TABLE 15.—*Soil reactions preferred by 25 crops*

Crop	Average soil reaction preference [1]
Alfalfa	Neutral.[2]
Asparagus	Slightly alkaline (active alkalinity 5 to 10).
Barley	Do.[2]
Beets	Slightly alkaline (active alkalinity 5 to 10).
Blueberries	Strongly acid (active acidity 100 to 500).
Cabbage	Slightly alkaline (active alkalinity 5 to 10).
Carrots	Neutral.
Cauliflower	Slightly alkaline (active alkalinity 1 to 10).
Celery	Do.
Corn	Neutral.
Cranberries	Strongly acid (active acidity 100 to 500).
Lettuce	Slightly alkaline (active alkalinity 1 to 10).
Lima beans	Slightly acid (active acidity 1 to 10).
Oats	Decidedly acid [2] (active acidity 10 to 100).
Onions	Slightly alkaline (active alkalinity 1 to 10).
Peas	Slightly acid [2] (active acidity 1 to 10).
Potatoes	Decidedly acid (active acidity 10 to 100).
Radishes	Neutral.
Raspberries	Slightly acid (active acidity 1 to 10).
Red clover	Do.
Rye	Do.
Spinach	Do.
Sugar beets	Neutral.[2]
Watermelons	Slightly acid (active acidity 1 to 10).
Wheat	Neutral.[2]

[1] Expressed as parts of active acidity or alkalinity per 10,000,000. The equivalents in the logarithmic pH values often used are: Active acidity 100=pH 5; active acidity 10=pH 6; neutrality=pH 7; active alkalinity 10=pH 8.

[2] Both yield and quality reported to be superior at the reaction given.

E. T. WHERRY.

SOIL Bacteria of Two Main Groups Fix Air Nitrogen With the breaking up of winter and the beginning of warm spring weather, countless billions of bacteria in every pound of soil start to grow and multiply. It is this development in the spring, and the continued growth of these bacteria during the summer and fall, that interest the soil bacteriologist and are of economic importance to the farmer. It is generally known that without the agencies of decay, life on the earth would soon be impossible, and that only through the continued breaking down of nitrogenous material and the building up of soluble nitrates are most plants able to grow and furnish food for man and other animals. Most arable soil is deficient in nitrogen, especially if it has been cropped. It is therefore important in this day of automotive power and lessening quantities of farmyard manures to know how the supply of nitrogen in the soil may be replenished through the action of bacteria, and what they do with the nitrogen to make it available for higher plants.

Combining the nitrogen of the air into compounds for the building up of proteins within the bodies of certain microorganisms is called nitrogen fixation by organisms. That is, the nitrogen of the air becomes organic matter through the agency of the microorganisms. There are two main groups of bacteria which are able to do this very difficult work (difficult for man to accomplish even with his large factory, expensive equipment, and great electrical power), those which live within higher plants for mutual benefit (symbiosis) and those which live free in the soil.

Nodule-Forming Bacteria

Most conspicuous of the symbiotic bacteria and most important to the farmer are those which form nodules on the roots of legumes, such as alfalfa, clover, and beans. In exchange for sugars and other foods which they obtain from the legume, the bacteria which live in the nodules give to the plant the nitrogen which has been taken from the air. If the soil is rich in nitrogen, the bacteria may use the soil nitrogen instead of that in the air. In this case no special benefit could be expected from growing the legume; whereas in the other case the nitrogen in the soil remained there and more is added from the air.

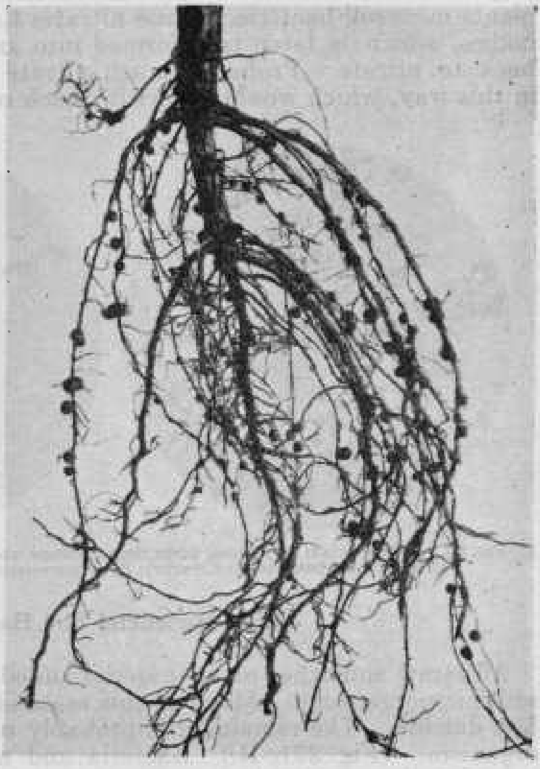

FIG. 220.—Nodules on soy-bean roots which have been formed by bacteria which supply the plant with nitrogen taken from the air

