Cannot Be Maintained Without Legumes and Grasses

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DOES YOUR SOIL dry out more slowly after a heavy rain than it used to? Does it stay too wet to be worked several days longer than it should? Either of these conditions is a warning of what is happening to many of our soils that have been growing corn, soybeans, and small grains year after year. Under such treatment even the best corn-belt soils finally reach the point where they drain too slowly and cannot get enough air for high production.

We are concerned here chiefly with the way some of our best corn-belt soils are deteriorating. We cannot afford to let these soils be ruined. They are the "bread basket" of the United States — they have fed and must continue to feed a lot of people. These are the soils that were largely responsible for the increase in food production during and after World War II. If they are ruined, the United States is through as a great nation.

What Should Soil Be Like?

Good soil must have water, air, and the right temperature for strong germination of seeds. After the plants become established they will make satisfactory growth if they can get the nutrients they need, if the soil is neither too sour nor too sweet, and if they can get enough water and air. The soil's ability to supply enough water and air for good plant growth depends on its physical condition.

To be able to supply growing crops with enough water, the soil has to be open and porous. Rainfall must enter it readily. It must be in condition to hold immense quantities of water for the crop to use between rains. A 75-bushel corn crop in Illinois may use as much as 2,000 tons of water an acre to make its growth — equivalent to more than 18 inches of rain. Much of this water must be stored in the soil if

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the crop is not to suffer. An open porous soil acts like a sponge in letting the water in and holding it.

An open porous soil will also let excess water — water that fills the larger soil pores during heavy rains — drain away quickly. This is necessary because plant roots will not grow well in a waterlogged soil. If free water remains too near the surface for too long a time, as often happens on poorly drained soils after a crop is planted in the spring, the plants will have shallow, weak root systems. Later in the season, when there is usually less rain and the soil dries out to a depth of several feet, these shallow roots cannot reach the moisture and the crop suffers. Weak, shallow roots cannot support vigorous, healthy plants.

To be productive, soils must be well ventilated, which again means that they must be open and porous. The innumerable processes that go on in productive soil need plenty of free oxygen from the air. The most desirable soil organisms, those that have so much to do with productivity, cannot thrive in a soil that does not get enough air. Nutrients in organic matter cannot be used by growing plants until the organic matter is broken down by decay; this takes oxygen. Some plant nutrients, such as nitrogen, phosphorus, and sulfur, must be in the highest oxidized form before most plants can use them. Since 95 percent or more of the nitrogen in most soils is in the organic matter, plants on poorly drained and poorly ventilated soils, where organic matter has little chance to decay, quickly show the effects of a lack of usable nitrogen. On such soils, money spent for commercial fertilizers is largely wasted because they alone cannot make a compact soil open and porous.

Are All Soils in Bad Condition?

The answer of course is *No*. How much the physical condition of the original soil has changed depends on how it has been handled.

On farms where lime and fertilizers have been used as needed and crop rotations that include legumes and grasses have been followed, the soil is still in good condition. On other farms where plowing, planting, and harvesting of grain crops, particularly corn and soybeans, have gone on year after year without the adding of needed plant nutrients or the growing of grasses and clovers, the soil is in very poor physical condition. It is compact, drainage and movement of air are very slow, and crop yields are much lower than formerly.

Between these two extremes there are all stages of physical deterioration, depending on the care the soil has received.

Why Are Corn-Belt Soils Changing?

We are concerned here particularly with what is happening to our best corn-belt soils, those that have no natural handicaps. Their subsoils drain well and they are on level to gently sloping land, so that

with some care erosion can be controlled. When first put under cultivation, they were well supplied with organic matter and with food for the growing crops. They could hold a lot of water, while excess water was able to drain away quickly after tile drains were installed and kept in good working order to provide an outlet. Their tilth, or structure, was nearly ideal. What has happened to change this?

To answer this question, we need to know more about what these soils are like. They contain a high percentage of tiny flat or plate-shaped particles, many of which are so small they cannot be seen even under a high-powered microscope. Originally most of the particles stuck together in crumbs (aggregates), many of which were about $\frac{1}{250}$ inch in diameter or larger. When a soil has a high percentage of clusters, or crumbs, this size, it is said to be well aggregated. Such crumbs are large enough to permit air and water to move freely into and through the soil, the soil works nicely, absorbs water rapidly, holds large quantities of water, and drains quickly. In other words, the soil has good tilth.

On many farms the desirable tilth of the original soils has been largely destroyed. The crumbs of soil particles have been broken apart and the tiny particles now fit so closely together that enough air for good plant growth cannot get into the soil. Water enters very slowly, and when the soil becomes filled with water, as happens in the early spring or after a prolonged wet spell, it cannot drain away fast enough. The soil can no longer hold enough water in the way that plants can use it for good growth.

