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Food For the Soil

Legumes

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Soil is the most precious of the material possessions of the farmer. It represents the most valuable bequest he can leave to his children and their children. The farm buildings may burn, they can be replaced; the trees may die or be destroyed, another crop can be grown in a generation; but if the soil is lost the farm becomes a barren waste, which nature alone, working for hundreds of years, can replace. In a few years the soil may be so injured that it will require decades to repair it. To maintain the soil of his farm in as good condition as when he acquired it, or even to improve it, is one of the most important duties of the farmer. The soil turned by the plow represents so much capital, for it contains material which the plant uses for food. Ten chemical elements are necessary for plant growth. They are: carbon, oxygen, hydrogen, nitrogen, phosphorous, potassium, magnesium, calcium, sulphur and iron. Each of these elements is as essential as any other. For example, if a soil contains no iron, a crop can not be grown upon it. Every soil is, however, so well supplied with iron that the yield of the common crops will never be limited by the fact that the plant cannot secure enough to make the maximum growth. The same is true of some of the other

BACTERIA ARE SMALL, BUT MIGHTY

They have made a crop grow on a soil which was barren.

essential elements, but not of the five elements, calcium, sulphur, potassium, phosphorous, and nitrogen. These are the ones that are lost or are removed from the soil most rapidly. They are the ones the farmer must sooner or later add to his soil if he is to maintain or increase its fertility. The rapidity of loss of these elements depends in part on the type of farming, that is, whether the entire crop is sold (hay), whether only a part is sold (grain), or whether the products sold contain but small quantities of these elements (butterfat).

CERTAIN ELEMENTS MUST BE BOUGHT

If the farmer finds that his soil is becoming low in phosphorus, potassium, sulphur or calcium, he can repair the damage by purchasing some substance that contains the needed element and adding it to his soil. In brief, the repair process means that he must purchase the fertilizer from some one who owns one of the natural deposits. Thus the farmer of Wisconsin buys rock phosphate mined in Tennessee or Florida and transports it to his particular soil. For his supply of these elements he is dependent on some one else's supply.

NITROGEN NEED NOT BE BOUGHT

Nitrogen is the element that most frequently determines the size of the crop. It is removed from the soil in large amounts by the crop, and also large quantities are removed each year by the drainage water. If the farmer tries to replace the nitrogen, which has been lost or removed, by securing a supply from a natural deposit, he finds it so expensive that under ordinary farm conditions, it is not a profitable undertaking.

The sole store of phosphorous, potassium, magnesium, calcium, iron, and sulphur is in the soil. A supply of nitrogen is likewise in the soil where it is combined with other elements. The great natural store of nitrogen, however, is in the air. Every farmer who owns an acre of land owns 70,000,000 pounds of nitrogen. It is not directly available as a fertilizer for, unlike that in the soil, it is not combined with other elements. Nature has so arranged things that whereas the farmer loses his capital of nitrogen from the soil more rapidly than that of the other elements, he has also been provided with a means by which he can be compensated for this loss by drawing on the great reserve supply that is in the air.

In this process he must use a leguminous plant, like clover, alfalfa, beans, peas, sweet clover, or vetch, and the bacteria which have the power to enter and produce nodules or tubercles on the roots of these legumes. These two plants, the legume and the bacteria, working together can make use of the uncombined nitrogen that is in the air. It is believed that the bacteria first fix the nitrogen in some form in which it becomes available to the green plant, and that the plant furnishes the necessary food to the bacteria. Thus the two plants living together are mutually helpful, the bacteria are enabled to grow under conditions that otherwise would not permit growth, and the green plant is enabled to grow luxuriantly under conditions which would furnish but a small yield. The farmer growing legumes and bacteria can make some use of the millions of tons of free nitrogen that belong to him. By this process he can replace the nitrogen removed from the soil either in the crops, in the animal products he sells, or in the drainage water. In other words, by employing the agencies that nature has provided the farmer is independent of every one else in maintaining the nitrogen supply of his soil. The maintenance of the farm's fertility depends in no small part on how successfully and to what extent the farmer makes use of this peculiar relation between legumes and nodule-forming bacteria.

CHOOSE LEGUMES BEST FOR WISCONSIN SOILS

The farmer must select the legume or legumes that will grow best in his part of the country and on his particular piece of land. If his soil is acid, a leguminous plant must be selected that will grow well on such a soil. It is known, for example, that alfalfa is affected more by acid soil than is red clover, and clover more than are soybeans. The temperature is also important; alfalfa does not withstand cold so well as clover. The farmer and his advisers must learn that little progress can be made in opposition to nature. She has provided some legume that will grow well on his soil, and that is the one for him to use.

