Saline and Sodic Field
Demonstration project 2007-2013

- ***Tile drainage will help decrease the soluble salt level over time but does not address parts of the field that have <u>sodium issues</u> as well.***
- ***Reclamation of soils that are both <u>saline</u> and <u>sodic</u> requires a <u>soil amendment</u> to improve productivity***

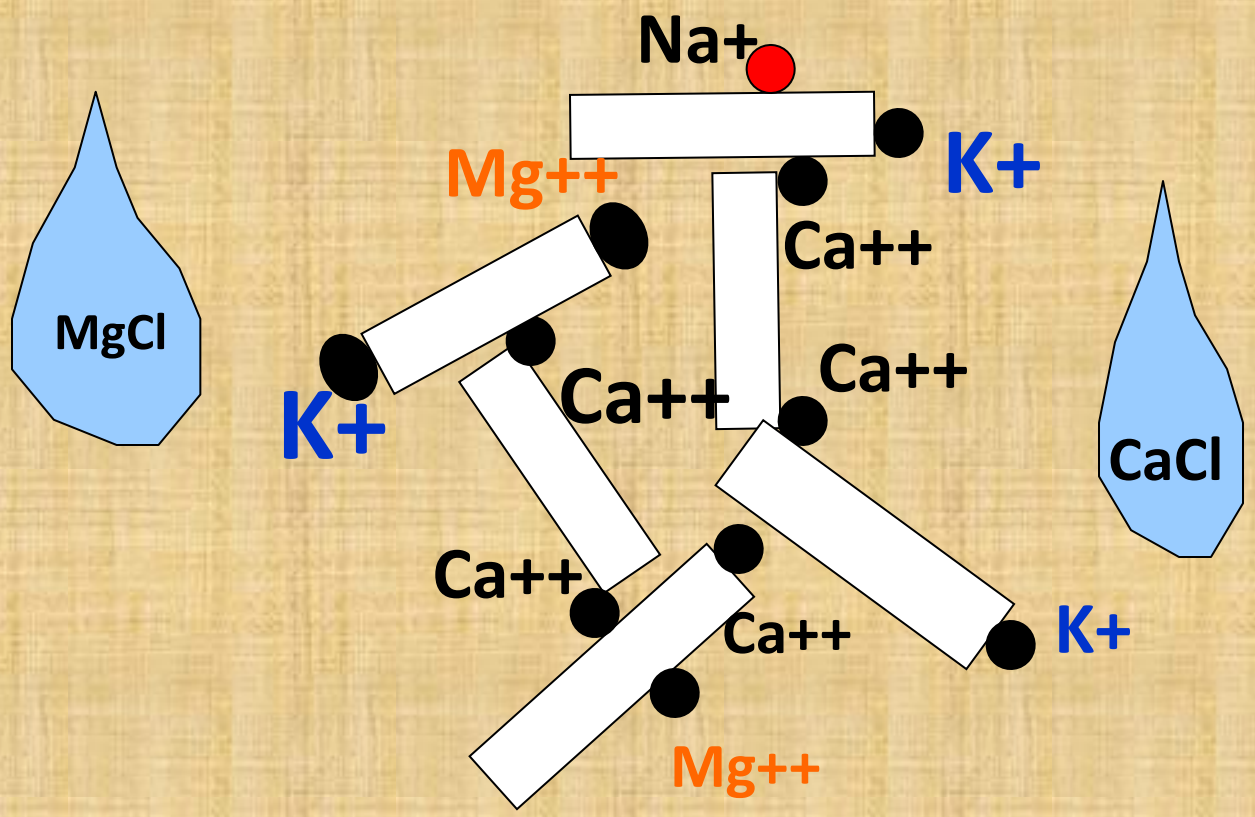
Good Soil
Very Productive

- Good soil structure
- Water table many feet from surface all year
- Good water infiltration at the surface
- Good water percolation through the soil profile
- Low salinity (e.c.) less than 1.0 mmhos
- Low sodium – Usually less than ESP 4% (SAR <4)

Good Soil : Non Saline – Non Sodic

Good structure, good water infiltration, soft when dry

Low salt (less than 1.0 mmhos/cm) Low sodium (low sodium)



