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Attention is called to the "Wants" column. All are invited to use it in soliciting information or seeking new positions. The name and address of applicants should be given in full, so that answers will go direct to them. The "Exchange" column is likewise open.

THE STRUCTURE AND PHYSICAL PROPERTIES OF SOILS.[1]

THERE is no more important economic problem to-day than the production of food and textile fibre to support the life of a rapidly increasing population and to supply their rapidly increasing wants in this age of advancing civilization. Agriculture is the basis of all manufactures, trades, and commerce, and the soil is the basis of all agriculture. This was not generally recognized until Liebig's brilliant generalization of the mineral theory of plant growth, and there was in consequence no material advance in agricultural methods or practices until his time. Since then this mineral theory has been the subject of a vast amount of the most patient research, carried on in the field, laboratory, and plant house. At first it was only considered necessary to determine the chemical composition of a soil and the composition of a given crop to indicate whether the soil had all the elements of plant food in the relative amount contained in the plant, to show whether the soil was well adapted to the crop, or how it could be made so by the addition of chemical substances. Then it was found that all soils have sufficient plant food for ages to come, and that continued cropping during the lifetime of a man would not reduce this amount materially. Then it was claimed, and is still held by many, that only a very small part of the plant food in the soil is in a condition to be readily available to plants, and if this available food is not used up it quickly reverts to a rocky and insoluble form. Then it was endeavored, by the use of solvents of various strengths, to determine how much of this plant food is at any time available to plants; and failing in this, the work has been pushed blindly forward with plat experiments, trying all kinds of mixtures of all kinds of fertilizers, on all kinds of soils, indiscriminately, as one might go into a drug store in the dark and blindly try all the drugs to cure dyspepsia, for it is dyspepsia that affects the plant more often than any thing else,—an inability to appropriate and assimilate the food within reach. We are spending vast sums of money for commercial fertilizers, which are used indiscriminately on all classes of soil, whether they be light and sandy, or stiff with clay.

The physical character of the soil has been considered, in all or nearly all the investigations I have ever seen, a vague, complex, but, on the whole, a relatively unimportant factor. The soil is considered a unit. Soils differ physically, just as men differ physically. There is a type of soil suited to grass, another to wheat, others to the different grades of tobacco, and still others to trucks and vegetables. The whole appearance and aspect of the soils differ to the eye and touch.

It is a notorious fact that changing seasons of wet or dry, or hot or cold, have far more effect on the crops than any combination of manures. This in itself is a significant fact.

In ten years a soil may be so worn out as to become a barren waste. This is not from any loss of plant food, for the amount so removed from the soil is relatively so small that it cannot be detected with any certainty. But the fact confronts us, that the wheat and corn lands of the great North-west are deteriorating, and the wheat and tobacco lands of our own State are deteriorating, both as to quality and quantity of product.

I come now to the main point of this paper, that the exhaustion of soils is physical rather than chemical; that vegetation, under given climatic conditions, is dependent upon the circulation or movement of water in the soil, and that it is possible to change the physical conditions of the soil so as to control this water circulation, and so control the growth and development of the plant. Nay, further, that the chief benefit derived from the use of commercial fertilizers and manures is their physical effect on the soil, which modifies the relation of the soil to water, rather than, as heretofore supposed, to the actual amount of food they supply the plant. The soil is to be considered as a vast irrigating pump which provides standing room for the plant and supplies it constantly with nutritive fluids. If too much water is supplied the plant is inclined to develop leaf in large excess; if too little water is supplied the growth is stunted, but it puts on relatively more fruit. It is a mean between them that is desired for all plants, but a different mean for each class of plants.

The soil is composed of minute fragments of rocks and minerals, with varying quantities of organic matter. Even the poorest and most barren soils are shown by chemical analysis to have sufficient plant food for countless generations of plant life, while in ten years or less a soil may be "worn out," and made for a time a barren waste.

However compact and continuous and close textured a soil or sub-soil looks, there is still about fifty per cent by volume of empty space between the solid particles. That is, a cubic foot of soil will hold half a cubic foot of water, if all the space is filled. Clay soils have more empty space than sandy soils. We have found on the average about forty-five per cent by volume of empty space in sandy soils and fifty-five per cent in clay lands. The amount of empty space in the soil may readily be calculated by dividing the weight of soil by the specific gravity, which gives the actual volume of the soil grains, and subtracting this from the total volume occu-

[1] Abstract of a paper read by Professor Milton Whitney of the Maryland Agricultural Experiment Station before the University Scientific Association, March 25, 1891.