After the legume is selected, the farmer must see that the proper bacteria are at hand, for with few exceptions, it may be said that each kind of a legume is benefited only by the particular kind of bacteria that has been associated with it in nature. If the legume is a native, it is probable that the soil contains plenty of the proper kind of bacteria and the only seed the farmer needs to sow is that of the legume. But if the legume is one that is not native to that region, for instance alfalfa and soybeans in Wisconsin, the farmer must likewise sow the proper kind of bacteria on his field.

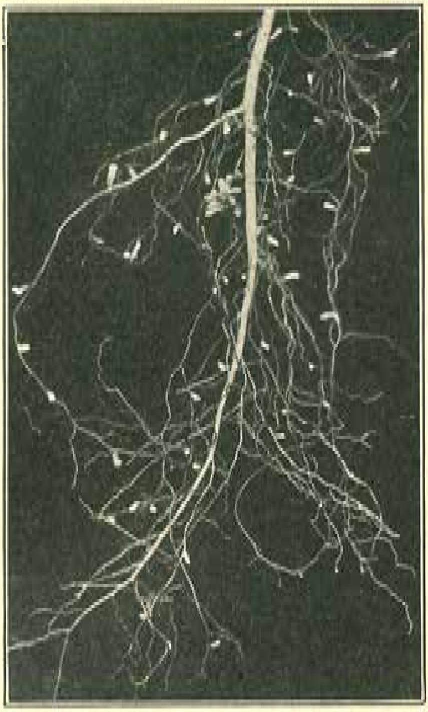

FIG. 2.—THE HOME OF THE MICROSCOPIC CROP

The nodules contain great numbers of the bacteria that are drawing nitrogen from the air and making it available to the leguminous plant.

Without the bacteria he may get a fair crop, but all of the nitrogen will have to come from the soil, while with the proper bacteria present a large part of the nitrogen will be taken from the air. The farmer buys his alfalfa or soybean seed or sows that which he himself has raised. In case of the bacteria the same method is followed. If he has grown alfalfa and, if, on examination, has found the roots well studded with nodules (Fig. 2), he may be certain that in the soil of the field on which the legume has been grown plenty of the right kind of bacteria are present. He has only to scatter some of this soil over the surface of the new field in order to seed it with the proper bacteria. If he must purchase the bacteria, he may obtain some soil from a neighboring farmer whose alfalfa roots are well covered with nodules, or he may secure the seed (bacteria) from some one who has the facilities for growing the bacteria in the laboratory.

EACH LEGUME HAS ITS OWN KIND OF BACTERIA

The legume seed should not contain weed seed; it should be of the right variety and have a high germinating value. The bacteria must likewise be pure, of the kind to produce nodules on the legume that is to be grown and show a high germination. To secure these properties in both seed and bacteria, the farmer must rely on his own supply or deal with trustworthy and long established dealers whose chief asset is the good will of their customers.

Just how effective the combination of legume and bacteria will be in maintaining or increasing the nitrogen content of the soil depends on the disposal made of the legume. If the entire plant is returned to the soil, the nitrogen content thereof will gradually be increased, because, as a rule, the nitrogen taken from the air will more than equal that lost in the drainage from the field. If the crop is removed and sold for hay, there will probably be no increase in the nitrogen content of the soils, for that removed and sold and that lost in the drainage will be greater than the amount taken from the air by the bacteria and green plant. In other words, when a leguminous crop is sold there is probably little opportunity for the farmer to increase the fertility of his fields, but the supply of nitrogen in the soil will be exhausted much less rapidly than when a non-legume is grown because the bacteria and the legume will draw a part of their nitrogen from the air.

THE STORY THE PICTURES TELL

The pictures tell a story of what may be done under the most favorable conditions in building up a soil that is infertile because of lack of nitrogen. Pure quartz sand, which contained no more plant food than a pile of ground glass, was supplied with all the elements needed by the plant for its growth, except nitrogen. In one portion of the sand legumes without the nodule-forming bacteria were grown. Four such crops of legumes were grown and added to the soil. Every crop was a failure. In another portion of the sand legumes and the proper bacteria were grown. Each of these four crops was a success. As a measure of what had been accomplished, a crop of a non-legume, oats, was grown. In the sand in which legumes alone had been grown the oat crop was a failure (Fig. 9). This sand did not contain enough nitrogen to enable normal growth to take place. In the sand in which four crops of legumes together with bacteria had grown the oats gave a luxuriant crop. Legumes and bacteria are changing the sand to a *soil;* with the legume alone the sand remains *sand.*

If the farmer is to make use of the nitrogen of the air, he must grow legumes and bacteria. He must become a grower of the green plant, the legume of his choice, and a grower of bacteria, the choice of the legume.

