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agronomy news

Salinity Issues in Colorado

Irrigated Colorado land is increasingly affected by excess salts.

Salinity is an increasingly important problem in many irrigated areas of Colorado. Batie and Healy (1993) describe excess salinity as "the most pervasive problem associated with irrigated agriculture." It has been estimated that 25 to 35% of the irrigated land in the western U.S. is affected by salinity. Colorado is no exception to this: statewide, it is estimated that almost 1 million acres are impacted by excess salts. This month's newsletter focuses on salinity issues in Colorado and will attempt to clear up some commonly held misperceptions.

Salinized fields may appear white in extreme cases.

Simply stated, salinity problems are caused by the accumulation of soluble salts in the rootzone. In high amounts, these excess salts reduce plant growth and vigor by altering water relations or by causing ion-specific toxicities or imbalances. Establishing good drainage is the universal cure for these problems, but as we will see in this newsletter, salinity problems are much more complex than these generalities would indicate.

Salt Sources Saline soils and poor quality irrigation water can be found in many areas of Colorado. These salts originate mainly from the natural weathering of minerals or from fossil salt deposits left from ancient sea beds. Salts tend to

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Salinity Issues

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accumulate in soils of arid environments as irrigation water or groundwater seepage evaporates, leaving minerals behind. Irrigation water may contain salts picked up as the water moves across the landscape, or the salts may come from man-induced sources such as municipal runoff or water treatment. As water is used and reused, salts levels tend to increase as the water is consumed, transpired or evaporated. Irrigation water containing 750 mg/L salt (EC~1.2 dS/m) would carry about 1 ton of salt for every acre foot of water applied to the land. Over time, this salt builds up to damaging levels if it is not leached from the rootzone.

In Colorado, we have saline soils, sodic soils, and saline sodic soils, often in close proximity. Because these problems must be managed differently, it is important to understand their cause, effect, and the best management options. Visual symptoms of crop stress are not diagnostic of which type of salinity is present. In fact, yield reductions of 25 to 30% due to salinity have been reported without any visible crop symptoms. The most widespread salinity problems in our state are found in the Arkansas River Valley, the South Platte River Valley, and in the Colorado River Basin. Interestingly, the salinity problems and salt sources are distinctly different in each of these three regions.

The Arkansas River is one of the most saline rivers in the U.S. Average total dissolved solids (TDS) in the river ranges from about 500 mg/L at Pueblo to 3500 mg/L at the state line near Holly. Salinity in the alluvial aquifer is even higher. These salts are primarily calcium and sodium bicarbonate and sulfate and originate mainly from minerals leached from sedimentary rock deposits in the foothills to the east of Canon City. Due to siltation of the river bed and a subsequent rise in the water table, poor drainage is impeding leaching and in some cases causing salts to further concentrate as groundwater seeps to the surface and evaporates. The Patterson Hollow HUA project, headed by Jim Valliant, is dedicated to addressing these problems through improved irrigation systems and water management.

The Colorado River, by contrast, typically contains about 500 ppm (or mg/L) TDS on the West Slope near the Utah line. Plentiful supplies of good quality irrigation water limit salinity problems on irrigated fields in the region. In spite of this, there has been a strong focus on salinity control in this basin due to a treaty with Mexico obligating the U.S. to reduce salt

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Salinity Facts

- *An estimated 980,000 acres of irrigable land in Colorado are affected by salts.*
- *Crop losses may occur with irrigation water containing as little as 700-850 mg /l TDS or EC ≈ 1.2 dS/m.*
- *Salinity is often measured by electro-conductivity (EC) and reported as millimhos per centimeter (mmhos/cm) or deci Siemens per meter (dS/m).*
- *Generally, salt is thought of as ordinary table salt or sodium chloride. However, many types of salt are common in Colorado soils (see box, page 9).*

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loading to the river. Salinity problems in this area are due in part to deep percolation of irrigation water picking up fossil salts from the Mancos Shale, an ancient sedimentary marine deposit. Irrigation return flows carry sodium, magnesium and calcium chloride and sulfate back to the river, degrading water quality. Cooperative Extension has a long history of work on salinity control projects in the basin. Currently, Dick Bartholomay and Dan Champion are heading CSU salinity efforts on the West Slope. Allowing for seasonal and annual river flow fluctuations, they report that there has been a slight downward trend in salt loading to the Colorado River since 1970.

