Toxic Salt Reduction (acre)

Definition

Reducing or redistributing the harmful concentrations of salt and/or sodium in a soil (sometimes referred to as leaching).

Purpose

To permit desirable plants to grow.

Conditions where practice applies

On land where the accumulation of salt and/or sodium at or near the surface limits the growth of desirable plants.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

TECHNICAL GUIDE
SECTION IV

NATIONAL
SUPPLEMENT
610-NS-1

Toxic Salt Reduction (acre)

Planning considerations for water quantity and quality

Quantity

1. Effects on the water budget, especially on infiltration, deep percolation, and ground water recharge. Consider the variability (volume and timing) of the leaching fraction, the need for additional irrigation water, and the impact of drainage if installed as an associated practice.

Quality

1. Effects on irrigation induced erosion, sedimentation, and soluble and sediment-attached substances in irrigation tailwater.

2. Effects of leaching on the volume of toxic salts and soluble nutrients and pesticides removed from the root zone. Identify the ultimate residence of the chemicals and the surface and ground water impact of drainage if installed as an associated practice.

MONTANA SUPPLEMENT
Toxic Salt Reduction (610)

Planning Considerations: All salt-affected sites are somewhat unique in that they have variations in levels of salinity, different kinds of salts, somewhat different climatic patterns, and varying soil materials.

Salt-affected soils have been classified into three categories. These are:

1. Saline soils

   EC >4 mmhos/cm at 25°C
   SAR 0-12
   pH <8.5

2. Saline-sodic soils

   EC >4 mmhos/cm at 25°C
   SAR >12
   pH usually <8.5

3. Sodic soils

   EC <4 mmhos/cm at 25°C
   SAR >12
   pH usually >8.5

The saline soils, because of the low amount of sodium and the excess salts, are generally flocculated. The infiltration rates and permeability of these soils are equal to or higher than that of similar nonsalt-affected soils.

Saline-sodic soils are similar in appearance to the saline soils as long as excess salts are present. With leaching, most of the excess soluble salts may be removed. If this happens, the soil particles will become dispersed. The soil then becomes unfavorable for the infiltration and internal movement of water. It also becomes difficult to till. To prevent this dispersed soil condition from occurring, water with excess salt may be used for leaching.

Sodic soils have dark-colored surfaces that are highly dispersed. These soils are very difficult to leach because of the low infiltration rate and poor permeability.

Soil amendments may be needed when leaching to help correct the sodic condition of the saline-sodic soils and the sodic soils. The amendments generally used are calcium sulfate (gypsum), elemental sulfur, or sulfuric acid.

Because of this uniqueness of sites, an onsite investigation must be made before a toxic salt reduction practice is established. The information needed to plan toxic salt reduction is the kinds and amounts of the salts affecting the soils, the electrical conductivity in millimhos per centimeter (mmhos/cm), and/or in some cases the sodium adsorption ratio (SAR).

When collecting soil, it is important to combine several samples from various parts of a field to get an average sample. In a homogeneous or uniform field, ten samples taken from different locations should be adequate. Depth of sampling is another important consideration. Saline and sodic soils should have samples taken from 0 to 6 inches, 6 to 12 inches, and 12 to 24 inches. These three depth increments should be kept as separate samples.

Soil samples should be labeled with the producer's name, the date, and analyses needed. The samples should be submitted to a qualified commercial or university laboratory for reliable results.

Treatment

The source of the water for wet soils should be located. The possibility of draining the wet, salty area should be investigated. In the event drainage is considered, arrangements must be made for the disposal of any salty water, whether from high water tables or irrigation water.

Mechanical or chemical weed control and seedbed preparation are very important to ensure successful establishment of grasses, legumes, or annual crops on seep areas. Chemical weed control on seep areas under irrigation is usually preferred because moisture infiltration rates should be higher, which in turn makes it easier to leach the salts. Tillage also tends to break down the soil structure, which will reduce water infiltration rates.

One successful method for leaching saline-sodic soil is to use extremely saline water, with at least 30 percent of the cations being calcium and magnesium. The high salinity flocculates the clay--even in the presence of sodium. Better quality water is then substituted for the saline water to complete the leaching process.

