

Troubleshooting Problem Areas: Plant Tissue and Soil Analysis

Demonstration Project Update

John S. Breker

Soil Scientist, AGVISE Laboratories



 johnb@agvise.com

 [@jsbreker](https://twitter.com/jsbreker)

Troubleshooting nutrient deficiencies with plant and soil sampling

John S. Breker

John T. Lee



johnb@agvise.com



[@jsbreker](https://twitter.com/jsbreker)

Plant tissue analysis as a tool

- Snapshot in plant lifecycle
 - Measure of nutrient uptake so far
 - Reflection of plant history
- Sufficiency ranges and DRIS index provide context for “normal” or “critical” nutrient concentrations in plant tissue
- Valuable tool for agronomists
 - Insight into things seen and unseen

Plant tissue analysis as a tool

1. Confirm visible nutrient deficiency symptoms (e.g., nitrogen vs. sulfur)
2. Diagnose problem areas
 - Slow or uneven growth
 - Unusual symptoms
3. Compare fertilizer efficacy (rate, placement, timing)

Limitations of plant tissue analysis

- Sufficiency ranges are not universal or permanent
 - Research on specific plant parts for specific growth stages
 - Interpolation for growth stages with limited or no research basis
 - Survey ranges, not evaluated for plant response
- Snapshot in plant life cycle
 - Reflection of history
 - No crystal ball for the future

Troubleshooting kit

Be sure you are collecting the correct plant part and sampling from enough plants (see directions on reverse side). The interpretation of plant analysis is based on the plant part tested and the stage of growth. Sampling instructions for many crops are shown on the other side of this bag. Be sure to collect a good and enough sample for the laboratory to do the laboratory analysis (see directions). Always collect a good soil had sample when trouble shooting problem areas. A good soil had soil sample is also very helpful. Please do not include plant roots in your samples.

Be sure you are collecting the correct plant part and sampling from enough plants (see directions on reverse side). The interpretation of plant analysis is based on the plant part tested and the stage of growth. Sampling instructions for many crops are shown on the other side of this bag. Be sure to collect a good and enough sample for the laboratory to do the laboratory analysis (see directions). Always collect a good soil had sample when trouble shooting problem areas. A good soil had soil sample is also very helpful. Please do not include plant roots in your samples.

AGVISE
LABORATORIES

DATE RECEIVED _____
DATE SAMPLED _____

FIELD NO. _____
FIRM SUBMITTING SAMPLES _____
NUTRIENT DEFICIENCY PROJ. _____
CULTURE NO. _____
NORTHWOOD, ND 58267

Field ID _____
Sample ID _____
County _____
Township _____
Section _____

GOOD

Complete Analysis
Potash Phosphorus Option
Individual Nutrients

Total Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulfur, Zinc, Iron, Manganese, Copper, Sulphur, Boron (Sulfur included on small gram)

Other Tests _____

AGVISE
Nutrient Deficiency
Troubleshooting

AGRI-VISE LABORATORIES
604 Highway 104
Northbrook, IL 60062
Phone: 708-487-2700
Fax: 708-487-2701

1202 N. Silver Maple, P.O. Box 167
Mantoloking, NJ 08053
Phone: 908-684-0074
Fax: 908-684-0075

SHADED AREAS MUST BE COMPLETED

How to fill out soil sample sheet

AGRI-VISE LABORATORIES
604 Highway 104, P.O. Box 167
Northbrook, IL 60062
Phone: 708-487-2700
Fax: 708-487-2701

SHADED AREAS MUST BE COMPLETED

Account Number or Account Sticker

Field Description

Good area

Bad area

Sample ID

Nutrient Deficiency Proj.

SHADED AREAS MUST BE COMPLETED

No copy of this form will be returned with your results.

[illegible][illegible]

2018 Nutrient Deficiency Project

AGVISE is sponsoring a nutrient deficiency project this growing season. This project will help you figure out if a problem area in a field is caused by a nutrient deficiency or some other cause. This includes everything you will need to troubleshoot problem areas in one field. There is no charge for any testing done for this project. We want to help customers gain experience in troubleshooting problem areas; this involves collection of plant tissue and soil samples from the area with symptoms and an adjacent area with good plant growth. Besides collecting plant and soil samples, we would like you to take pictures of individual plants that have symptoms and of plants that have normal growth.

Please follow the instructions below on sample collection and shipping and sending plant pictures to AGVISE Laboratories.

Instructions:

1. **Identify a problem area** in a field that has probable nutrient deficiency symptoms (do not sample areas that have standing water).
2. **Take samples:** Based on crop type and growth stage, collect the plant part shown on the back of the tissue sample bag. Collect one tissue sample in the area with possible nutrient deficiency symptoms (good), and one tissue sample in an adjacent area (~50 feet) into the crop that looks normal (good). Place samples in the tissue bags marked "Good" and "Bad". Fill in the field ID, crop name, crop stage, and plant part on each sample bag. **Fill in AGVISE account information** on each sample bag.
3. **Soil samples:** Collect one soil sample in the tissue sample bag. **Fill in the field ID, "bad" plant tissue samples.** On the soil sample from each location you collected the "good" and "bad" plant tissue samples. On the soil sample from each location you collected the "good" and "bad" plant tissue samples. **Fill in AGVISE account information** on the "Good" and "Bad" plant tissue samples. **Fill in AGVISE account information** on the "Good" and "Bad" plant tissue samples.
4. **Pictures of bad and good plants:** Take a picture of individual plants from each location you collected the "good" and "bad" plant tissue samples. These will be used to support the potential nutrient deficiency diagnosis. **Please send the pictures to John Hecker via email 3821 or via email (john@agvise.com).**
5. **Shipping samples to AGVISE:** We have included prepaid USPS shipping labels to put on the shipping box. **AGVISE:** We have included the pictures to John Hecker via email 3821 or via email (john@agvise.com).
6. **Shipping box:** Please use a box to ship the samples. We would like you to use a box that is 18" x 18" x 18" or larger. The box should be padded with foam or other material to protect the samples during shipping. The box should be labeled with the following information: "AGVISE Laboratories" and "Nutrient Deficiency Project".

If you have any questions, please call before you collect the tissue and soil samples for this project.
Northwood - John Lee: office 701-587-6010, cell 701-739-0521
Northwood - John Hecker: office 701-587-6010, cell 701-680-3822
Bismarck - Richard Jency: 320-843-4109, cell 320-815-4100

404 Highway 13 West
PO Box 404
Northwood, ND 58402
(701) 587-6010
FAX (701) 680-3822
email: john@agvise.com
john@agvise.com

Agricultural Testing

Troubleshooting with plant tissue analysis

- Information from good and bad areas (paired samples required)
 - Plant tissue sample (speedometer)
 - Soil sample (gas tank)
- Observations and field information
 - Plant symptoms, photographs
 - Fertilizer applied (rate, placement, timing, source)
 - Soil conditions (waterlogged, very dry)

Photography quality is important, but framing your comparison is key



Troubleshooting with plant tissue analysis

Collect within 7-10 days after visible symptoms appear (results questionable later)

- Correct plant part for correct growth stage
- Do not forget soil samples (0-6" depth acceptable)

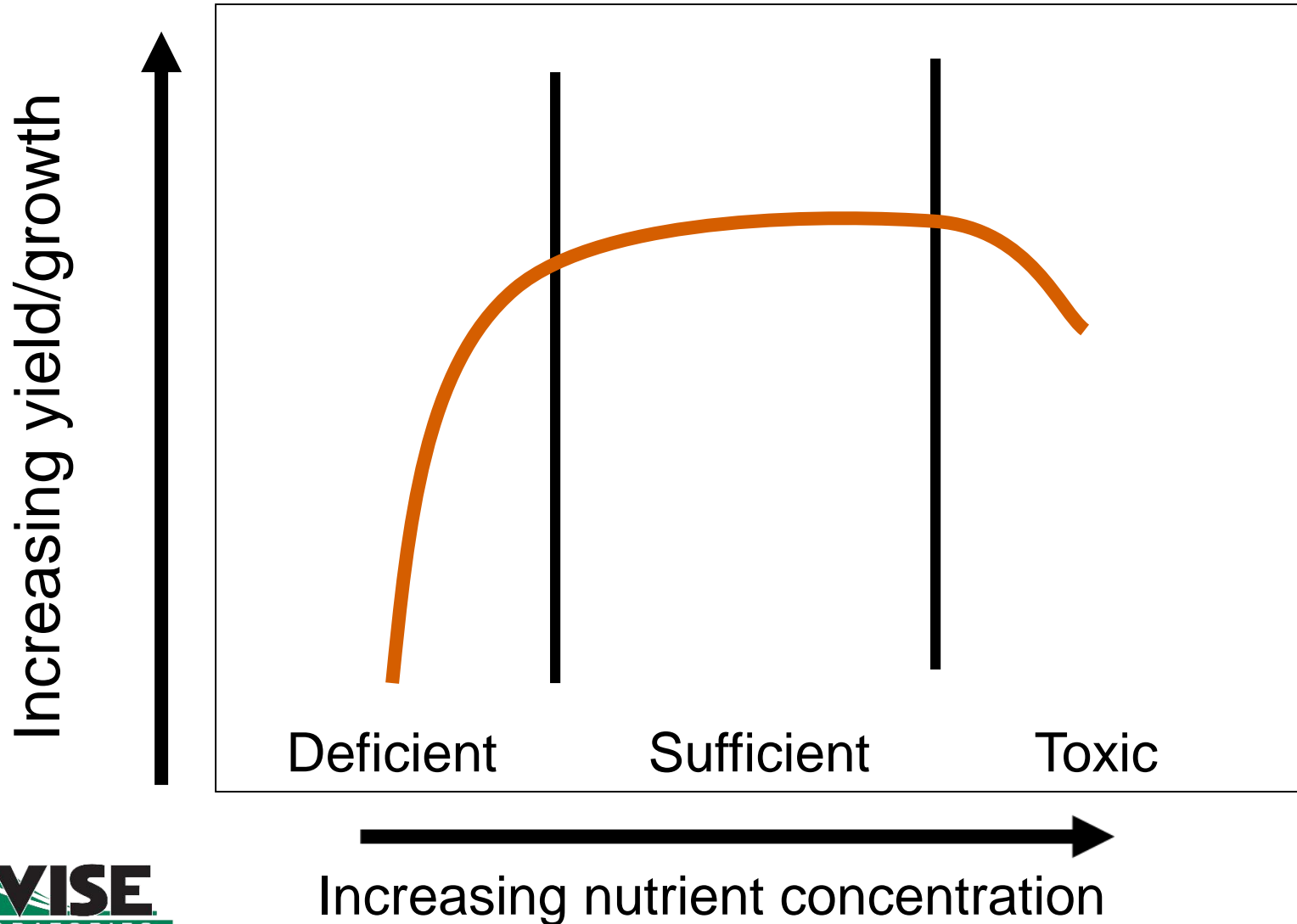
Handling the samples

- Bush off any soil or dust (Fe and Mn contamination)
- Ship sample immediately or keep cool in refrigerator
- Sample bags have holes to allow moisture to escape

