Diagnosing SOIL SALINITY

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Diagnosing Soil Salinity

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The proper management and treatment of salt-affected soils depends upon accurate knowledge of the nature and severity of the salt problem at hand. Inadequate information may lead farmers to plant salt-sensitive crops where they should plant salt-tolerant ones, or to fail to apply chemical amendments where they are needed. Instances are even known where gypsum has been applied, at considerable expense, to soils that already contained large amounts of this mineral as a natural constituent.

Visual observations of soils and of plants growing on them are rarely sufficient to diagnose a salinity problem adequately. Such observations often indicate a salt-affected soil, but salinity problems may exist with no visual symptoms being evident. Salinity may reduce the yields of crops as much as 25 percent without visible symptoms. Moreover, visual observations may lead to a false diagnosis. For example, gypsum, a salt that is essentially harmless to plants, may form a white crust on the surface of soils and indicate salinity where none really exists.

Reliable diagnosis of salinity requires the right kind of laboratory tests on samples that are truly representative of soils. Such sampling and testing involves some time and moderate expenses, but experience has shown that this procedure pays good dividends.

The salts that cause salinity are soluble in water and move with the water in soils. Water movement in soils is complex. It is influenced by the permeability of the various soil layers, the surface relief, rainfall, and irrigation and cropping practices. In furrow-irrigated fields, the salt content of the soil in the ridge may be much greater than that in the bottom of the furrow. Thus, the salt content of soils may vary greatly at different soil depths (vertically) and across the area (horizontally) within short distances. Moreover, salt distribution in a certain area may change markedly from time to time. Diagnosing salinity by soil testing, therefore, is trustworthy only to the extent that the samples accurately represent conditions in the field. It is pointless to make accurate laboratory tests of samples unless good judgment and great care are employed in selecting sampling sites and in taking the samples.

Selection of Sampling Sites

Samples for tests should be taken from places in the field where salinity is suspected, and, for comparative purposes, from nonsaline places, if such places occur. If the field supports cultivated or native vegetation, the appearance of the vegetation may be useful for selecting affected and unaffected areas. For fields of 40 acres or less, two sampling sites in apparently affected areas and two sites in presumably unaffected areas

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Figure 1.—**Soil samples for diagnosis should be taken where salinity is suspected (bare areas) and, for comparative purposes, from areas having comparatively good plant growth.**

usually suffice. Proportionately more sites should be sampled in fields larger than 40 acres. If moderately and severely affected areas can be distinguished, samples representing each area should be taken.

Taking the Sample

The equipment needed for taking soil samples consists of a tool for removing the soil, a bucket or similar container for mixing the sample, waterproof sample containers that will hold about a pint of dry soil, and tags or labels for identification. A sampling tube, or a barrel auger, if available, is preferred for drawing the sample, but a trenching spade or post-hole digger may also be used. The waterproof containers may be waxed paper or plastic bags, waxed cardboard cartons, or metal cans. If moist saline soil is placed in a container that is not waterproof, salt will be absorbed by the container as the soil dries and the sample will be altered.

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***Figure 2.*—Equipment for taking soil samples.**

Because field conditions vary greatly, a standard sampling procedure that will apply to all situations cannot be given. There is no substitute for good judgment and experience in taking soil samples. Farmers are advised to obtain the aid of their county extension agent or local Soil Conservation Service technician when taking soil samples, if possible.

If the soil has distinct layers that vary in texture, for example, the samples should be taken by layers. Visible or suspected surface salt-crusts should be sampled separately. In the absence of distinct layers, samples should be taken to the plow depth (6 to 8 inches) and at 12-inch-depth intervals thereafter.

In fields growing a crop, samples should be taken throughout the major depth of the root zone, which may vary from 6 inches for shallow-rooted crops to 4 or 5 feet for deep-rooted crops. With uncropped fields, sampling to a depth of 3 or 4 feet is conventional. In furrow-irrigated fields, separate samples should be taken in the ridge and in the adjacent furrow.

If a trenching spade is employed, a thin vertical slice of the soil should be taken that represents the entire sampling interval. The soil is placed in a bucket or similar container, mixed thoroughly, and about a pint of the mixture taken for the sample. The rest of the soil is discarded. A tag or label should be placed both inside and outside of the container, and the label should indicate the location and depth at which the sample was taken.

Field Information To Accompany Samples

Field observational data recorded at the time of sampling are effective aids for interpreting laboratory tests and for recommending corrective treatments and management practices. The field data for each sampling site should include: (1) a brief description of the soil—the soil type, if known, and any unusual characteristics, such as the presence of a plow sole or hardpan; (2) a description of plant conditions, if the field has vegetation; (3) the topography and drainage conditions, including the depth to water table; (4) the source and quality of the irrigation water; and (5) the method of irrigation. Most laboratories that make soil tests for farmers supply field data sheets to be filled out for each sampling site.