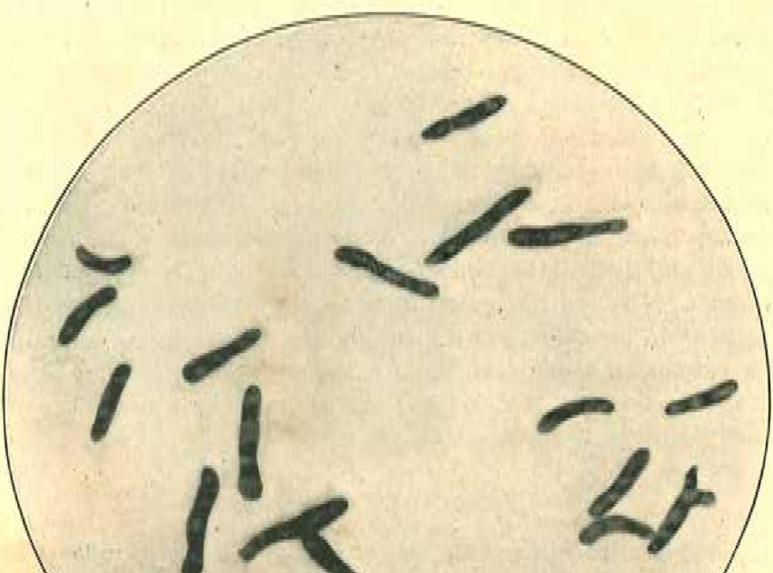

FIG. 3.—A PART OF THE MICROSCOPIC CROP

The nodule-forming bacteria of alfalfa appear in this picture 2,250,000 times larger than they actually are.

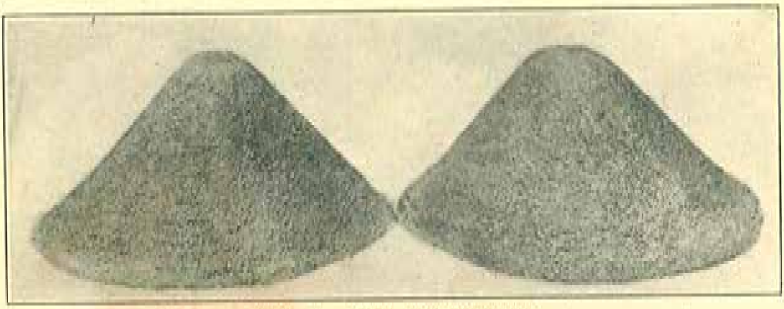

FIG. 4.—THE BEGINNING

Two piles of pure white sand.

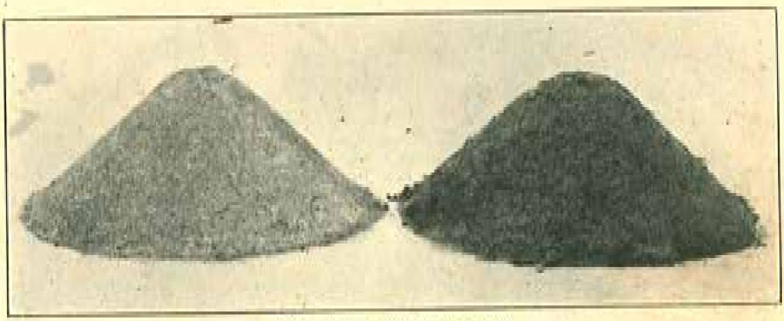

FIG. 5.—THE RESULT

The pile of sand on the left on which four crops of uninoculated legumes have been grown and to which they have been added is still white infertile sand. The pile on the right on which four crops of legumes and legume bacteria have been grown and to which they have been added is well on the way to become a fertile *soil* as is shown by its dark color.

