

mum crops is not based to any extent on our ability to control the temperature of the soil.

There remain, therefore, only two factors in the production of plant food that we can hope to control to any marked degree; these are air and moisture. We will consider the least important of these first. We shall find that they are rather closely related to each other, in some respects.

If air be excluded from the soil it does not stop bacterial action, but sets up action that destroys an important plant food—the nitrate. This explains why water-soaked soils sometimes refuse to produce crops when first drained. The nitrates have all been destroyed as fast as produced.

The absence of sufficient air in the soil to support beneficial fermentations may be due to two things—too much water, or too compact condition of the soil. The one difficulty is remedied by drainage, the other by tillage. The presence of too much air is injurious only in that it causes the soil to dry out too rapidly. This must be remedied by compacting the soil by machinery.

We have now considered all but one of the factors that can possibly influence the production of plant food in the soil, only to find that so far as the effect of tillage is concerned, our power over them is discouragingly small. It may be added that the addition of certain chemical fertilizers to the soil, as lime, for instance, may have an important influence in setting free plant food already in the soil, but this subject is too broad to be covered here, and besides it lies more in the province of the chemist than the physicist, and we are here considering more particularly the influence of physical conditions which may be under our control.

It was stated at the outset that tillage has two objects, the production of plant food and the utilization of that food by growing crops. We have learned that the production of plant food is very largely the work of bacteria, and that these bacteria depend for their activity upon certain conditions of food, light, heat, air and moisture. We have considered our control, or lack of control, over all these conditions except that of moisture. We have now to learn that bacteria are themselves plants, and with the same conditions of food, heat, air light and moisture that control the growth of higher plants. In general the same conditions that pro-

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duce available plant food cause crops to be able to use this food; hence we do not use one set of field operations for producing plant food and another to enable crops to utilize it, for those operations each accomplish the other. It has been found that the same degree of moisture that best facilitates bacterial action is also best for the growth of field crops. We have left, therefore only the consideration of our control over the moisture content of the soil. Practically all our operations of tillage are directed toward this end, the control of soil moisture. Were it possible for us to exercise complete control over this one condition, leaving the other conditions mentioned above almost to chance, we could produce crops the smallest of which would be large as compared with our average crops now. It is absolutely true that rain is a poor substitute for irrigation. In experiments in which control of the moisture content of the soil was the main object, ordinary crops were made to produce 4 to 17 tons of dry matter per acre. This is equivalent to 5-19 tons of moisture. Let us consider now the principles which underlie our control over soil moisture.

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