Sodic Soil – Gypsum Project
Mayville, ND 2008 – 2011

• Sodic soil areas being recognized locally
  – Tile drainage is revealing areas of sodic soils
  – As the total soluble salt levels decreased by tile drainage, the sodium issue becomes more apparent
  – Reclamation of the sodic areas with gypsum is necessary to improve productivity
Sodic Soil – Gypsum Project
Mayville, ND 2008 – 2011

- Field Tile drained fall 2007
- Field zone soil tested - Fall 2007
  - 14 acre zone with high sodium and salts
    - Sodium 1811 ppm (20% on exchange)
    - Total soluble salts = 2.7
- Gypsum application in Spring 2008 and 2009
No Sodic/saline Soil on the map?
Sodic/Gypsum Project (Long-Term Project)

• Point and Zone sampling each year (GPS)
  – Field has been zone sampled each year
• Nutrient Trends over time
  – Sodium
  – Soluble salts
  – pH
  – Remaining nutrients
Soil Productivity

Based on Salinity and Sodium Level

- **Good Productivity**
  - Non saline
  - Non-sodic

- **Moderate Productivity**
  - Moderate salinity
  - Non-sodic

- **Low Productivity**
  - Moderate to high salinity
  - Moderate to high sodium level
Highly Productive Soil

- Good structure, good water infiltration, soft when dry
- Low salt (less than 1.0 mmhos/cm)
- Low sodium (less than 2% sodium)

Diagram showing the elements Mg, Na, Ca, K, MgCl, CaCl, and MgSO₄.
Saline (Salty) Soil

• Saline soils are caused by a water near the soil surface for at least part of the year.
• Saline soils have an electrical conductivity value (e.c.) value greater than 2.0 mmhos/cm (1:1 routine test run by all laboratories)
• Saline soils usually have a white surface and have good structure (they feel soft)
• Saline soils cause yield loss in many crops in the Montana, Canadian Prairies, Dakotas and western MN.
• Saline soils can be low or high in sodium
Saline Soils (salt greater than 2.0 mmhos/cm) 
Sodium is low (less than 4%)

good structure, good water infiltration, soft when dry

Osmotic affect caused by Salts hurt plant growth
Saline Soil (white salt)

Osmotic affect restricts plant growth: In normal soil, plant sap has a higher salt concentration than the surrounding soil water solution. This causes water to come into the plant through the root, to equalize the concentration of salts (osmosis). If the soil solution has a higher salt concentration than the plant sap, water stops flowing into the plant. The plant dies of “water stress” even though the soil is very wet.
# Saline Soil Classes

* Based on routine laboratory 1:1 soil to water method

<table>
<thead>
<tr>
<th>Salinity Class</th>
<th>* E.C. Value (mmhos/cm)</th>
<th>Influence on crop yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-saline</td>
<td>0.0-0.5</td>
<td>None</td>
</tr>
<tr>
<td>Very slightly saline</td>
<td>0.6-1.0</td>
<td>Sensitive crops may have yield reduction</td>
</tr>
<tr>
<td>Mod Saline</td>
<td>1.1-2.0</td>
<td>Yields of many crops reduced</td>
</tr>
<tr>
<td>Strongly saline</td>
<td>2.1-4.0</td>
<td>Yields of most crops reduced</td>
</tr>
<tr>
<td>Extremely saline</td>
<td>Greater than 4.0</td>
<td>Few plants will grow</td>
</tr>
</tbody>
</table>

Table represents medium and fine textured soils
Saline Soils

- How do soils become saline?

Water evaporates at the Surface and leaves salts (white salts on surface)

Capillary action brings Water to the surface by suction

2.5’ sandy soil

4-5’ for a clay soil

A series of wet years will bring the water table closer to the surface and salt levels will increase at the surface increasing saline area size
Salinity Near Drainage Ditch
Saline Soils

Saline soil beside drainage ditch

- Road
- Water in ditch
- Water table
- Water flow
- Maximum salinity
- Maximum crop damage
- Salts wicked to surface
- Too far
Saline Soils - Seeps

How saline seeps develop

(Recharge area)
Sandy loam

Water

Loam

Saline seep area
(white soil crust)

Fine texture soil

Coarse soil material acts like pipe
Saline Soil Structure

Yellowish flecks are calcium sulfate (gypsum)

White flecks are calcium and magnesium carbonates
Sodic Soil

Poor structure (pudding when wet), poor water infiltration, hard when dry

High sodium (4-15% sodium) Low salt (less than 2.0 mmhos/cm)

Excessive sodium causes soil particles to orient in layers and seal
Sodic Soil

- Soil Test Levels
  - >3-5% sodium on base saturation
  - >15% sodium is defined as sodic soil
  - pH greater than 8.5
  - Low soluble salts (<2.0 mmhos/cm 1:1 method)

- Sodic soils can occur naturally
- Sodic soils are created by poor irrigation techniques
- Many sodic soils also have high salts
Sodic Soil

• Physical problems
  – High sodium destroys soil structure (wet pudding)
  – High sodium seals surface (poor infiltration)
  – High sodium reduces water percolation through the soil profile.
  – When a sodic soil becomes dry it becomes hard like a brick!
  – Sodium can be toxic to plants at high levels
Saline and Sodic (Real Mess)
Salt greater than 2.0 mmhos/cm and Sodium is higher than 15%

Fair soil structure because excessive salts keep soil flocculated (soft)
Fair water infiltration because excessive salts

Poor crop growth due to osmotic affect caused by salts and sodium ion affect
Saline

Good

Sodic & Saline
Reclaiming Sodic Soil must include improved drainage!