Why are these clusters or crumbs of soil breaking down on many farms? There are several reasons, all of which fall under three general headings: use of poor crop rotations, failure to apply lime and fertilizers as needed for high crop yields, and working the soil too much, especially when it is too wet. Let's look at these reasons in more detail.

Corn and soybeans have been grown too much of the time. The best soils will lose their good tilth if they are kept in row crops. Our corn-belt soils were among the best in the world, but on many farms they are showing the bad effects of too much corn and beans.

Organic matter has not been maintained at high enough level. In our climate organic matter is always associated with good tilth. As the organic matter in the soil is reduced the tilth becomes poorer. Active organic matter like that supplied by legumes and grasses is really what gives life to the soil. It not only contains nearly all the soil nitrogen and large amounts of other plant nutrients but is also a soil conditioner. Active organic matter is too low in many soils, especially where corn and soybeans have been grown all the time.

Our soils have been worked too much and too often. Working a soil breaks down the crumbs or clusters of soil particles. Crops like

corn and soybeans require, in addition to the preparation of a seedbed every year, cultivation to control weeds during the growing season. This repeated working eventually destroys the tilth. In preparing a seedbed many farmers work the soil until it is finer than necessary. Such working of the soil destroys its structure unnecessarily and leaves a dust layer on the surface. When soaked up by rain this dust layer forms a dense, compact mass which will not absorb air or water readily. If there is too little organic matter in the soil, even less air and water can get into the soil through the dust layer.

Our soils have been left without a protective cover too much of the time. In addition to being bare every year while the seedbed is being prepared and while the young crop is making its early growth, corn, small grain, and soybean land is unprotected during the winter. After corn, beans, and small grains are harvested, the fields usually lie idle until the next spring. As has been emphasized for years, fields in this condition are subject to loss of plant nutrients by leaching and to loss of soil by erosion.

In addition these fields suffer much damage from the force of falling raindrops. This pounding breaks down soil crumbs, and the fine particles of clay and silt and even the coarser particles of sand are splashed a foot or more into the air. On sloping land these particles are washed away. Even if the land is level and soil particles are not washed away, they may settle back on the surface several feet from where they were. A lot of damage has been done. The fine particles in being splashed about by the raindrops fill the soil pores or open spaces near the surface, forming a seal through which water and air cannot pass readily. Each succeeding storm breaks down more soil crumbs and makes the seal tighter. To guard against such damage, a close-growing crop like grass or a mulch of crop residues should be kept on the land as much of the time as possible.

Much damage is done when soils are too wet. The damage may be due to working the soil, to tramping by livestock, or to packing the surface by heavy machinery. Soil crumbs are broken down and the soil particles are packed together tightly, forming hard clods when the soil dries out (clods are simply compact chunks of soil which have been pressed together so tightly that water cannot get into them easily or move through freely). The damage done in a single operation like plowing may make the preparation of a seedbed difficult for several years.

Tramping over wet soil by livestock is also bad, particularly on stalk and stubble ground. A cow may sink into wet soil 8 inches or more, and at the bottom of each track there is a compressed ball of mud which become a hard clod when it dries. Such walking is hard on the cow and hard on the soil.

Heavy machines, like tractors, combines, and corn pickers, squeeze

the life out of wet soils. It is a temptation, of course, to get into the fields in the spring before the soil is really dry enough to work, especially if the season is late. Also, when grain is ready and a heavy storm may flatten it to the ground, it may not seem safe to delay combining. But we need to realize how much damage the machinery may do to the soil and avoid it so far as possible.