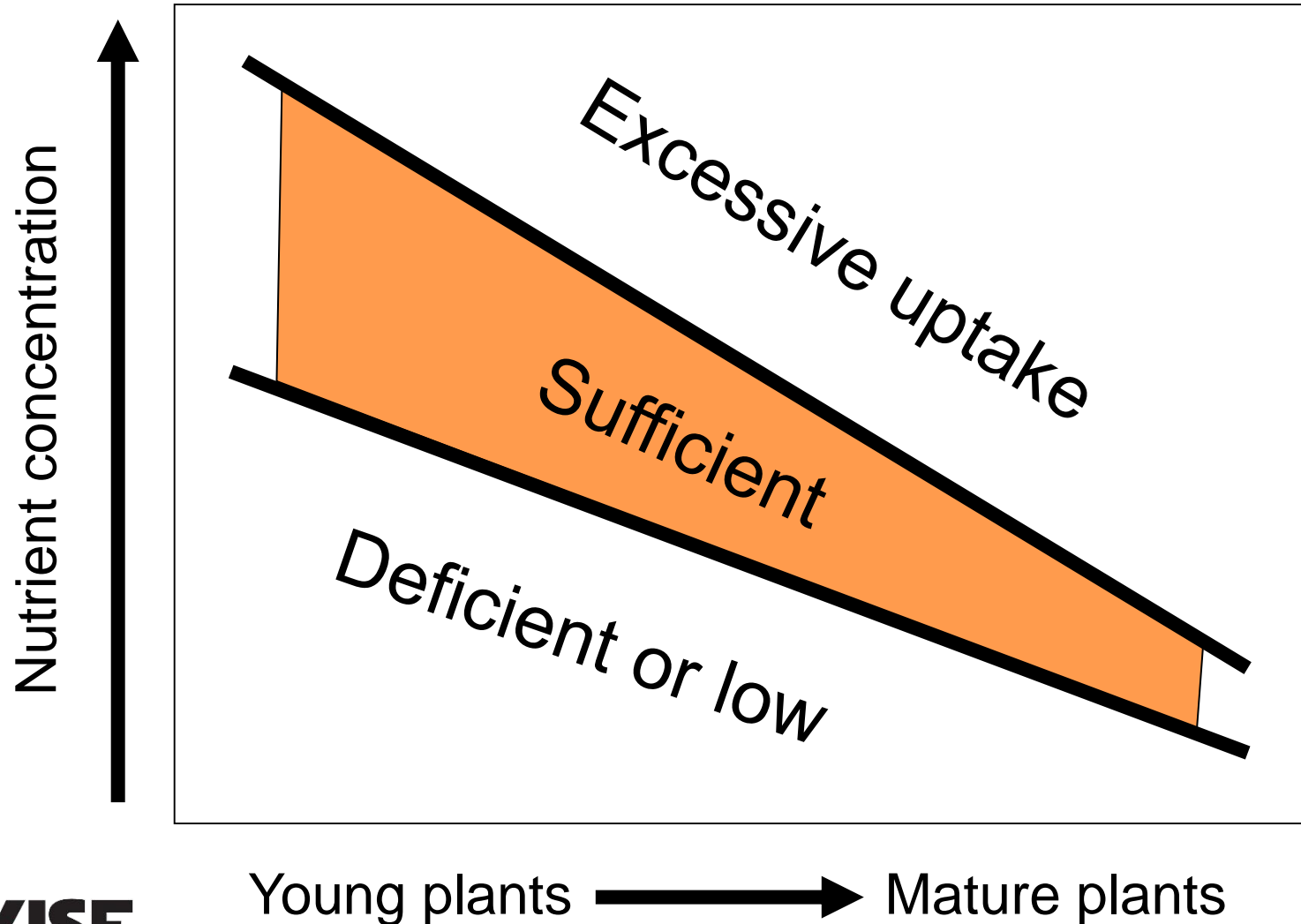
Interpreting analysis results

- Sufficiency range
 - Range deemed adequate for each nutrient
 - Specific for plant part and growth stage
 - University research on most crops
- DRIS Index (Diagnosis Recommendation Integrated System)
 - Numerical index calculated for each nutrient based on relative amount in the plant
 - Indexes within -20 to +20 are **normal**
 - Ranks nutrient of largest concern
 - University research only on major crops

Sufficiency range interpretation



Sufficiency range interpretation



Diagnosis Recommendation Integrated System (DRIS)

Corn plant tissue analysis

Plant age (d)	Nutrient content ratio		
	N/P	N/K	K/P
30	15	1.4	11
60	15	1.6	9
80	14	1.8	8
110	15	1.7	9

Ratio of N/P stays the same as healthy plants age

Diagnosis Recommendation Integrated System (DRIS)

Corn plant tissue analysis Shorter plants

N	P	K	S	Ca	Mg	Na	Zn	Fe	Mn	Cu	B
%							ppm				
3.4	0.49	2.7	0.30	0.97	1.14	0.03	11	871	208	13	11
L	S	L	S	S	H	S	L	VH	H	S	S
DRIS											
-18	-3	-2	-16	8	70		-78		46	-3	-3

DRIS indicates that zinc is the most limiting nutrient

Real world troubleshooting

Classic examples from real customers

- Visible symptoms on plants (photographs)
- Information from good and bad areas
 - Soil samples
 - Plant tissue samples
- Field information from grower and agronomist

Example 1: Twisted wheat

Notes:

- Twisted, withered leaf tips after tillering
- 'Rattail' appearance

Good area



Bad area



Example 1: Twisted wheat

Soil analysis				Plant analysis						
		Good	Bad				Good		Bad	
N	lb/acre				N	%	5.9	H	5.6	H
P	ppm	23	29		P	%	0.38	S	0.37	S
K	ppm	207	202		K	%	3.5	H	3.4	H
S	lb/acre	22	15		S	%	0.35	S	0.32	S
Zn	ppm	1.22	0.39		Zn	ppm	38	S	28	S
Cu	ppm	0.69	0.40		Cu	ppm	4	L	3	L
B	ppm	0.5	0.2		B	ppm	10	S	8	S
Fe	ppm	80	48		Fe	ppm	106	S	106	S
Mn	ppm	26	17		Mn	ppm	98	S	109	H
Cl	lb/acre	5	4		Cl	%	0.19	L	0.13	L
pH		5.0	5.1							
EC	dS/m	0.57	0.17							
OM	%	3.8	1.5							
CEC	cmol(+)/kg	12.4	8.4							

Example 1: Twisted wheat

Soil analysis					Plant analysis					
		Good	Bad				Good		Bad	
N	lb/acre				N	%	5.9	H	5.6	H
P	ppm	23	29		P	%	0.38	S	0.37	S
K	ppm	207	202		K	%	3.5	H	3.4	H
S	lb/acre	22	15		S	%	0.35	S	0.32	S
Zn	ppm	1.22	0.39		Zn	ppm	38	S	28	S
Cu	ppm	0.69	0.40		Cu	ppm	4	L	3	L
B	ppm	0.5	0.2		B	ppm	10	S	8	S
Fe	ppm	80	48		Fe	ppm	106	S	106	S
Mn	ppm	26	17		Mn	ppm	98	S	109	H
Cl	lb/acre	5	4		Cl	%	0.19	L	0.13	L
pH		5.0	5.1							
EC	dS/m	0.57	0.17							
OM	%	3.8	1.5							
CEC	cmol(+)/kg	12.4	8.4							

Visual deficiency symptoms

Copper deficiency

Withered, twisted leaf tips

'Rattail' appearance



Chloride deficiency

Non-distinct symptoms

Manifests as leaf disease spots



Example 1: Twisted wheat

- Plant tissue: low Cu, low Cl
- Soil test: low Cu, low organic matter, coarse-textured soil
- Visual symptoms verify Cu deficiency
- Apply Cu with small grains
- Select non-Cu sensitive crops

Example 2: Thin, stressed durum

Notes:

- Chlorosis and necrosis starting in lower canopy
- Drought-stress appearance



Example 2: Thin, stressed durum

Soil analysis					Plant analysis					
		Good	Bad				Good		Bad	
N	lb/acre	26	182		N	%	4.5	S	3.0	D
P	ppm	21	25		P	%	0.31	S	0.25	S
K	ppm	611	631		K	%	2.1	S	1.8	S
S	lb/acre	360+	360+		S	%	0.41	S	0.50	S
Zn	ppm	1.30	1.84		Zn	ppm	19	L	13	L
Cu	ppm	1.00	1.11		Cu	ppm	8	S	7	S
B	ppm	1.0	6.8		B	ppm	202	VH	1872	VH
Na	ppm	35	301		Na	%	0.07	S	0.30	VH
Cl	lb/acre	24	68		Cl	%	1.17	VH	0.42	S
EC 1	dS/m	0.23	0.44							
EC 2	dS/m	1.24	3.52							

Example 2: Thin, stressed durum

Soil analysis				Plant analysis					
		Good	Bad			Good		Bad	
N	lb/acre	26	182	N	%	4.5	S	3.0	D
P	ppm	21	25	P	%	0.31	S	0.25	S
K	ppm	611	631	K	%	2.1	S	1.8	S
S	lb/acre	360+	360+	S	%	0.11	S	0.50	S
Zn	ppm	1.30	1.84	Zn	ppm	19	L	13	L
Cu	ppm	1.00	1.11	Cu	ppm	8	S	7	S
B	ppm	1.0	6.8	B	ppm	202	VH	1872	VH
Na	ppm	35	301	Na	%	0.07	S	0.30	VH
Cl	lb/acre	24	68	Cl	%	1.17	VH	0.42	S
EC 1	dS/m	0.23	0.44						
EC 2	dS/m	1.24	3.52						

Boron > 3 ppm toxic?

