THE COMPARATIVE RATE OF FORMATION OF SOLUBLE MATERIAL IN CROPPED AND VIRGIN SOILS AS MEASURED BY THE FREEZING-POINT METHOD

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In studies looking toward the maintenance of soil productivity, the importance of information regarding the changes a soil undergoes in passing from a virgin or fertile condition to a semi-productive state has long been recognized. Many chemical methods have been devised to measure such changes, the relative solubility of the soil constituents in water, and mineral and organic acids of different strengths being the basis of comparison. Much valuable information has been afforded by such researches, but no consistent correlation between the crop-producing power of soils and the amount of plant-food elements soluble in any of the reagents tried has been found. Recently Jordan (1) made studies of several soils of different productive power. All the common methods of analysis were made use of, including continuous leaching with water. While there appeared to be some relation between the organic matter extracted by water in one and ten-day periods, respectively and the dry matter of barley produced, the general conclusion was drawn that there was no consistent relation between the crop-producing power of the soils and either their composition as determined by total analysis or the material soluble in any of the solvents used. A review of the available literature shows this conclusion to be in accord with the findings of numerous other investigators.

It was pointed out in a previous publication (2) that the rate of formation of soluble material as measured by the freezing-point method under different conditions of moisture content and temperature was on the whole greater in a virgin than in the corresponding cropped soil. A difficulty experienced in carrying on the experiments referred to was the tendency for the concentration of the soil solution to reach a maximum and decrease within a period of 30 days. This tendency was more pronounced in the case of the virgin than of the cropped soils and consequently the concentration of the solutions tended to approach each other in this time rather than diverge, as might otherwise have been the case.

Experiments conducted with the view of ascertaining the effect of washing soils with distilled water until the concentration of the soil solution was reduced to only a few parts per million, upon the subsequent rate of formation

FIG. 1. DIAGRAM SHOWING THE RATE OF FORMATION OF SOLUBLE MATERIAL IN CROPPED AND VIRGIN SOILS

FIG. 2. DIAGRAM SHOWING THE RATE OF FORMATION OF SOLUBLE MATERIAL IN CROPPED AND VIRGIN SOILS

of soluble material, brought out the fact that when soils are so treated the tendency for the concentration of the solution to reach a maximum and then decrease is largely obviated (3). The idea, therefore, suggested itself that if the cropped and virgin soils to be compared were washed as above described and the rate of increase of the concentration of the solution measured, more accurate information regarding the rate of formation of soluble constituents might be obtained.

DESCRIPTION OF SOILS STUDIED

Six soils representing the prevailing types of upland soils in the vicinity of East Lansing were selected for this investigation. Soil 1 is a silt loam of the Miami series and represents the remains of a moraine. It has been under cultivation for 75 years or more but has been handled fairly well. Nevertheless, there has been a marked decrease in its content of organic matter and the crop-producing power has materially changed.

Soil 2 is of the same formation as no. 1. This piece of land has been handled very carelessly and is in an exceedingly poor condition.

Soils 3 and 4 are from low areas surrounded by morainic and till plain formations, respectively. These areas are small in extent and receive considerable wash from the surrounding high land. Both soils are quite high in organic matter and though they have been cropped for many years, their productivity has not appreciably decreased.

Soil 5 is a sand from a till plain area. It has been under cultivation for more than 60 years and is much depleted as a result of tenant farming. The last few years it has been receiving better treatment, and it will be exceedingly interesting to note if any change in the rate of formation of soluble material results from a continuation of this treatment.

Soil 6 is a very fine sandy loam of morainic formation. It belongs to the Miami series and has been under cultivation many years. The system of management has been good and while it is not as productive as originally, it still grows good crops and cannot be classed as a depleted or "run down" soil.

METHOD OF PROCEDURE

Seventy-five grams of air-dry soil were placed on a coarse filter paper in a funnel and washed with distilled water until the soluble material was practically all removed, as indicated by the freezing-point method. When water ceased to drain from the soil, it was thoroughly stirred and samples placed in ordinary freezing-point tubes. By this procedure the soil retained sufficient water so that a short column $\frac{1}{8}$ to $\frac{1}{4}$ inch in height stood over the soil in the tube. The tubes were stoppered and placed in a constant temperature chamber at 25°C. Shortly after the tubes were placed in the chamber the stoppers were removed for a moment to relieve any air pressure which might have developed at the higher temperature. Every few days the contents of the tubes were thoroughly stirred and the tubes allowed to remain unstoppered for a short time to allow the escape of any gas which might have accumulated. The freezing points of the soils were determined in the usual manner after 5, 10, 20 and 40 days. The data obtained are presented in table 1 and in graphic form in figures 1 and 2.

