returns on crops with a high acre value. Thus, applications of manure are likely to be more profitable on crops like corn, burley tobacco, potatoes, and vegetables than on crops like small grain or pasture.

WHEN MANURE is used as a topdressing or mulch to help combat soil washing or blowing, the application should just precede the time of greatest hazard. Often that will mean applying the manure fairly soon after the crop has been planted.

Losses of nitrogen by volatilization of ammonia are sharply cut as soon as the manure is covered by soil. Research in Denmark indicated that if manure spread and plowed under immediately is rated 100 in crop-production ability, manure spread and plowed under 2 days later rates as 71, and manure plowed under 2 weeks after spreading can be rated as 49. Spreading manure just ahead of a tillage operation that will incorporate it with the soil, therefore, is preferred when the manure is not used as a topdressing.

Other research in Denmark demonstrated that manure spread and plowed under just before the crop is planted is more effective than manure spread and plowed under at earlier dates. A farmer who uses such a plan of manure management should keep in mind, however, that factors other than the need for conserving nutrients in manure may be more important in determining the best time for plowing.

When dairy barns of the stanchion type or farrowing sheds for hogs must be cleaned often, a manure carrier or gutter cleaner that empties directly into the spreader saves work. Such a setup frequently makes it convenient to spread manure on frozen or snow-covered ground. Studies in Vermont showed that this practice resembles partial drying insofar as its effect on losses of ammonia through volatilization are concerned. These losses of nitrogen, therefore, will have to be balanced against the labor-saving features of the system.

Composts, Peat, and Sewage Sludge

H. W. Reuszer

Organic materials once were the only fertilizers used by farmers. They were mainly plant and animal products high in protein and were used for their nitrogen-supplying value. The demand for many of them in making feed and the lower cost and greater availability of plant nutrients in mineral fertilizer have led to the replacement of most of them as fertilizer.

Other organic materials, such as composts, peat, and sewage sludge, continue to be used to improve soil. They are called soil amendments rather than fertilizers because of their low content of plant nutrients.

They may be incorporated into the soil or used as mulches. Heavy rates of application are the rule. Thus they have the double effect of contributing some plant nutrients and improving the physical condition of the soil.

Sometimes the amendments represent utilization of materials that otherwise would be wasted. Some have an unusual composition, and special practices are needed to use them successfully.

IN COMPOSTING, a microbiological process, organic materials are partially decomposed by the activity of microbes. Hemicelluloses (the gumlike substances), cellulose (the plant fiber), and lignin, (the woody material) make up

50 to 85 percent of mature plant materials. The lower percentages occur in the leguminous plants, the intermediate ones in nonleguminous crops, and the higher amounts in wood. The rest of the plant is largely water-soluble substances and protein and small amounts of fat and ash.

Microbes readily attack the water-soluble substances, hemicelluloses, and cellulose, which rot quickly.

Lignin is quite resistant to attack. Its nature changes somewhat, but it disappears only slowly.

From the readily decomposable substances, microbes get energy to carry on their activities and the carbon they need for building their cells.

About 20 percent of the carbon in the decomposed part may be synthesized into microbial cells. The remainder enters the air as carbon dioxide and becomes available for photosynthesis by new generations of plants.

About one-half of the total dry matter originally present is decomposed by the time the compost is ready for use. Three-fourths of this loss is represented by a decrease in hemicelluloses and cellulose.

Microbial cells contain 5 to 10 percent of nitrogen. So, if large amounts of energy substances are present, considerable nitrogen is needed for synthesis of cells. The amount of energy available and consequently the amount of nitrogen needed depend on the amount of material susceptible to decomposition by the microbes.

Materials like sphagnum plants and highly lignified wood tissues, which resist decomposition, have low nitrogen requirements. For the usual farm crop residues, a nitrogen content of 1.5 percent is enough for a maximum rate of decomposition. Microbes do not assimilate all the nitrogen in materials that have higher nitrogen values, and the excess is subject to loss by volatilization, leaching, or denitrification. Actually, values of 1 to 1.25 percent of nitrogen are adequate.

Mature nonleguminous plant residues are low in nitrogen and high in substances that supply energy for microbial growth. When they are incorporated into soil, microbes assimilate available nitrogen from the soil and cause a shortage of nitrogen for crop growth.

This nitrogen-depleting effect can be overcome by adding enough available nitrogen to supply the needs of the microbes. The nitrogen may be supplied by commercial fertilizer added with the organic matter if it is turned under directly. If used as bedding for livestock, the feces and urine of animals supply the nitrogen. A third (but more expensive) way to overcome the nitrogen-depleting effect is to compost the material.

