higher SOM.
- Lower pH (Central Iowa has calcareous soils, pH>7.5).
- Previous crop (Soybean vs Corn).

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Reducing Uncertainty in Soil and Tissue Test Interpretations

- Sending samples to two different labs.
- Consider different calibration categories if these categories exist.
- Using scouting data, aerial imagery, historical yield maps, management history or rainfall observations.

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Reducing Uncertainty in Soil and Tissue Test Interpretations

- Excluding disease, pest or drainage problem areas.
- Trying alternative tests: e.g. assessing soil biological activity.
- Compare or benchmark soil and tissue sufficiency categories within the same area or with fields with the same management.

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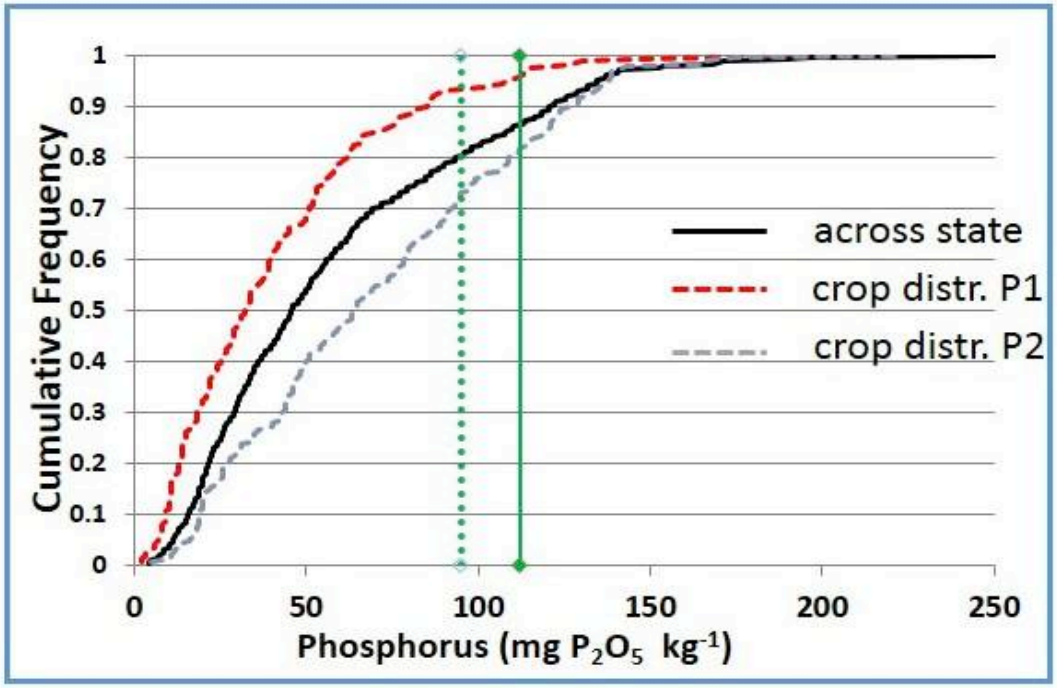
Benchmarking Nutrient Status of Your Farm

- Comparing nutrient status of your field (s) to that of across state, crop district or a local grower group.

- P1-"Target Good" and P2 –"Target Bad" sampling area.



Low Optimal High/Excessive

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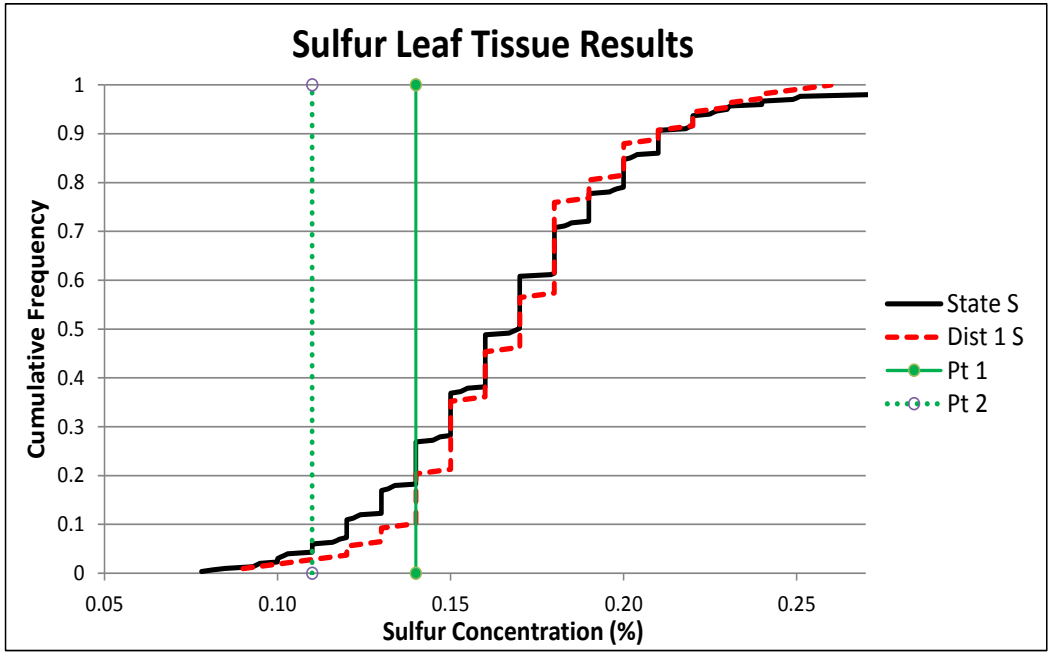

Low Optimal High/Excessive

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Benefits of Benchmarking Nutrient Status

- Allows to establish a baseline for future comparisons.
- Can reduce the bias of soil and tissue test interpretations.
- But it is important not to focus much on individual soil or tissue values but more on the categories of nutrient sufficiency.

