The Chemical Composition of Virgin and Cropped Indiana Soils.

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In November, 1913, the Soils and Crops Department of the Purdue Agricultural Experiment Station collected samples of a large number of typical virgin and cropped soils, with a view to determine the chemical composition, to see if there was any appreciable difference in them. The samples were taken with an auger and each sample represented not less than five borings to a depth of six and one-half inches. Subsoil samples were taken at the same time and represented the layer from a depth of 12 to 18 inches. Great care was taken to select fields where uniform and typical samples could be secured. The samples in each case represent a heavily cropped soil and an adjacent virgin soil of the same type which had never been cropped. The virgin soil samples were taken from a line fence row, or from a woodlot which had never been cultivated. The separate samples were properly prepared and analyzed for various elements. Also composite samples were prepared from the virgin soils, the virgin subsoils, the cropped soils and the cropped subsoils. The composites were made by taking equal weights of the separate samples and thoroughly mixing them. The analyses of the separate samples not being completed up to the present time, the analyses of the composite samples only are given in this paper.

There is a rather widespread idea that the chemist can take a sample of soil and by making a complete analysis, determine without any other information just what element is deficient in the soil and needed as a fertilizer. This is not true, and it is very seldom that an analysis alone will indicate the needs of a soil. The chemist can tell with a fair degree of accuracy just how much of each element is present in the soil, but he is not able from a chemical analysis alone, to say what various crops are able to extract from the soil. The ability to determine the fertilizer needs of various crops on different types of soil is more or less a matter of

experience and is based largely upon the results of field fertilizer tests. However, a chemical analysis of a soil is often of great benefit in studying problems of soil fertility.

It is generally recognized that the removal of plant food by crops is not the only factor which may change the composition of a cultivated soil. The agencies of wind and water play a very great part in effecting changes. Insects, worms and animals often work through the soil and subsoil, causing variations and intermixtures. The crops themselves bring up from below quite a little plant food and deposit it near the surface in the decaying roots and stubble. In spite of the fact that the tendency of nature is to build up and replenish the fertiliy of soil, there is no question but that the destructive system of cultivation that has been followed by the farmers of this country has more than counter-balanced nature's tendency to upbuild, and as a consequence the soil has become more or less depleted. It is believed that the analyses presented in this paper show what chemical changes have been effected in the average soil of Indiana by cropping it for from sixty to eighty years.

TABLE I.

Analysis of Composite (31) Virgin and Cropped Soils.

Material.	Virgin Soil.	Virgin Subsoil.	Cropped Soil.	Cropped Subsoil.
Insoluble silica, etc.	88.49%	87.30%	89.59%	86.37%
Potash (K_2O) (Acid soluble)	.26	.36	.23	.34
Soda (Na_2O) (Acid soluble)	.20	.20	.17	.21
Lime (CaO) (Acid soluble)	.43	.34	.43	.51
Magnesia (MgO) (Acid soluble)	.41	.60	.40	.60
Manganese oxid (Mn_3O_4) (Acid soluble)	.14	.08	.07	.09
Ferric oxid (Fe_2O_3) (Acid soluble). Alumina (Al_2O_3) (Acid soluble)	5.03	8.01	5.31	8.60
Phosphoric acid (P_2O_5) (Acid soluble)	.12	.07	.11	.07
Sulphur trioxid (SO_3) (Acid soluble)	.06	.05	.06	.04
Volatile matter	5.28	3.20	3.88	3.25
Total	100.42	100.21	100.22	100.08
Total nitrogen	.18	.07	.13	.06
Total potash (K_2O)	1.83	1.88	1.94	1.92
Total humus	1.98	.60	1.04	.40
Acid humus	1.16	.44	.84	.48

A glance at the analyses in Table I will show that although most of the soil ingredients have not changed enough to make any great difference in the chemical composition of the virgin and cropped soils, there are some notable exceptions.

The most serious losses from the standpoint of soil fertility are those of nitrogen, which shows a loss of 28%, and the organic matter, which shows a loss in the volatile matter of 26%, and in the humus of 47%. These losses are without doubt the main reason why our cropped soils are no longer as fertile as they formerly were. Fortunately the remedy for replacing nitrogen and organic matter is not beyond the means of the average farmer. Greater care in utilizing crop residues and barnyard manure, also the growing of legumes in a good crop rotation are necessary steps in replacing these vital losses. The purchase of organic matter, other than farmyard manure, is out of the question, while the use of nitrogenous fertilizers which often give profitable returns, can only be recommended as a temporary resort.

