# SPECIAL ARTICLES

## THE ROLE OF MICROORGANISMS IN THE CONSERVATION OF THE SOIL

CONSIDERABLE public attention has been focussed in recent years upon the problem of soil conservation, largely because of the effort made by the Federal Government to initiate large-scale investigations and to establish soil conservation agencies and special experiment stations in all parts of the country. Most of the investigations in this field have been largely based upon agronomic approaches and practical methods for preventing soil and water losses. Although some attention has been paid to the physical and chemical soil conditions, comparatively little consideration has been given to the possible role of the numerous soil-inhabiting microorganisms in the process of soil conservation. It is also generally recognized that soil organic matter, with which the soil organisms are intimately connected, plays an important part in conserving the soil; however, little is known as to whether this phenomenon is due to the organic matter as a whole or whether only a certain fraction of the organic matter is involved in the process.

A consideration of this important national problem, from a microbiological point of view, brings forth several phases which deserve careful investigation, namely: (1) the function of the cells of microorganisms, especially the mycelium of the fungi and actinomycetes, as soil-binding agents; (2) the production by microorganisms, notably by bacteria, of specific substances, such as slimy materials, which aid in binding the soil particles; (3) the specific stage of decomposition of organic matter added to the soil when it is most active in bringing about a binding or aggregation of the soil particles; (4) the formation, as a result of decomposition, of chemical complexes, comprising certain humus constituents, such as the so-called "humic acid" compounds, which exert a physical or perhaps even chemical effect upon the inorganic soil particles.

In a series of studies carried out at the New Jersey Agricultural Experiment Station, an attempt has been made to throw light upon some of these problems. These studies comprise both laboratory and field investigations.

Because the soil microorganisms differ in the type of growth and in the nature of the substances synthesized, it is logical to suppose that some organisms will affect the physical properties of the soil to a different degree or in a different manner from others. In order to ascertain the extent of soil binding and aggregation brought about by microorganisms, artificial soils were employed consisting of sterile sand-bentonite and sand-clay mixtures. Sucrose or cellulose were used as sources of energy, and nutrient salt solutions were added. The artificial soils were adjusted to optimum moisture and inoculated with pure cultures of fungi and bacteria or with a soil infusion. After various periods of incubation, the contents of the flasks were analyzed, using certain procedures designed to show relative differences in the binding effect upon the soil particles.

Certain typical results are presented in Table I.

TABLE I

BINDING EFFECT OF MICROORGANISMS UPON THE FINE PARTICLES IN SAND-BENTONITE MIXTURES[1]

| Energy source | Organism | Pipette method: Unbound material in 50 gm | Pipette method: Bound | Slope method: Unbound material in 50 gm | Slope method: Bound |
|---|---|---|---|---|---|
| | | gm | per cent. | gm | per cent. |
| Sucrose | Control | 2.12 | 0 | 1.1 | 0 |
| " | *Rhizopus nigricans* | 2.07 | 3 | 0.7 | 36 |
| " | *Aspergillus niger* | 1.60 | 25 | 0.3 | 72 |
| " | *Azotobacter indicum* | 1.57 | 26 | 0.45 | 60 |
| " | *Bacterium fluorescens* | 1.90 | 10 | 0.7 | 36 |
| " | Soil infusion | 1.76 | 17 | 0.6 | 45 |
| Cellulose | Control | 1.86 | 0 | 0.8 | 0 |
| " | *Trichoderma köningi* | 1.54 | 18 | 0.6 | 26 |
| " | *Trichoderma+A. fumigatus* | 1.61 | 14 | 0.65 | 21 |
| " | *Trichoderma+Penicillium* | 1.48 | 21 | 0.6 | 26 |
| " | Soil infusion | 1.11 | 41 | 0.45 | 45 |

[1] Incubation period, 23 days for sucrose cultures and 55 days for cellulose cultures.

They show beyond a doubt that soil microorganisms exert an important binding effect upon the fine soil particles and that the degree of binding depends on the organisms involved. The contents of the flasks containing the fungi showed that the whole mass of artificial soil was held together by an extensive mycelial network. When the material was dried, it fell apart in a granular state. The contents of the flasks inoculated with *Azotobacter indicum* were held together by the slimy substances produced by the organism. Similar results were obtained by the use of sand-clay mixtures.

It is well established that when fresh or decomposed organic matter is added to the soil it brings about favorable changes in the physical properties of the soil, with a tendency to decrease soil erosion. The favorable effect is believed to be due primarily to a mechanical binding of the soil particles by the organic matter and to an increased aggregation of the soil brought about by physico-chemical interactions between the organic matter and the soil constituents. Increased moisture-absorbing and moisture-holding capacities might also be a factor. These changes increase percolation and infiltration, which in turn decrease run-off and erosion. If there were no microorganisms in the soil to decompose the organic matter the effect would be largely mechanical. However, when fresh organic matter is added to the soil countless organisms immediately begin to decompose it. Decomposition products and substances synthesized by the organisms interact with the fine soil particles, causing them to aggregate. The organisms themselves also tend to bind the soil particles.