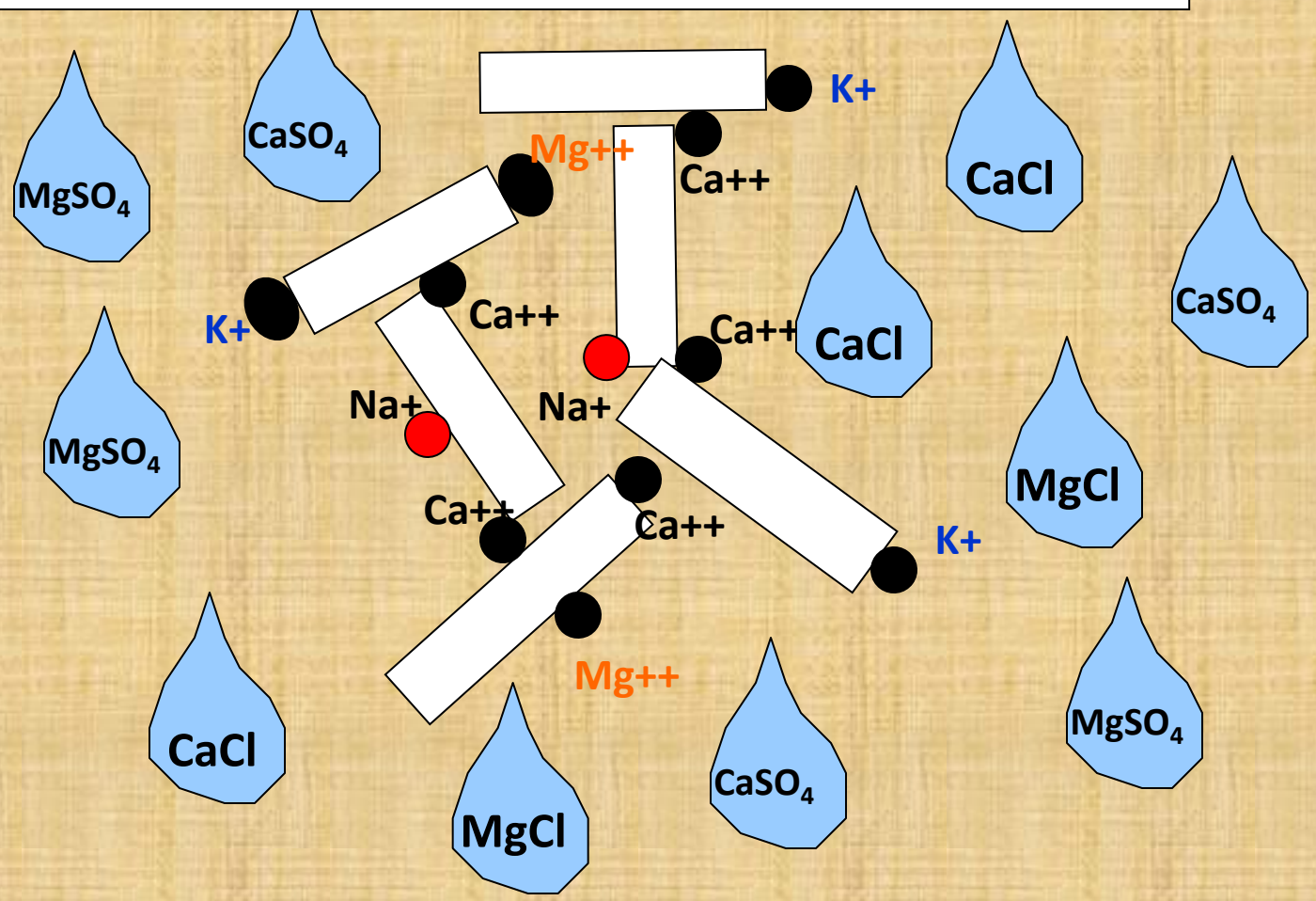
Saline (Salty) Soil

- Saline soils are caused by a high water table too close to the soil surface. (water wicks to the surface)
- Very saline soils can have <u>white surface</u>, which is the salts left behind when water evaporated away
- Saline soils have good structure and feel soft (the salts give them good structure)
- Saline soils have an electrical conductivity value (e.c.) value greater than 2.0 mmhos/cm (1:1 routine test)
- Saline soils cause yield loss in many areas of Montana, North and South Dakota and western MN.
- Saline soils are low in sodium

Saline Soil : Low Productivity

Good structure, Good water infiltration, High water table, Soft when dry

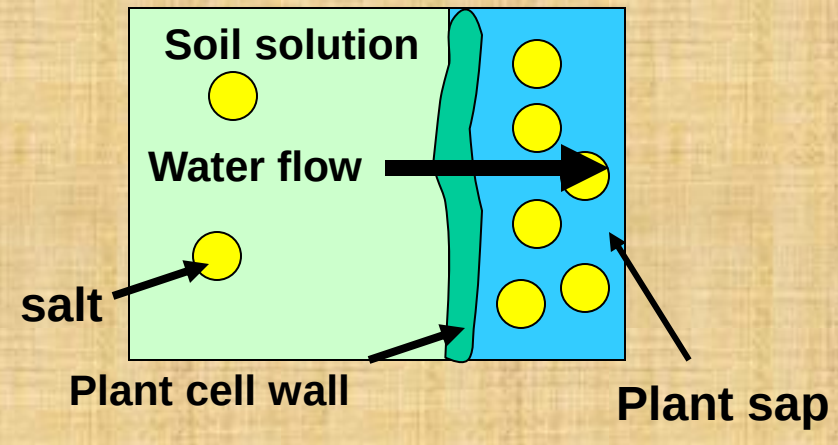
High salt test (e.c. higher then 2.0 mmhos/cm) - low sodium



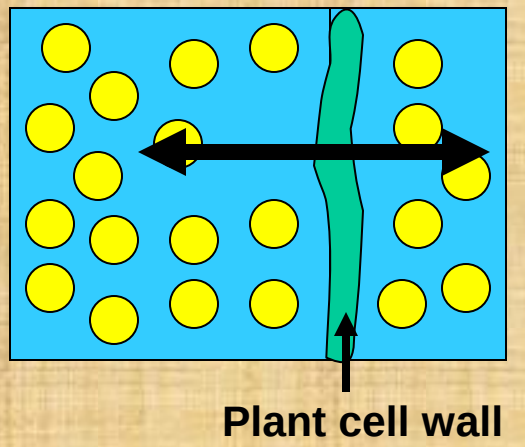
Saline Soil (white salt)

<u>Salts: Osmotic affect restricts growth:</u> In normal soil, plant sap has a higher salt concentration in the root than the surrounding soil water solution. This causes water to come into the plant through the root cell membrane, 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 root. The plant dies of "water stress" even though the soil is very wet.

Normal soil water flows into plant.



Saline soil water flow into the plant root is restricted



Sodic Soil – Low Productivity

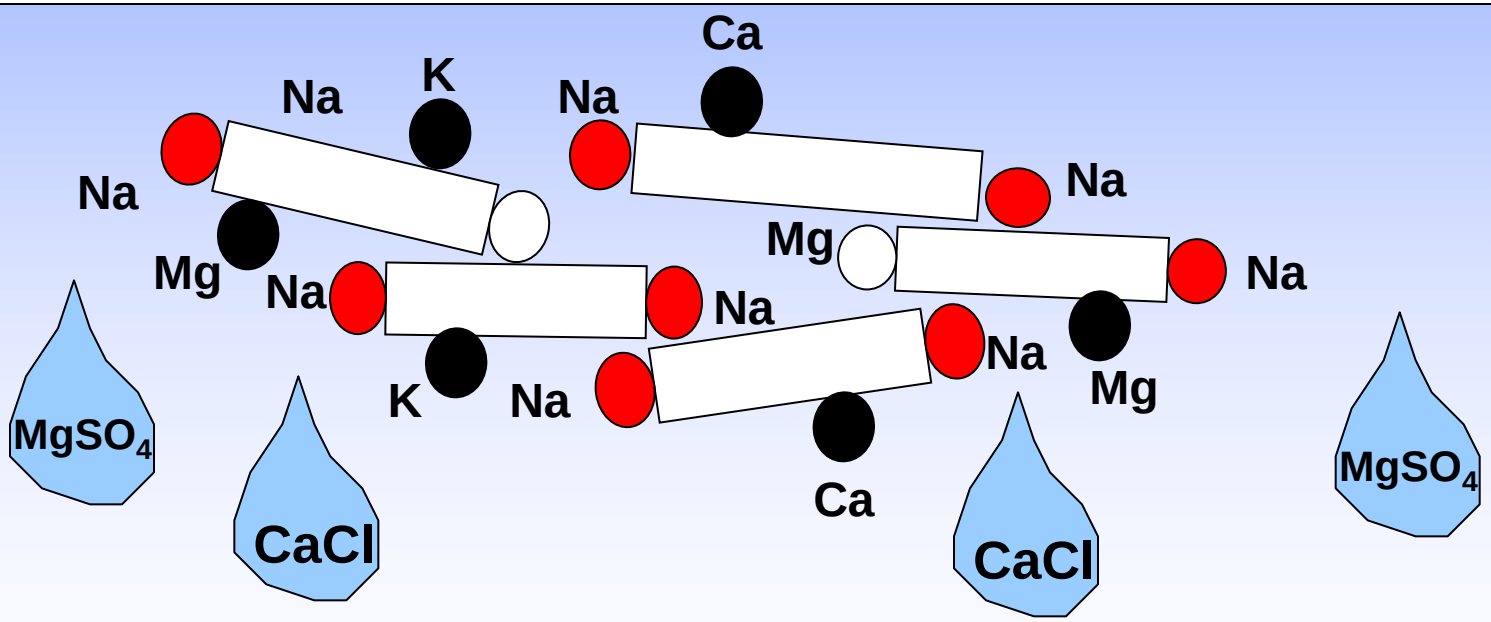
- High sodium destroys soil structure
  - Disperses soil particles
    - Becomes like pudding when wet
- High sodium seals up soil surface and reduces surface water infiltration and percolation in the soil
- Soil Test Levels
  - Soluble salts less than 2.0 mmhos (1:1 method)
  - >15% sodium on routine soil test (>15 SAR)
  - pH usually greater than 8.5