Two main objectives are accomplished by composting.

First, readily decomposable substances are removed, and the percentage of nitrogen content is increased. Thus there is no danger that a nitrogen shortage will be induced when composts are added to soils.

Second, the physical nature of the material is changed. The decomposition of cellulose causes the plant material to lose its strength and to break easily. It becomes friable, crumbly, and easier to handle and incorporate into the soil. That is important when hand tools or small tillage implements are used.

With some materials, such as manure or municipal garbage, a third result of composting is the removal of obnoxious odors.

THE COMPOSITION of composts is variable. The moisture content is usually in the neighborhood of 75 percent, but it may be as low as 40 percent. A high moisture content makes the finished compost weigh more than the dry weight of the material originally placed in the heap. That is the basis of statements that 1 ton of plant residues will produce 2 tons or more of compost. Its value, of course, is in the dry matter.

Composts commonly contain 2 percent of nitrogen, but the content may be 1.5 to 3.5 percent in the dry matter.

The phosphorus content of dry composts is about 0.5 to 1.0 percent. Potassium values probably are twice as high. These values will be correspondingly higher if phosphate and potash are added to the compost.

The nitrogen of composts is only slowly available and never approaches that of inorganic sources of nitrogen. Its slow availability lowers the possibility of leaching and extends availability over the entire growing season. Presumably the availability of phosphorus and potassium in composts approaches that of inorganic sources.

Composts are essentially low-analysis fertilizers, and large amounts must be used to obtain adequate additions of plant nutrients to soils.

THE MAXIMUM EFFECTS of composts on soil structure—increased aggregation, pore space, and water-holding ability—and on crop yield usually occur only after several years of use.

Composts increase crop yields as much as do equal additions of manure from the bedding of horses and cattle. Composts should be used in much the same way as manure with regard to amount and method of application and reinforcement. Because compost is like farmyard manure in physical nature, composition, and value, we sometimes call it synthetic manure.

Composts are good to use as mulches in gardens or around shrubbery. Applied 2 or 3 inches deep, they conserve soil moisture, lower soil temperatures in hot weather, help control weeds, and contribute nutrients.

Applications on small areas of large amounts of compost may supply the entire nutrient needs for the successful production of crops. If the composted materials come from a large area, the land from which they come loses its share of organic matter. One can overcome some of that loss by using rotations of sod crops whose roots restore the physical condition of the soil. The amount of organic matter that can be returned to the soil over any large area of land can be no larger than the amount produced on it. Because, furthermore, some is used by animals and man, only moderate rates of compost applications can be attained over any large area.

Before you decide whether to practice composting in practical farming operations, you should compare the soil-improving value of compost and that of the fresh residues from which it is made.

In 12 years of comparisons at the Rothamsted Experimental Station in England, turning under fresh straw to which nitrogen was added gave 10 to 20 percent greater yields of potatoes, barley, and sugar beets than composts prepared from the same amount of straw and nitrogen.

At the New Jersey Agricultural Experiment Station, fresh residues, applied on an equal organic-matter basis, produced double or triple the aggregation of silt and clay particles produced by composts prepared from the same materials.

One must also realize that (since one-half the organic matter is lost in composting) fresh residues applied at the same rate will cover twice the area that can be covered by composts. When it is feasible to do so, one should return plant residues directly to the soil in preference to composting; doing so leads to greater soil improvement and saving of labor. Sufficient nitrogen and other nutrients in the form of commercial fertilizers should be added to meet the needs of the crop.

In some situations, however, composting meets a need and is a highly desirable practice.

The first is in areas where commercial fertilizers are expensive, labor is cheap, and implements are simple. Composts prepared from plant, animal, and human wastes have been used extensively for many centuries in India, Japan, and China. More than one-half the nitrogen and a higher proportion of the phosphorus and potassium returned to the soil in Japan in 1946 were supplied by composts. Composting practices in some countries include the use of town garbage and night soil; a supplementary benefit thus is improved sanitation.

Composts also are used when soil is used intensively as in market gardening, in which frequent tillage and almost complete removal of crops (sometimes even the roots) may lead to soil deterioration. Composts are used to overcome this effect.

Special composts are needed for growing mushrooms. They used to be prepared from horse manure, but more and more they are made from definite mixtures of plant products and commercial fertilizers, which supply nitrogen and potash.