The salinity problems on the S. Platte River increase as the water moves eastward to the state line. The two causes for the increase in dissolved solids are salt concentration and salt pickup. The surface water in the basin picks up both naturally occurring and human induced salts as it moves downstream. These salts are concentrated as the water is consumptively used and evaporated. While drainage problems exist in isolated areas, they are not as pervasive as in the Arkansas River Valley. High pH (alkaline) soils also seem to be causing producers more problems, likely due to an accumulation of sodium. At present, no formal programs are in place in the S. Platte basin to address these issues, in spite of increasing reports of salt problems. Mahdi Al-Kaisi is working with producers on water management in the basin and Israel Broner is interested in organizing a more focused research and extension program on salinity. In the meantime, producers are left to cope with declining soil quality and reduced crop yields.

Reagan Waskom
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Table 1. Terms, units, and useful conversions for understanding water quality analysis reports.

Symbol	Meaning	Units
Total Salinity		
EC	Electric condicutivity	mmhos/cm μmhos/cm dS/m
TDS	Total dissolved solids	mg/L ppm
Sodium Hazard		
SAR	Sodium adsorption ratio	---
ESP	Exchangeable sodium percentage	---

Conversions

1 dS/m = 1 mmhos/cm = 1000 μmhos/cm

1mg/L = 1 ppm

TDS (mg/L) ≈ EC (dS/m) x 640 for EC < 5 dS/m

TDS (mg/L) ≈ EC (dS/m) x 800 for EC > 5 dS/m

TDS (lbs/ac-ft) ≈ TDS (mg/L) x 2.72

Key

mg/L = milligrams per liter

ppm = parts per million

dS/m = deci Siemens per meter at 25° C

mmhos/cm = millihos per centimer at 25°C

Managing Irrigation to Control Salinity

Careful monitoring, drainage, and timely leaching help manage salinity on irrigated land.

Irrigation water, even high quality ground and surface water, carries with it dissolved salts. As the water is removed from the soil through the processes of evaporation and plant transpiration, the salts are left behind and begin to accumulate in the zones of water removal. Unfortunately, the zones of water removal are at the soil surface where seeds and seedlings must deal with them, and in the root zone where larger plants must overcome the attraction of water to the dissolved salts in order to remove water for growth. Eventually, even with high quality water sources, irrigation without regard to salinity management will result in the build up of salts to levels that will reduce plant growth.

Where salts have accumulated in soils to levels that begin to reduce plant growth, the only means of correcting the problem is through the establishment of adequate leaching and/or drainage. The addition of chemical amendments, soil conditioners, or fertilizers will not only be ineffective in offsetting plant growth reductions

Table 2. Suggested limits for irrigation water use.

Classes of water	**Electrical Conductivity (μmhos)***
Class 1, Excellent	250
Class 2, Good	250-750
Class 3, Permissable[1]	750-2,000
Class 4, Doubtful[2]	2,000-3,000
Class 5, Unsuitable[2]	3,000

*Micromhos/cm at 25 degrees C
[1]Leaching needed if used
[2]Good drainage needed and sensitive plants will have difficulty obtaining stands

Table 3. The sodium hazard of water based on SAR values.

SAR values	**Sodium hazard of water**	**Comments**
1-10	Low	Use on sodium sensitive crops must be cautioned.
10-18	Medium	Amendments (such as gypsum) and leaching needed.
18-26	High	Generally unsuitable for continuous use.
>26	Very High	Generally unsuitable for use.

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Irrigation

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due to salinity, they could exacerbate the problem by adding more salts to the root zone. Conceptually, the processes of leaching and drainage are nothing more than rinsing the dissolved salts out and below and/or away from the root zone of the plant.

There are several ways in which the removal of salts can be accomplished. The various methods can be grouped into three main categories. First, salts can be moved well below the root zone by adding extra water applied above the needs of the plant. This method is referred to as the **leaching requirement method**. The second method, where soil moisture conditions dictate, couples the leaching requirement method with **artificial drainage** to facilitate the removal of salts from the soil. Third, salts can be moved away from the root zone to locations in the soil, other than below the root zone, where they are not harmful. In this article we will refer to this third method as **managed accumulation.** Each of these options will be further discussed below.