Sodic Soil: Poor Productivity

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

High sodium levels cause <u>dispersion</u> which <u>destroys soil structure</u>

Low salt (< 2.0 mmhos/cm) & High sodium (>15% ESP or >15 SAR)



Excessive sodium causes soil structure to collapse and soil particles to orient in layers, which severely limits water infiltration to the soil

Saline and Sodic Soil Very Low Productivity

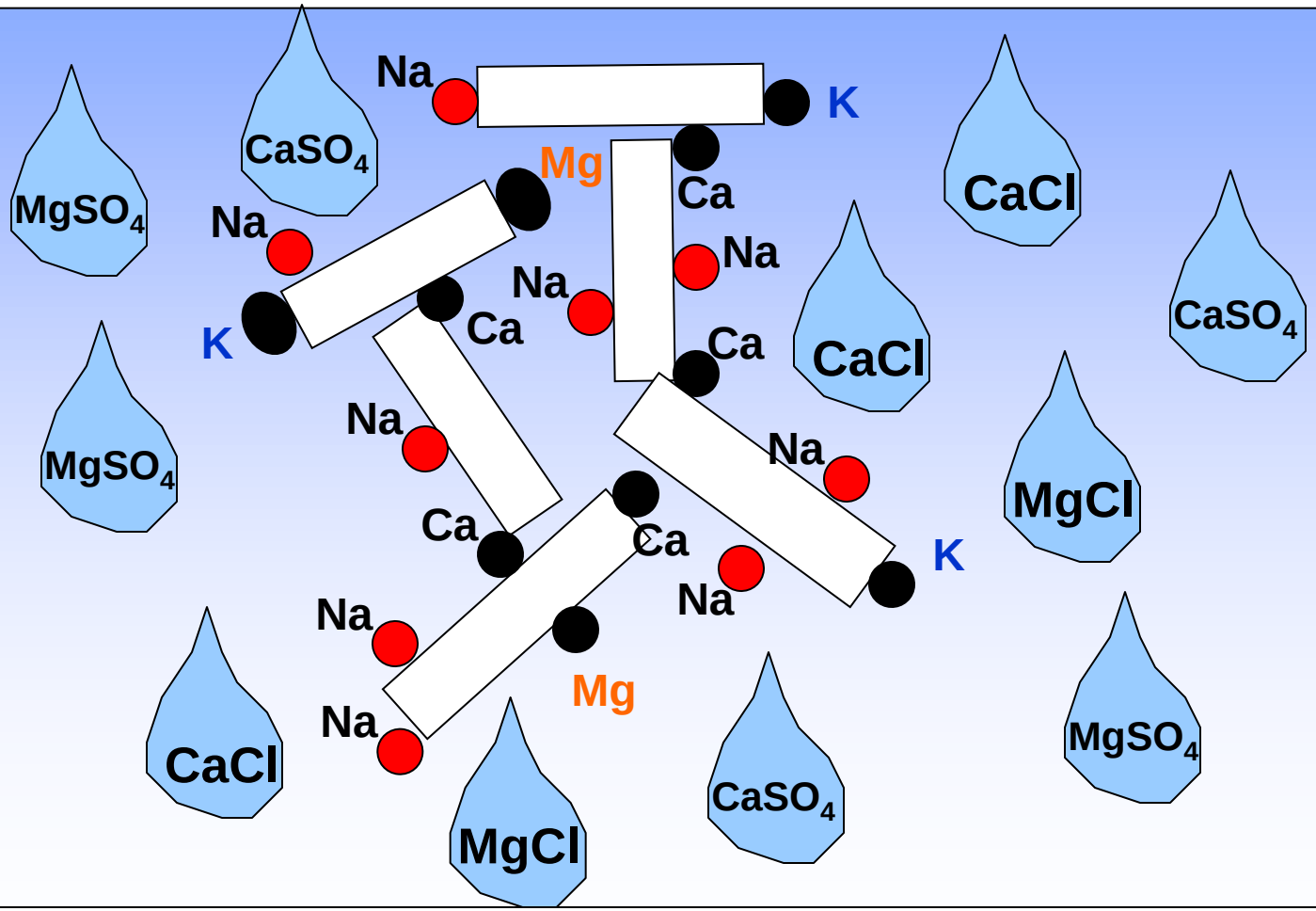
- Good soil Structure (because of high salts)
  - Water table too close to surface
  - High salt reduces yield due to osmotic affect on water uptake

    High sodium seals up soil surface and reduces surface water infiltration and percolation in the soil
- Soil Test Levels
  - Soluble salts more than 2.0 mmhos (1:1 method)
  - >15% sodium on routine soil test (>15 SAR)
  - pH usually greater than 8.5

Saline and Sodic (Real Mess)

