SALINITY DOWN UNDER

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Salts are everywhere. They're in our bodies. They're in the food we eat. They're in the soils in which we grow our food and fiber. They're in our water unless we specifically (and at great expense) treat the water to remove them.

The native concentrations of salts usually don't cause problems; indeed, some salts are required for normal biological operations. But if salts get concentrated in an area- be it our bodies or a field or an area within a field- the salts can cause problems. In this paper, we will discuss soil salinity in general terms. Individual salinity causes and effects require individual solutions but those solutions will be based on the science presented here.

Fortunately, there are management methods that can be used to reduce or eliminate the adverse effects of salinity, if salinity becomes a problem in your field. In this paper, we first will discuss how those saline soils develop. Then we will present some management methods to reduce or eliminate the detrimental effects of salinity in those areas. A very brief overview of relative responses of some crops to salinity will follow. Finally, we will briefly discuss some salinity measurement techniques. In this paper, we will address saline soils developed under two conditions- saline seeps and irrigation-induced saline soils.

DEVELOPMENT OF SALINE SOILS

Salts are moved with water. When water moves from one area of a field to another, some salts are carried with the water. If the water moves through an area of soil where the native salt concentration is high, the water will dissolve some of those salts and the salt concentration of the moving water will increase. Significant amounts of salt can also be added with irrigation water.

Whether the salts are added in the water or are present in the soils naturally, it is water moving through the soil that can move the salts. This water movement and resulting salt movement can be beneficial or detrimental. For example, water in excess of crop needs can move (leach) salts downward and out of reach of the crop roots, preventing the salts from interfering with crop root function. Conversely, water movement can cause salts to accumulate in areas where they reach high concentrations and become detrimental to a crop.

Even the process of plant roots absorbing water can make salinity problems worse. When the roots absorb water, they absorb only the water and leave behind any salts. Over time, the salts that get left behind in the root zone can accumulate to levels that interfere with crop root functions with detrimental effects on the crop.

Saline seeps are a result of the combination of geological, climatic, and management factors. Development of a seep starts at the recharge area. This is an area high in the landscape where all available water is not used by crops. Excess water drains internally downward, out of the root zone. As it moves through the soil, the water dissolves and accumulates salts. At some point in the subsoil, the water reaches a layer of very low permeability. The salt-laden water accumulates above the slowly permeable layer and forms a perched water table. Over time, the water from the perched water table will move laterally, downward in the landscape. Where the slowly permeable layer intersects the soil surface, the salt-laden water will also reach the soil surface. The water will evaporate, leaving the salts behind to accumulate and form a saline seep (Halvorson, and Black, 1974).

Instead of a slowly permeable layer, the downward-moving water might reach a more permeable horizontal layer such as lignite. The salt-laden water will then move laterally in the highly permeable layer until it reaches the soil surface (Doering and Sandoval, 1976). The water then evaporates, leaving behind the salts to accumulate.

The layer of high or low permeability doesn't have to reach the soil surface for a saline seep to form. If the layer is near the soil surface, the salt-laden water can move to the soil surface via capillary action. Again, the water will evaporate and leave behind the salts, forming a saline seep.

In the case of irrigation-induced saline soils, the very act of irrigation is the cause for the salinity. Every irrigation event adds some salt to the soil because all irrigation waters contain some amount of salt. Some amount of leaching is required eventually to move those salts downward, out of the crop root zone. For high-quality irrigation water (with low salt concentration), small amounts of salt are added with each irrigation. For irrigation water with high salt concentration, more salt is added with each irrigation. When crop roots absorb water, they absorb only the water, leaving the salts behind in the soil. Without any water (either irrigation water or precipitation) in excess of crop needs to leach the salts downward and out of the root zone, the salts are left to accumulate in the root zone. The accumulation takes place more rapidly when the irrigation water has a high concentration of salt.

MANAGING SALINITY

Salinity management is water management.

In the case of the saline seep, the long-term solution includes controlling the water at the recharge area. Intensive, flexible cropping systems are required to reduce or eliminate the internal drainage that eventually moves and carries salts to the seep area (Black et al., 1981). More intensive cropping may require fewer or no years of fallow or growing crops that use more water in a growing season, such as alfalfa (Brun and Worcester, 1974; Halvorson and Reule, 1980). If it is not possible to reduce or eliminate recharge, then the saline water can be intercepted with an artificial drain. Proper disposal of the saline drainage water will be required.