Leaching Requirement The leaching requirement method has been well documented and researched for the last half century. This method is a mass balance of salts in the soil where one attempts to match additions of salt in irrigation water by leaching the same amount of salt from the bottom of the root zone (salt in = salt out) thereby preventing harmful accumulation of salts.

The amount of salt in any water is the concentration of salt multiplied by the volume of water. Therefore, if we let 'C' and 'V' designate concentration and volume, and 'i' and 'l' designate irrigation water and leachate, we can write a simple salt balance equation as follows:

$$C_i \times V_i = C_l \times V_l$$

(or, salt in = salt out)

We can rearrange the equation so that we get:

$$V_l/V_i = C_i/C_l$$

It should be noted here that the concentration of salt in water is related to the electrical conductivity (EC) of the water as follows:

$$C\ (\text{meq/l}) = 10 \times EC\ (\text{dS/m})$$

Published salinity tolerance limits for plants are generally expressed in terms of electrical conductivity, so for simplicity we can rewrite the second equation as follows:

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Table 4. Potential yield reduction from saline soil (EC_e) and irrigation water (Ec_w) for common irrigated crops in Colorado.[1]

Crop	EC_e[2]	EC_w[3]	EC_e	EC_w	EC_e	EC_w	EC_e	EC_w	ECe
	% yield reduction								
	(0%)		(10%)		(25%)		(50%)		(Maximum)
	dS/m								
Barley	8.0	5.3	10	6.7	13	8.7	18	12	28
Wheat	6.0	4.0	7.4	4.9	9.5	6.4	13	8.7	20
Sugar beet[4]	7.0	4.7	8.7	5.8	11	7.5	15	10	24
Alfalfa	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	15.5
Potato	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10
Corn (grain)	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10
Corn (silage)	1.8	1.2	3.2	2.1	5.2	3.5	8.6	5.7	16
Onion	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.5
Beans	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.5

[1]Adapted from "Quality of Water for Irrigation." R. S. Ayers. *Jour. Of the Irrig. And Drain. Div.*, ASCE. Vol. 103, No. IR2, June 1977, p. 140.
[2]EC_e means electrical conductivity of the saturation extract of the soil reported in dS/m at 25 C.
[3]EC_w means electrical conductivity of the irrigation water in dS/m at 25 C.
[4]Sensitive during germination. EC_e should not exceed 3 dS/m for garden beets and sugar beets.

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$$V_l/V_i = EC_i/EC_l$$

In the above equation, the ratio of the volume of leachate to irrigation water is the leaching requirement. If one measures the EC of their irrigation water and chooses a value of the EC of the leachate, the leaching requirement can be calculated. Because salt should be controlled to levels that are not harmful to plant growth, the EC of the leachate should be chosen as the published limit for the plant of interest (see table 4).

The use of a leaching fraction requires a couple key considerations. The leaching of salts can only occur if the soil is adequately drained. In other words, there should be no shallow water table to prevent the downward movement of the leachate, and the soil should be permeable enough to allow the extra water to flow through the profile without having to greatly increase irrigation set times or saturate the soil for long periods of time. Long irrigation set times may result in an inability of the grower to keep up with irrigation needs in other parts of the field and may cause excessive runoff. Long periods of saturation may result in aeration problems for the plant.

Additionally, if the application of irrigation water is not uniform, proper leaching will not be attained, and even higher, faster accumulation of salt may occur in the areas of the field that receive lower application amounts. Localized salinity problems may occur in fields that have poor water distribution and/or low-lying areas in the field where excess water from surrounding areas drains to. Therefore, the importance of irrigation uniformity can not be overstated.

For most surface irrigation systems in Colorado (furrow and flood) irrigation inefficiency is generally adequate to satisfy the leaching requirement. Surface irrigators should compare leaching requirement values to measurements of irrigation efficiency to determine if this is true for their operations. Adding more water to satisfy a leaching requirement will only further reduce irrigation efficiency and may result in the loss of nutrients, pesticides, and soil.