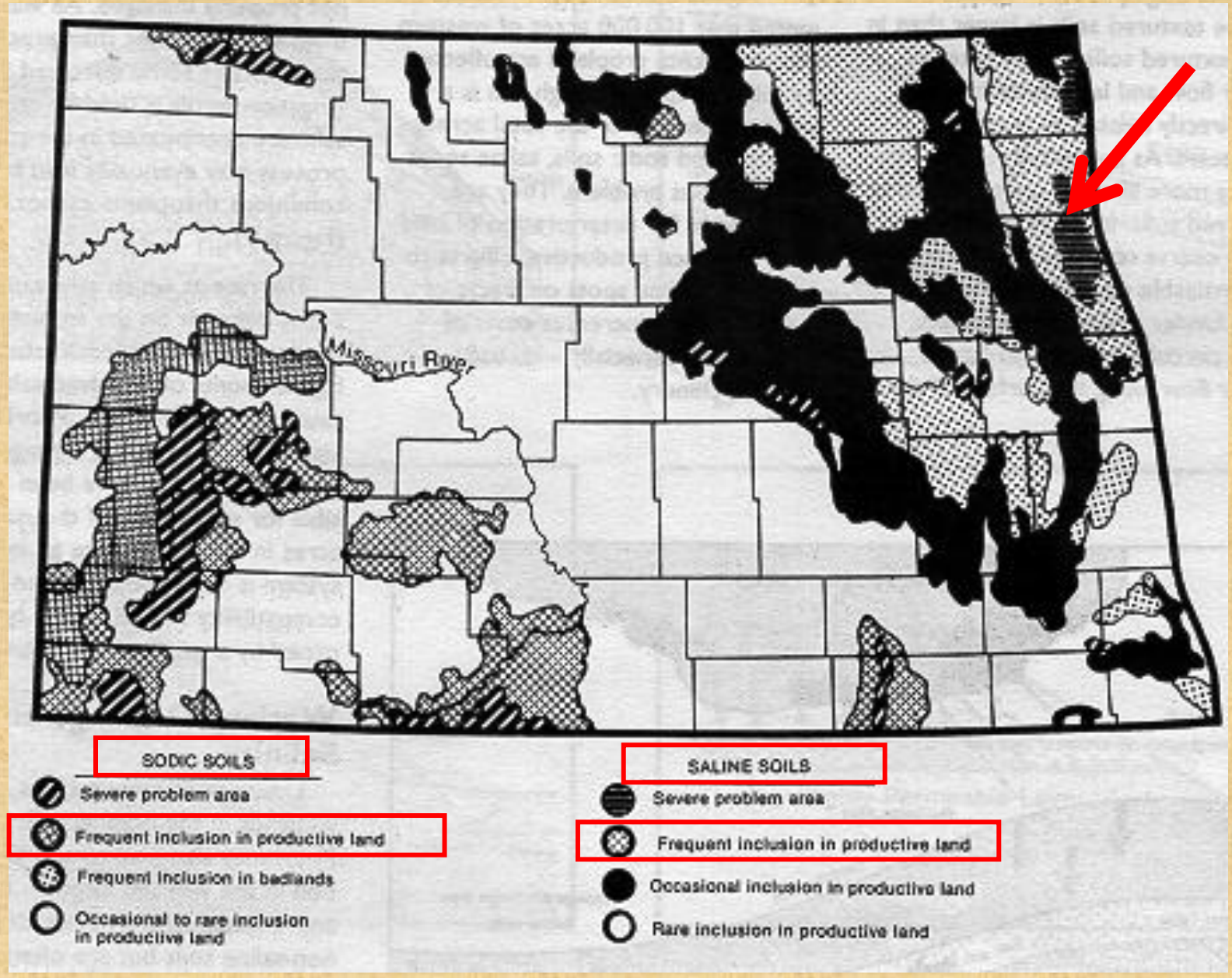
Salt greater than 2.0 mmhos/cm and Sodium higher than 15%

Good soil structure – high salts keep soil flocculated (soft)
Fair water infiltration because of high salt (very low productivity)

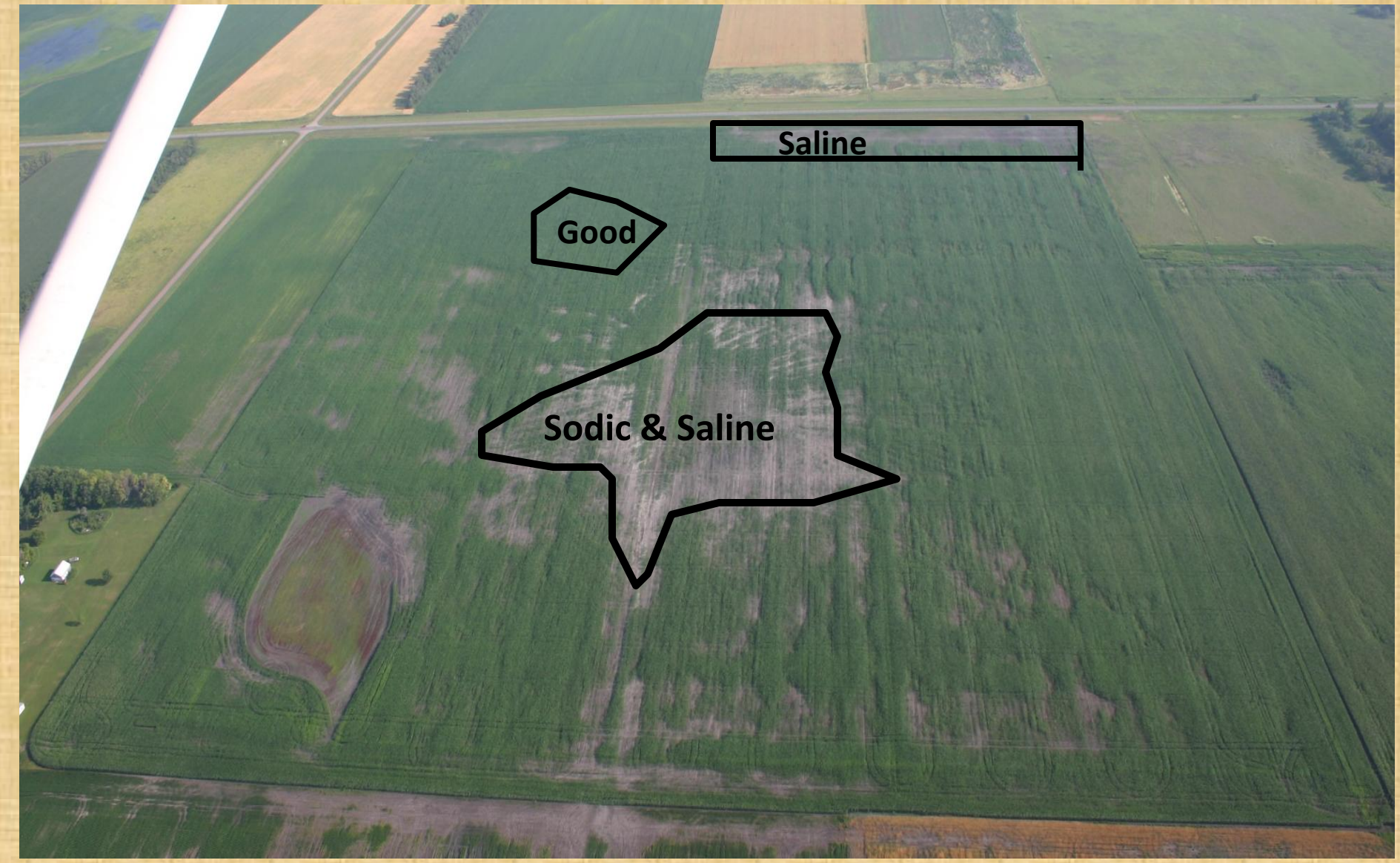


Poor crop growth due to osmotic affect caused by salts and sodium ion affect

Saline & Sodic Field Project - Mayville ND



Greg Reidman – Consultant Mike Kozojed – Farmer



Saline/Sodic Soil Project Mayville, ND 2008 – 2011

- Field Tile drained fall 2007
  - Good Area: Low salt and low sodium
  - Saline Area: High salt and low sodium
  - Saline & Sodic Area: High salt and high sodium

