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INTERPRETATION OF SOIL ANALYSES

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INTERPRETATION OF SOIL ANALYSES

BY W.T. McGEORGE

A landowner is often in doubt as to the alkali content of his soil and often, too, as to the need for commercial fertilizer, the natural fertility, or his other soil problems which an examination of the soil will help to clarify. Some of these problems require a chemical analysis, notably as to alkali and plant food availability, while others may be answered by a mechanical analysis or examination. In order to help farmers answer some of these questions, the Agricultural Experiment Station maintains a soil testing service for citizens of the state. No charge is made for this service.

This circular is prepared in answer to a demand for help in interpreting the report of a soil analysis and is intended for those who are not familiar with the terms used and the methods of expressing a chemical analysis.

SOIL REACTION (*p*H VALUE)

The *p*H test on soils is an electrometric measurement of the reaction of the soil—that is, it determines whether the soil is acid, alkaline, or neutral and just how acid or alkaline it is. A neutral soil is one that is neither acid nor alkaline. The *p*H of a soil is represented by a scale somewhat in the same manner that numbers on a thermometer scale represent temperature. On the *p*H scale 7.0 represents a neutral soil. Numbers below 7.0 represent acid soils, the lower the number the stronger the acidity. Numbers above 7.0 represent alkali soils, and the larger the number the stronger the alkalinity. From *p*H 7.1 to 8.0 soils are considered weakly alkaline, 8.0 to 9.0 alkaline, 9.0 to 10.0 strongly alkaline, and 10.0 to 11.0 excessively alkaline. Black alkali begins to appear at about *p*H 8.6 and increases with an increase in *p*H above 8.6. From the scale given in Figure 1 the condition of the soil can be readily learned from the *p*H value. Most crops make their best growth at some point very close to neutrality or *p*H 7.0. The most desirable range is from 6.5 to 7.5. Serious injury from black alkali, or high *p*H value, does not begin to manifest itself until about 8.6 to 9.0, and then it depends upon the soil type as to just how great the injury will be.

TOTAL SOLUBLE SALT

This test, sometimes abbreviated as "T.S." or "T.S.S." is made to determine the amount of soluble salt in the soil. The different salts which comprise this group are commonly known as "white alkali" but should be referred to as salinity in order not to be confused with black alkali. It represents the soluble salts carried onto the land by irrigation water or drawn up from below if a high water table exists. It is deposited on the land by the ex-

