SPECIAL ARTICLES

THE EFFECT OF THE REPLACEMENT OF OTHER CATIONS BY SODIUM ON THE DISPERSION OF SOILS

THE effect on physical properties of soils by the replacement of other cations by sodium in the base exchange complex of soils has been the subject of much study by soils investigators. It was the subject of a report[1] of one of the Committees of the Section of Hydraulics of the American Geophysical Union in 1936. The summary of the report states in part: "Laboratory experiments in general show that such physical measurements as moisture-equivalent, permeability, deflocculation, absorption of water-vapor, heat of wetting, density during drying, hardness of crumbs of the dried soil and cohesiveness are all increased by the substitution of sodium- or potassium-ions in the exchange-complex and are decreased by the substitution of calcium or hydrogen."

A number of soils investigators have reported that treatment of soils with sodium salts and subsequent leaching results in dispersion of the soil colloids and in an increase in the water-holding capacity of the soil. The moisture equivalent of the soil usually is taken as a measure of its water-holding capacity. The moisture equivalent has been reported to be correlated with other physical properties of the soil. In connection with studies on the effect of organic matter and other fertilizers on some of the water relations of soils, the writers have had occasion to make a number of moisture equivalent determinations on salt-treated soils. The results of these tests show that neither the treatment with sodium salts nor subsequent leaching of the salt-treated soils with distilled water materially affects the moisture equivalent.

The results of some of the tests are shown in the accompanying table. Three California soils were tested, Yolo clay, Farwell loam and Aiken loam; and a Wooster silt loam from Wooster, Ohio. All these soils except the Aiken loam, a red lateritic soil, have relatively large base-holding capacities. For example, the Yolo clay has a total of 27.3 milligram-equivalents per 100 grams of soil. These soils were treated with $NaNO_3$, NaCl and Na_2SO_4, but only the results with the chloride are reported, since the other salts gave similar results.

TABLE I

MOISTURE EQUIVALENTS OF SALT-TREATED AND UNTREATED SOILS

Soil	Natural untreated soil	Natural soil mechanically stirred	Soil treated with 1 N NaCl sol. and leached with distilled water	Soil treated with 1 N NaCl sol. and leached with distilled water, mechanically stirred
Yolo clay	27.2 ± .04	28.4 ± .07	28.1 ± .05	28.6 ± .02
Wooster silt loam	20.3 ± .04	22.3 ± .05	20.4 ± .04	22.1 ± .04
Aiken loam	32.6 ± .05	33.7 ± .06	33.1 ± .05	33.8 ± .05
Farwell loam	24.8 ± .03	26.7 ± .04	25.8 ± .03	26.5 ± .05

Enough of each sample was placed in a standard centrifuge cup to give a 30-gram sample of water-free soil.[2] The salt-treated samples were soaked in one normal salt solution for a period of about 12 hours. The soil was then drained and the samples washed with fresh solutions and then leached five times with distilled water while in the centrifuge cups. This treatment in the case of Yolo clay raised the sodium in the base exchange complex from 4.4 to 12.1 milligram-equivalents per 100 grams of soil; and in the case of the Wooster silt loam the soil was about 65 per cent. saturated with sodium. Some of the samples were also stirred with a glass rod just before placing them in the centrifuge. This stirring, however, did not equal the mechanical manipulation the soil would receive if it were transferred from a leaching funnel to the cups, as probably was done in previous work of this kind. Samples without salt treatment and leaching were also prepared, and some of these were mechanically stirred in the same manner as the salt-treated samples. Sixteen samples for each treatment were run in separate centrifuge sets of four each.

The salt-treated leached samples have slightly higher moisture equivalents than the untreated samples, but the differences are much less than reports of previous work suggest,[3] and the difference is not significant in the case of the Wooster silt loam. Mechanical agitation of the untreated soils in every case increased the moisture equivalent more than the salt treatment did.

The very large increases in moisture equivalent which are thought to result from the dispersions due to the replacement by sodium may simply be due to the technique used, since the moisture equivalent may be materially affected by a number of factors.[4] In our tests we attempted to keep the procedure in making the determinations of the salt-treated and check samples as nearly identical as possible.

That mechanical agitation markedly increases the moisture equivalent is shown in tests with the Aiken loam by running the samples in an unbalanced centrifuge load. The moisture equivalent of the soil was raised from 32.6 to 40.1. We have encountered some

[1] F. J. Veihmeyer, *Transactions American Geophysical Union*, seventeenth annual meeting, Part 2: 318–326, 1936.

[2] F. J. Veihmeyer, O. W. Israelsen and J. P. Conrad, California Agr. Exp. Sta. Technical Paper 16: 1–65, 1924.

[3] L. T. Sharp and D. D. Waynick, *Soil Sci.*, 4: 463–469, 1917.