The most prevalent composting in the United States is by gardeners who save garden residues, weeds, tree leaves, lawn clippings, and kitchen wastes.

COMPOST is produced commercially in many places.

A few operations in the United States use manure from stockyards or large dairies. An installation at the stockyards in Chicago uses a mechanized process and can treat 50 tons of manure daily. Plans have been made to compost all of the 75,000 tons of manure produced annually at the stockyards. These preparations command a premium price and are used on gardens and lawns.

A plant at Wyster, Holland, produces 120,000 tons of compost a year from municipal refuse. The annual production of compost is sold at a low price to farmers, and the demand for it is great.

In general, it may be said that commercial production of compost is limited to situations where the cost of assembling the material is not charged to the composting operation itself.

TWO SOURCES of compostable material may get greater—wood residues (from lumbering, woodworking plants, and improvement cuttings in forests) and organic wastes in cities.

The total annual quantity of unutilized wood residues was estimated in 1956 by the Forest Service to be 1.4 billion cubic feet at sawmills and woodworking plants. An almost equal quantity was left as logging residues in the forests. About 700 million cubic feet of the residues at sawmills and plants was fine material, such as sawdust, which requires no further reduction in size for use in soil improvement. A large part of the wood residues accumulate at points remote from possible agricultural use, but in some sections, as in the North Central States, nearly all lumbering operations are on farms. Wood residues are also quite accessible for agricultural use in the Northeast and the South.

The use of these residues has been confined mainly to sawdust and shavings because of their favorable physical form and accumulation in large amounts.

All available supplies of sawdust and shavings in parts of new England are used as bedding for dairy cows. The manure is used on crops. Waste wood is also converted to chips for use as bedding. The cost may be so high, however, that the use of chips may be restricted to localities where supplies of sawdust and other forms of bedding are inadequate and transportation costs make wood chips competitive with other bedding materials.

Wood residues can be incorporated directly into the soil. They also can be composted. Both sawdust and woodchips make excellent mulches for blueberries, strawberries, fruit trees, ornamentals, and garden crops. Because woody plant materials are low in plant nutrients, they need extra nitrogen and phosphate when they are composted or added to soil.

Municipal organic wastes of garbage and street refuse are composted for agricultural use in many European cities and in the Far East. In this country they have been disposed of mostly by land filling, soil burial, or incineration, but there is an increasing interest in the possibility of disposing of them by composting because of the growing scarcity of areas to be filled in, objections to air pollution produced by incineration, and the possibility of reducing costs of waste disposal from the sale of the compost.

The staff of the Sanitary Engineering Research Project of the University of California in 1953 completed a series of experiments on composting municipal wastes. They found that a wide variety of wastes could be composted successfully. Shredding the material (after cans and bottles had been removed) to permit uniform mixing was found desirable. No further modification was found necessary. Turning the heaps every 3 or 4 days meant that finished compost could be produced in 2 or 3 weeks. The composts contained as much plant nutrient as did compost from crop residues. Its value for soil improvement should equal those of manure or composted farm residues.

Almost any natural organic product can be composted with proper care—cornstalks, straw, hay, tree leaves, wood residues, coconut husks, animal and human excreta, garbage, wastes from wineries and breweries, and many more. The microbes are not choosy.

For making composts, you must provide proper aeration, moisture, nutrients, and temperature for microbial decomposition. Those factors and the nature of the material affect the time required for preparation and the final composition. Composting is usually carried out by piling organic materials into heaps where reasonable control of these factors can be maintained.

Air should penetrate the entire compost heap to allow microbes to act and finish the compost in a minimum of time. Aeration depends on size of air spaces within the heap, the height of the pile, and the moisture content.

The coarse materials, like cornstalks, cause large air spaces, excessive aeration, and rapid loss of moisture and heat from the heap. They should be cut to 6-inch lengths or mixed with finer materials before composting. Excessive aeration can be reduced by compacting the pile and by increasing its height. Fine materials, such as sawdust, are hard to aerate and may be mixed with coarser materials or turned oftener. Cereal straws and tree leaves have good properties for composting.

Compost heaps should be built no more than 6 feet high so air can penetrate to the bottom of the pile. Width and length may be adjusted for convenient handling.

Excessive moisture cuts aeration by filling air spaces in the material and by increasing compaction.

Only a slow partial decomposition takes place when aeration is insufficient. Intermediate products of anaerobic microbes, such as organic acids and reduced nitrogenous and sulfur compounds, are formed. Many have offensive odors.