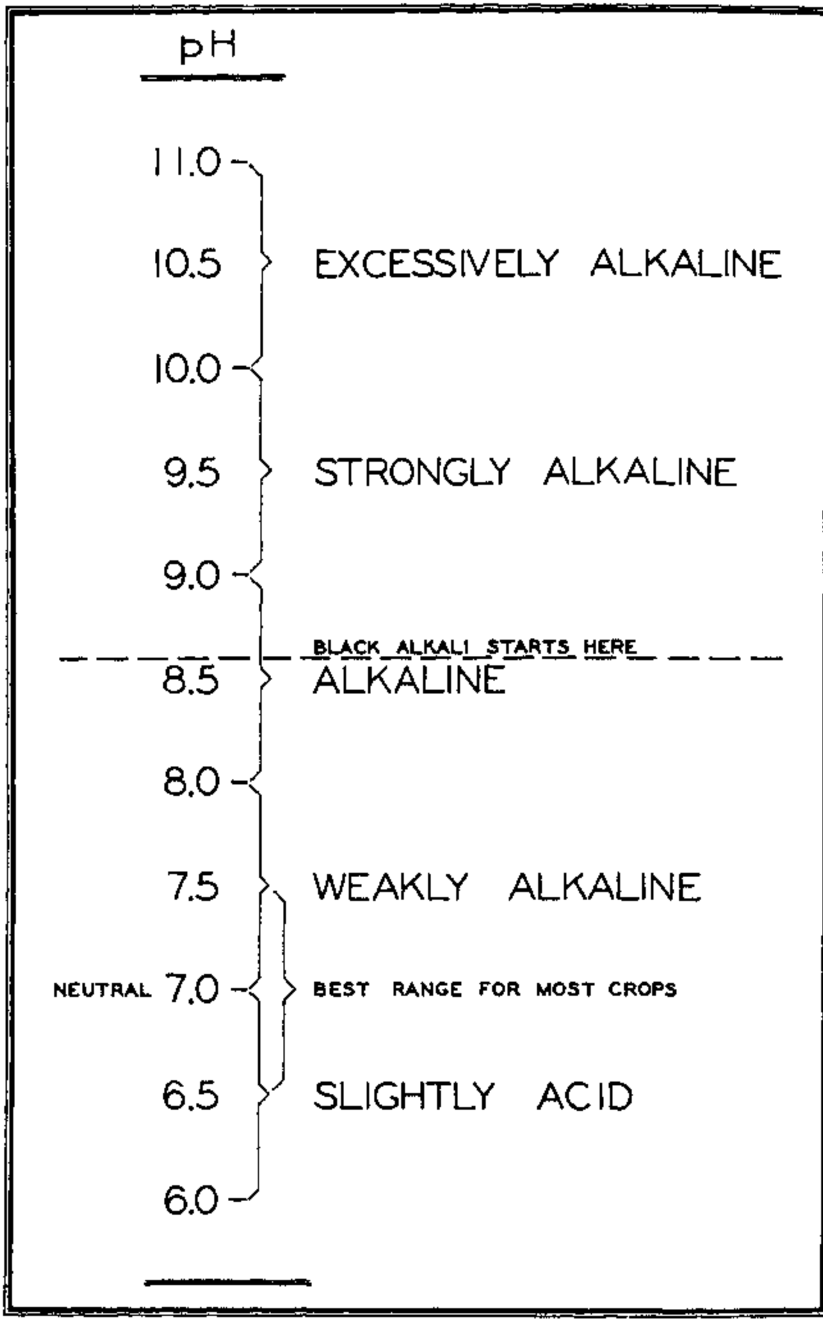

Figure 1.—Chart for explaining *p*H of soil in terms of alkalinity.

cessive evaporation that characterizes semiarid regions like Arizona. Total salts are expressed as parts per million of soil which is equivalent to pounds of salt per million pounds of soil. Thus 500 parts per million T.S. means that the soil in question contains 500 pounds salt in 1,000,000 pounds of soil. Since an acre-foot of Arizona soil weighs approximately 4,000,000 pounds, one can obtain the pounds of salt (white alkali) per acre-foot by simply multiplying parts per million by 4. To convert parts per million to percentage just move the decimal point four places to the left. Thus 5,000 parts per million is equivalent to 20,000 pounds per acre-foot or 0.5 per cent.

At just what concentration the salts begin to injure crops cannot be definitely stated. For example, experiments have shown that in a sandy soil where injury was caused by 2,000 parts per million salt, in a clay soil, using the same water, injury did not show until the salt concentration had reached 4,000 parts per million. In most cases 5,000 parts per million, or 20,000 pounds per acre-foot, is considered the point above which none but the most resistant plants will grow. It is advisable to keep the salts below 2,000 ppm for most crops. The following limits are suggested as reasonable for interpreting the salt analysis of a soil:

0 to 700 ppm	negligible
700 to 1,500 ppm	weak salinity
1,500 to 3,000 ppm	medium strong salinity
3,000 to 8,000 ppm	strong salinity
8,000 to 15,000 ppm	very strong salinity
above 15,000 ppm	excessive salinity

A number of factors determine or modify the interpretation of these limits. As already mentioned, less alkali can be endured by crops in a sandy soil than in a clay or clay loam. Other conditions must also be considered, such as the mechanical structure of the soil—whether puddled or open and friable; depth of water table; and plant food deficiency. The presence of any undesirable condition will lower the tolerance of the crops for salt in the soil.

PHOSPHATE (PO_4)

Among the plant food elements which the soil must supply to the crop, phosphate, in available form, is most often deficient in Arizona soils and in such cases must be supplied in the form of commercial fertilizer. If large amounts of animal manure are available at reasonable price this material can be used to change the insoluble phosphate in the soil to an available form. In view of the phosphate deficiency an effort has been made to develop a method which will measure the available phosphate in Arizona soil. While it is impossible to imitate accurately the plant root by chemical tests in the laboratory, the test in use is considered reasonably accurate. This test should be interpreted from the report of analysis as follows:

0 to 5 parts per million (ppm) PO_4 indicates that the soil is de-

ficient in available phosphate and will usually give response to phosphate fertilization with most crops.

5 to 10 parts per million (ppm) PO_4 indicates that the soil is probably deficient in available phosphate and will give profitable response with some crops.