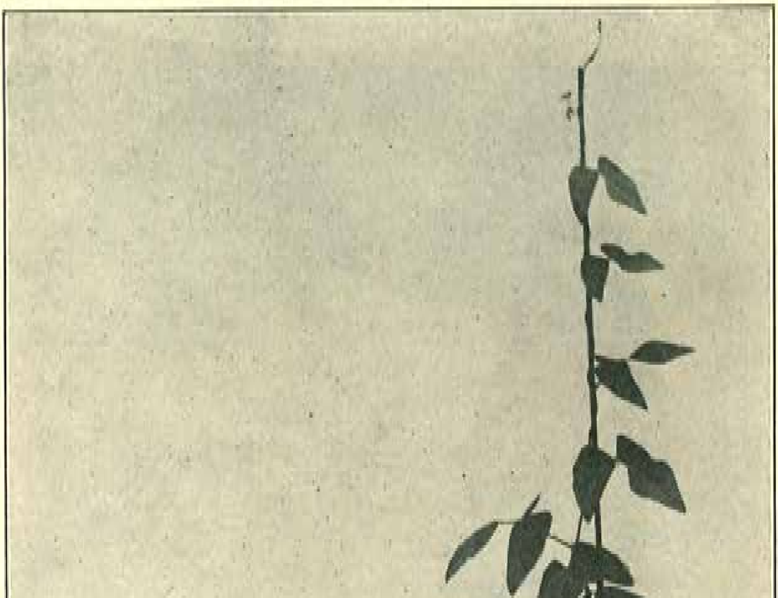

FIG. 6.—THE SECOND CROP

The uninoculated plant is limited in its growth by lack of nitrogen; the inoculated plant is using the nitrogen of the air.

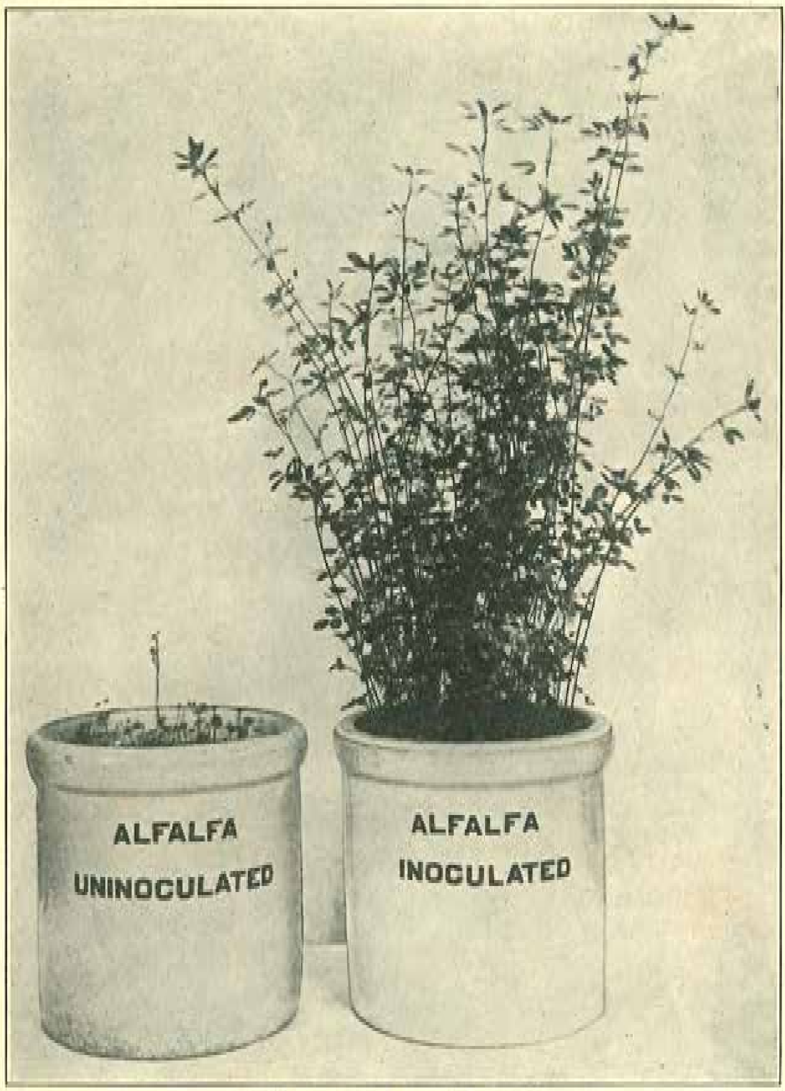

FIG. 7.—THE THIRD CROP

The two previous crops of uninoculated legumes returned to the soil, do not supply nitrogen enough to enable alfalfa to grow. In the jar on the right the plant is using the nitrogen fixed by the two previous crops of legumes and is supplementing this by nitrogen from the air.

FIG. 8.—THE FOURTH CROP

Sweet clover a failure following three previous crops of uninoculated legumes, all returned to the soil. In the jar on the right, the plant has two sources of nitrogen, that of the air and that left in the soil by three crops of inoculated legumes.

FIG. 9.—THE FIFTH CROP

Oats following four crops of uninoculated legumes which have been returned to the soil, grow but little better than they would in the sand at the beginning. The sand is not becoming a *soil*. In the jar on the right, the sand is becoming a *soil*. Enough nitrogen has been added from the air by the four previous crops of legumes and bacteria working together to enable the oat crop to grow luxuriantly.

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