Leaching can be done on a limited basis at key times during the growing season, particularly when a grower may have water of high quality available. Surface water in most areas of the state tends to have lower salinity than shallow, alluvial groundwater. Deep groundwater may also be of high quality and can be of lower salinity than either shallow groundwater or surface water. In situations where a grower may have multiple water sources of varying quality, planned leaching

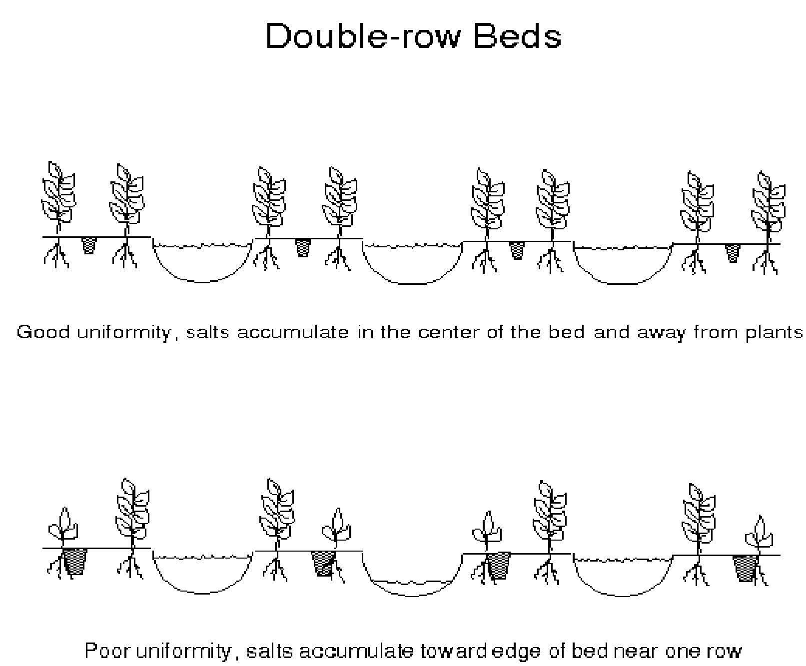

Figure 1. Typical salt accumulation pattern in double row beds.

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events at key salinity stress periods for a given crop may be considered. Most crops are highly sensitive to salinity stress in the germination and seedling stages. Once the crop has grown past these stages it can often tolerate, and grow well in higher salinity conditions. Planned periodic leaching events might include a large, post-harvest application to push salts below the root zone to prepare the soil (especially the seedbed/surface zone) for the following spring. Fall is the best time for a large, planned leaching event, because nutrients have been drawn down that at other times during the season would move with leaching water and be lost. Additionally, in most years the soil water contents have been drawn down providing the most control over leaching salts to desired depths without pushing them further into shallow groundwater where they may become contaminants.

As can be seen, each case is individual and all the soil, groundwater, drainage and irrigation system conditions for a given field should be considered in developing a sound leaching plan.

Leaching plus Drainage Where shallow water tables would otherwise limit the use of the leaching requirement as discussed above, artificial drainage may be employed. Drainage ditches can be cut in fields below the water table level to channel away drainage water and allow the leaching of salts. Tile or plastic drain pipe can also be buried in fields in a drainage collection network. Proper design and construction of a drainage system is critical and should be performed by a trained professional. Consultation with local NRCS, or Extension agricultural engineering personnel will provide ideas and direction on proceeding properly with drainage system design.

With all artificial drainage situations, consideration must be given to the disposal of the drainage water. Some restrictions on the discharge of drain water to streams may apply in certain situations and should be investigated with the appropriate agency. In the case of regulated discharge, treatment or collection and evaporation of the water on site may be required and may add significant costs to the use of artificial drainage.

Artificial drainage provides the advantage of being able to use high quality, low salinity irrigation water (if available to a grower) to completely remove salts from the soil. It should be noted here that artificial drainage systems will not work where there is no saturated condition in the soil. Water will not collect in a drain if the soil around it is not saturated.