Addition of manure is a useful physical treatment that improves soil structure in sodic soils despite the dispersed nature of the soil clay. Increases in permeability because of the addition of manure have been ascribed to the physical separation of soil particles. Very high rates of manure are needed to accomplish this procedure (50 to 300 tons/acre). Such rates of manure application are normally feasible only when huge quantities of animal waste are locally available.

Crop residues have been successfully used to increase permeability of sodic soils. The more fibrous crop residues, which decompose slowly, are most effective at increasing permeability. Cereal grain residue, left at the surface or worked into the soil, are particularly effective.

Planning Criteria:

I. Irrigated cropland with a water table.

Saline soils:

1. Drainage must be applied.

2. Huge quantities of good quality water are usually needed to leach large areas of saline soils.

3. Water must be applied in amounts great enough to leach the salts out of the soil profile.

4. The application of water for leaching will be designed specifically for each site.

5. Disposal of the tailwater is an important consideration because of governmental restrictions on salinization of surface water and ground water. Montana law may require a discharge permit if drain water is of poorer quality than receiving water.

6. Sprinkler irrigation is more efficient than flooding at removing soluble salts. Sprinkler irrigation allows the soil to remain unsaturated, which results in a more complete salt removal with less water than by flooding.

7. See table 1 for plant materials that can be established on saline soils.

Saline-sodic and sodic soils:

1. Drainage must be applied.

2. After the soil is drained, soil amendments in the form of gypsum (calcium sulfate), elemental sulfur, or sulfuric acid may be applied if needed to help leach the salts from the soil profile.

3. Water must be applied in amounts great enough to leach the salts out of the soil profile.

4. The application of water for leaching will be designed specifically for each site.

5. When reclaiming irrigated cropland by leaching, the water source must be evaluated; the amount and quality of water to be applied and the application procedure must be planned to fit the soil.*

6. See table 1 for plant materials that can be established on problem soils.

*Soil porosity of 40 percent is common for many agricultural soils. One pore volume on four feet of soil would be 1.6 feet or 19.2 inches of water. To reclaim four feet of saline soil would require enough water to saturate the profile plus 2 pore volumes, meaning about 4 feet of water.

II. Irrigated cropland--well drained saline soils.

Saline soils:

1. Treatment should be the same as "Irrigated cropland with a water table" (I. above) except that drainage should not be required.

Saline-sodic and sodic soils:

1. Treatment should be the same as "Irrigated cropland with a water table" (I. above) except that drainage should not be required.

III. Managing saline irrigation water.

Use of moderately saline irrigation water can soon lead to hazardous accumulations of salt in the soil profile. Forty inches of irrigation water with an EC of 2 mmhos/cm will introduce one ton of salt to an acre of land. Enough water must be added to a soil to meet crop water requirements, as well as to leach excessive salts from the profile.

Irrigation water that is suitable for one soil may be unsuitable for another. Sodium affects clayey soils more than it affects sandy soils. Soluble salts are leached from sandy soils more readily than from clayey soils.

Dryland saline seeps.

Planning Considerations: Saline seeps are recently developed, wet, saline areas in nonirrigated soils on which crop production is reduced or eliminated. The soil surface is intermittently or continuously wet, and white salt crusts are often present.

Typically, a saline seep develops when rain falls on the upslope position ("recharge area") and moves down through the soil, picking up salts on the way. The water that is not stored in the crop rooting zone under summer fallow or used by an annual crop growing in the area continues to move downward until it reaches an impermeable layer, which impedes its progress. It then flows laterally, picking up salts, until it reaches a position lower down the slope ("discharge area") where the water table is closer to the surface. The ground-water table rises to a critical level from which the salt-laden water reaches the surface by capillary action or lateral flow of free water from the exposed conducting layer. This water, which contains the dissolved salts, gradually evaporates, and the salts are left at the surface. As the salt builds up at the surface, the rate of evaporation slows down because of the attraction of salt particles for water. Thus, these areas of high salt concentration tend to stay wet for long periods of the year.

Techniques needed to improve dryland saline and sodic soils are different from those used for irrigated soils. Gypsum, for example, acts too slowly to be a useful amendment on dryland soils.