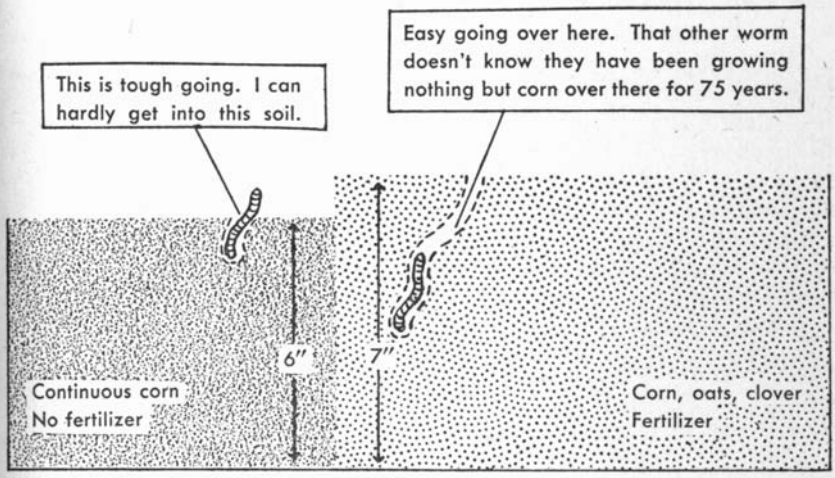
Not enough use has been made of good rotations and soil treatment. The famous Morrow plots of the Illinois Agricultural Experiment Station show how different systems of management affect the physical condition of the soil. The cropping systems have remained practically unchanged since the plots were started in 1876; some of the plots have received fertilizers since 1904. A comparison of the unfertilized plot which has grown corn every year with the corn-oats-clover plot which has received manure, lime, and phosphate brings out several striking facts:

1. The soil on the plot that has grown corn every year without lime has become too acid to grow red clover. Its pH is only 4.8 while the pH of the rotation plot receiving lime is 6.2.

2. Only 3 percent of the soil on the unfertilized continuous-corn plot is organic matter. On the fertilized rotation plot organic matter makes up nearly 6 percent of the soil. The top 6 inches of the rotation plot has 30 tons more organic matter an acre than the top 6 inches of the continuous-corn plot.

3. The unfertilized continuous-corn plot has become more compact and less porous than the rotation plot. The top 6 inches of the corn

MORROW PLOTS SHOW THAT A GOOD ROTATION KEEPS SOIL LOOSE



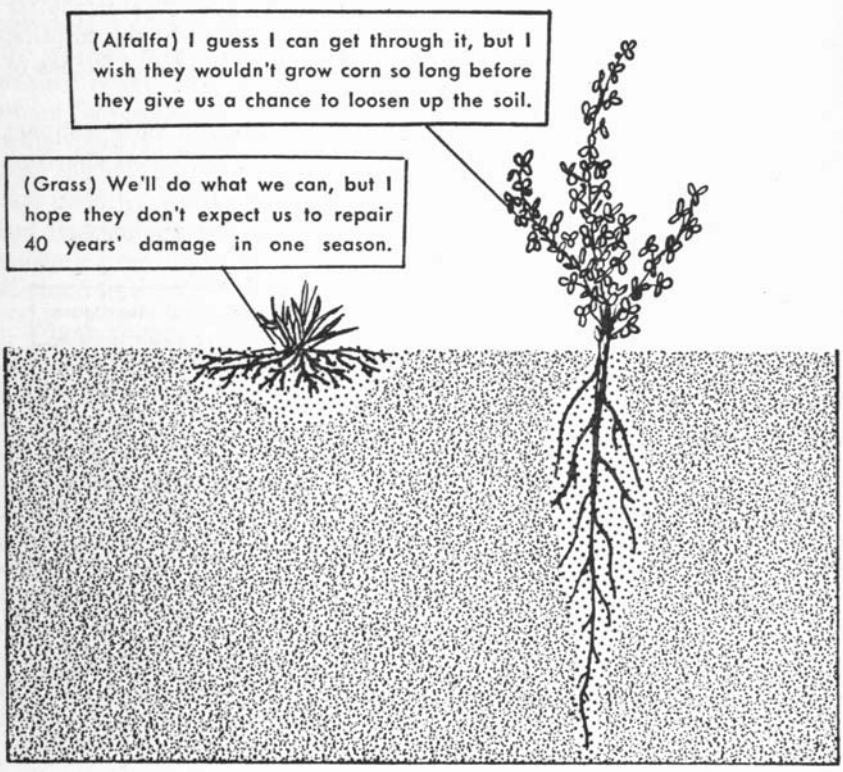
plot weighs 100 tons an acre more than the top 6 inches of the rotation plot. On the corn plot a cubic foot of soil weighs 85 pounds; on the rotation plot only 75 pounds. This means there is much less open space in the soil on the corn plot.

4. On the rotation plot aggregates — clusters or crumbs of soil — larger than about $\frac{1}{250}$ inch in diameter make up almost half (46.6 percent) of the weight of the soil. Only a third (32.2 percent) of the soil on the continuous-corn plot is in aggregates this size.

5. The rotation plot can hold much more water — a quantity equal to 76 percent of its own weight. The continuous-corn plot can hold only 56 percent of its own weight.

6. Yields have been several times as high on the rotation plot. From 1904 to 1949 the average yield of corn on the unfertilized continuous-corn plot was 24 bushels an acre and on the fertilized rotation plot, 74 bushels. For 1938 to 1949 yields averaged 23 bushels on the continuous-corn plot and 97 bushels on the rotation plot.