Above 10 ppm PO_4 the soil is probably not deficient, and most crops will not respond profitably to phosphate fertilization when this much available phosphate is present in the soil.

It is of interest to state that phosphate fertilizers are readily and strongly fixed by Arizona soils and will not leach away in the drainage. It is of further interest to state that this fixed phosphate remains in an available form over a period of several years and will therefore be of use to later crops if not all used by the crop to which it is added. In other words phosphate fertilization permanently improves the fertility of Arizona land.

NITRATE NITROGEN (NO_3)

There are many forms of nitrogen in soils, and their availability to plants is usually measured by the rate at which it will change to the form of nitrate. This is the form in which most plants absorb nitrogen from the soil. In view of this the nitrate test is used to determine whether nitrogen fertilization is necessary.

In interpreting a nitrate test on irrigated lands a number of conditions must be taken into consideration. Nitrate is not fixed by the soil like phosphate and potash and therefore moves wherever the water goes. Therefore, if a soil sample is taken soon after an irrigation, the test will be low and probably misleading. On the other hand, if the sample is taken when the soil is dry, the test will be high and equally misleading. It is suggested that the soil sample for a nitrate test be taken about 1 week before an irrigation.

If the nitrate test shows 10 parts per million (ppm) N this should be considered a good supply. This amounts to about 40 pounds nitrogen per acre-foot of soil and is equivalent to an application of about 250 pounds calcium nitrate which is a good application.

POTASH (K)

Arizona soils are well supplied with available potash and there has as yet been found no profitable response to potash fertilizers. For this reason tests are rarely made for available potash in Arizona soils, although the method in use is quite satisfactory.

Soils analyzing as low as 20 parts per million potassium (ppm K) have not shown any evidence of potash deficiency. This is equivalent to 165 pounds sulphate of potash per acre-foot which is considered an average application. It appears then that 20 ppm K will probably serve as a minimum value until the need arises for potash fertilizers on Arizona soils.

CALCIUM (CA) (LIME)

No tests are made on Arizona soils for lime in irrigated lands, as all these lands are well supplied with lime in the form of caliche or calcium carbonate. However, when soils are heavy and the farmer wishes to make them mellow and more tillable, lime in the form of gypsum can be used to accomplish this. Sulphur can also be used in improving soil structure, and in consideration of the price of the two materials one should know that, on the basis of equal weights, sulphur is more than 5 times as effective as gypsum—that is, 1 pound of sulphur will, after it decomposes in the soil, do the same work as more than 5 pounds of gypsum. Sulphur must be placed deep enough in the soil to be kept moist, as it is of no value until it has been changed to sulphuric acid. This change is brought about by soil bacteria if the moisture conditions and air are favorable for the organisms.

THE MECHANICAL ANALYSIS OF A SOIL

Some of the differences in soil productivity are due to the many sized particles which go to make up the soil mass. These particles vary in size from that too small to be seen with a microscope to gravel. Soils are classified, according to texture, by the predominating size of the particles. In view of the above occasional requests are received for mechanical analyses of Arizona soils. Some data and a chart, Figure 2, are submitted to help in classifying soils from a mechanical analysis.

The sizes which are accepted as standard in the United States for designating soil particles are as follows:

	Millimeters
Fine gravel	2.000
Coarse sand	1.000
Medium sand	0.500
Fine sand	0.250
Very fine sand	0.100
Silt	0.050
Clay	0.005

That is, all particles less than 0.005 mm. in diameter are clay, all particles not greater than 0.250 mm. and not less than 0.100 mm. are very fine sand, etc.

In routine mechanical soil analyses only clay, silt, and sand are usually determined, and in such analyses sand represents all particles from 0.05 to 2.0 mm. in diameter. From such analyses the soil can be classified by reference to Figure 2. Several soil analyses are presented here for illustration.

Soil no.	1	2	3
Sand, per cent	91	22	69
Silt, per cent	5	32	14
Clay, per cent	4	46	17

Referring these data to Figure 2 where they are designated by number, *1* is a sandy soil, *2* is a clay soil, and *3* is a sandy loam.