Example 2: Thin, stressed durum

- Plant tissue: deficient N, excessive B, high Na
- Soil test: toxic B, high Na, very high subsoil salinity
- Crop rotation and selection: boron toxicity, subsurface salinity
 - No issues during sunflower years (more tolerant to boron toxicity)

Case studies from 2018

Cooperative project with customers across the region

1. Purple corn in southern MN
2. Stunted safflower in southwest ND
3. Yellow wheat in northern ND

Case study 1: Purple corn

Notes:

- Shorter (V3 vs. V6)
- Purpling on leaves, striped appearance
- Necrosis on lowest leaf margin



Case study 1: Purple corn

Soil analysis				Plant analysis							
		Good	Bad				Good		Bad		
N	lb/acre	80	50		N	%	3.55	S	2.33	L	
P	ppm	11	7		P	%	0.18	L	0.12	D	
K	ppm	175	190		K	%	3.2	H	2.8	S	
S	lb/acre	120	120		S	%	0.20	S	0.29	S	
Ca	ppm	6611	9417		Ca	%	0.60	S	1.13	VH	
Mg	ppm	493	471		Mg	%	0.41	S	0.35	S	
Zn	ppm	0.85	0.77		Zn	ppm	24	S	19	L	
Cu	ppm	0.61	0.69		Cu	ppm	8	S	6	S	
B	ppm	2.2	2.1		B	ppm	7	S	9	S	
Fe	ppm	6.9	8.2		Fe	ppm	176	S	674	VH	
Mn	ppm	1.2	1.8		Mn	ppm	75	S	79	S	
pH		7.9	7.7								
EC	dS/m	0.74	2.19								

Case study 1: Purple corn

Soil analysis				Plant analysis					
		Good	Bad			Good		Bad	
N	lb/acre	80	50	N	%	3.55	S	2.33	L
P	ppm	11	7	P	%	0.18	L	0.12	D
K	ppm	175	190	K	%	3.2	H	2.8	S
S	lb/acre	120	120	S	%	0.20	S	0.29	S
Ca	ppm	6611	9417	Ca	%	0.60	S	1.13	VH
Mg	ppm	493	471	Mg	%	0.41	S	0.35	S
Zn	ppm	0.85	0.77	Zn	ppm	24	S	19	L
Cu	ppm	0.61	0.69	Cu	ppm	8	S	6	S
B	ppm	2.2	2.1	B	ppm	7	S	9	S
Fe	ppm	6.9	8.2	Fe	ppm	176	S	674	VH
Mn	ppm	1.2	1.8	Mn	ppm	75	S	79	S
pH		7.9	7.7						
EC	dS/m	0.74	2.19						

Case study 1: Purple corn

- Plant tissue: deficient P, low Zn
- Soil test: low P, low Zn, high salinity
- Starter P & Zn to correct problem
 - Seed safety with salinity
 - Salinity limits plant nutrient uptake
- Recognize salinity stress in crop choice

Case study 3: Poor stand, stunted safflower

Notes:

- Poor germination, small plants
- Pattern follows landscape



Case study 3: Stunted safflower

Soil analysis					Plant analysis					
		Good	Bad				Good		Bad	
N	lb/acre	36	37		N	%	5.52	H	5.40	H
P	ppm	25	23		P	%	0.32	L	0.27	L
K	ppm	400	257		K	%	5.6	H	4.8	H
S	lb/acre	17	12		S	%	0.3	S	0.32	S
Ca	ppm	1285	884		Ca	%	1.19	S	1.42	S
Mg	ppm	542	223		Mg	%	0.47	L	0.66	S
Zn	ppm	1.42	0.94		Zn	ppm	53	H	68	H
Cu	ppm	0.83	0.45		Cu	ppm	12	S	7	S
B	ppm	0.40	0.33		B	ppm	17	S	23	S
Fe	ppm	87	93		Fe	ppm	1540	VH	1438	VH
Mn	ppm	28	37		Mn	ppm	244	H	809	VH
pH		5.6	4.5							
EC	dS/m	0.30	0.15							

Case study 3: Stunted safflower

Soil analysis				Plant analysis			
		Good	Bad			Good	Bad
N	lb/acre	36	37	N	%	5.52 H	5.40 H
P	ppm	25	23	P	%	0.32 L	0.27 L
K	ppm	400	257	K	%	5.6 H	4.8 H
S	lb/acre	17	12	S	%	0.3 S	0.32 S
Ca	ppm	1285	884	Ca	%	1.19 S	1.42 S
Mg	ppm	542	223	Mg	%	0.47 L	0.66 S
Zn	ppm	1.42	0.94	Zn	ppm	53 H	68 H
Cu	ppm	0.83	0.45	Cu	ppm	12 S	7 S
B	ppm	0.40	0.33	B	ppm	17 S	23 S
Fe	ppm	87	93	Fe	ppm	1540 VH	1438 VH
Mn	ppm	28	37	Mn	ppm	244 H	809 VH
pH		5.6	4.5				
EC	dS/m	0.30	0.15				

Aluminum toxicity
when pH < 5.0-5.5

Aluminum toxicity on wheat seedlings

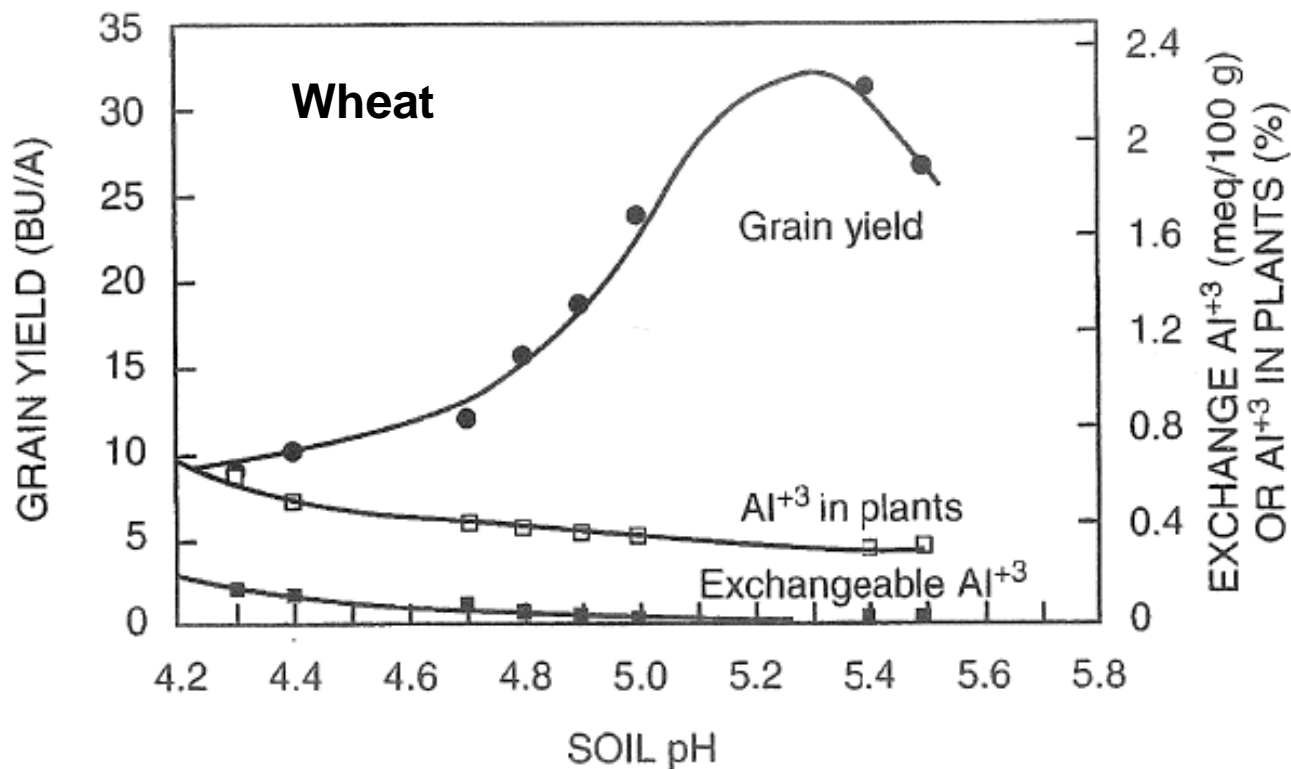
High
 Al^{3+}



No Al^{3+}

Low pH makes more exchangeable Al^{3+}

More Al^{3+} reduces grain yield



Case study 3: Stunted safflower

Property	Depth (inch)	Good	Bad
pH	0-2	4.5	4.3
	2-6	6.1	4.6
	6-12	6.1	5.8
Aluminum (ppm)	0-2	24	91
	2-6	1.8	25
	6-12	0.3	0.4
Manganese (ppm)	0-2	52	52
	2-6	16	30
	6-12	7.5	4.6

Case study 3: Stunted safflower

- Plant tissue: low P in both, very high Mn
- Soil test: low pH, VERY high Al
- Crop choice, Al-tolerant varieties
- High seed-placed P rate
- Lime application
- Other land use?