Saline & Sodic Area Amendment Plan

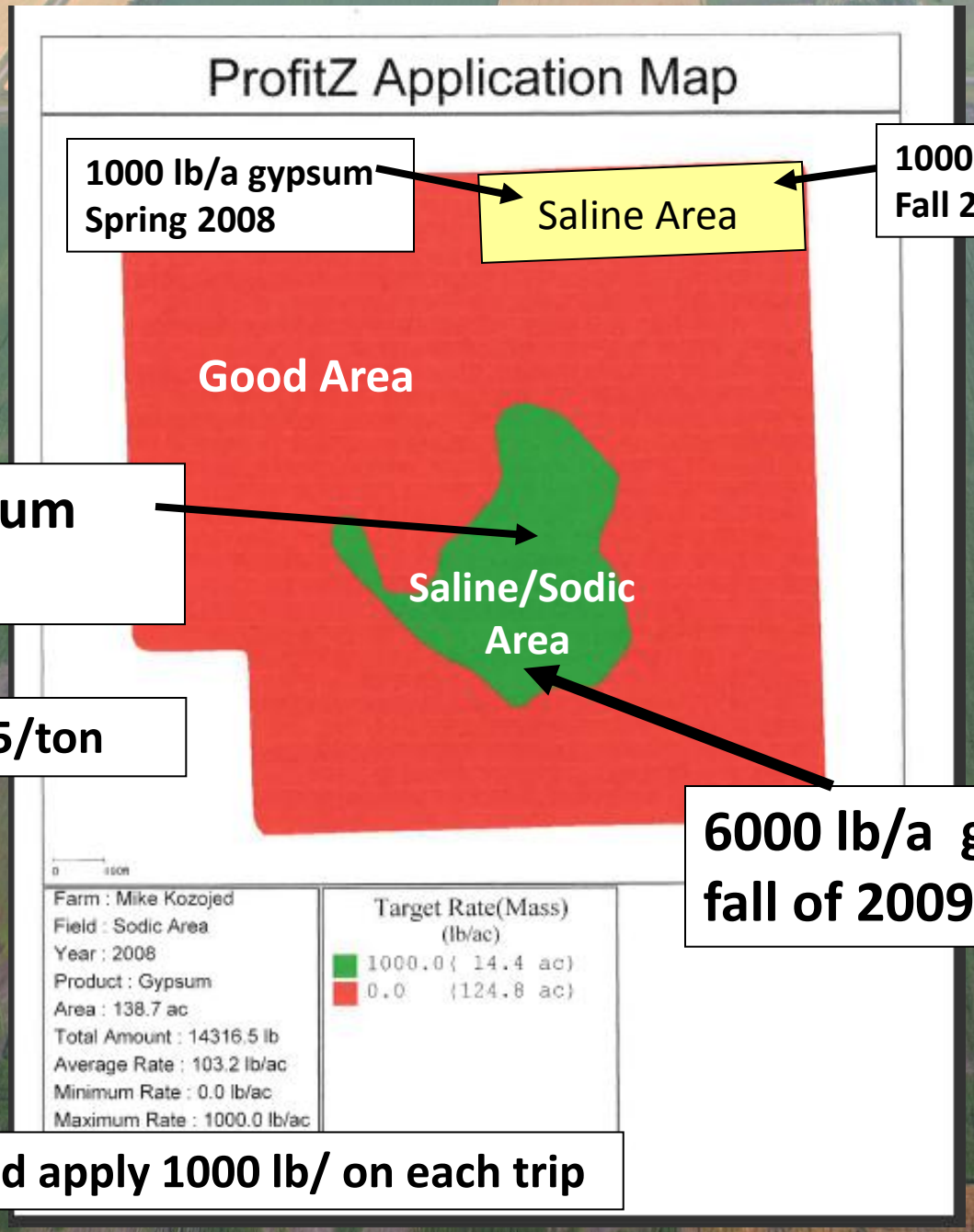
- Saline & Sodic area needs amendment to leach the sodium from the profile along with the salts.
  - Gypsum ($CaSO_4$) applied at several tons/a
  - Ca replaces Na on soil and water carries Na out bottom of the root zone through the tile
  - Future concerns about sodium sealing up the soil around tile (hard to place the gypsum in the subsoil near the tile)

Saline Only Area Amendment Plan (none)

- Saline Only: Does not need any amendment to leach the soluble salts from the soil
  - No Gypsum ($CaSO_4$) is needed (no sodium problems in this area)
  - Main concern is high salinity and how many years it will take to leach the soluble salts from the soil profile through the tile drainage (need wet years to leach the salt from the profile)

Good Area
No Amendments

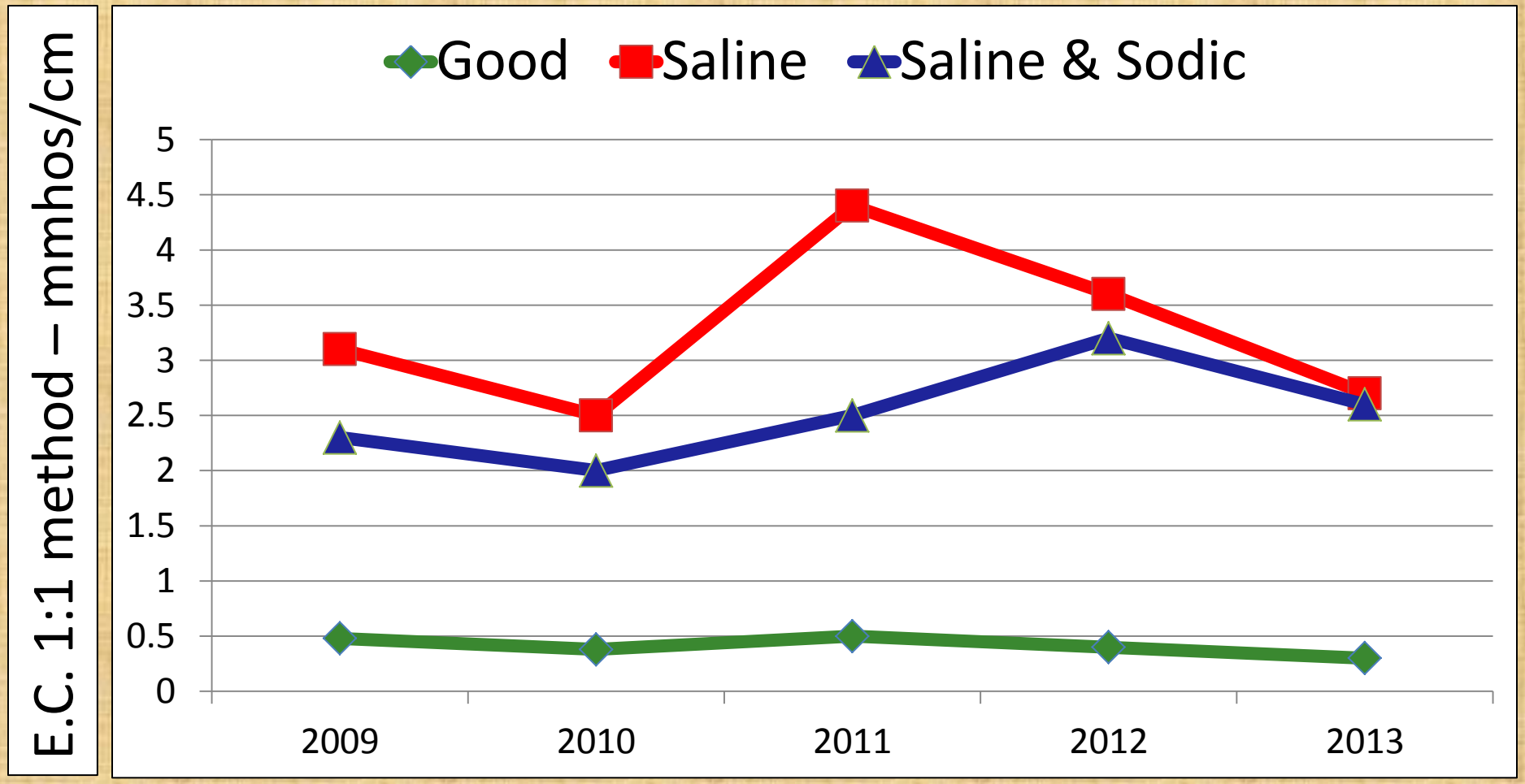
- Good area: Benefits of tile drainage
  - Earlier planting (higher yield potential – all areas)
  - Less N lost to denitrification
  - Less soil compaction (tilling when soil is dryer)
  - More inches of soil for plants to root to explore