Because saline seeps occur on nonirrigated cropland and other adjacent lands, only water from annual precipitation is available to leach the salts back into the soil profile, and leaching with additional water and use of soil amendments are generally not viable practices. In fact, saline soils will usually be made worse by addition of soil amendments. Fertilizer, gypsum, or sulfuric acid are all salts of one kind or another, so adding these materials to a saline seep will generally only create a bigger problem.

The most effective way to correct and control the saline seep problem is to use as much as possible of the current precipitation that falls on the recharge area for crop or forage production before it percolates beyond the root zone and moves into the seep.

Forage crops such as grasses and alfalfa use more water than cereal grains or oil crops because they have deep root systems, are perennial, and have a longer growing season. For many saline seep areas, the fastest and best way to solve the problem is to seed alfalfa in the recharge area. (See tables 2, 3, and 4.)

Planning Criteria:

I. Controlling the water in the recharge area.

1. Because of the uniqueness of each saline seep, onsite investigations must be made before planning the reclamation practices. The initial review should include a review of the site with the operator, collecting historical information about the seep and the cropping history of the suspected recharge area, planning the location of monitoring wells, and discussing alternative saline seep control practices with the producer.

2. Elevations will be obtained on all investigation wells to help determine movement and source of ground water. This aids in identification of recharge area. Monitoring wells provide information on the depth to the impermeable layer and the depth to the water table. These wells will require monitoring for an indefinite period to determine the water level. The level of water in the subsoil must be known to determine the cropping practices needed to control the level of the water table that feeds the saline seep.

3. Plant deep-rooted perennials such as alfalfa to dry the soil profile in the recharge area where depth to the impermeable layer is more than 5 feet.

4. Flexible or annual cropping may be used to dry the recharge area if the soils are 5 feet or less in depth to the impermeable layer.

5. Select plants from tables 2 and 3 to remove excess soil moisture from the recharge area. Use planting dates in the practice Pasture and Hayland Planting 512.

6. After the ground water has been removed from the recharge area, an intensive cropping system must be applied to prevent the buildup of a new water table. See "Flexible Cropping" in the Conservation Cropping Systems (328) standard.

II. Establishing plants in the saline seep.

1. An electrical conductivity (EC) test must be made of the plow layer or top few inches of soil in the seep. This information is used to determine what plant materials can be established in the seep. (See table 1.)

2. To control the buildup of salt on the soil surface, vegetation should be established in the seep area as soon as it starts to dry.

3. The ground water moving into the saline seep from the recharge area must be controlled before the seep can be planted.

4. Weeds and grasses such as kochia and foxtail barley must be controlled by tillage or with chemicals. A seedbed should be prepared if the soil in the seep area is not too wet.

5. Seed should be planted with a drill whenever possible. Wet soils may be planted by broadcasting after weed control has been accomplished. These wet sites may also be planted by drilling on frozen ground (frost seeding) in late winter.

6. If the water table is above 4 feet, mow and remove all vegetation in the fall to prevent excess snow accumulation and water table rise. If the water table is below 4 feet, weeds and grass can be left to catch snow. The resulting snowmelt will leach the salt downward in the soil and thereby improve grass growth.

Planning considerations for seedbed preparation and seeding of salt-affected areas:

Although the saline seep discharge areas and other saline subirrigated sites are not traversable during most of the year, it is imperative that there is weed control and seedbed preparation whether it be mechanical or chemical. Weed competition and heavy trash are the biggest obstacles in seeding and establishing plant materials on saline sites. Late fall is usually the only time that these sites are safely traversable. Seeding should be done in late fall or during a snow-free period in winter. The seed should be in the ground, ready to utilize early spring precipitation (which dilutes surface salts), increasing the probability of germination and establishment. The seeding depth should be between one-fourth inch and one-half inch, planting into a firm seedbed.

When saline seeps begin to dry and some leaching from rainfall takes place, then salt concentrations are frequently higher at depth than they are at the immediate soil surface. Shallow tillage is generally recommended for saline soils. Deep tillage may, in many cases, simply bring more salts to the surface and make the problem worse.

Shallow tillage and timeliness of seeding are particularly important to get grass seedings and crops in early so they germinate when surface salt levels may be temporarily lowered.

A number of weeds are very salt-tolerant. Chemical weed control along with tillage is essential to get crops, particularly forages, properly established.

Nitrogen and phosphorus fertilizer applied to moderately saline soils have shown definite benefits in increasing yields of both annual crops and perennial grass crops. Soil test and fertilize accordingly.