Case study 4: Yellow durum wheat



Notes:

- Yellowing of upper leaves
- Worse on hilltops, thin stand



Case study 4: Yellow durum wheat

Soil analysis					Plant analysis					
		Good	Bad				Good		Bad	
N	lb/acre	102	62		N	%	4.85	S	4.46	S
P	ppm	9	7		P	%	0.34	S	0.37	S
K	ppm	234	277		K	%	4.2	H	3.6	H
S	lb/acre	36	22		S	%	0.30	S	0.29	S
Zn	ppm	0.38	0.29		Zn	ppm	21	S	22	S
Cu	ppm	0.50	0.52		Cu	ppm	7	S	6	S
B	ppm	1.67	1.45		B	ppm	5	S	7	S
Fe	ppm	8.7	6.9		Fe	ppm	535	VH	522	VH
Mn	ppm	2.12	2.72		Mn	ppm	64	S	46	S
Cl	lb/acre	19	5		Cl	%	0.65	H	0.38	S
Ca	ppm	5221	5996		Ca	%	0.80	H	0.76	H
Mg	ppm	404	488		Mg	%	0.23	S	0.25	S
Na	ppm	49	29		Na	%	0.01	S	0.09	S
pH		8.0	8.2							
EC	dS/m	0.60	0.46							
CCE	%	3.2	5.8							

Case study 4: Yellow durum wheat

- Plant tissue: same
- Soil test: same
- Based on visual symptoms, S deficiency most likely
- Symptoms were not corrected with AMS application
- Inconclusive, other factors:
 - Herbicide carryover (dry conditions, surface pH)
 - Water availability, positional nutrient availability

Summary

- Single plant tissue analysis report is usually not enough
- Plant tissue concentrations are affected by:
 - Plant size, growth stage
 - Fertilizer rate, placement, timing, source (4Rs)
 - Soil moisture, compaction
- Both soil and plant tissue samples are needed
 - Soil nutrient supply truly lacking?
 - Other factors limiting nutrient uptake

Each field needs a discussion

Troubleshooting is:

- Symptoms
- Causes
- Management



Soil sampling after banded nitrogen application

John S. Breker

John T. Lee



johnb@agvise.com



[@jsbreker](https://twitter.com/jsbreker)

Common questions

“How much anhydrous ammonia did you put down?”

“Did I lose fall-applied nitrogen over the winter?”

“I cannot remember if nitrogen was even applied!”

“Was that enough sidedress nitrogen?”

All questions about auditing banded nitrogen application with soil testing.

How do you sample after banded N application?

- Fertilizer concentration in band will be much (MUCH) higher than surrounding soil
- University research trying to assess the average, usually for fall soil sampling
 - Certain number of off-band soil cores for each on-band soil core (usually 3 or 4)
 - Certain distance between band and crop row
 - Dependent on locating band, band-center spacing and orientation

In-season banded N project

Banded urea (46-0-0) application

- Rate: 75 and 150 lb N/acre
- Depth: 4 inch
- Center: 30 inch

Three weeks later...

- Collected soil samples (0-6 inch) across entire 30-inch row
- Analyzed for ammonium and nitrate

Urea bands are really concentrated
150 lb N/acre, 30-inch center



Knock-Yourself-Out™ Soil Sampler



Phew...now that's done!

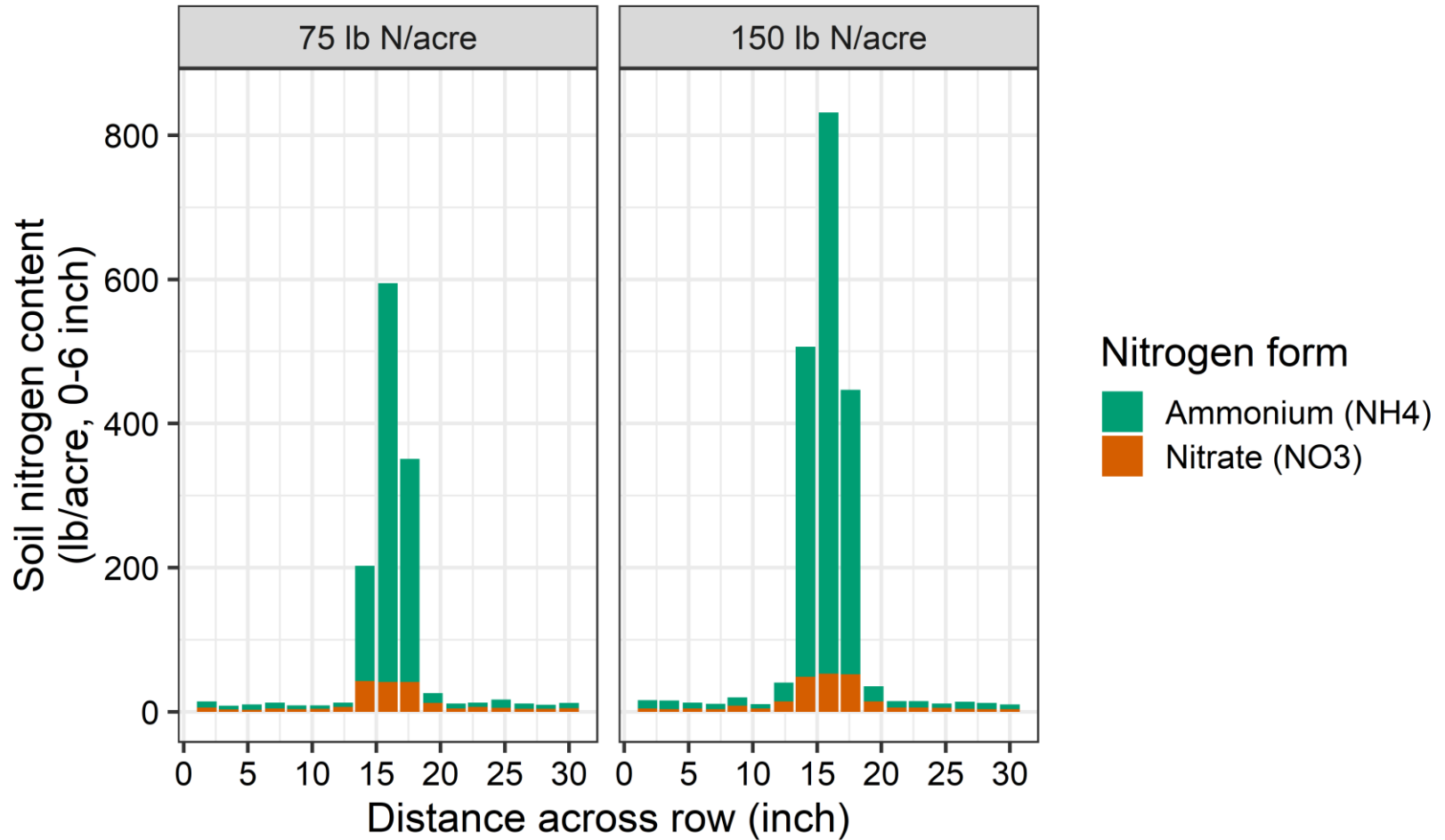


**Clean slice
across row**

Knock-Yourself-Out™ Soil Sampler



Soil nitrogen distribution across row



AGVISE Laboratories, Northwood, ND

What is the N rate?

In-band area (5 inch), averaged

Applied N rate lb/acre	Inorganic N recovery (NH ₄ + NO ₃) lb/acre, 0-6 inch depth
75	383
150	595

Across entire row (30 inch), averaged

Applied N rate lb/acre	Inorganic N recovery (NH ₄ + NO ₃) lb/acre, 0-6 inch depth
75	78
150	119

Nitrification inhibition

- Only 10% of fertilizer N converted from ammonium to nitrate in three weeks
 - Soil temperature and moisture were conducive for rapid nitrification
- Concentrated ammonium bands delay nitrification
- Limitations on near-seed fertilizer placement
- Issues for fertilizer co-application in band

How do will you sample banded N applications?

- Collect all soil across the row
 - Shovel, measuring tape, massive soil sample
 - Knock-Yourself-Out™ Soil Sampler, patent pending
 - Repeat 15-20 times across field
- Collect selective soil cores
 - Take 3-4 off-band cores for each on-band core
 - You must know location of band-center
 - Hitting the band-edge will throw result average
 - Error, error, error...