The physical nature of the composting material frequently is altered little under anaerobic conditions, and it remains hard to handle. Poor aeration is overcome by turning the heap.

The best moisture content of the compost heap is between 50 and 70 percent—the weight of the moisture should be 1 to 2.5 times that of the dry organic material. Decomposition is slowed down when the heap is drier than that; anaerobic conditions set in, particularly at the bottom of the heap, when it is wetter. Water is best applied to the layers as the pile is built up.

Many fresh dry plant residues are somewhat hard to wet. They can be wetted best by applying the water in a fine spray. If necessary, water should be added on 2 or 3 successive days at the start of the composting period.

Letting water run out at the bottom of the pile should be avoided because nutrients are lost. Fresh green materials, such as grass clippings, contain too much moisture for proper composting. They should be left to wilt before piling or should be mixed with about one-third their weight of dry material. Rainfall may increase moisture in the heap. If the moisture becomes excessive, it can be reduced by turning and loosening the pile. Small heaps that have a high proportion of exposed surface may become unduly

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dry. Water should be added to them as needed.

Most plant residues will form composts in time if they simply are put in a heap and kept moist.

Sometimes nutrients are added. Mature residues of nonleguminous plants require the addition of about 15 pounds of actual nitrogen per ton of dry material—equal to the nitrogen in 70 pounds of ammonium sulfate or calcium cyanamide, 45 pounds of ammonium nitrate, or 30 pounds of urea. Any of them are satisfactory. Calcium cyanamide and urea give a slightly basic reaction, which promotes rapid decay. If ammonium sulfate is used, an equal amount of finely ground limestone should be added to neutralize the acidity arising from the sulfate anion.

Residues of leguminous plants and young nonleguminous plants may contain 1.5 to 3.5 percent of nitrogen and need no additional nitrogen. Substantial losses of nitrogen occur if such residues are composted directly, because the amount of nitrogen present is in excess of that assimilated by the microbes. Such materials should be mixed with residues of low nitrogen content. Two or three parts of mature, nonleguminous residues mixed with young plants or with leguminous plants give a satisfactory mixture.

Other organic nitrogenous substances, such as cottonseed and soybean meals and dried blood, may be added to composts to give the proper nitrogen content. The cost of nitrogen in these forms is greater than in the inorganic form. Liquid and solid excreta of animals and sewage sludge also may be used to supply nitrogen to composts

The microbes need so little phosphate and potash that ordinary plant residues supply enough for composting. To sawdust or plant residues that become leached before composting, it may be wise to add phosphate and potash—about 20 pounds (or 3 gallons) of superphosphate and 5 or 10 pounds of potassium sulfate or potassium chloride to a ton of residue.

The phosphate and potash increase the fertilizing value of the resulting compost. A complete fertilizer with an analysis such as 10–6–4 may be used to supply nitrogen, phosphate, and potash. The fertilizer should be added to give the proper amount of nitrogen in the beginning compost. Extra care should be taken to prevent leaching. If that cannot be done, it is preferable to reinforce the compost when it is applied to the soil instead of in the pile.

Rotting proceeds slowly at temperatures near freezing. Microbial processes increase at higher temperatures. The rate nearly doubles for every rise of 18° F. in temperature.

Microbes themselves produce heat as a byproduct of the decomposition. They release large amounts of heat in the pile; since it is nearly self-insulating, the temperature of the pile rises. Microbes that grow best at ordinary temperatures initiate the decomposition and carry it on until a temperature of about 115° to 120° is reached. That temperature kills them, and another group of microbes takes over. They are called thermophiles, or thermophilic organisms, because they can carry on at high temperatures. They raise the temperature inside the heap to 140° to 170°. This rise in temperature, which usually persists 2 or 3 weeks, indicates that the composting is proceeding normally. It greatly shortens the time required for the decay of the plant material. The rapid dissipation of heat in small or open heaps may keep temperatures down too low.

The high temperature also kills disease-causing organisms, insects, and weed seeds, except in the outer parts and the bottom of the heap. When the heap is turned, those parts should be turned to the center of the pile so that they also will be subjected to the high temperatures.

Residues of diseased plants should be composted only if they can be completely subjected to the high temperatures in the interior of the heap. That is seldom possible with small piles; if so, they should be burned to avoid spreading disease.

