WORKING WITH SOIL ORGANISMS

A radio talk by Charles Thom, Principal Mycologist in Charge Soil Microbiology, Bureau of Chemistry and Soils, U. S. Department of Agriculture, delivered through WRC and 39 other radio stations associated with the National Broadcasting Company, during the National Farm and Home Hour, January 19, 1931.

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You ask if the general public can have any real interest in the microorganisms of the soil. First let us think a moment about the soil itself. Nothing gets much closer to us than soil. Our crops grow in it. Our food supplies depend upon it. It is the basis of all agriculture. Closer still, soil gets upon or into everything we handle. No matter how carefully we try to exclude dirt, the wind drives it into our houses, upon our clothing, into our eyes, our ears and our noses. We even swallow considerable quantities of it. The proverb, we must eat a peck of dirt before we die, is not far from being true.

It becomes of interest then if an ordinary level teaspoonful of moist earth from the garden - excluding things like roots, bugs and worms that we can see -- may be expected to contain such a microbic population as this:

Bacteria (the smallest microorganisms) . . . 100,000,000 to 400,000,000.
Actinomycetes (a little larger but still very small . . . 5,000,000 to 25,000,000.
Pieces of mold (larger still, but still too small to be seen with a reading glass) . . . . 50,000 to 500,000.

Add to this aggregate few to many thousands of protozos or one-celled animals, algae or things related to the pond scums and nematodes like the hookworm. Now suppose we "lump" this whole population by saying that at a conservative estimate it will not total less than 100 millions and may reach 500 millions or more to the level teaspoonful.

What are these organisms and what are they doing?

I went out into a garden in December, two months after frost had killed the vegetables and the usual grasses found there. The leaves of all these plants had first wilted then turned brown, greenish brown or almost black - many of them had fallen upon the soil and become slimy, almost rotten; the bases and ragged stems were discolored or blotched with black, green, and brown. - What did these changes mean? When we examined them with the microscope the patches of black and green and brown were shown to be countless numbers of mold spores and fruit bodies which had developed after the feeding organs of these molds had made havoc of the dead plant tissue. We could find them in the very centers of coarse weeds. Along with the molds, slimy and other bacteria, protozoans and nematodes flooded our cultures - their numbers in this decaying material were from 100 to a thousand times the numbers already given you for soil itself, and al

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this dead and decaying material loaded with microbes falls to the ground to mix with the mess and multitude already there and become a part of next year's earthy material. Part of them die but always millions survive and join the millions already there to complete the process of destroying the dead material.

If we dig down through the garden soil about as deep as we plow or spade, we find the dark smear of decomposing organic matter (called humus) all the way down, and our microscopes show millions upon millions of microorganisms. Dig deeper and the numbers fall off greatly and those we find seem to be inactive. But the millions in the top few inches include many kinds which either originated there or have long become permanent residents. Like the plants we know in the field and garden, some of them are useful, some are useless curiosities and some are harmful like weeds; others are pathogenic to plants and animals. All play some part in the ceaseless round of changes by which all of the available materials are used over and over again. And this has been going on for ages. Everything spoiled or offensive has been dumped upon the ground, or buried in it - eventually to disappear and become a part of the soil, andyet we see little change in the soil due to the materials we add.

The first function of the microorganisms is to break down the many forms of waste animal and plant products and make them humus again. The population must be as complex as the job. Some microorganisms are found everywhere and seem able to attack every kind of matter. Others are very particular. They specialize in rotting wood, in grass stems, or in leaves, or in dead animals. Some carry the disintegration just a little way and stop, some make a fairly complete job of it. Other kinds begin with partially rotten matter and carry the rotting process further. Eventually the round is completed and the material taken from the soil to form the bodies of plants and animals, looks like humus again as a result of microbic activity.

Even then the mixture is very complex. Soil differs from volcanic ash or silt or sand in the presence of these organic residues; the black, brown or gray colors common in garden soils are due to plant and animal remains incorporated into it. The odor characteristic of soil is due to one group of microbes - the actinomycetes.

The organic part of the soil is very complex. Literally hundreds of chemical compounds have been isolated from it and identified. It is fully capable of maintaining the hundreds of millions of organisms already discussed. The population is equally capable of decomposing the material we leave or put upon the soil.

Right here, we must stop and answer that question I know some of you want to ask - Is there room for all these microbes in the soil? Let us do a little figuring - the average soil bacterium is pretty small - it is comfortable with an allowance of about what we call a cubic micron - a micron is 1/1000 of a millimeter and a millimeter is about 1/25 of an inch - then a cubic micron is one billionth of a cubic millimeter. There are 1000 cubic millimeters in a cubic centimeter and 3 or 4 cubic centimeters in a teaspoonful. That makes room for 1000 billions of bacteria in one cubic centimeter - so don't worry about them. If there were 100 million of them present they would only need one ten-thousandth of the space - or put it this way - suppose one hen be considered comfortable in a space of one cubic foot - then each of the hundred million may be compared to a hen in a space 25 by 40 feet and 10 feet high. But the soil mass is something like 70% solid matter, that reduces our hypothetical hen to a free space approximately 3000 cubic feet - a room 10 by 30 by 10 feet high - with its walls well lined with food so she might still be comfortable.

Is it clear then that there are great possibilities of microbic activity when a varied assortment of millions of microbes is always present in the soil and ready for tremendously increased activity if we only furnish the right conditions for them.

These possibilities are either good or bad. Among the countless millions present some are destructive of soil fertility - they break down, use up or destroy the food needed by our crop plants - they are weeds - competitors for needed material; destroyers of accumulated supplies; they contribute little or nothing to the working efficiency of a soil.

Other millions break down waste matter, disintegrate the fibrous material, pour out carbon dioxide for our crops to use, produce ammonia and other nitrogen products which are eagerly absorbed by crop roots; others tear down earthy matter and make it available; all leave behind the inert material often called humus, which gives the soil its color, makes it friable, and helps it hold water.

Our task then, is to find out the ways of these vast populations, to devise means for controlling them. We can not separate out single elements in this multitude for direct stimulation or repression. We can only hope to control by changing the conditions for great masses of organisms in such a way as to favor the activities we want. For example - we plow, we spade, we work in fertilizer, we cover up trash, or weeds, or manure. Stirring the soil with added fertilizer works in air and works the moisture through the mass. This permits millions of microbes to grow freely but interferes with other millions.

We must know in any particular situation which we want: great activity or depressed activity. For some purposes it is best to let land lie idle. Some fertilizing elements should be allowed to decompose upon the surface. Others should be plowed in deeply. At one time we may get the best results from cultivating deeply and stirring air thoroughly into the soil; again we should pack or harrow or roll to reduce activity.

With so many millions of organisms of so many kinds to deal with, then our task is to study each of these activities and reach some underlying principles for controlling the soil population. Then and only then guesses and "rule of thumb" methods can be forgotten, for we will be able to plan for what we want and get it.