Soil sampling after banded N applications

- Extreme variability between on-band and off-band soil cores
- You must obtain all soil across the row for a *reasonable average*
 - Error still exists
 - Beyond the realm of practical
- You can learn if *some* N was applied; however, the application rate remains elusive

Improving saline and sodic soils with tile drainage

John S. Breker

John T. Lee

AGVISE Laboratories



johnb@agvise.com

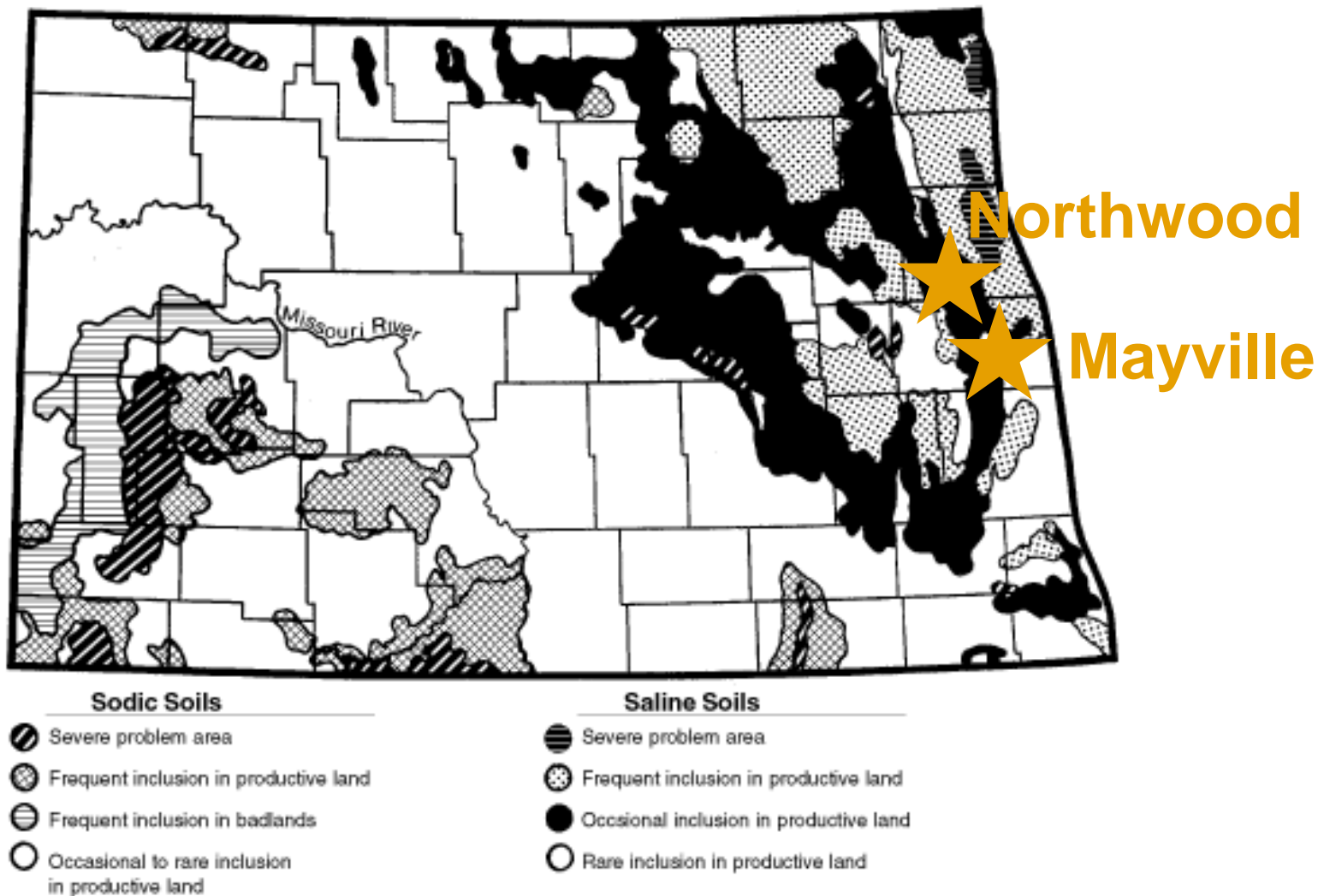


[@jsbreker](https://twitter.com/jsbreker)

Long-term tile drainage projects

- Saline soil near Northwood, ND
 - Drain tile installed Summer 2002
 - Ten GPS-marked sampling sites
- Saline-sodic soil near Mayville, ND
 - Saline-sodic and saline areas in field
 - Drain tile installed 2007
 - Gypsum applied, total 5 ton/acre in 2008 & 2009

Saline and sodic soils in North Dakota





2003 soybean

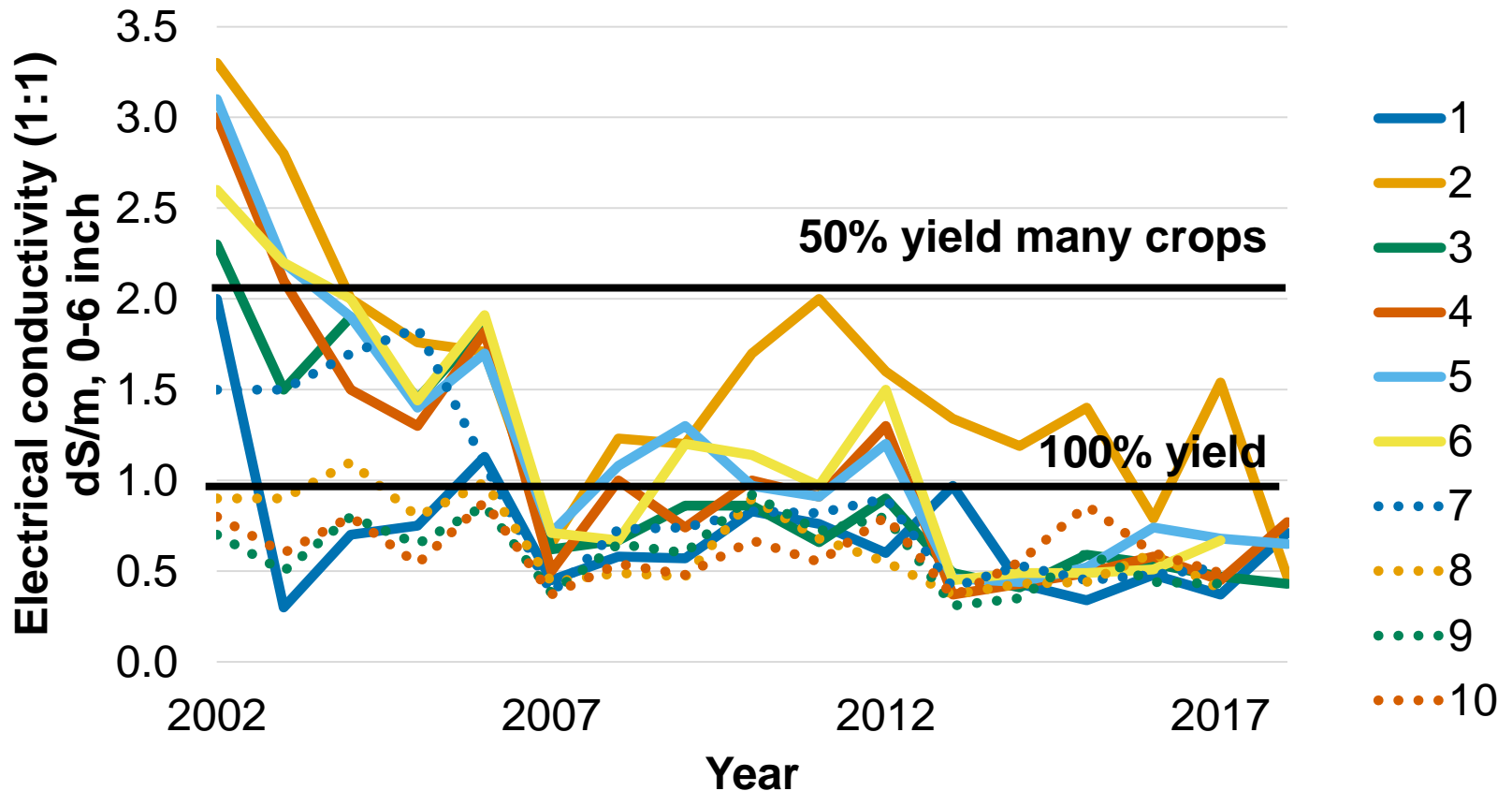
Grady Thorsgard, farmer
Sandy loam to loam
pH 7.9-8.2
Carbonate (CCE) 3-6%
Organic matter 4.0-5.5%