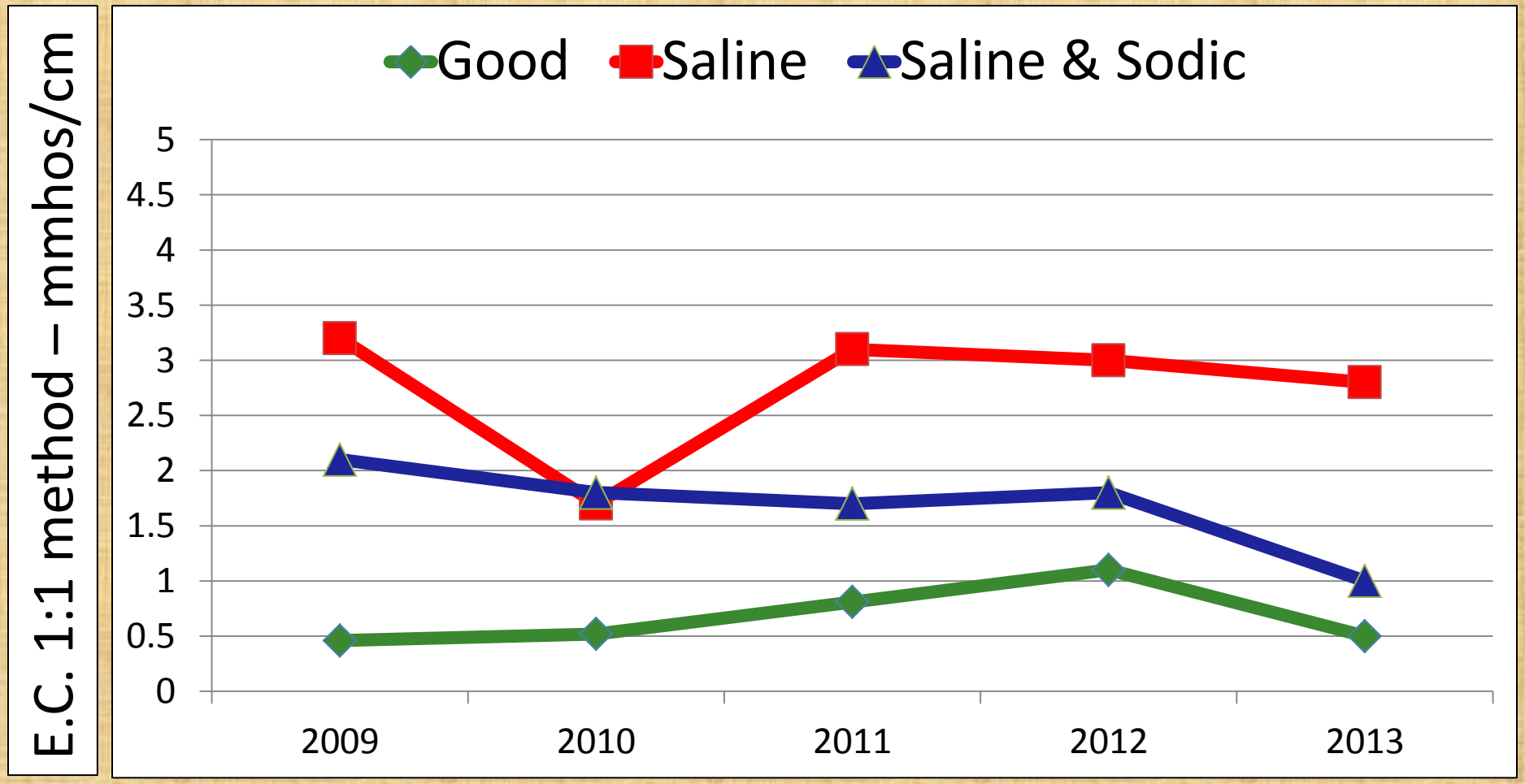
Gypsum cost $125/ton

Equipment could apply 1000 lb/ on each trip

Topsoil Salinity (e.c.) 2009-2013



Subsoil Salinity (e.c.) 2009-2013



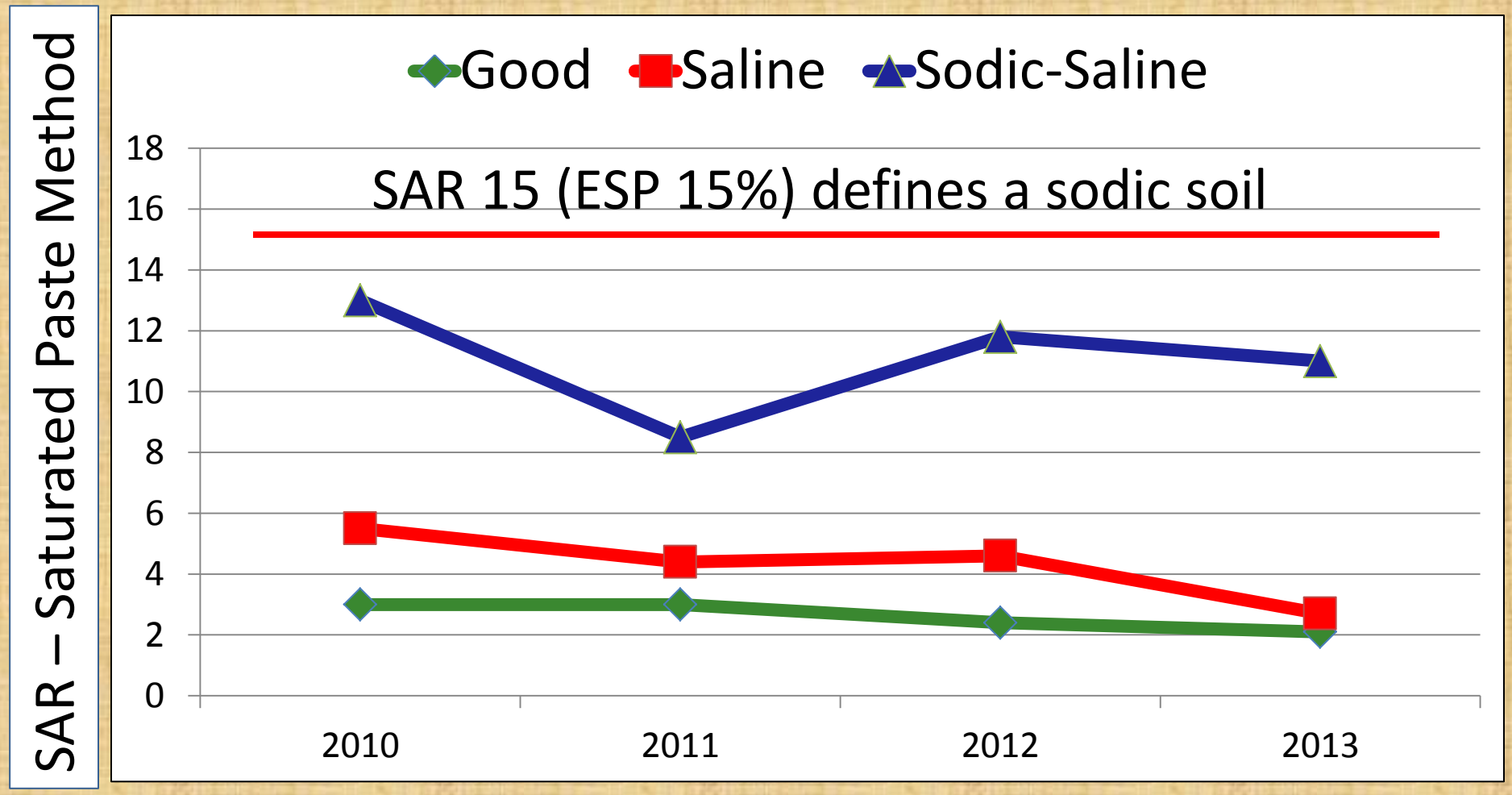
Monthly Rainfall (Grand Forks)
2002 – 2013 April -October

Extra rainfall needed too leach the salts and sodium from soil profile

	5 yr Ave	02	03	04	05	06	07	08	09	10	11	12	13
April	1.0	1.0	.6	.2	.4	.9	.6	.5	1.3	1.0	2.9	1.2	.7
May	2.7	1.3	4.0	4.4	2.8	2.4	5.1	.9	2.1	4.8	3.0	1.6	4.5
Jun	3.5	6.2	3.0	.8	7.0	.6	4.5	3.0	3.8	3.5	3.0	3.0	3.1
July	3.2	4.9	2.8	2.2	.7	.9	1.7	3.6	1.8	2.1	3.7	3.1	.85
Aug	2.9	6.8	1.0	2.9	5.0	5.4	2.8	3.0	2.7	1.7	2.2	2.2	1.1
Sep	2.0	1.4	2.2	3.3	1.4	2.8	1.0	3.8	1.3	5.7	1.2	0.1	2.5
Oct	2.0	1.0	.9	2.1	2.5	1.2	3.0	3.9	3.5	2.1	.5	2.9	2.8
Total	17.2	22.5	14.5	15.9	19.9	14.1	18.9	18.7	16.6	20.7	16.3	13.9	15.5

Red number indicates a month or year with rainfall higher than 5 year average

Topsoil SAR (Sodium Adsorption Ratio)
2010-2013



Crop Rotation

- 2007 (Tile installed in Fall)
- 2008 Corn (gypsum applied)
- 2009 Prevent Plant (gypsum applied)
- 2010 Winter wheat
- 2011 Corn
- 2012 Corn
- 2013 Prevent Plant – Cover Crop
- 2014 – Corn ????

2013 cover crop
Good Area (No Salts)

2013 cover crop
Saline Site

2013 cover crop
Sodic-Saline Site

Biomass and Estimated Available N from Cover Crop

Site ID	Biomass N in Cover Crop	Estimated Available N
		(50% of Biomass N)
Good (Low Salts)	190 lb/a N	95 lb/a N
Saline (High Salts)	34 lb/a N	17 lb/a N
Saline/Sodic (High Salt & High Sodium)	26 lb/a N	13 lb/a N

Biomass N determined by collecting above ground material from an area and determining the N content of the dry weight of the cover crop.

Available N calculated based on 50% of total N in biomass being available for crop use Over the next growing season

Soil Nitrate