FIELD INFORMATION FOR SOIL SAMPLING SITE

Site No. 9 Collected by: John Smith Date collected: 6/2/62

Location: Jack Jones farm SE 1/4 NW 1/4 Sec. 6 T5S R7N

Description: Holtville clay loam; plow sole at 6 inches

Vegetation: Bare area in cotton field

Topography: Flat; slope less than 1%.

Drainage conditions: Water table at 7 feet.

Source and quality of irrigation water: Colorado River; Elec. cond. = 1.2 millimhos/cm; sodium-adsorption-ratio = 3

Method of irrigation: furrow

Figure 3.—A completed field observational sheet for a soil sampling site.

SOIL TESTS

After the representative soil samples and accompanying field information are obtained, the next step in the diagnosis of salt-affected soils is to have the right kind of tests made. Methods of making tests and of reporting results may vary. Some laboratories make tests that are more than adequate in some respects and markedly deficient in other respects. Other laboratories make tests that are difficult to interpret because of the methods used or the way the results are reported.

Kinds of Tests To Have Made

Soluble salts may be harmful by increasing the salt concentration of the soil solution or by causing the surfaces of the soil particles to adsorb excessive amounts of sodium, or both. High concentrations of salt in the soil solution retard plant growth directly, and excessive amounts of sodium on the soil particles cause the soil to have low water-intake rates and poor tilth. The objectives of the soil test, therefore, are to obtain an estimate of the salt concentration of the soil solution and to determine if an excessive amount of adsorbed sodium is present.

It is not practical to make direct measurements of the salt concentration of the soil solution, because the concentration varies with the water content of the soil and removal of the soil solution at field water contents is difficult. Part of the solution in soil that has been saturated

REPORT ON SOIL TESTS

Site No. 3 Collected by: John Smith Date collected: 6/5/62

Location and sampling depth: Jack Jones farm SE 1/4 NW 1/4 Sec. 6 T5S R7N; 0-6 inch

Saturation extract:

Electrical conductivity - 19.8 millimhos per centimeter at 25° C.;

Sodium - 138 milliequivalents per liter;

Calcium plus magnesium - 148 milliequivalents per liter.

Sodium-adsorption-ratio ($Na/\sqrt{Ca+Mg/2}$): 16.1

Estimated exchangeable-sodium-percentage: 18

Soluble-calcium-requirement: 1.5 milliequivalents per 100 grams.

pH value: 7.6 Lime test: present ✓ absent ____

Figure 4.—Example of a satisfactory soil test report.

with water and mixed to a paste can be removed readily, however, and the salt concentration of this solution serves as a reliable index to the concentration at field water contents. For most soils, the solution from saturated soil paste is about one-half as concentrated as the soil solution shortly after irrigation and about one-fourth the concentration of the soil solution when plants have reduced the water content to the wilting point.

Salt-free water conducts practically no electricity, but water containing dissolved salts conducts quantities of electricity in proportion to the total concentration of salts present. Measurement of the electrical conductivity of the solution obtained from soil paste provides, therefore, a good index of the average salt concentration of the soil solution under field conditions. The unit usually employed to report the electrical conductivity of solutions is millimhos per centimeter at 25° C.

When sodium salts predominate, sodium replaces or exchanges with some of the calcium and magnesium that is normally adsorbed on the surface of the soil particles. Each soil has a reasonably definite total capacity for adsorbing such salt constituents. In general, the adsorption of sodium is excessive when more than about 15 percent of the exchange (adsorption) capacity is satisfied by sodium. The percentage of the exchange capacity satisfied by sodium is commonly termed the "exchangeable-sodium-percentage." This percentage can be estimated from knowledge of the sodium and the calcium plus magnesium concentrations of the solution removed from soil paste, or it can be determined with greater accuracy by more involved chemical methods. For diagnostic purposes, the estimation method usually suffices.

If the soil sample has an excessive exchangeable-sodium-percentage, additional tests should be made to determine how much and what kind of chemical amendment should be applied to remove the excess adsorbed sodium. The additional tests needed are the soluble-calcium-requirement, pH reading, and lime content. The soluble-calcium-requirement is used to estimate the amount of soluble calcium that should be supplied by the addition of a chemical amendment, whereas the pH reading and lime content determine the kind of amendment to be applied.

Certain salt constituents, notably sodium, chloride, and boron, may be specifically toxic to plants. Many fruit crops accumulate excessive amounts of sodium and chloride and, as a consequence, develop leaf burn symptoms. Although small amounts of boron are essential for plant growth, larger amounts are toxic. Occasionally, soils are found that contain toxic amounts of boron. U.S. Department of Agriculture Information Bulletin 211 entitled, "Boron Injury to Plants,"[1] gives methods for diagnosing boron toxicity.

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[1] For sale only. Send 10 cents in coin to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for a copy.

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Figure 5.—**A test kit for diagnosing soil salinity.**

Where To Get Tests Made

Most State governments operate soil-testing laboratories in conjunction with either their agricultural experiment stations or their agricultural extension service. In some areas, commercial testing laboratories are available. The testing service to be employed will, therefore, depend upon the local situation. In any event, before soil samples are submitted for testing, it should be determined if the laboratory can make the proper kinds of tests.