TABLE 1

Freezing-point depressions at different periods of cropped and virgin soils maintained at 25°C., and the corresponding parts per million of soluble material

SOIL	ORIGINAL		AFTER 5 DAYS		AFTER 10 DAYS		AFTER 20 DAYS		AFTER 40 DAYS	
	Freezing point depressions	Soluble material	Freezing point depressions	Soluble material	Freezing point depressions	Soluble material	Freezing point depressions	Soluble material	Freezing point depressions	Soluble material
		<i>p.p.m.</i>		<i>p.p.m.</i>		<i>p.p.m.</i>		<i>p.p.m.</i>		<i>p.p.m.</i>
1. Virgin.....	0.001	25	0.021	525	0.034	850	0.045	1125	0.035	875
Cultivated....	0.000	000	0.009	225	0.012	300	0.012	300	0.018	450
2. Virgin.....	0.000	000	0.012	300	0.025	625	0.027	675	0.025	625
Cultivated....	0.000	000	0.008	200	0.011	275	0.007	175	0.010	250
3. Virgin.....	0.002	50	0.018	450	0.034	850	0.032	800	0.035	875
Cropped.....	0.001	25	0.013	325	0.034	850	0.030	750	0.030	750
4. Virgin.....	0.000	000	0.024	600	0.034	850	0.032	800	0.026	650
Cropped.....	0.000	000	0.016	400	0.032	800	0.026	650	0.029	725
5. Virgin.....	0.000	000	0.018	450	0.019	475	0.024	600	0.020	500
Cropped.....	0.000	000	0.004	100	0.004	100	0.007	175	0.010	250
6. Virgin.....	0.000	000	0.010	250	0.016	400	0.026	650	0.022	550
Cropped.....	0.000	000	0.008	200	0.010	250	0.019	475	0.024	600

DISCUSSION

The data presented show that the tendency for the concentration of the soil solution to reach a maximum and decrease before the end of the 40-day period was practically overcome by the washing. Some tendency for the concentration to decrease was exhibited by the virgin sample of soil 1 and by both the cropped and virgin samples of soil 4. The changes, however, were not sufficient to affect the conclusions.

Three of the soils studied, nos. 1, 2 and 5, showed a decidedly greater rate of formation of soluble material in the virgin than in the cropped samples. In addition, the total concentration of the soil solution was much higher in the case of the virgin samples. Of the remaining soils two, nos. 3 and 4, showed very little difference in either the rate of formation of soluble material or the total concentration of soil solution attained. It is noteworthy that these two soils are the ones which have shown very little change in productivity as a result of several years' cultivation. Soil 6 showed only a slightly greater rate of formation of soluble material in the virgin than in the cropped sample, the final concentration of soil solution being virtually the same. If the rate of increase of concentration of the soil solution under the conditions used is a criterion of the productivity of soils, one must conclude that this soil is not seriously depleted.

How much of this formation of soluble material is due to biological activities and how much to the direct solubility of the soil constituents, is a question which offers opportunity for much interesting research. This with other problems arising from the work presented is under investigation in the soils laboratories of the Experiment Station.

The writer realizes that the number of soils used in these experiments is small but the data are so in accord with the crop-producing power of the soils that he feels justified in suggesting that a marked decrease in the rate of formation of soluble material is one of the changes a soil may undergo as a result of several years of cultivation with the return of little fertilizing material.

The writer desires to express his gratitude to Dr. M. M. McCool for many helpful suggestions in connection with the above investigation.

REFERENCES

- (1) JORDAN, W. H. 1916 Measurements of soil fertility. N. Y. State Agr. Exp. Sta. Bul. 424.
- (2) MCCOOL, M. M., AND MILLAR, C. E. 1918 Soluble salt content of soils and some factors affecting it. Mich. Agr. Exp. Sta. Tech. Bul. 43.
- (3) MCCOOL, M. M., AND MILLAR, C. E. Mich. Agr. Exp. Sta. Unpublished data.