After drainage appears adequate, the leaching process can begin. Table 5 gives a rough rule-of-thumb for how much water is required to leach salts. The actual salt reduction will depend upon water

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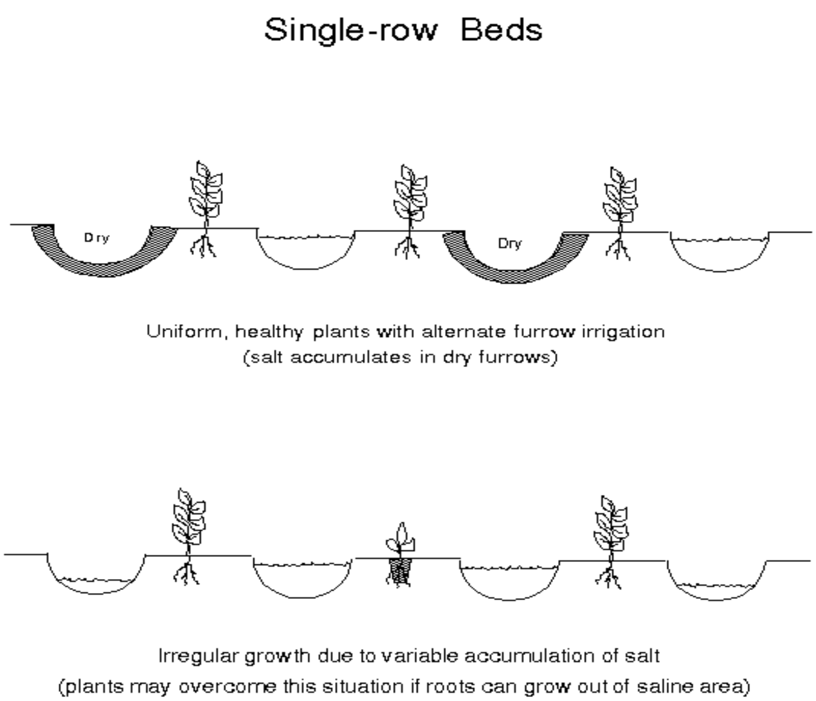

Figure 2. Typical salt accumulation patter in alternate furrow and every furrow irrigation regimes.

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Table 5. Estimated water application needed to leach salts.

Percent Salt Reduction	Amount of Water Required
50%	6 inches
80%	12 inches
90%	24 inches

quality, soil texture and drainage.

For example, if a soil's electrical conductivity is 8 mmhos/cm, and we want to reduce electrical conductivity down to 4 mmhos/cm, this represents a 50% reduction in salts. Therefore, 6 inches of water would be required.

Managed Accumulation In addition to leaching salt below the root zone, salts can also be moved to areas away from the primary root zone under certain crop bedding and surface irrigation system configurations. Several examples of managing salt accumulation in this manner are illustrated in Figures 1 and 2. The basic idea is to ensure that the zones of salt accumulation stay away from germinating seeds and plant roots. In all of the configurations in Figures 1 and 2, irrigation uniformity is imperative. Without uniform distribution of water, the salts will build up in areas where the germinating seeds and seedling plants will experience growth reduction and possibly death.

Double-row bed systems require uniform wetting toward the middle of the bed. This leaves the sides and shoulders of the bed relatively free from injurious levels of salinity. Without uniform applications of water (one furrow receiving more or less than another) salts will accumulate closer to one side of the bed where a seedrow would be. Periodic leaching of salts down from the soil surface and below the root zone may still be required to ensure that beds are not eventually salted out.

Alternate furrow irrigation may be desirable for single-row bed systems. This is accomplished by irrigating every other furrow and leaving alternating furrows dry. Salts will be pushed across the bed from the irrigated side toward the dry furrow, accumulating there. Care must be taken to ensure that enough water is applied to wet all the way across the bed so that salts will not build up in the planted area. This method of salinity management may result in plant injury in cases where large rainfall events fill the normally dry furrows and push salts back across the bed toward the plants. This same phenomenon will occur if the normally dry furrows are ever accidentally irrigated.

Sprinkler irrigation Sprinkler irrigated fields where irrigation water quality is poor present a challenge because it is often difficult to apply enough water to leach the salts and you cannot effectively exploit row or bed configurations to manage accumulation. Growers need to monitor the soil EC and irrigation water salinity where water quality is poor. In some cases, the only viable management option is to plant salt-tolerant crops. Sensitive crops, such as pinto beans cannot be managed profitably in saline soils. Where adequate irrigation water exists above crop requirements, a leaching fraction can be calculated for sprinkler irrigated fields as:

$$\%\,Leaching\ Requirement \quad \frac{EC_{water}}{2\ x\ EC_{max}}\ x\ 100$$

In this equation, EC_{max} = the maximum soil EC wanted in the root zone.