Tile drainage installed in 2007
Crop Rotation

• 2005 Corn
• 2006 Corn
• 2007 Corn (Tile installed)
• 2008 Corn
• 2009 Prevent Plant
• 2010 Winter wheat
• 2011 Corn
Amending Sodic Soils

• Gypsum – CaSO$_4$
  – Most commonly used calcium amendment for reclaiming sodic soils
  – Relatively inexpensive
  – Common rates are tons/acre
Amending Sodic Soils

• Calcium \((Ca^{+2})\) replaces Sodium \((Na^{+1})\) on the soil
  – Calcium forms a stronger bond than sodium
• Sodium must be leached out of the soil (Tile)
• Soil structure will be improved
  – Water infiltration is improved (less crusting)
  – Water percolation through the soil profile is improved
  – Toxic affects of sodium on plant growth removed
### How much Gypsum to apply?

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Current soil %</th>
<th>Desired soil %</th>
<th>Na to be replaced</th>
<th>Amendment - 6 &quot; Soil</th>
<th>Gypsum Tons/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>11383018</td>
<td>15</td>
<td>1</td>
<td>4.361</td>
<td>7.50</td>
<td></td>
</tr>
</tbody>
</table>

AGVISE Soil Scientists will help with calculation!
Sodic/Saline

1000 lb/a gypsum
Spring 2008

Saline only

1000 lb/a gypsum
Fall 2009

4000 lb/a gypsum
Spring 2008

Gypsum cost $125/ton

Sodic/Saline

4 trips a 1000 lb/a with applicator

6000 lb/a gypsum
fall of 2009
• **Sodic and Saline area**
  – Tile drainage will remove salt from the topsoil first improving crop germination and yield.
  – Sodium will be replaced by the calcium from the gypsum. Sodium will be leached from the soil. Water infiltration will be improved

• **Saline area**
  – Tile drainage will remove salt from the topsoil first improving germination and production.

• **Highly Productive area**
  – Tile drainage will allow earlier planting and reduce losses of N due to denitrification
## Salt Tolerance of Field Crops
*(Based on 1:1 common Salt Method)*

<table>
<thead>
<tr>
<th>Crop</th>
<th>Salt Level 100% Yield</th>
<th>Salt Level 75% Yield</th>
<th>Salt Level 50% Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>1.7</td>
<td>2.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Sugarbeets</td>
<td>1.6</td>
<td>2.6</td>
<td>3.3</td>
</tr>
<tr>
<td>*Corn</td>
<td>1.2</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.0</td>
<td>1.7</td>
<td>2.3</td>
</tr>
<tr>
<td>Flax</td>
<td>.9</td>
<td>1.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Canola</td>
<td>.9</td>
<td>1.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Soybeans</td>
<td>.8</td>
<td>1.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Potatoes</td>
<td>.8</td>
<td>1.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Edible Beans</td>
<td>.6</td>
<td>1.1</td>
<td>1.6</td>
</tr>
</tbody>
</table>

*Corn tolerates moderate salinity and uses lots of water through the season*
Has Gypsum Decreased Soil pH?

Once most of sodium is leached, pH should decrease to about 7.8-to 8.2.
Sodium Levels Have Decreased

![Graph showing the decrease in sodium levels from 2009 to 2011 for East Sodic Point, West Sodic Point, and Composite Sample Red zone.](image)
% Sodium Has Decreased

Want % Sodium to be less than 4% long term
Soluble Salt Levels

Soluble salts mmhos/cm

East Sodic Point
West Sodic point

1:1 routine salt method
Soluble Salt Levels

Soil core locations not GPS in zone sample so the cores are not from the same spots each year.

1:1 routine salt method
Corn vegetation images 05,06,07,08,2011

No images 2009 PP, 2010 winter wheat

Red = Bare surface/low veg

Blue = High vegetation

Tiled 2007
2008 corn – 82 bu/a

Dry Yield
Mike Kozojed - Mike Kozojed - Norway 2 NW 1_4

**Client Information:**
- Client: Mike Kozojed
- Farm: Mike Kozojed
- Field: Norway 2 NW 1_4

**Legend Information:**

<table>
<thead>
<tr>
<th>Units = bu/ac</th>
</tr>
</thead>
</table>
| Greater than 125.0 -->
| 102.4 - 125.0 -->
| 77.5 - 102.4 -->
| 52.5 - 77.5 -->
| 25.1 - 52.5 -->
| Less than 25.1 -->

<table>
<thead>
<tr>
<th>Range</th>
<th>Area (ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than 125.0</td>
<td>27.65 ac</td>
</tr>
<tr>
<td>102.4 - 125.0</td>
<td>29.61 ac</td>
</tr>
<tr>
<td>77.5 - 102.4</td>
<td>21.18 ac</td>
</tr>
<tr>
<td>52.5 - 77.5</td>
<td>25.18 ac</td>
</tr>
<tr>
<td>25.1 - 52.5</td>
<td>20.58 ac</td>
</tr>
<tr>
<td>Less than 25.1</td>
<td>19.32 ac</td>
</tr>
</tbody>
</table>

**Field Information:**
- Crop: Corn
- Start Date: 11/12/2008
- Product: Corn
- Elapsed Time: 11.326 h
- Area: 143.55 ac
- Average Yield: 82.1 bu/ac
- Average Dry Weight: 4,595.1 lb/ac
- Total Yield: 11,778.9 bu
- Total Dry Weight: 659,619 lb
- Average Moisture: 21.54 %
- Productivity (area/hour): 12.67 ac/h

Field information and legend apply to active map layer only.
2011 corn – 130 bu/a
Sodic Soil - Gypsum Project

- AGVISE will continue to test soil each fall (Sampling by Greg Reidman) for salinity and sodium levels for many years
- Grower and consultant will track increases in crop productivity
- This project will educate all of us on how fast a sodic soil can be improved with tile drainage and gypsum in our region
Questions?