High rates of manure application, 20 to 30 tons per acre, have improved crop establishment and crop yields on saline soils. The manure increases the organic matter content and water-holding capacity of the soil. In this way more water is available to plants even though the salts are present. When the manure mulch is present on the soil surface, it will assist in reducing evaporation and the concentration of salts at the surface of the soil. Manure will also assist in water movement through the soil to leach the salts down.

It is recommended that mixtures of forage crops rather than single species be used in seeding salt-affected soils.

It may be that adapted species will need to be established on the seep's perimeter and allowed to spread gradually across the seep through vegetative reproduction. Periodic reseeding of the seep areas as the water table is lowered may be made to speed up revegetation.

Since six row barley is the most salinity-tolerant cereal available, it normally should be the first crop seeded when recropping of the area begins.

Table 1. Plant materials that may be established on saline or saline-sodic or sodic soils.

Plant materials	Seeding Rates, PLS, lbs/ac. drilled	Seeding Rates, PLS, lbs/ac. broadcast	Upper salinity tolerance mmhos/cm*
Perennial grasses			
beardless wildrye[1]	7	14	20
tall wheatgrass	10	20	20
altai wildrye	12	24	18
slender wheatgrass[2]	6	12	18
tall fescue	5	10	16
western wheatgrass	6	12	14
Russian wildrye	6	12	12
Fairway crested wheatgrass	4	8	10
standard crested wheatgrass	5	10	10
creeping meadow foxtail	3	6	8
intermediate wheatgrass	7	14	8
pubescent wheatgrass	7	14	8
smooth brome	5	10	7
orchardgrass	4	8	6
Perennial legumes			
birdsfoot trefoil	5	10	7
alfalfa	5	10	6
cicer milkvetch	8	16	6
Annual crops			
barley	80	80	12
wheat	60	60	6
oats	60	60	6

[1]Always plant as a dormant seeding; requires cold stratification to induce germination. [2]Plant only in mixtures.

*Electrical conductivity ranges (mmhos/cm): Low 0-4 Medium 4-8 High 8-12 Very high 12+

Table 2. Rooting depth, net soil water depletion, and average hay yield after 5 years for 10 adequately fertilized alfalfa cultivars grown near Fort Benton, Montana.

Cultivar	Root depth	Net soil water depletion* (5 yrs. cumulative)	Average hay yield/yr.
	(feet)	(inches)	(lb/acre)
Beaver	24	41*	4500
Roamer	24	39	4600
MS 243	24	37	4300
Grimm	16	28	3700
Ladak 65	22	26	4400
Ladak 75	20	28	4500
Drylander	17	25	4700
Vernal	17	23	4600
Kane	16	21	5400
Rambler	17	19	4800
Average	20	28	4600

*Net soil water depletion is the amount of water the crop used in excess of precipitation.

Table 3. Rooting depth and net soil water depletion for 12 grass and forage species after 5 years production near Fort Benton, Montana.

Species	Rooting depth	Net soil water depletion* (5 yrs. cumulative)
	(feet)	(inches)
Intermediate wheatgrass	15	29
Basin wildrye	18	26
Kenmont tall fescue	15	25
Green needlegrass	15	23
Slender wheatgrass	15	22
Pubescent wheatgrass	15	22
Western wheatgrass	11	20
Altai wildrye	14	Unknown--Estimated to be high
Russian wildrye grass	10	19
Crested wheatgrass	13	16
Tall wheatgrass	9	17
Sainfoin	14	23
Cicer milkvetch	15	23

*Net soil water depletion is the amount of water the crop used in excess of precipitation.

Table 4. Rooting depths and soil water use by 10 dryland crops grown near Fort Benton and Culbertson, Montana.

Crop	Rooting depth	Soil water use*
	(feet)	(inches)
Safflower	6.2	10.3
Flax	6.2	7.8
Mustard	5.9	7.6
Winter wheat	5.2	8.0
Sunflower	5.2	7.3
Kochia	5.0	7.0
Rape seed	4.9	6.9
Barley	4.3	5.3
Spring wheat	3.9	6.0
Corn	3.9	3.7
Sweetclover		
1st year	5.9	10.9
2nd year	8.5	15.9

*"Soil water use" is the average annual water used by the plant, which is different from net soil water depletion shown in tables 2 and 3.