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Soil and Tissue Testing for No-Tillers

- Difficult to find soil and tissue tests calibrations specifically for no-till conditions.

- Conduct your own nutrient response trials to identify fields or areas within fields that are more likely respond to macro or micro nutrients.

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Replicated Strip Trials to Identify Need in Micronutrients

- Difficult to find any soil and tissue tests calibrations specifically for no-till conditions.

- Trying alternative tests: biological or soil moisture based tests.

- Conduct your own nutrient response trials and learn which fields or areas respond.

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On-Farm Network®: On-Line Database of Individual Trial Reports

Location

All Watersheds	All Counties
Flint-Henderson	Hardin
Upper Iowa	Lee

Display Results
Clear Results

Year	Watershed	County	Crop	Trial Type	Trial Detail	Yield Difference bu/A	Trial ID	Trial Report	Stalk Nitrate Report	Scouting Report
2013	Flint-Henderson	Lee	Corn	Plant Nutrition - Manure + Nitrogen	Manure + N vs Manure	23.9	ST2013IA278A	View		
2013	Upper Iowa	Hardin	Corn	Plant Nutrition - Manure + Nitrogen	Manure + N vs Manure	-1.5	ST2013IA012A	View		

Average Yield Difference of the 2 records displayed: 11.2 bu/A.

Return on Investment

To calculate ROI of the selected trials, enter a market price for this crop and the cost per acre.

Market Price: $ 5

Cost Per Acre: $ 30

Return on Investment: $26.000 per acre.

Display Results

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On-Farm Network®: On-Line Database of Individual Trial Reports

Year

All Years
2013
2012
2011
2010
2009
2008
2007

Crop

All Crops
Corn
Soybeans

Trial Type and Detail

All Trial Types	All Trial Details
Cover Crop	2 Pass vs 1 Pass Tillage
Crop Protection - Fungicide	30" Rows vs 15" Rows
Crop Protection - Fungicide and Herbicide	80-200-240 vs 39-100-120
Crop Protection - Fungicide and Insecticide	Acceleron vs Untreated
Crop Protection - Fungicide and Plant Nutrition	Accomplish LM vs Untreated
Crop Protection - Fungicide, Herbicide and Insecticide	Accomplish vs Untreated
Crop Protection - Herbicide	Actuate vs Untreated

Location

All Watersheds	All Counties
Apple-Plum	Adams
Big Papillion-Mosquito	Black Hawk
Blackbird-Soldier	Boone
Blue Earth	Bremer
Boone	Buchanan
Boyer	Buena Vista
Copperas-Duck	Butler

Display Results

Clear Results

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Improving Reliability of Soil and Tissue Testing

- Using additional information: scouting, aerial imagery, yield levels, yield response, drainage class or rainfall.

- Asking agronomist and scientists about the accuracy and predictability of soil and tissue tests.

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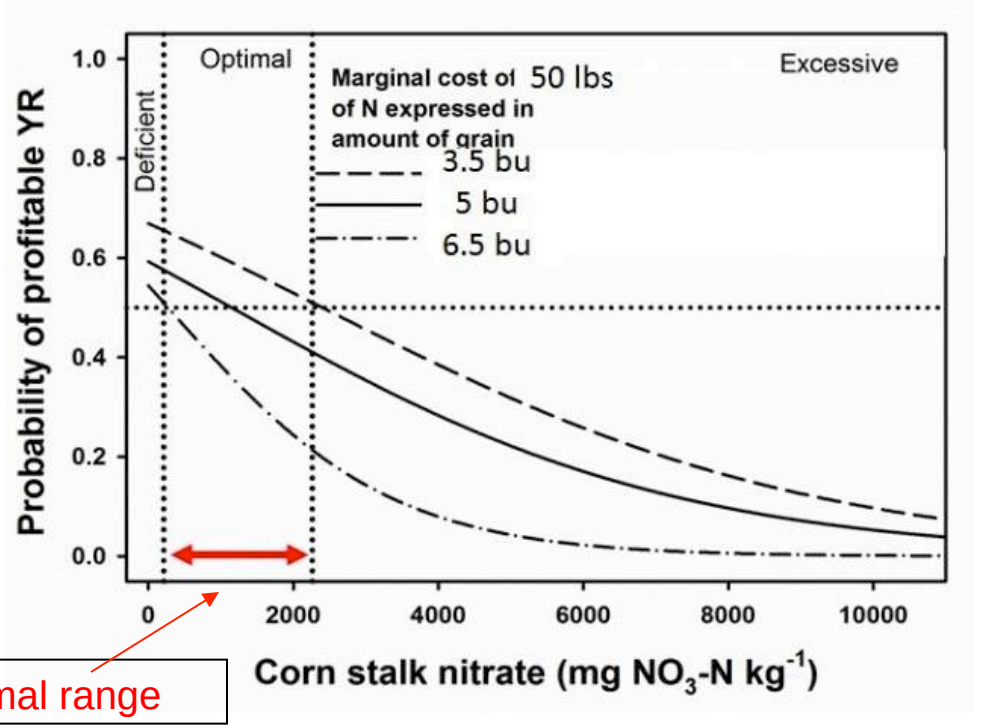
Example of Testing Reliability of Late-Season Tissue Test

- Using on-farm trials we can estimate probabilities of economic yield response to extra N at different values for the corn stalk nitrate test.



Soil and Tissue Testing as Diagnostic Tools

- Plant nutrient status is a function of at least three different factors:
- 1) nutrient concentration in soil solution (intensity);
- 2) capacity factors (what is released from the solid phase);
- 3) soil buffer capacity (a ratio of concentration and capacity).

- Ideal tests should consider both the sufficiency level and balance of available nutrients.