Whether legumes have nodules on their roots can be seen by carefully digging up (not pulling) the plant and removing the soil. (Fig. 220.) If nodules are not found, it means either that the proper bacteria were not present in the soil or that soil conditions have made them inactive. In the first case the proper bacteria for that legume may be supplied by artificial cultures or brought over in soil from another field where nodules have been produced. In the second case, liming or other treatment is necessary to correct the unfavorable soil conditions.

The free-living nitrogen-fixing bacteria of the soil obtain their carbonaceous (sugar) and mineral foods from the soil, and their nitrogen from the air. A demonstration of the activity of these organisms is not so simple as in the case of the nodule organisms, but it nevertheless goes on in soils which are not acid and which contain the necessary carbonaceous food. (Fig. 221, A.) Most farmers know that if a soil "rests" it becomes richer. Though the cause may not be evident, they should realize that in the surface soil are innumerable bacteria and other organisms which are growing, dying, and transforming the inert plant-food elements into available forms.

Bacteria Which Transform Nitrogen

The organic matter added to the soil as farmyard manure, green plants, crop residues, or other wastes are decomposed more or less rapidly, depending on the substance and soil conditions. The nitrogenous portion of this material is attacked by several groups of soil bacteria and other microorganisms, resulting in the production of ammonia. Under normal conditions this never accumulates in a soil. It remains until the nitrifying bacteria oxidize it to nitrate, and as this process is continuous and rather slow, accumulation occurs only with the nitrates. This seldom happens, for in addition to plants most soil bacteria will use nitrates to build up protein in their bodies, which is later transformed into ammonia and then slowly back to nitrate. Probably much nitrate is saved by the bacteria in this way, which would otherwise leach out of the soil and be lost.

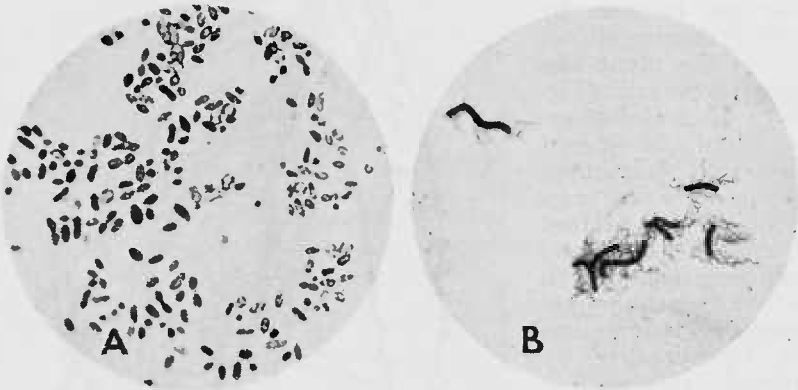

FIG. 221.—Soil bacteria as they appear under the microscope when heavily stained. A, free-living nitrogen fixing bacteria (Azotobacter); B, cellulose-destroying bacteria (*B. cytaseus*)

Other Beneficial Soil Bacteria

All straw and other plant material added to a soil are attacked by soil microorganisms. Much of this material is transformed into carbon dioxide. The remainder is probably used for the growth of the organism. (Fig. 221, B.) Bacteria and molds are very active in breaking down this plant material, but in doing this they require soluble nitrogen in the form of ammonia or nitrates. They are then in competition with the crop plants for nitrogen, if there is cellulose present to be destroyed. Being smaller and more active, the bacteria can easily steal the nitrogen, leaving the crop to suffer for want of nitrogen.

There are many other kinds of soil bacteria. Some of them have special functions, whereas others do not, or their function is not yet known. Whether they appear important, every soil microorganism has its effect upon others. What this effect is and how to control soil processes presents problems for scientific investigation, which can be solved only after many years of painstaking research.

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