The U.S. Salinity Laboratory does not test soil samples except for its own investigations or those conducted for other Government agencies. Farmers who have some acquaintance with chemistry and who encounter salinity problems frequently may wish to make their own tests. U.S. Department of Agriculture Circular 982 entitled, "Tests for Salinity and Sodium Status of Soil and of Irrigation Water,"[2] gives directions for assembling equipment and for making tests on soil as well as on irrigation water. A complete kit for making the tests described in Circular 982 is also available commercially.

[2] For sale only. Send 15 cents in coin to Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for a copy.

INTERPRETATION OF SOIL TESTS

A satisfactory report on tests for the diagnosis of salt-affected soils will give values for the electrical conductivity of the saturation extract in millimhos per centimeter at 25° C. and for the exchangeable-sodium-percentage. If the exchangeable-sodium-percentage exceeds 10, the soluble-calcium-requirement expressed in milliequivalents per 100 grams of soil should also be given, as well as the pH reading and information as to whether the soil contains lime.

If the electrical conductivity of the saturation extract is 4 millimhos per centimeter or less, all but the very salt-sensitive crops may be grown. Only moderately salt tolerant crops may be grown if the value for electrical conductivity is between 4 and 8, and only highly salt tolerant crops if the value is between 8 and 16. Practically no crops can be grown on the soil without prior leaching to remove excess salts if the electrical conductivity value exceeds 16. Information on the salt tolerance of some common crops is given in the U.S. Department of Agriculture Information Bulletins 194, "Salt Tolerance of Grasses and Forage Legumes," and 205, "The Salt Tolerance of Vegetable Crops in the West." [3]

[3] For sale only. Send 5 cents in coin for AIB 194 and 10 cents in coin for AIB 205 to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for copies.

U.S. Department of Agriculture AIB 217, "The Salt Tolerance of Field Crops," is out of print. Copies may be found in certain agricultural libraries.

The exchangeable-sodium-percentage indicates the extent to which adsorbed sodium is affecting the physical properties of a soil. Water-intake rates and tilth are usually markedly impaired at exchangeable-sodium-percentage values greater than 20 for sandy soils and greater than 10 for clay soils. Many fruit crops are specifically sensitive to sodium, and the leaves may be affected by sodium toxicity when the exchangeable-sodium-percentage is as low as 5 or less.

The soluble-calcium-requirement indicates the excess of adsorbed sodium over any native gypsum that may be present and is therefore related to the amount of chemical amendment needed. Because a small amount of adsorbed sodium is not objectionable, no application of amendment is ordinarily required unless the soluble-calcium-requirement exceeds 2 milliequivalents per 100 grams of soil. Gypsum is a suitable amendment for nearly all soils containing excess adsorbed sodium, but sulfur and sulfuric acid, especially if large amounts are needed, should be applied only to soils containing lime. For soils having pH readings of less than 7 and containing no lime, the application of lime will be useful for the replacement of adsorbed sodium. U.S. Department of Agriculture Information Bulletin 195 entitled, "Chemical Amendments for Improving Sodium Soils" contains further information regarding the use of chemical amendments.

SUMMARY

1. The proper management and treatment of salt-affected soils depends upon accurate knowledge of the nature and severity of the problem.

2. Visual observations of soils and of plants growing on them are rarely sufficient to diagnose a salinity problem adequately. The reliable method for diagnosis consists of making the right kinds of tests on representative samples of soil.

3. The value of soil tests depends upon the accuracy with which the samples represent conditions in the field.

4. Soil samples should be taken with care at several depths from places where the soil appears to be salt-affected and, for comparison purposes, from places where the soil appears to be unaffected.

5. Field information should accompany the soil samples.

6. Soil tests should give the electrical conductivity of the extract from saturated soil paste and the exchangeable-sodium-percentage.

7. If the exchangeable-sodium-percentage exceeds 10, additional tests are necessary for the soluble-calcium-requirement, pH reading, and lime content.

8. Soil tests should be interpreted properly, and maximum use made of field information.

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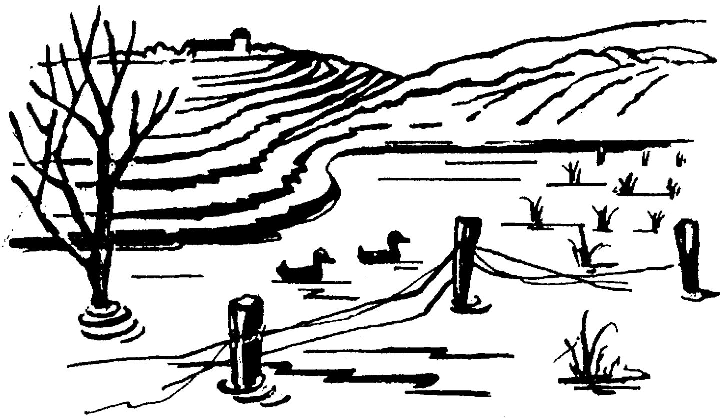

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