Turning the compost heap hastens the decomposition by increasing the supply of air for the microbes. Heaps may be turned every 3 or 4 days in commercial operations. In some mechanized processes, air is blown continuously through the composting mixture. In farm and garden practices, the compost should be turned at least once about 3 weeks after its preparation. More frequent turning is desirable to assure mixing and more uniform decomposition of the heap. The number of turnings may be adjusted to facilities available and the desired time for completing the compost.

Occasionally some practices are advocated that are not essential. Inoculation with prepared cultures of microbes is sometimes said to hasten the process and lead to a better product.

Experiments at the University of California tested soil, horse manure, partially composted material, and a commercial preparation of selected cultures as inoculants. None had any significant effect on the course of composting. It appears that the materials used in composting have enough of the microbes on their surfaces to start and continue decomposition.

Mixing small amounts of soil into composts is unnecessary, but the soil may help conserve nitrogen and other nutrients. A thin layer of soil on the outside surfaces of a heap will aid in retaining moisture. A shallow pit does the same, but the pit should be in a well-drained place, because accumulation of water in a poorly drained pit will produce anaerobic conditions.

When is the composting process completed? In large, well-prepared heaps, a drop in the interior temperature to values near air temperature and easy crumbling of the materials in the hand indicate completion.

Full composting in small heaps usually requires 3 months under favorable conditions of moisture and temperature. Composts prepared late in the fall in regions of cold winters may not be ready for use until early the next summer. Under commercial conditions, with large heaps and frequent turning, composting time may be shortened to 2 or 3 weeks. With some mechanized processes, only 10 days are required for fresh material, and that may be shortened to 3 days if the beginning material is already partly decomposed.

Bins of simple construction are desirable for home or garden-scale composting. A bin will help to maintain moisture at the edges of the heap and prevent blowing. It should be about 4 feet wide, 5 feet high, and as long as needed to hold the material available for composting. No floor is needed.

It is well to have two bins side by side with one common wall. The compost may be forked then from one bin to the other for turning and mixing. The compost that is ready for use may be kept in one bin while fresh compost is started in the other.

Snow fencing with posts at the corners makes a satisfactory bin. A variety of timbers, arranged in log-cabin fashion, or boards nailed to corner posts provide satisfactory enclosures. Only narrow cracks should be left between the timbers or boards. More permanent structures may be built of concrete blocks or bricks. Small openings should be left near the bottom of such walls to permit penetration of air. One end of the bin should be closed with removable boards to permit access for mixing and removal of the compost.

PEAT is a widely used organic soil amendment. It is made up of plant remains that have accumulated over the centuries under relatively airless conditions in bogs.

Peats may be divided into two main types, according to the kind of plants from which they were formed. One is sphagnum peat—or peat moss, or highmoor peat—which is derived from species of the sphagnum plant. The other, formed from the sedges, reeds, mosses, or trees is called lowmoor peat.

Peat derived from trees is sometimes grouped separately as forest peat, or peat mold. It is intermediate in composition between sphagnum peat and that derived from sedges and reeds. Forest peat contains many finely divided particles of wood and is often used for mulching.

Sphagnum peats on a dry-matter basis have an ash content usually below 5 percent, nitrogen 1 percent or less, and phosphorus and potassium below 0.1 percent. They are very acid, with pH values between 3.0 and 4.5. Fresh sphagnum peats have a high water-holding capacity equal to 15 to 30 times their own weight, but that is cut in half following drying. Cellulose and hemicellulose make up about 40 percent of sphagnum peats, but they are resistant to decomposition by microbes.

Lowmoor peats are more variable than sphagnum. Their dry matter contains 5 to 40 percent of ash, 1.5 to 3.5 percent of nitrogen, and less than 0.1 percent of phosphorus and potassium. They can hold 3 to 8 times their own weight of water. Their pH values range from 3.5 to 7.0. Because most of the cellulose and hemicellulose in them has been decomposed, they have a high amount of ligninlike substances.

Peats improve the water-holding ability of most soils and give better physical structure to fine soils. Heavy applications equal to 25 to 50 percent of the volume of the soil often are made with that in mind. They are used mostly on specialty crops and home grounds.

Undecomposed or slightly decomposed forms of sphagnum, if incorporated into the soil, require small amounts of nitrogen. Acid peats are used for acid-loving plants as a direct growth medium or by mixing into the soil or as a mulch on the place where they are grown. The acidity of such peats may need to be neutralized with ground limestone if they are to be used for ordinary plants.

Peats, especially the coarser grades of sphagnum, are good livestock bedding and poultry litter. In 1950 in the United States an estimated 161,000 tons of peat were used for soil improvement and 31,000 tons for stable bedding and poultry litter.