This leaching fraction should be applied to coincide with periods of low soil N and residual pesticide. Again, fall is often an optimal time to move salts be low the rootzone to facilitate spring planting.

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meet . . .

Grant E. Cardon is an associate professor in the Department of Soil and Crop Sciences. His primary research focus is in the management of irrigation to conserve water and to minimize the impact of irrigation on the degradation of surface and groundwater and soils. Currently, he is engaged in research on nutrient and water use projects in various regions of Colorado and on soil and water quality as impacted by acidic mine drainage. He teaches courses in Irrigation Management/Water Quality and Environmental Soils.

Dr. Cardon would be a good resource for questions about water quality and best management practices for irrigation.

Dr. Cardon joined the Colorado State Faculty in 1992. He holds a Ph.D. in Soil Science from the University of California, Riverside and a B.S. in Soil Science from Utah State University.

events

August 5-6, 1998, Colorado State University Cooperative Extension/ Agricultural Experiment Station **Corn Management Clinic Field School**. Contact CSU Extension Soil and Crop at 970-491-6201 for information.

Common Salt Compounds

Salts are ionic crystalline compounds consisting of a cation and anion. Salts tend to degrade water quality because of their high solubility.

Salt compound	Cation (+)	Anion (-)	Common name
$NaCl$	sodium	chloride	table salt (halite)
Na_2SO_4	sodium	sulfate	Glauber's salt
$MgSO_4$	magnesium	sulfate	epsom salts
$NaHCO_3$	sodium	bicarbonate	baking soda
Na_2CO_3	sodium	carbonate	sal soda
$CaSO_4$	calcium	sulfate	gypsum
$CaCO_3$	calcium	carbonate	lime (calcite)

Understanding Sodic versus Saline Soil Management

You say alkali, I say saline. Are we talking about the same thing?

The term "alkali" is frequently used to describe soils that are high in salt. But sometimes people use the term to mean high pH, and at other times, it means high sodium. So we can discuss these problems in the same language, I have avoided the word "alkali" and defined the terms below.

Definitions:

Basic = high pH

Saline = high salts

Sodic = high sodium

In-Field Diagnosis Some visual symptoms can be used to diagnose these problems, but ultimately soil testing is the best way for an accurate diagnosis.

High pH soil doesn't usually look any different from soil with neutral pH. However, sometimes the plants growing in that soil give us clues about the problem. High pH reduces the availability of some nutrients (zinc, iron, phosphorus). Therefore, symptoms of yellowing of middle to upper leaves (signs of zinc and iron deficiency) or dark green coloring with purpling of the lower leaves and stems (signs of phosphorus deficiency) can be signs of high soil pH. In particular, looking for symptoms can be useful when growing high pH susceptible plants (dry beans, silver maples).

Plants growing in saline soils may appear water stressed. This is because the high salt content of the soil actually prevents water movement from the soil to the plant root. Water will naturally move from areas of low salt content to high salt content. Sometimes a white crust is visible on a saline soil surface. If a soil is both saline and sodic, a brownish-black crust sometimes forms due to dispersion of soil organic matter. By the time these crusts are visible, the problem is severe, and plant growth is usually minimal. Laboratory analysis can be used to diagnose these problems before the plant growth is so severely damaged.

Laboratory Diagnosis Soil testing labs typically evaluate pH and EC (electrical conductivity) as part of a routine analysis. If the pH warrants, analysis of the sodium adsorption ratio will also take place. The lab results can be evaluated with the following table.

Specific Ion Effects Soil salinity is caused by accumulation of salts. It is a general problem from a combination of salts. However, sometimes a specific salt can cause toxic reactions in plants, which is separate from the general salt effect. Sodic soils are one example of specific ion

Salt-Affected Soil Classification

Classification	Electrical Conductivity (dS/m) [1]	Soil pH	Sodium Adsorption Ratio (SAR) [2]	Soil physical condition
Saline	> 4.0	< 8.5	< 13	Normal
Sodic (alkali)	< 4.0	> 8.5	≥ 13	Poor
Saline-Sodic	> 4.0	< 8.5	≥ 13	Normal
High pH	< 4.0	> 7.8	< 13	Varies

[1]dS/m = mmhos/cm

[2]If reported asExchangable Sodium Percentage or ESP, use 15% as threshold value.