IT TAKES TIME TO REPAIR THE DAMAGE DONE BY HARD FARMING



In 1949, when both plots were in corn, the corn-oats-clover plot yielded 104 bushels an acre, more than five times as much as the 20-bushel yield of the continuous-corn plot. Part of this higher yield is no doubt due to there being more plant nutrients in the treated plots, but good physical condition must also be credited for a large share.

Many acres of corn-belt soil are going in the same direction as the unfertilized continuous-corn plot.

What Can We Do About It?

The answer to this question has been implied in what has already been said, but let us emphasize it further.

Do not grow corn, soybeans, and small grains all the time. They are hard on the soil. They require too much working of the soil and do not furnish good cover. As a result the soil granules, or crumbs, are broken down and there is too much erosion from most soils. Even our best soils will lose their good tilth if kept in row crops and small grains year after year.

Keep adding organic matter. Turn under all crop residues instead of burning them. Take care of animal manure, on farms where it is produced, so that as much of its value as possible is retained and returned to the land. And above all, use legumes and grasses because they are the best source of soil organic matter.

Do not work the soil too much or too often. Give it a chance to rest by growing crops that do not have to be plowed or cultivated each year. Legumes and grasses are such crops, and they will help the physical condition of the soil more if they are left on the land two years instead of one.

Keep the soil covered as much of the time as possible. Bare soils suffer from erosion and the beating action of raindrops. The best cover is a sod crop but a mulch of crop residues furnishes a lot of protection. Cornstalks broken down flat to the ground across the slope furnish much more protection than if left standing; if the stalks are shredded and evenly distributed over the ground, the protection is even better. Soybean straw does not protect the land as well as shredded cornstalks, but distributing it evenly over the land is much better than dumping it out of the combine in piles or windrows, as usually happens, and leaving much of the soil without cover.

Sometimes the control of insect pests, like the corn borer, makes it necessary to fall-plow for spring-seeded crops. If so, there is not much that can be done about it. But if plowing can be done in the spring, most soils will suffer much less damage.

Keep off wet soils as much as possible. Many who have had a hard time preparing a good seedbed have realized how much damage

was done the year before by working the soil too wet. Yet some will do it again, even when they could avoid it. Tramping wet soils by livestock, particularly on stalk and stubble ground, destroys soil tilth. Heavy machinery damages wet soils and should be kept off whenever possible.

Adopt a good crop rotation, one that fits your needs, and stick to it. A rotation that will keep the soil in good condition must include grasses and deep-rooted legumes. They keep the soil open below the plowed layer. Using legumes for this purpose is much better than trying to loosen up the soil with deep-tillage machines, which give only temporary relief. No stable soil crumbs are formed by the machines and nothing is done to prevent the soil from running together again and becoming as tight as before. Breaking up the soil by deep-tillage machines is usually too expensive for the short time it is effective.

Just how effective cropping systems can be in determining yields and improving soil tilth is shown by the following results from the Ohio Agricultural Experiment Station. Remember that the higher the degree of aggregation, the higher the percentage of soil particles that cling together in crumbs or granules. In other words, the higher the degree of aggregation the better the soil tilth.

Cropping system	*Degree of aggregation of the soil*	*Corn yield per acre*
	perct.	*bu.*
Corn, oats, 2 years of alfalfa-bromegrass	54.2	67.9
Corn, oats, alfalfa	53.0	58.8
Corn, oats, sweet-clover catch crop	45.2	46.9
Corn, oats (residues returned)	40.1	39.2
Corn (residues returned)	23.4	22.5

These are the results of a ten-year experiment. The soil is a heavy dark-colored clay on nearly level land. No fertilizers were used. In another experiment on the same kind of soil, fertilizers gave little or no increase in yields. The main problem has not been one of plant nutrients but one of keeping the soil open and porous so water can get through to the tile drains. Close spacing of the tile drains will not solve the problem. The only satisfactory solution is to grow grasses and deep-rooted legumes often enough to keep the soil open.

Don't wait. The payoff won't start until you translate these words of advice into action right on your farm. There is no point in waiting until the soil begins to go bad before doing something. Start a good program, whatever the present condition of your soil. Above all, START NOW.

Urbana, Illinois April, 1950

Cooperative Extension Work in Agriculture and Home Economics: University of Illinois, College of Agriculture, and the United States Department of Agriculture cooperating. H. P. Rusk, *Director*. Acts approved by Congress May 8 and June 30, 1914.

20M—4-50—43635