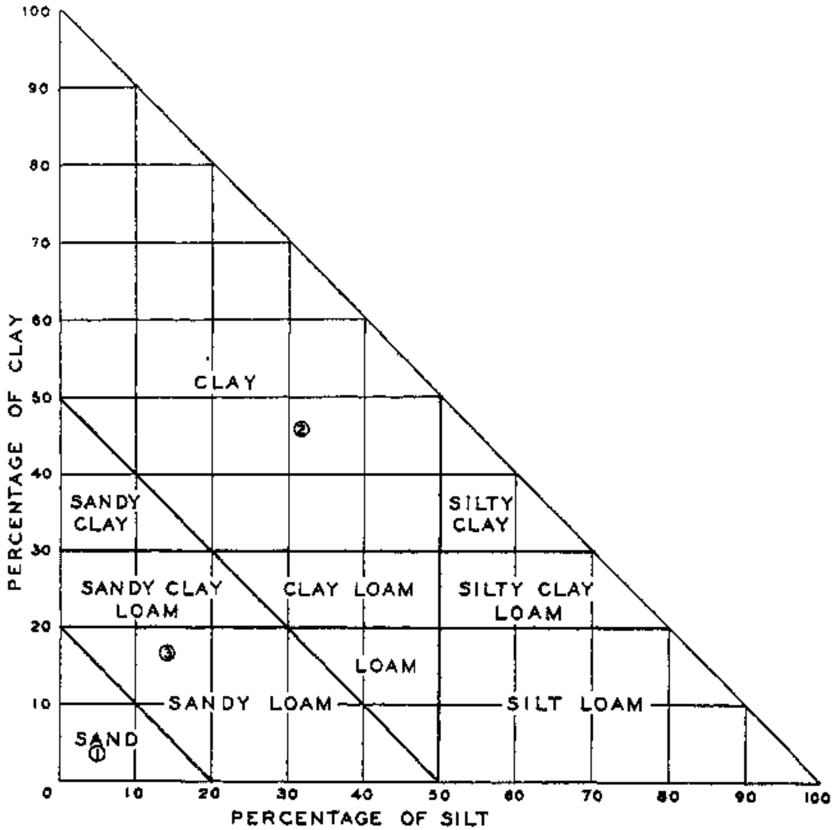

Figure 2.—Chart for use in classifying soils as to texture from a mechanical analysis.

MOISTURE EQUIVALENT (M.E.)

Farmers in regions where irrigation is practiced often become accustomed to using the moisture equivalent (M.E.) determination a great deal. It represents very closely the optimum moisture content of the soil for plant growth. Also it is an approximate measure of soil texture, clay soils having the highest M.E. and sandy soils the lowest. M.E. values[1] based on dry weight of soil are:

Fine sand	4.3
Sandy loam	10.3
Fine sandy loam	12.3
Silt loam	19.8
Clay loam	23.1

[1] W. W. Wier, "Soil Science."

SAMPLING A SOIL

In taking a sample of soil for analysis one should keep in mind that the analysis can be no more accurate than the degree to which the sample represents the area of land in which one is interested.

Soils vary so greatly in irrigated areas that it is difficult to follow a definite method of sampling for all conditions.

For a plant food analysis the sample may be taken with a spade, soil tube, or auger. If with a spade, a vertical cut is made to a depth of 1 foot. The soil should be cleaned from the hole and a thin slice (½ inch thick) taken off the side. Repeat this procedure at about six locations in each soil type to be sampled. If a soil tube or an auger is available the six samples can be taken to the same depth more easily. If all subsamples are similar in type, they can be composited into a single sample for analysis, but if variation is sought, each sample may be analyzed separately. While soil tubes are rarely found on the farm, they are extremely useful tools for checking the moisture conditions in the fields and for examining the soil for hardpan and other undesirable underground conditions. Unfavorable productivity factors are more often present in the subsoil than in the surface soil and therefore escape attention.

In sampling a soil for an alkali analysis one will have to rely upon his own judgment. He may be interested in an alkali crust and would then just take a surface sample. If interested in a slick spot several borings should be made and a separate sample for every 4 inches taken so that the soil layer in which the salt is concentrated can be determined. If interested in alkali over a large area then the same procedure suggested for the plant food sample will be satisfactory.

White crust on the surface of the soil shows definite salinity.

A brown to dark fluffy surface soil usually represents calcium chloride salinity.

Dark, slippery, or puddled areas which take water poorly indicate black alkali.

These observations together with notations on the conditions in the subsoil, drainage, and a consultation of the soil survey map will materially assist in interpreting the soil analysis.