SEWAGE SLUDGE is the solids remaining from the treatment of sewage in disposal plants. Various methods of digestion and removal of the solids reduce the organic matter in the plant effluent to a safe point. The resulting sludge is filtered off and may be burned or sold or given away for use as fertilizer.

The value of the sludge for soil improvement depends on the method used for treating the sewage.

Activated sludge comes from disposal plants in which aerobic treatment is obtained by bubbling large quantities of air through the digesting sewage. The sludge is then allowed to settle in large settling tanks, drawn off, and filtered. The filtered material still contains 80 to 85 percent of water. If it is to be sold as fertilizer, it is dried by heat to a moisture content of 5 to 10 percent. Activated sludge contains 30 to 40 percent of ash, 5 to 6 percent of nitrogen, and 1 to 3.5 percent of phosphorus.

Digested sludges come from disposal systems in which solids are allowed to settle out and are then digested anaerobically. On a dry-matter basis, they contain 35 to 60 percent of ash, 1 to 3 percent of nitrogen, and 0.5 to 1.5 percent of phosphorus. They are allowed to air-dry on sand filter beds outside or in greenhouses where they are protected from rain. Because of their low content of plant nutrients, they are seldom sold for fertilizer.

Activated sludge has a higher nutrient content, lower moisture, better physical condition, and no odor. Available nitrogen in activated sludge is almost equal to that in cottonseed meal and costs about the same. When it is added to soil, about one-half the nitrogen is nitrified in 4 weeks. More than 50,000 tons of activated sludge are produced annually by the sewage disposal plant of Milwaukee, Wis. There is a wide demand at good prices for this product for fertilizing grass in lawns, parks, and golf courses.

All sewage sludges are low in potassium because compounds of potassium dissolve readily in water. They must then be supplemented with a potash fertilizer when used on soils that have too little potassium. Additional phosphate also is needed on some soils, depending on the amount of sludge used.

Sludges contain appreciable quantities of the minor elements, copper, boron, manganese, molybdenum, and zinc. A few experiments indicate that they are available for plant growth.

Sanitary aspects must be considered when digested sludges are applied. Pathogenic organisms may escape the treatment process. It is not advisable to use digested sludge on root crops or low-growing vegetables that are to be eaten raw. Incorporation into the soil 3 months ahead of planting leads to destruction of the disease organisms. Digested sludges give rise to bad odors, which can be overcome by immediate incorporation into the soil. Activated sludges have no bad odor and microbes are killed in the heat treatment.

Maintaining Organic Matter

W. V. Bartholomew

Soil organic matter is dynamic material. It changes continually through further decomposition, but it maintains a degree of stability in quantity and in quality through the additions of new raw materials.

Organic matter is a temporary product—a stage in a natural cycle of elements. Each increment remains in the soil while it passes through the several slow biological oxidation changes that eventually reduce it to carbon dioxide, water, and mineral elements. As it passes through the cycle, it is replaced by organic matter formed from fresh residues.

Organic matter is formed in the biological decomposition of plant and animal residues. In the decomposition process, some of the plant substances are converted rapidly to carbon dioxide, water, and mineral elements (mineralization), and other substances may be only chemically altered at first.

The microbiological activity is high when fresh plant residues begin to decay. As the micro-organisms consume the more easily decomposable materials, the level of activity gets less and less. When only the more resistant plant substances remain along with the series of new organic materials synthesized by the micro-organisms, the microbial activity becomes slow—akin to a smoldering fire—and is the cause of constant loss of organic matter from soil.

The amount of organic matter in soil at any time hinges on the speed of the microbiological activity and the amount of fresh residue material that is added each year. The principles that regulate microbiological decomposition—which affect mechanical losses of soil and determine the amount and kind of residues returned to the soil—therefore are the principles that govern the level of organic matter in soil.

A number of things affect the speed of activity of soil microbes. We can control some of them. Others depend on the weather. Some are determined by early geological processes and the kind of plant cover that prevailed before man became interested in soil organic matter. Among the factors are temperature, moisture, aeration, acidity, supply of plant nutrients, tillage, and the kind and the amount of crop residues and manures returned to the soil. Cropping systems and soil management exert strong influences on most of these factors.

Microbes are most active in a moist soil. Microbial activity is depressed when a soil is extremely wet or dry. Air is excluded from the soil pore spaces in a wet soil, and the lack of air slows decomposition. Although microbial ac-