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Sodic/Saline

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Types of Salinity Problems

Salinity hazard	affects →	plants	can lead to→	saline soil condition
sodium	affects →	soils	can lead to →	sodic soil condition

effects. When sodic conditions are present, soils become dispersed and have low permeability. In addition to very limited water movement, the high sodium levels compete with calcium, magnesium, and potassium for uptake by plant roots. Therefore, excess sodium can induce deficiencies of other cations (positively charged nutrients). High levels of other cations (calcium, magnesium, potassium) can also cause imbalances and induce nutrient deficiencies.

Cations (+)	**Anions** (-)
Calcium	Sulfate
Magnesium	Bicarbonate
Potassium	Chloride
Sodium	Borate
	Nitrate

Anions (negatively charged nutrients) can also have specific ion effects. For example, sulfate and bicarbonate can cause shifts in the cation balance by reducing calcium and magnesium uptake and increasing sodium and potassium uptake. High chloride levels can cause burning in susceptible tree and vine crops and can reduce the quality of potatoes. Excess boron in soils or water can also cause toxic effects, such as leaf cupping and burning of leaf margins.

The most common of these specific ion effects in Colorado is sodicity.

After diagnosis, now what do we do? For any soil-related problem, we have at least three options to correct the problem:

1) change the plant species to a more tolerant species, OR
2) change the variety to a more tolerant variety, OR
3) change the soil. Often, changing the soil is the most difficult of these options.

Salinity Solutions The only proven soil treatment for high soil salts is leaching the salts out. In order for this treatment to work, there must be:

1) adequate drainage and
2) acceptable irrigation water quality (sodium adsorption ratio < 10 %).

First of all, drainage must be improved. This can be accomplished with organic soil amendments or physical improvements like drain tiles or French drains.

There are some new products on the market which claim to enhance water infiltration into saline soils. They could possibly be beneficial in the leaching process, but we do not have local data on these products.

Sodicity Solutions When soils are high in sodium, our goal is to replace the sodium with calcium and then leach the sodium out. There are two possible approaches:

a) dissolve the limestone (calcium carbonate) or gypsum (calcium sulfate) already present in the soil, OR
b) add calcium to the soil.

If free lime is present in the soil, it can be dissolved by applying sulfur or sulfuric acid. The sulfur products can reduce pH which will dissolve the lime, thus freeing up the calcium. If free lime or gypsum are not present in adequate amounts as determined by soil test, then calcium will have to be added. The most common form of calcium used for this purpose is gypsum, although calcium chloride, which is more expensive, will react more quickly. After broadcasting the calcium source on the soil surface, incorporate it, and be sure adequate moisture is present to dissolve the gypsum.

Make sure drainage is adequate prior to amending the soil, and after application of a sulfur product or a calcium source, then leach the sodium out as described above.

Remember!!!

1) Adding sulfur products only makes sense when:
   a) a soil is sodic AND has free lime present OR
   b) a soil is basic.
2) Adding calcium sources, such as gypsum or calcium chloride to saline soils only increases the salt content further and aggravates the salinity problem.

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web sites

USDA Soil Salinity Laboratory
http://www.ussl.ars.usda.gov/

Soil Quality Institute
http://www.statlab.iastate.edu:80/survey/SQI/sqihome.shtml

Utah Salinity Publication
http://ext.usu.edu/publica/agpubs/salini.htm

Texas Salinity Publication
http://agcomwww.tamu.edu/agcom/publish/extpubs/engine/B1667.pdf

Salinity Primer
http://www.uvm.edu/~dross/papers/salindex.htm

Other References:
Fact Sheet 0.503: Salt-affected soils. Cardon, G.E. and J.J. Mortvedt. Colorado State University Cooperative Extension. 1984.

Fact Sheet 0.504: Salt- and sodium-affected soils. Cardon, G.E., and J. J. Mortvedt. Colorado State University Cooperative Extension. 1994.

Fact Sheet 0.505: Crop tolerance to soil salinity. Soltanpour, P.N. and R.H. Follett. Colorado State University Cooperative Extension. 1995.

Fact Sheet 0.506: Irrigation water quality criteria. Follett, R.H. and P.N. Soltanpour. Colorado State University Cooperative Extension. 1992.

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