Based on crop water use data obtained on deep glacial till soils at Fort Benton and Culbertson, Montana, safflower and flax were the deepest rooted, and safflower was the greatest water user of the annual crops. First-year sweetclover was almost as deep-rooted as safflower and flax and used slightly more water.

References

Brown, P. L., A. D. Halvorson, F. H. Siddoway, H. F. Mayland, and M. R. Miller. 1982. Saline Seep Diagnosis, Control, and Reclamation. U.S. Department of Agriculture Conservation Research Report No. 30.

Majerus, M. 1981. Plant Materials for Saline-Alkaline Soils. Soil Conservation Service, Montana, Plant Materials Technical Note No. 26.

Schaefer, W. M. 1982. Saline and Sodic Soils in Montana. Montana Cooperative Extension Service Bulletin 1272.

Dryland Saline Seep Control. 1979. Alberta Agriculture Publication No. Agdex 518-5.

H. M. Holm and J. L. Henry. 1982. Understanding Salt-affected Soils. Saskatchewan Agriculture, Regina, Saskatchewan.

H. M. Holm. 1983. Soil Salinity, A Study in Crop Tolerances and Cropping Practices. Saskatchewan Agriculture, Regina, Saskatchewan.

Saline Seep Handbook. 1979. Montana Cooperative Extension Service Bulletin 1205.

National Agronomy Manual. 1980. USDA Soil Conservation Service. Section 507.36.

JOB SPECIFICATION
Toxic Salt Reduction (Irrigated Land) (610-A)

______________________________ (owner/operator)   ______________________________ (Fld. No., CTU No., CIN)

Date ____________________   Area affected ____________ Ac.

Scope: This specification provides direction for reducing toxic salts in saline irrigated land. (Fill in those blanks that are needed.)

Toxic Salt Reduction

1. Soils name and texture: ____________________
   Depth: ____________ Permeability: ____________
   Available water-holding capacity per foot: ____________

2. Electrical conductivity (EC)_____: Sodium adsorption ratio (SAR)_____:
   pH_____

3. Kinds of salts present: ____________________

   Soil amendments to be used: ____________________

4. Source of excess water and salts (canal seeps, poor irrigation water management, etc.): ____________________

5. Description of the drainage system to be installed: ____________________

6. Amount of water to be applied for leaching (acre-inches): ____________
   Time of application: ____________________

7. Evaluation of water to be used for leaching: EC________: SAR________

8. Plant materials to be seeded in problem area: (See page 2 of this job specification.)

9. Seedbed preparation: ____________________

10. Fertilizers and rates to be used: ____________________

11. Weeds to be controlled: ____________________
    Recommended herbicides: ____________________

Additional job specification sheets needed to apply this practice are checked below and will be attached.

[ ] Conservation Cropping System 328
[ ] Grasses and Legumes in Rotation 411
[ ] Pasture and Hayland Planting 512
[ ] Pasture and Hayland Management 510
[ ] Other ____________

SEEDING PLAN AND RECORD

Planned Seeding

Plant species (1)	Lbs PLS/ac. (Pure Stand) (2)	% of mixture ÷ 100 (3)	Lbs PLS/ac. needed in mixture (col. 2 x col. 3) (4)	Acres to be seeded (5)	Total PLS needed (col. 4 x col. 5) (6)

Special provisions [ ] None [ ] See attached sheet.

SCS Approval

______________________________ ______________________
(SCS technician) (date)

Certification

Kinds, Rates, and Quantities of Seed Planted

Plant species (1)	Lbs PLS/ac. (Pure Stand) (2)	% of mixture ÷ 100 (3)	Lbs PLS/ac. in mixture (col. 2 x col. 3) (4)	% PLS = % germination x%Purity÷100 (5)	Bulk seed needed per lb PLS [100÷%PLS (col. 5)] (6)	Lbs. bulk seed needed/ac. (col. 4 x col. 6) (7)	Acres seeded (8)	Total lbs. bulk seed needed (col. 7 x col. 8) (9)	Total bulk seed actually planted (10)

I hereby certify that this practice has been established in accordance with these specifications.

______________________________ ______________________ ______________________
(SCS technician) (date) (date seeding was comple