While the phosphoric acid and potash show only about 10% loss, it should be remembered that this 10% was the most available portion of these important elements. Fertilizer practice in the older and more worn lands of Indiana shows that there has been a loss in these elements and that in a great many cases their use as fertilizers is very profitable. Due to the fact already mentioned that the soil through natural agencies is constantly in motion, it should be pointed out that the addition of one or two tons of rock phosphate per acre to the land for the purpose of increasing the phosphorus content of it for a long time to come, is a practice of doubtful efficiency. There is a strong probability of loss of such fertilizer, due to removal by wind or water, or to being buried out of reach of the plants by these or other natural agencies. Smaller amounts of more available phosphorus or potash fertilizers, on the other hand, will be quickly utilized by the crops and hence not so liable to be lost. Experiments which have been conducted by the Purdue Experiment Station show greater profit from the use of acid phosphate than from raw rock phosphate. (Bul. 155, Purdue Experiment Station and the 27th Annual Report, Purdue Experiment Station, 1914.)

The analyses of calcium and magnesium in the virgin and cropped soils show no apparent change. This is rather surprising as we have been led to think of these elements, especially calcium, as being very soluble. The loss of lime, as reported by the Rothamsted Station, has been shown

to be from 500 to 1,000 pounds per acre per year. There is one important difference in the Rothamsted soil and the average Indiana soil, and that is in the fact that the Rothamsted soils in the experiments reported have from two to four per cent. calcium carbonate. The Indiana soils shown in these analyses, on the other hand, have no calcium carbonate. The calcium and magnesium in these Indiana soils are in the form of more or less insoluble silicates. The inference to be drawn, therefore, would be that there is no great loss of calcium or magnesium in acid soils in which these elements are in the form of silicates. This does not mean that these soils do not need lime for, as a matter of fact, they respond readily to the application of lime, which is needed for the proper growth of clover. The need for lime is greater now than it was in the virgin soils because the organic matter has been burned out of the cropped soil. Given two soils with the same calcium and magnesium content and the same degree of acidity but with different amounts of organic matter, the one with the greater organic matter content will grow better crops of clover and will not be in so great a need of lime as the other.

The virgin and cropped soils show no great difference in the content of sulphur. Experiments in Wisconsin and Kentucky have shown that in a number of instances sulphur has been reduced in soils by cropping.

Manganese shows quite a loss in the cropped soil. The effect of manganese on soil fertility is attracting more or less attention among soil investigators, and although nothing definite seems to be known about its action, it is possible that it does play an important part in agriculture.

The changes in the content of silica, iron and aluminum are believed to be of no importance as plant foods. They do, no doubt, have a very important bearing upon the physical constitution of the soil. The writer believes that the constitution of the silicates of iron, and especially of aluminum, has more to do with injurious soil acidity than any other factor.

The method of determining soil acidity (limestone required) in this work is that given in Bulletin 107 (Revised edition), Bureau of Chemistry, U. S. Department of Agriculture. This method shows a relative acidity in soils that is believed to more nearly represent toxic acidity than any other method, especially in soils containing much organic matter. It is interesting to note that while the acidity of the cropped soil has increased, the acidity of the cropped subsoil has decreased.

TABLE II.

Fertility in Virgin and Cropped Soils.

Pounds Per Acre in Two Million Pounds of Surface Soil and Four Million Pounds of Subsoil.

Material.	Virgin Soil.	Virgin Subsoil.	Cropped Soil.	Cropped Subsoil.
Volatile matter	105,600	128,000	77,600	130,000
Humus	39,600	24,000	20,800	16,000
Nitrogen	3,600	2,800	2,600	2,400
Potassium (Total)	32,464	66,702	34,416	68,121
Potassium (Acid soluble)	4,615	12,773	4,080	12,063
Phosphorus (Acid soluble)	1,046	1,221	959	1,221
Calcium (Acid soluble)	6,864	9,724	6,864	14,586
Magnesium (Acid soluble)	4,953	14,496	4,832	14,496
Manganese (Acid soluble)	2,016	2,304	1,008	2,592
Sulphur (Acid soluble)	480	800	480	640
Limestone required (Acidity)	60	2,600	100	1,120

Table II gives the pounds of the different elements in the plowed soil of 2,000,000 pounds per acre, and in the subsoil of 4,000,000 pounds per acre. It shows the same relative differences as given in Table I, but in different terms.

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