After the recharge area is controlled or intercepted, precipitation will be required to move the salts downward at the seep area. Greater rainfall means the salts will be moved farther and more quickly.

Under irrigation, the salts are continuously being added to the soil in the irrigation water. Management of saline irrigation water must include some excess water for salt leaching. Rainfall in excess of crop water needs may provide adequate leaching, especially in the spring when crop water needs are small. In this way, the need to apply excess irrigation water for leaching might be avoided. If leaching is required during the growing season, less frequent irrigations of greater amounts will effect leaching. For example, if irrigations of 0.75 inch were formerly applied every 3 days, better salt management might be to apply 1 inch every four days or 1.25 inches every 5 days. The actual amount of leaching will depend on the salinity of the irrigation water.

If a saline water table is affecting the crop, water table management measures will be required. Such measures may include a grid artificial drainage to lower the water table or an interceptor drain if the saline water is moving laterally.

CROP RESPONSE TO SALINITY

Different crops respond differently to salinity. For example, barley, durum, triticale, and sugarbeet are listed as salinity-tolerant crops, while wheat is listed as tolerant to moderately tolerant to salinity. Rye, safflower, and oats are listed as moderately tolerant. Crops listed as moderately sensitive include corn, flax, millet, sunflower, and alfalfa. Among grasses, tolerance varies among cultivars. Wheatgrasses and wildryes are listed as tolerant to moderately tolerant. Smooth brome and blue grama are moderately sensitive to salinity. Finally, crops are generally more susceptible to salinity-induced damage in early growth stages, such as the emergence and seedling stages.

Most crop salt tolerance information was developed in California. The chemistry of salinity is different in the Northern Great Plains (sulfate-dominated salinity) so thresholds are greater and yield losses are somewhat smaller in the Northern Great Plains compared to those of California (chloride-dominated salinity), but the relative responses of different crops will be accurate.

For more specific information on crop salinity tolerance, see publications such as Maas (1986) or Tanji (1990).

MEASURING SALINITY

The traditional method of measuring soil salinity has been to collect a soil sample, dry and grind the sample, then add water to form a paste. To measure the total salt concentration in the sample, the electrical conductivity of the paste can be measured. To determine the actual ions (salts) and their concentrations in the sample, the solution is vacuum-extracted from the paste then the concentrations of ions of interest are measured in the extracted solution. Electrical conductivity and specific ion concentrations can also be measured in irrigation water to determine the hazards of irrigating with a particular water on a particular soil. University service laboratories or commercial laboratories can perform these tests, usually for a small fee.

Instruments are now available to measure the salinity of large areas without taking soil samples. These instruments include the Geonics EM38 (http://www.geonics.com/) and Veris 3100 or 2000 XA (http://www.veristech.com/). They are particularly useful in precision farming operations where large amounts of georeferenced data are handled routinely. These instruments can be used to measure the electrical conductivity, especially relative values, over large areas in relatively little time. Some lab analyses of soil samples may still be required to establish absolute electrical conductivities.

CONCLUDING REMARKS

Salinity management is water management. Because salts are either added in the water or moved with water, it is the water that must be managed to control salinity. For saline seeps, water must be used before it can leave the recharge area or intercepted before it can be discharged in a seep area. For irrigated areas, leaching and other irrigation management are required to reduce or eliminate salinity effects.

REFERENCES

Black, A. L., P. L. Brown, A. D. Halvorson, and F. H. Siddoway. 1981. Dryland cropping strategies for efficient water-use to control saline seeps in the northern Great Plains, USA. Agric. Water Management 4:295-311.

Brun, L. J. and B. K. Worcester. 1974. The role of alfalfa in saline seep prevention. N. Dak. Farm Res. 31(5):9-14.

Doering, E. J. and F. M. Sandoval. 1976. Hydrology of saline seeps in the Northern Great Plains. Transactions of the ASAE 19(5):856-861, 865.

Halvorson, A. D. and A. L. Black. 1974. Saline-seep development in dryland soils of northeastern Montana. J. Soil and Water Conservation 29(2):77-81.

Halvorson, A. D. and C. A. Reule. 1980. Alfalfa for hydrologic control of saline seeps. Soil Sci. Soc. Am. J. 44:370-374.

Maas, E. V. 1986. Salt tolerance of plants. Applied Agricultural Research 1(1):12-25.

Tanji, K. K. (editor). 1990. Agricultural salinity assessment and management. ASCE Manual No. 71. American Society of Civil Engineers, New York, NY.

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