Sept 9 - Standing Cover Crop

Site	0-6” Nitrate	6-24” Nitrate	24-36” Nitrate	0-36” Total
	N - Lb/a	N - Lb/a	N – lb/a	N – lb/a
Good	**7**	**30**	**32**	**69**
Saline	**48**	**105**	**76**	**229**
Sodic-Saline	**24**	**9**	**14**	**47**

What about CEC on these 3 soils?

- Cation Exchange Capacity (CEC) is a measure of a soils negative charge sites which hold positively charged cations
- CEC is closely related to soil texture
- Cations include Ca^{++}, Mg^{++}, Na^{+}, K^{+}, H^{+}
- The routine lab test measures the ppm of each cation. The ppm test values of the cations are used to calculate the CEC.
- CEC of soil doesn't change if texture doesn't change

Soil Texture vs. True CEC

Soil Texture	CEC Meq/100g
Sand, Loamy Sands (coarse)	0-10
Sandy loams (medium)	11-20
Silt Loams (medium)	20-30
Clay loam/ Clay (fine)	20-35

Based on soil texture determined by hydrometer – USDA soil texture class

Routine test method inflates CEC results on high pH soils with salinity

- Routine method for determining CEC is the ammonium acetate extraction (all labs).
- Soils with “soluble salts” have inflated Ca and Mg ppm test values (Ca & Mg in salt solution)
- High pH soils (> 7.3) have carbonates which inflate the Ca and Mg ppm test values
- The only true CEC method for high pH soil with soluble salts is a saturated paste method which is expensive

Saline/Sodic Project 2013
CEC Inflated by routine method

Site ID Sample Depth 0-6”	CEC Saturated Paste Method (TRUE)	CEC Common Method (Falsely Inflated)	Soluble Salts (1:1)	Carbonates (CCE)	%K Silly Means Nothing
	Meq/100 g	Meq/100g	mmhos/cm	%	
Good	32	39	0.4	3.9%	1.2%
Saline	27	56	2.7	10.4%	0.6%
Sodic/Saline	35	47	2.4	11.4%	2.0%

Soil Texture is Clay Loam at all sites – True CEC should be 25-35

Who cares if the CEC values are inflated due to salts and carbonates?