2004 corn



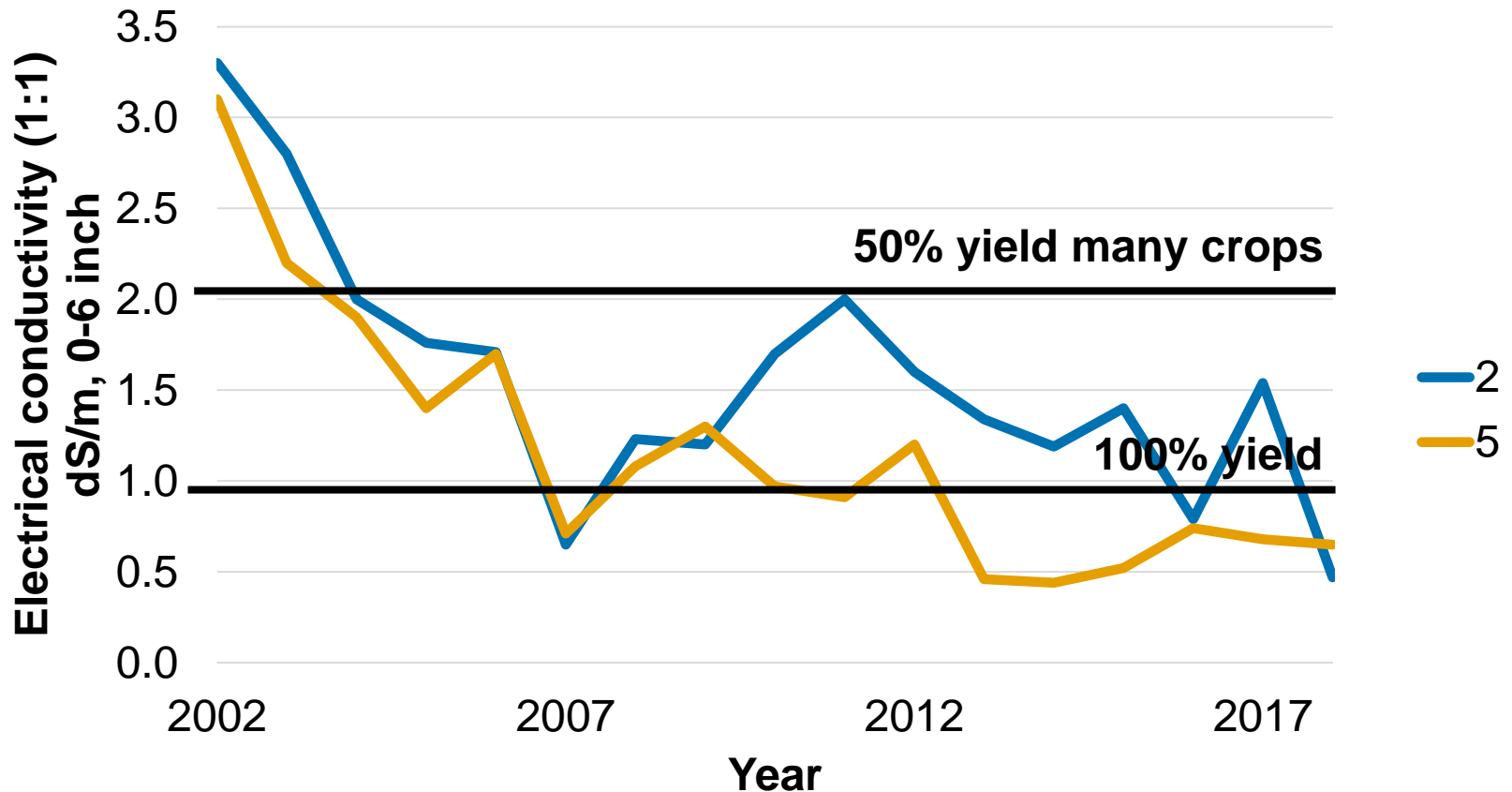
Saline soil, topsoil

Change in salinity (soluble salts)



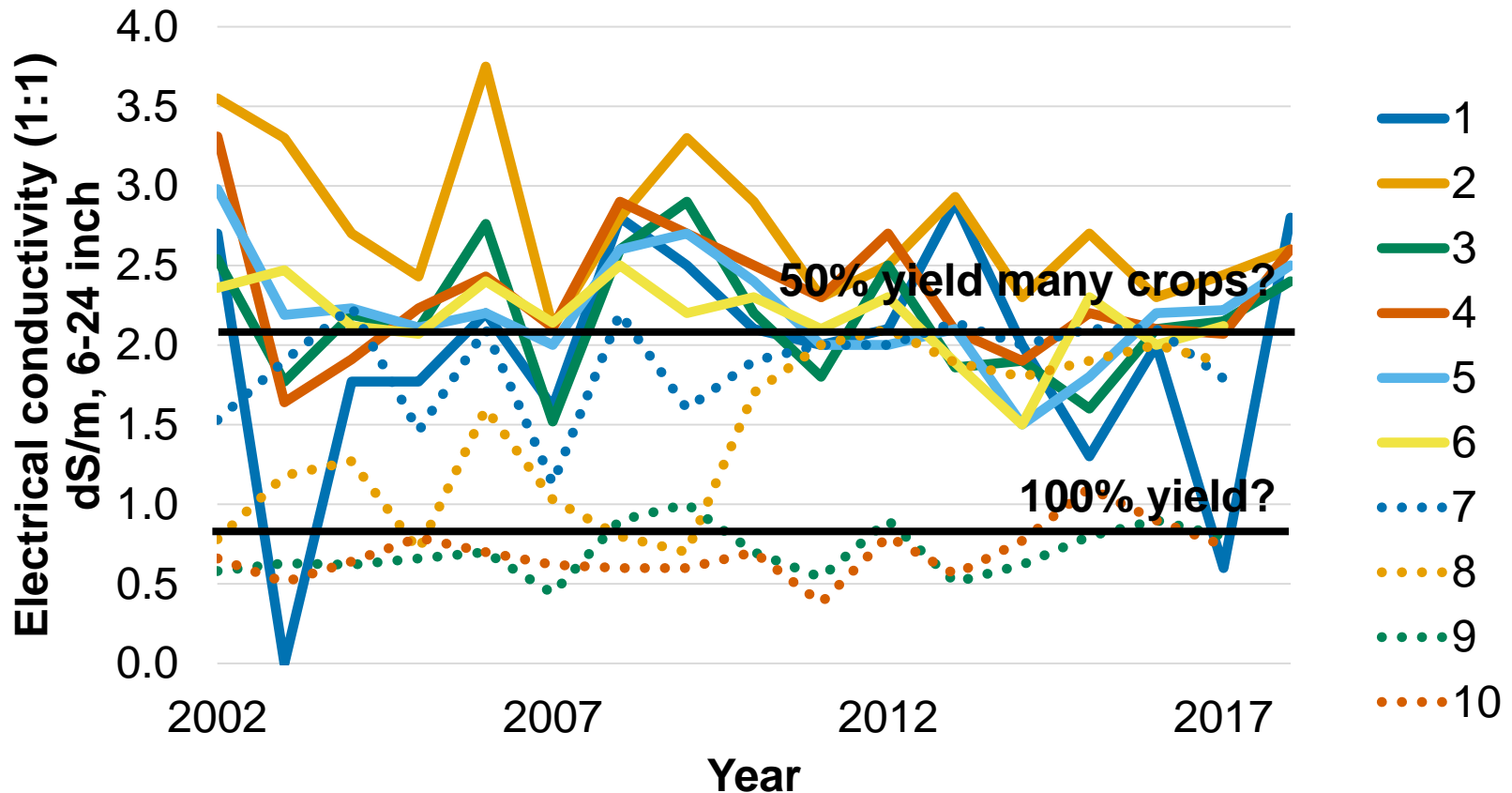
Saline soil, topsoil

Change in salinity (soluble salts)



Saline soil, subsoil

Change in salinity (soluble salts)



Tile drainage project

Saline soil, Northwood, ND

- Topsoil salinity declined in years with excessive spring or fall rainfall
- Several crops now produce good yields
 - Corn, soybean, sunflower
 - Soybean iron deficiency chlorosis (IDC) reduced
- Subsoil salinity will take longer to decline
- High subsoil salinity do not affect yield as badly as topsoil salinity
- Salinity can increase in dry years if upward capillary rise > downward leaching

Long-term tile drainage projects

- Saline soil near Northwood, ND
 - Drain tile installed Summer 2002
 - Ten GPS-marked sampling sites
- Saline-sodic soil near Mayville, ND
 - Saline-sodic and saline areas in field
 - Drain tile installed 2007
 - Gypsum applied, total 5 ton/acre in 2008 & 2009

Drain tile + Gypsum application ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)

Good area
Low salinity – low %Na

High salinity

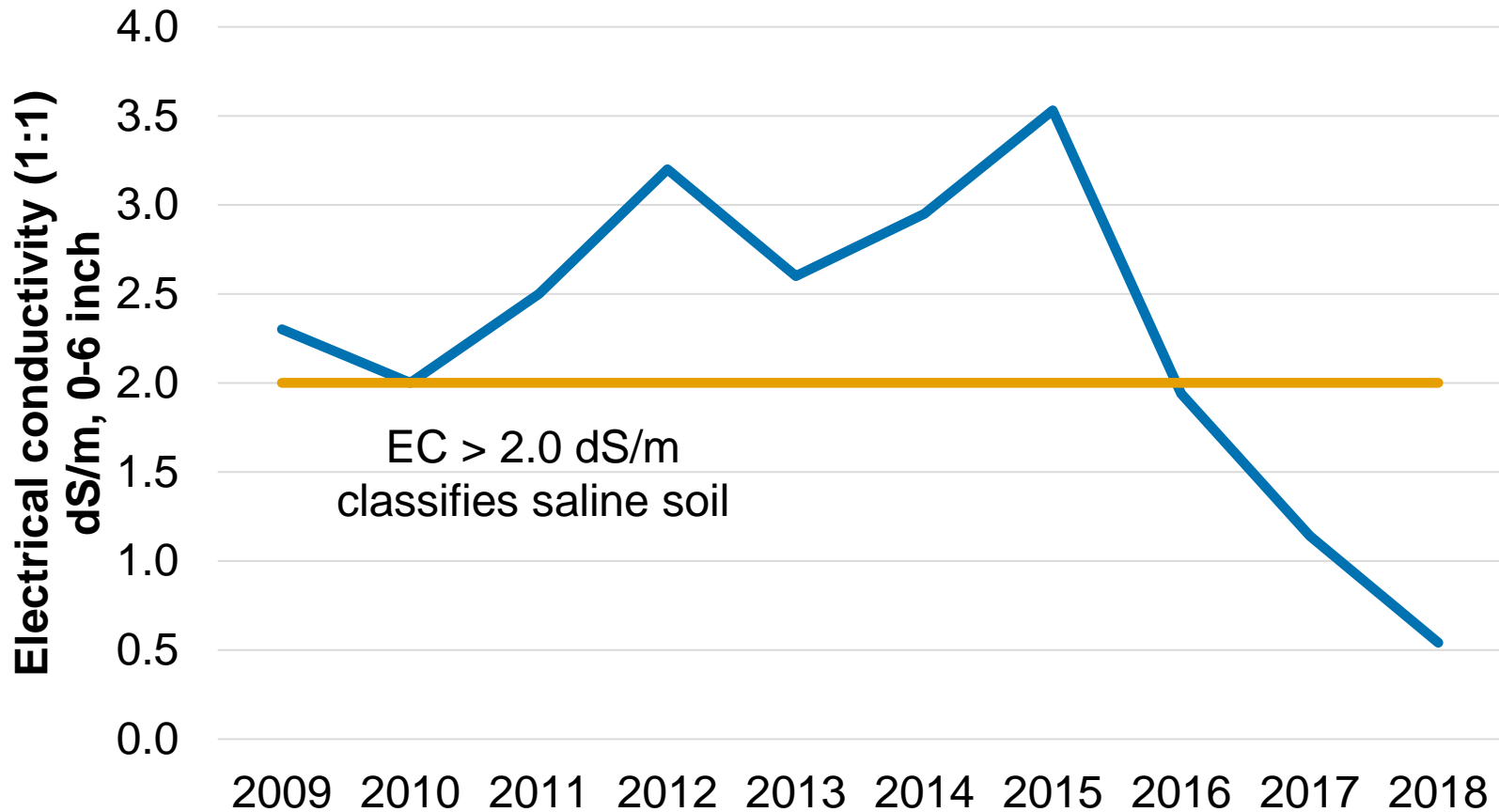
High salinity
High sodicity (%Na)