Since plants and humus deposits differ in chemical composition, it is likely that organic matter from various sources will not affect the physical properties of the soil alike. In certain experiments designed to determine the effect of various typs of organic matter on the physical properties of the soil, related to soil erosion, a field soil was treated with alfalfa, straw, manure and peat material. At various intervals the total organic carbon, moisture-holding capacity, infiltration capacity and dispersion ratio were determined. The results showed that all four types of organic matter increased the infiltration capacity, with peat being most effective. Alfalfa, straw and manure brought about a rapid increase in the number of water-stable aggregates, as measured by the dispersion ratio, with alfalfa producing the greatest increase. Peat caused only a small increase in aggregation. After three months' decomposition, under favorable moisture and temperature conditions, the increase in aggregation had almost disappeared in the case of straw and peat; it was still apparent to some extent in the case of the manure and was quite marked in the alfalfa-treated soil.

In conclusion it may be stated that the role of microorganisms in soil conservation is highly important and is closely associated with the transformation of the organic matter added to the soil.

The detailed results of these experiments and the methods employed will be published in *Soil Science*.

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## ON THE MOLECULAR WEIGHT OF THE TOBACCO MOSAIC VIRUS PROTEIN

IN recognition of the unreliability of the value of 17 million for the molecular weight of the tobacco mosaic virus protein, as calculated from the sedimentation constant[1,2] of $170–200 \times 10^{-13}$, Stanley[3,4,5] and his co-workers have recently attempted a correction for the molecular weight by a combination of the data obtained by means of the standard Ostwald viscometer and the Kuhn, the Eisenschitz and the Perrin equations. The assumptions were that one could estimate the value for the relative dimensions of the elongated particles from viscosity data, and that these relative dimensions could be used in calculating the asymmetry constant to be used in conjunction with the data obtained from the ultracentrifuge. It has been protested[5] that the failure of the protein-water system to follow the Poiseuill's and Fick's law is not of sufficient importance to impair the usefulness of these methods in determining the asymmetry constant, and that all the data relative to the size and shape of the virus protein molecule are in good agreement.

An appreciation of the extent to which sols of the virus protein deviate from Fick's law may be obtained from Fig. 1. The data presented were obtained from a

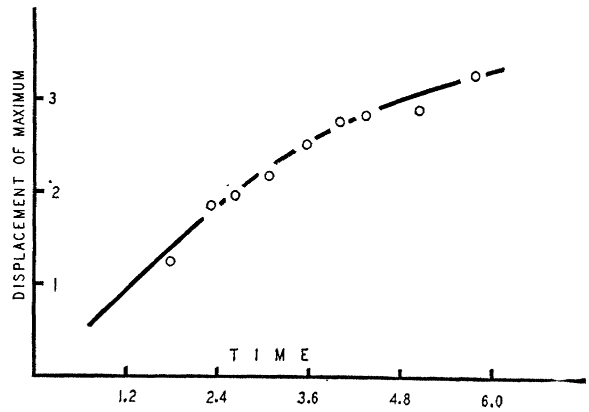


FIG. 1.

diffusion study, using the refractory method of Lamm,[6] of a sol containing .87 per cent. electrodialyzed protein dispersed in distilled water. As has been pointed out,[7,8] the curves obtained by plotting the displacement of the scale lines against the original line positions in the case of the virus protein are skewed, and the point of maximum displacement is shifted toward the solvent side. The rate of drift of the point of maximum displacement is shown in Fig. 1. The abscissa is in $10^5$ seconds; the ordinate is in millimeters. The ratio of the distance from the midpoint of the diffusion cell to the lens to the distance from the midpoint of the cell to the scale was .78. Substances that obey the normal laws of diffusion yield curves that are symmetrical with the maximum displacement at the original interface.

The normalized curves deviate markedly from the ideal. The maximum ordinates in normalized coordinates obtained after 1.78 and $5.85 \times 10^5$ seconds respectively were .62 and .74. The ordinate of the maximum for the ideal curve

$$y = \frac{1}{\sqrt{2\pi}} \quad e^{\frac{-x^2}{2}}$$

is .40. Following the "maximum height" method of

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[4] H. S. Loring, M. A. Lauffer and W. M. Stanley, *Nature*, 142: 841, 1938.
[5] M. A. Lauffer and W. M. Stanley, *Chem. Rev.*, 24: 303, 1939.
[6] O. Lamm, *Zeit. Physik. Chem.*, Abt. A 138: 313, 1928.
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