[4] F. J. Veihmeyer, J. Oserkowsky and K. B. Tester, Proc. and Papers, First International Cong. Soil Sci. (Washington, 1927) 1: 512–534, 1928.

soils, not given in the table, which become so dense during the centrifuging process that water will not pass through them. In some cases this condition has resulted when the centrifuge is brought up to speed too quickly, the soil becoming so compact water will not pass through it. This impervious condition has also been found when some of the soils were mechanically stirred in the centrifuge cups just before placing the samples in the centrifuge. In fact, in many cases standing water was found on the surface of the sample after centrifuging. We believe that under such conditions the moisture equivalent is meaningless. The results simply indicate that the soil was rendered impervious and the results obtained bear no relation to the textural properties of the sample.

The conclusion from our work with salt-treated samples is that more dispersion can be brought about by mechanical agitation than by salt treatment and leaching. These results indicate that the impervious conditions sometimes observed in the field, where the soil was pervious formerly, and attributed to the dispersion resulting from irrigation with salty water, may be brought about by mechanical working of the soil when too wet.

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PIGMENTATION IN THE ROOT OF THE COTTON PLANT

IN connection with investigations of the effect of fertilizers on the incidence of cotton root rot (*Phymatotrichum omnivorum*) repeated observations have been made of consistent relationships between the pigmentation of cotton roots and stage of plant development, soil characteristics and fertilizer treatment. In field experiments on Wilson clay loam, a non-calcareous soil of the Blackland prairie section of Texas, fertilizer treatments in which phosphoric acid dominated tended to accelerate the appearance of root rot, as evidenced by above-ground symptoms, while fertilizers in which nitrogen dominated produced a converse effect. These same fertilizers had, respectively, the effect of hastening or retarding the physiological age of the cotton plant. Associated with these effects there was also observed a gradation in the pigmentation of the root bark; in mid-summer the roots of plants from unfertilized plats were a pale yellow, those from plats treated with high-nitrogen fertilizers were of a lighter tint, while high-phosphate plants displayed a distinctly reddish shade. Later in the season, the unfertilized and high-nitrogen plant roots acquired this reddish cast, while that of the phosphate-fed roots was intensified, consequently the gradient of color was maintained until all plants were matured.

The roots of cotton seedlings grown on the calcareous soils of the blackland section are also pale yellow; the red pigmentation appears about the time that the first squares are set, and becomes more intense as the season advances, so that at the end of the season the roots exhibit a deep red coloration, regardless of fertilizer treatment. The Wilson soils have a lower pH value than those of the Houston series. Limited observations of cotton plants of comparable age grown on the acid soils of east Texas indicate that this red pigment does not appear until later in the development of the plant, and at maturity the intensity of the color does not approximate that of plants produced on the less acid to alkaline soils of the blackland section. Thus it appears that the reaction of the soil, physiological age of the plant and fertilizer treatment are factors in the pigmentation of the roots of cotton plants grown in this region.

A systematic study of the pigmentation of the cotton root was begun in 1935 and continued during 1936, on samples taken periodically throughout the growing season. Roots, as prepared for carbohydrate studies, were extracted with boiling alcohol whose final strength after contact with the plant material was not less than 80 per cent. In 1936, the plants were divided into two parts, namely, bark and woody tissues. The alcoholic extracts of the woody part were yellow; these changed to orange toward the end of the season. Those of the bark were yellow until the stage of square formation at which time the red coloration appeared, and this latter color became more intense as the season advanced. The bark extracts, even though they were intensely red, were found to contain some of the yellow. The variations in the reddish color of the bark, which are discernible to the eye before heating with alcohol, are intensified in the alcoholic extract; the extracted bark-tissue is also much more highly colored than the unextracted.

Comparisons were made of extracts from roots of plants grown on Wilson clay loam with 0-15-0,[1] 3-9-3, 9-3-3 and 15-0-0 fertilizers; an unfertilized check plat was also used. The volumes of the extracts were adjusted so that the same ratio of liquid to plant material was maintained. Using the plant grown on the 0–15–0 fertilizer plat as a standard, the relative color intensity of the extracts from the other treatments were determined with facility by the use of the colorimeter. The intensities of the red pigment of the bark of plants produced with the 0-15-0 and 3-9-3 fertilizers were greater than that of the check, while those of the 9-3-3 and 15-0-0 samples were less; the extremes were produced by the 0-15-0 and 15-0-0 fertilizers. These differences were obliterated late in the season.

Wayne,[2] Drueding[3] and Power and Browning[4] have

[1] $N–P_2O_5–K_2O$.

[2] E. S. Wayne, *The Pharmaceutical Journal and Transactions,* 3: 64–65, 1872.