- Inflated values for CEC are a clue that the "base saturation" values are wrong!!!!!
- Every soil with salts and carbonates has inflated CEC (caused by inflated Ca and Mg test values)
- Many reasons to apply K fertilizer, but a ratio of one nutrient to the other based on the routine test for cations is not one of them
- "Ratio Peddlers" are "uninformed"

Saline & Sodic Demo Project Progress in 5 years

- Salt levels are decreasing slowly in years with excess rainfall
- Dry periods like fall 2011 and all of 2012 – no decline in salts
- 2013 had enough rainfall early to reduce salinity
- Sodium levels are decreasing slowly
- Productivity of the field has increased, but will require more wet years to leach salts and sodium from surface soil to reach full yield potential.

Questions?

Saline and Sodic Project 2013 CEC Inflation by routine method

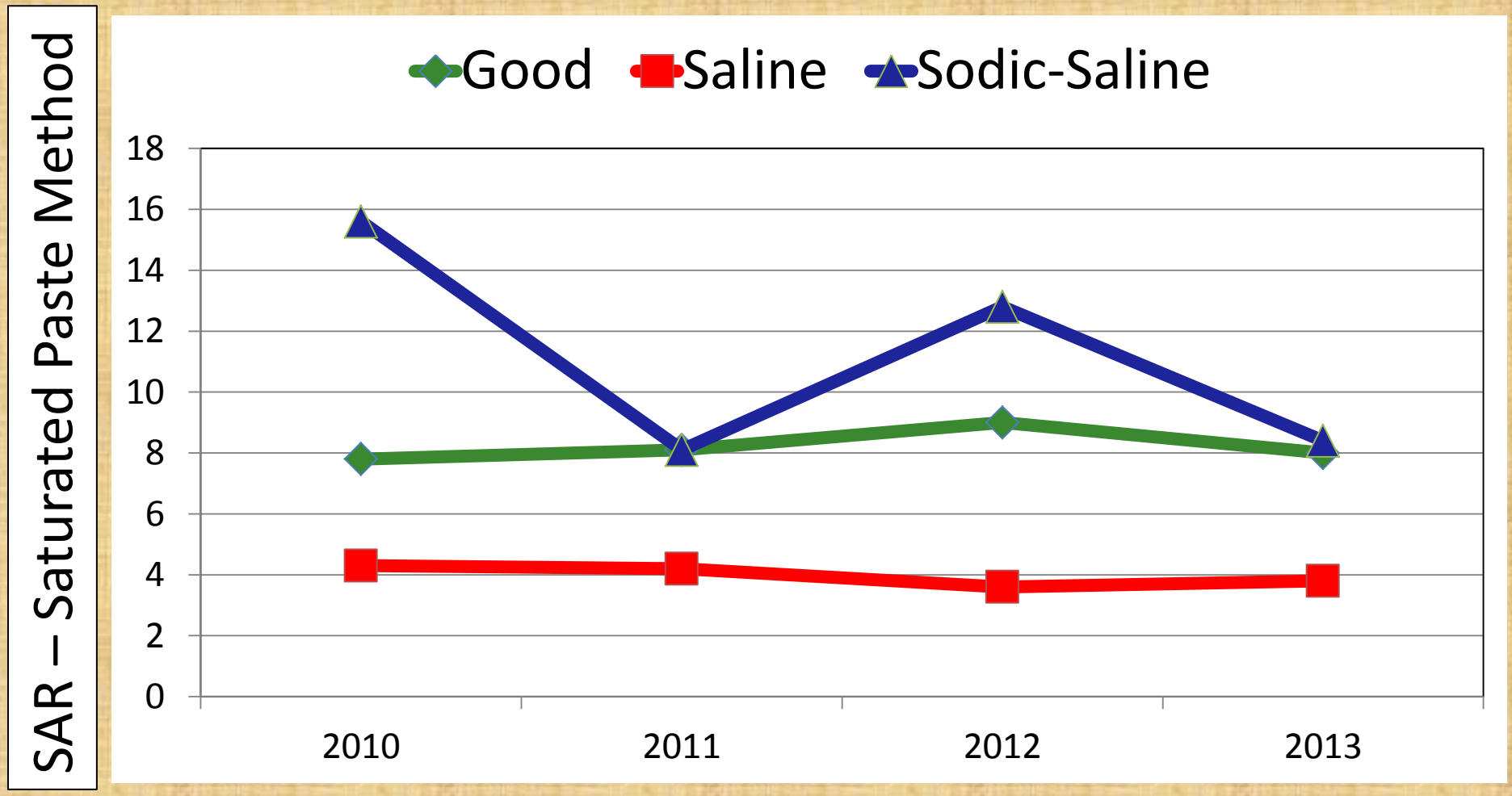
Site ID and depth	CEC True (Sat Na)	CEC common Method	Salts (1:1) meth	Carbonates (CCE)	pH (1:1)
	Meq/100 g	Meq/100g	Mmhos/cm	% by weight	
Good 0-6”	32	**39**	0.4	3.9%	8.5
Good 6-24”	22	**36**	0.4	19.7%	9.3
Good 24-36”	12	**32**	.5	12.7%	8.9
Saline 0-6”	27	**56**	2.7	10.4	8.2
Saline 6-24”	20	**45**	2.7	16.1%	8.4
Saline 24-36”	13	**44**	1.1	7.6%	8.4
Sodic/Saline 0-6”	37	**47**	2.4	11.4	8.3
Sodic/Saline 6-24”	12	**32**	.9	11.6%	8.5
Sodic/Saline 24-36”	23	**40**	1.6	18.8%	8.5

Routine ESP vs. SAR paste method

Sire ID and depth	ESP Routine Method	SAR Saturated paste Extract
Good 0-6”	2.0%	2.0
Good 6-24”	5.4%	8.0
Good 24-36”	5.6%	7.4
Saline 0-6”	2.6%	2.6
Saline 6-24”	3.8%	3.3
Saline 24-36”	5.1%	3.1
Sodic/Saline 0-6”	10.5%	11.1
Sodic/Saline 6-24”	8.1%	9.7
Sodic/Saline 24-36”	11.8%	14.0

SAR – Sodium Adsorption Ratio from saturated paste method
ESP – calculated Exchangeable Sodium Percentage calculated from routine cation method

Sodic Project - Subsoil SAR 2010-2013



Saline & Sodic Project Field 2013 Salt Method Comparison

Sire ID and depth	Soluble Salts (1:1) common	Soluble Salts Saturated paste Extract	Ratio Paste/ 1:1
	Mmhos/cm	Mmhos/cm	
Good 0-6”	0.3	0.7	**2.3**
Good 6-24”	0.5	1.3	**2.6**
Good 24-36”	0.6	2.5	**4.1**
Saline 0-6”	2.7	4.8	**1.8**
Saline 6-24”	2.8	6.4	**2.3**
Saline 24-36”	2.7	6.2	**2.3**
Saline & Sodic 0-6”	2.6	6.3	**2.4**
Saline & Sodic 6-24”	1.0	4.3	**4.3**
Saline & Sodic 24-36”	1.8	6.0	**3.3**