10,000 lb/acre gypsum
Spring 2008, Fall 2009

Gypsum cost \$125/ton
Photo taken 2007 or 2008

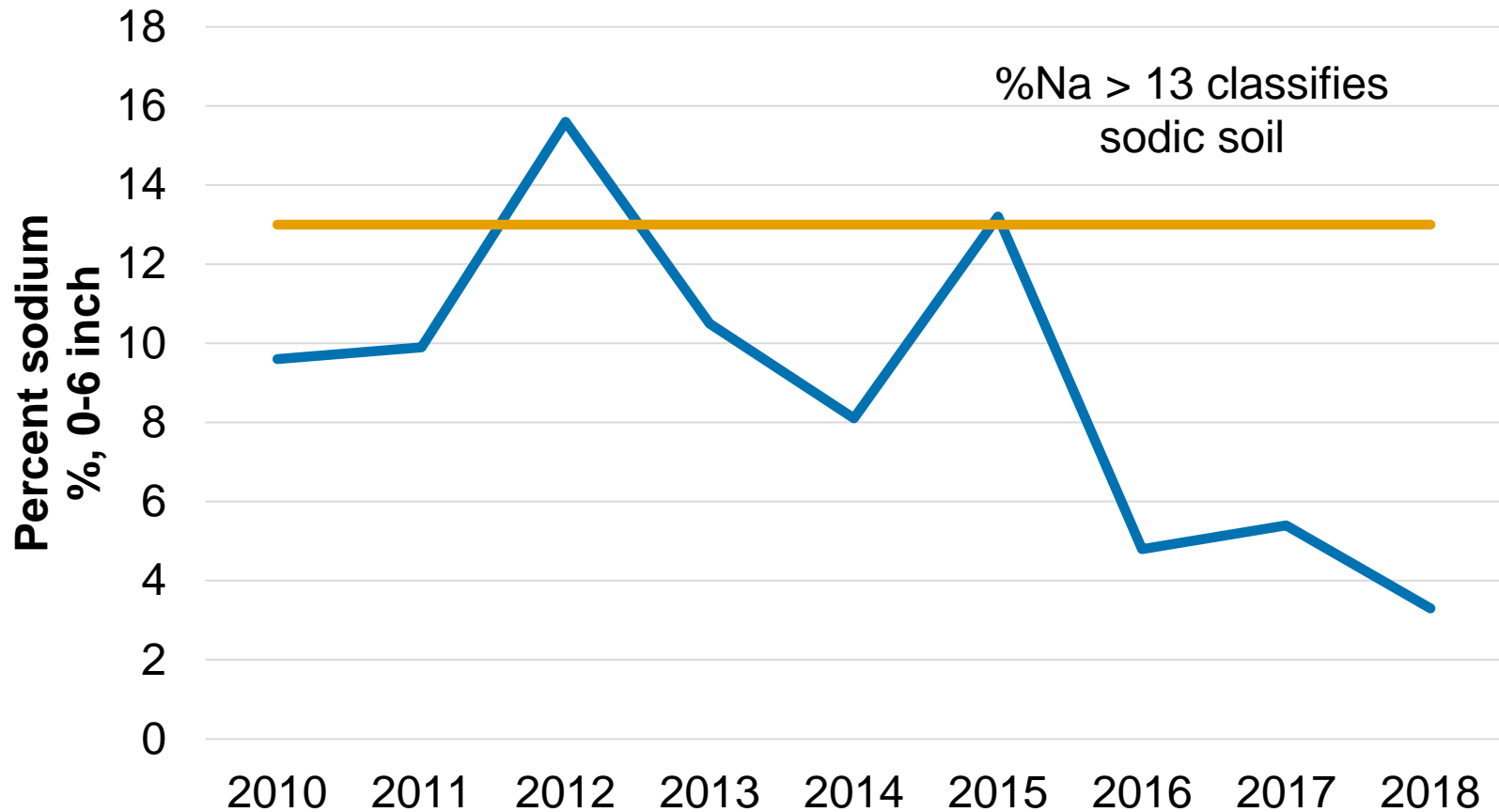
Saline-sodic soil

Change in salinity (soluble salts)



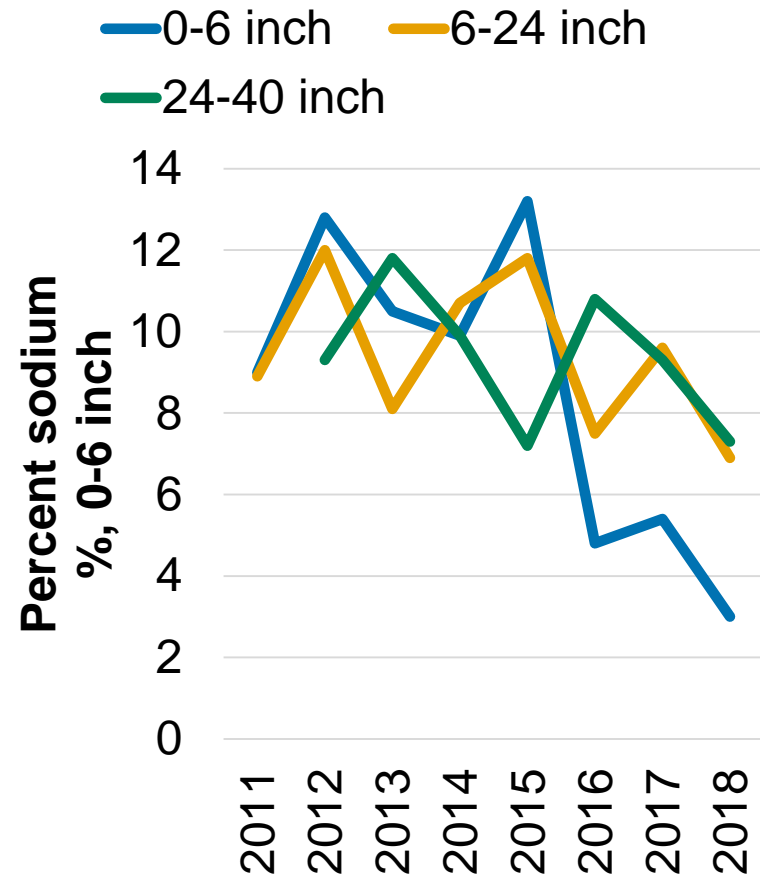
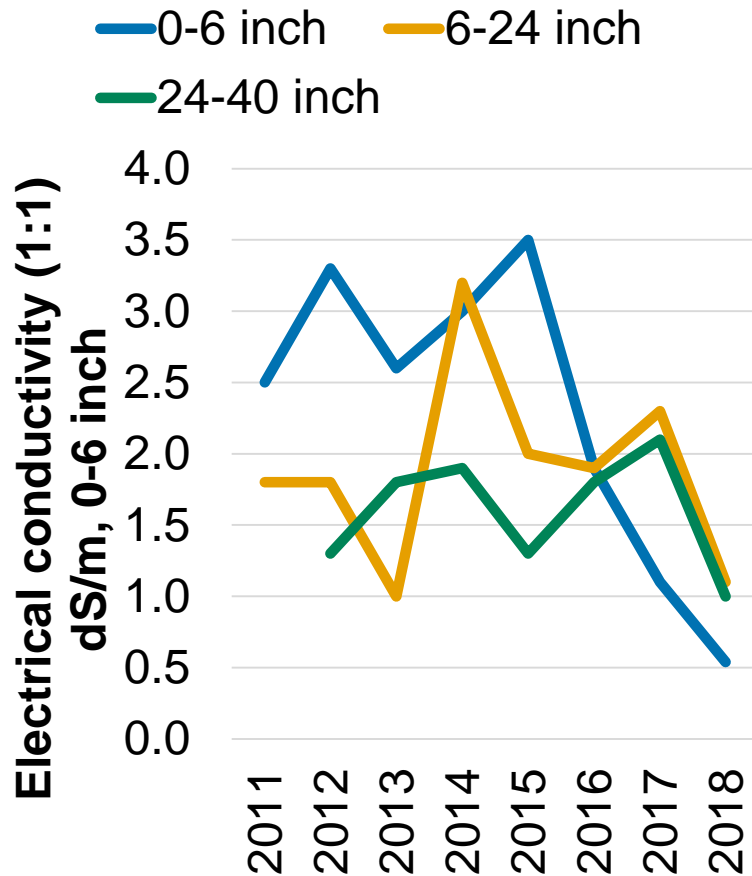
Saline-sodic soil

Change in sodicity (%Na = SAR)



