

planations of the phenomena have never been satisfactory. It is for the most part not an absorption phenomenon but a true chemical reaction consisting of an exchange of bases between a soluble salt and silicate, or else a neutralization of acid substances by the base of a salt giving rise to a soluble acid, as in the case in acid soils. In the case of peats and soils high in organic matter, organic compounds may cause similar phenomena. The writer has been unable to obtain or find any data which on careful consideration would lend support to the colloid absorption theory of soil acidity.

The new test for soil acidity which the writer had previously described<sup>5</sup> has now been tried on a very large number of soils and found entirely satisfactory. As is obvious, it is absolutely necessary to use *neutral* calcium chloride and zinc sulphide in the test. Merck's reagents have given perfect satisfaction. In reply to Harris,<sup>6</sup> the writer wishes to state that acid soils react without the use of calcium chloride and hence his comment does not apply.

Although soils are composed for the most part of silica and silicates, yet the function of the silicates in soil fertility has been almost entirely ignored. Their function in the inorganic world is analogous to that of the proteins and carbohydrates in the organic world. The complex nature and behavior of the silicates makes possible the great regulatory processes going on in soils. The property of certain silicates by means of which they change from an active acidic state, a condition in which they actively take up bases from solution, to a condition of inactivity, and also the change in the reverse direction, is of the greatest importance. This property makes possible the presence of an enormous amount of such silicates which prevent undue loss by leaching without giving rise to the excessively acid condition which would otherwise be necessary. The root hairs of plants are probably among the most delicate of all external organs in either plant or animal life. In the

soil there are a great variety of processes going on, resulting undoubtedly in the formation of not only beneficial substances, but also of some harmful ones. If this is the case, it is probable that nature has made some provision for inhibiting the deleterious action of the harmful substances on the delicate root hairs. It seems possible that the silicates may form temporary combinations with these substances and thus prevent unfavorable action on the root hairs. The wonderful influences, in other than physical ways, of a small amount of such silicates commonly called clay, on the fertility of sandy soils has been known for a long time, and a consideration of the above aids greatly in its explanation. The writer has in preparation a detailed paper dealing with the subject of soil acidity and related phenomena.

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A NEW METHOD OF MEASURING THE CONCENTRATION OF THE SOIL SOLUTION AROUND THE  
SOIL PARTICLES

IN conducting a thorough investigation on the general subject of soil temperature the influence of soluble salts on the lowering of freezing point of soils was also studied. It was observed that the phenomena of supercooling and freezing behaved in moist soils exactly the same way as in solutions. These facts suggested the ideas that the freezing point method might be employed to measure the concentration of the soil solution around the soil particles. In order to ascertain whether or not this could possibly be done a series of experiments was instituted, using different classes of soil with various moisture contents, or known concentration of solutions. It has been found that the freezing point of the soil solution around the soil particles can be determined with great ease. Solidification can be started when the soil mass is supercooled to only about 0.2° C., by simply moving the thermometer in the soil. The starting of the solidification is far easier in soils than in solutions. The freezing point of soils can be determined even when the moisture con-

<sup>5</sup> *Loc. cit.*

<sup>6</sup> *Loc. cit.*

tent is reduced to or slightly below the wilting coefficient. In the case of quartz sand, for instance, the freezing point can be measured when the amount of water present is only about 0.8 per cent. Below the wilting coefficient the solidification is started with some difficulty, and the duplicate determinations do not agree very closely, especially if the concentration of the solution is very high. Above the wilting point the solidification does not only start with great ease, but the determinations can be duplicated with a surprising closeness; the values either agree exactly with one another or show deviations of only a few thousandths of a degree, using the Beekmann thermometer.

In determining the freezing point of different classes of soil the remarkable fact was discovered that the freezing point lowering, and consequently the concentration of the soil solution varies directly with the amount of water present. The following figures show the freezing point lowering, using distilled water as a basis of comparison, of natural soils containing high and rather low moisture content.

TABLE I

*Freezing Point Lowering of Different Classes of Soil at Different Moisture Content*

Soil	Freezing-point Lowering	Per Cent. Moisture
Sand .....	0.033° C.	6.22
Loam .....	0.050	33.46
Clay .....	0.098	24.68
Clay .....	0.090	38.00
Peat .....	0.021	181.60
Sand .....	0.171	2.80
Loam .....	0.251	25.15
Clay .....	0.695	18.23
Clay .....	2.290	12.00
Peat .....	0.050	138.97

It will be evident from the above table that when the soils contain a high moisture content the lowering of the freezing point, and consequently the concentration, is rather small, and does not vary greatly between the different soils. But when the moisture content of these same soils is reduced considerably, the lowering of the freezing point is increased in some cases very greatly. When it is considered that

about 4,000 parts of mineral salts in 1,000,000 of water cause a depression of the freezing point of only about 0.090° C., the above figures for the soils with low moisture content represent an enormous concentration, especially in some cases.

In order to ascertain (1) the sensitiveness of the method to detect differences in concentration in the soil solution, and (2) to see whether the concentration of the soil solution can be increased by the addition of mineral salts, a complete nutrient stock solution was prepared from which solutions were made up varying in concentration from 80 to 4,000 parts per million. The freezing point of these solutions alone, and in contact with soils was determined. Some of the results thus obtained are shown in Table II.

TABLE II

*Lowering of the Freezing Point of Soils with a Nutrient Solution of Different Concentration*  
Lowering of the Freezing Point

	80 P. P. M.	2,000 P. P. M.	4,000 P. P. M.
<b>Solution.....</b>	<b>0.005</b>	<b>0.043</b>	<b>0.083</b>
Sand .....	0.005	0.040	0.085
Loam.....	0.005	0.036	0.067
Clay.....	0.006	0.037	0.065
Peat.....	0.005	0.021	0.050

The values for the soils represent the depression of the freezing point caused only by the addition of the respective solutions; the depression due to the soils themselves has been deducted.

An examination of the above results reveals the interesting fact that the lowering of the freezing point of the solutions in contact with the soils does not vary very much from that of the solution alone.

There is at present no other method capable of measuring the concentration of the soil solution in the soil or around the soil particles. The foregoing method has yielded, thus far, some very remarkable results, and promises to give us a better understanding of the fundamental principles governing the soil solution.

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