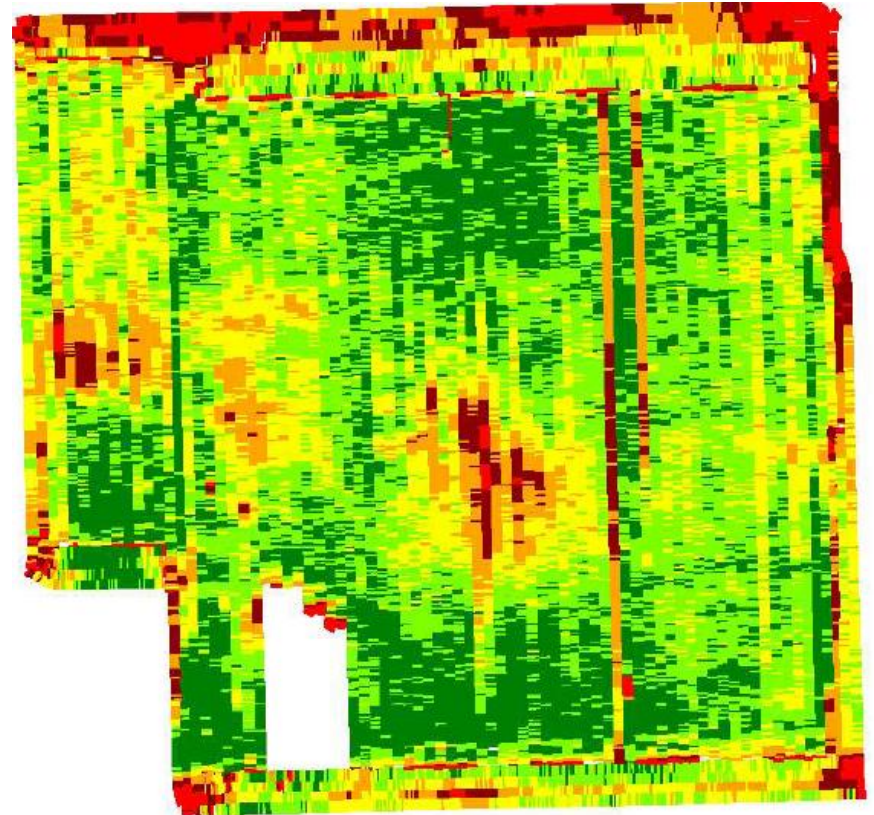
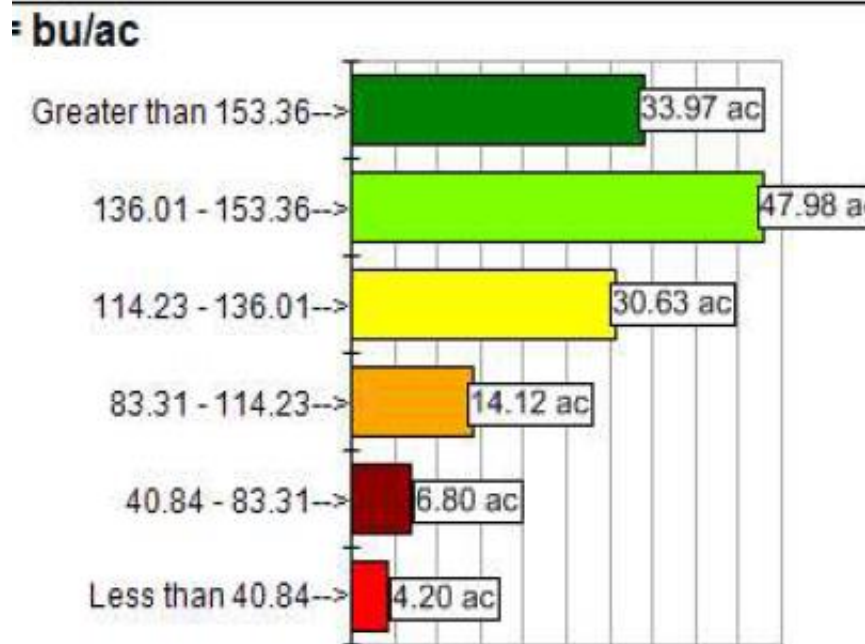
Saline-sodic soil

Changes in salinity and sodicity with depth



Corn yield 2014

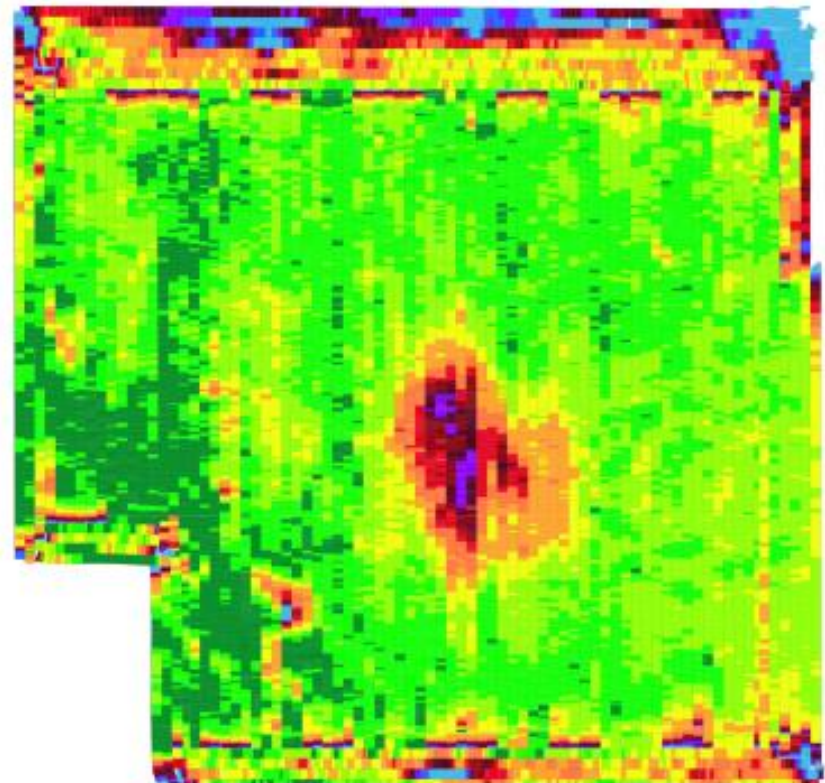
Average 133 bu/acre dry corn



Corn yield 2016

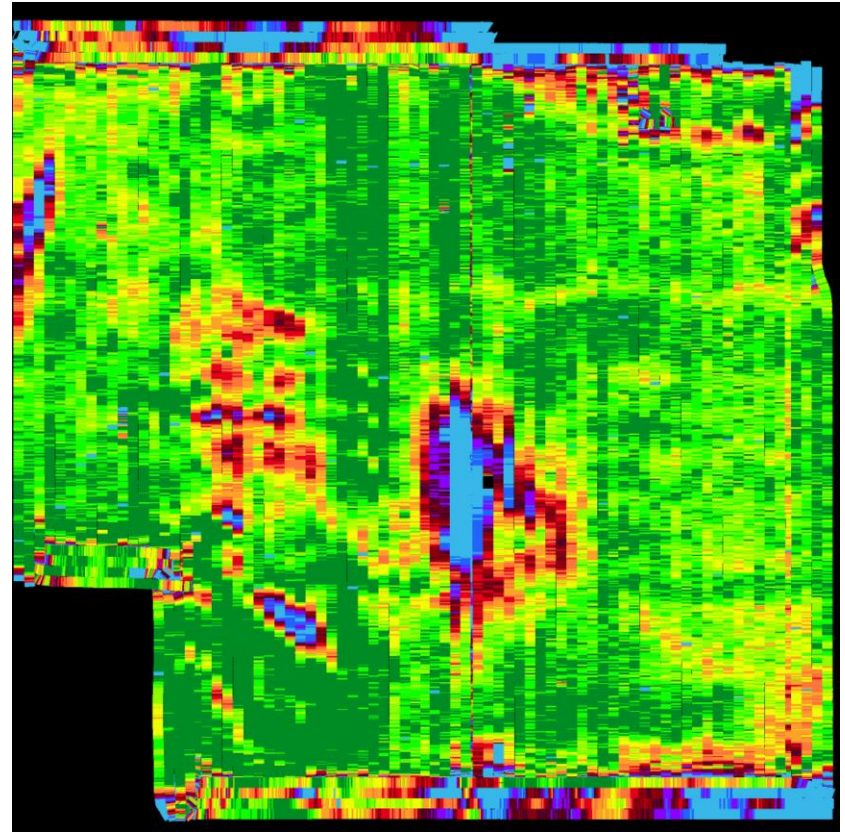
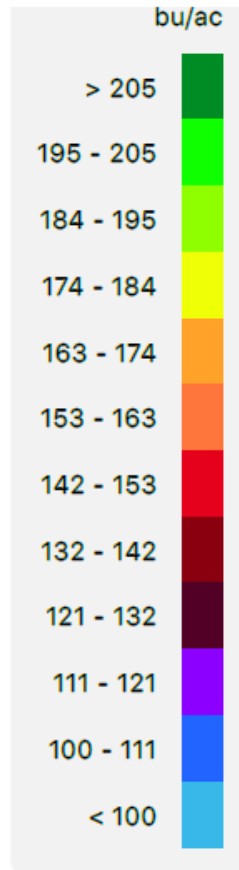
Average 184 bu/acre corn (17.9% moisture)

> 207 bu/ac
194 - 207 bu/ac
181 - 194 bu/ac
167 - 181 bu/ac
154 - 167 bu/ac
141 - 154 bu/ac
128 - 141 bu/ac
115 - 128 bu/ac
101 - 115 bu/ac
88 - 101 bu/ac
75 - 88 bu/ac
< 75 bu/ac



Corn yield 2018

Average 187 bu/acre corn



Tile drainage project

Saline-sodic soil, Mayville, ND

- Topsoil salinity and sodicity (%Na) consistently reduced past three years
- Subsoil salinity and sodicity (%Na) has not noticeably changed yet
- Saline-sodic area has become smaller, improved corn and soybean yields
- Saline area has not improved, water sits along road ditch and remains wet year-round

Thank you for your kind attention!

Are there any questions?

