No seed of the Carolina clover is available commercially; but where it is abundant, seedheads can readily be gathered and scattered where wanted. Seed of the low hop clover is not to be had in quantity, but that of the least hop clover can be bought in England under the name suckling clover or *Trifolium minus*. It can also be had from certain seed dealers in Oregon, who clean it out of alsike clover seed; but the Oregon seed is usually quite foul with weed seeds and there is at present no information as to how these weeds will behave in the East. Seeding of all of these clovers should be done in early fall or late summer. Much of the seed of the Carolina clover is hard, so that if a quick stand is wanted a rather heavy seeding must be made. No experiments have been made with these plants, but in view of the small size of the seed it seems as though five pounds per acre of the hop clovers and eight pounds of Carolina clover should be enough. To insure even distribution it is well to mix the seed with sifted loam or sand.

Humus-Producing Materials and the Making and Use of Compost

By R. A. Oakley and H. L. Westover

Organic matter, or humus, as a constituent of soil, bears a very important relation to the growth of plants. This is a fact that was discovered by man early in his agricultural efforts. Just as he had a knowledge of the plants that were worth his while to grow, it is reasonable to suppose he early learned the difference between poor and productive soils, and what common substances he could add to them to increase their productivity. That he knew little of the reasons for the results he obtained is not particularly to his discredit. Even in our enlightened generation we have failed to work out the complete story. But we have added to it and today we know more of the role of organic matter in the soil than we knew yesterday. Tomorrow we may make a further advance in our knowledge, for investigators are attacking the subject along some very promising lines.

The modern conception of fertilizers attaches even more importance to humus than was ever before accorded it, and this regardless of the efforts of Liebig and other apostles to argue the all-sufficiency of inorganic forms of nitrogen, phosphorus, and potassium. Good barnyard manure heads the list of fertilizers today, as it has headed it for generations, and will probably continue to head it for some time to come. Other fertilizers are highly important, but they can not fully replace this humus-supplying material.

Humus Defined

In the sense that it is now used, the word humus applies to decaying organic matter, or more strictly to decaying organic matter in the soil. In its adjective form the same word is used to designate organic materials that make humus when added to the soil. Common practice has made this usage acceptable.

Functions of Humus

One of the outstanding functions of humus is to improve the texture of soils. This is a physical function involving better aeration, water-holding capacity, and drainage, and incidentally the lessening of heaving due to alternate freezing and thawing in the winter and spring. By the proper use of humus, stiff, impermeable soils may be made friable, which, in addition to providing better water-absorbing capacity and drainage, also permits of better penetration by the roots of plants. Humus added to the soil gives it springiness and prevents the formation of a hard, unyielding surface. This is especially important in the construction of golf courses. While clay soils may be loosened by the incorporation of organic matter, sandy soils may be made more cohesive, thus giving them better water-holding capacity and making them less subject to blowing. In addition to changing the texture of the soil, humus modifies its temperature relations. Organic matter incorporated with the soil darkens it, thereby giving it a greater heat-absorbing capacity, and when it is applied as a topdressing it acts somewhat in the nature of an insulation.

An important physiological function of humus is to furnish suitable food for beneficial soil organisms, which in turn, among other things, supply nitrogen in a form available to growing plants. In fact, it is only through the action of certain soil organisms—notably the azotobacter group of bacteria—that humus can be made to yield nitrogen for the use of higher plants. Whether it is the nitrogen that organic matter yields or whether it is something else that is most responsible for its beneficial physiological action on plants, is not known. Recent investigations, however, indicate that green plants will not thrive in a medium totally destitute of decaying organic matter. Why this is true has not been ascertained; but certainly it is not for lack of nitrogen.

Some time, more will be known of the functions of humus in the soil, but it may be said with considerable certainly that future discoveries—no matter how valuable they may be—will only tend to emphasize the importance of decaying organic matter to plant growth.

Sources of Humus-Making Materials

While humus may be produced from decaying animal matter, very little is added to the soil from this source. Most of it is supplied by animal-made manures and by partly decayed vegetable debris, such as peat, sod, and leaf mold. It is a common practice to mix one or more of these materials with soil or sand, or both, thus making what is called compost. A little good barnyard manure may be made to go a long way by composting it with other decaying organic materials. Compost is a highly satisfactory source of humus and has proved the salvation of many golf courses.

Barnyard Manure

The only serious objection to barnyard manure as a humous material is that the supply is too limited. If it were not for this, there would be little interest taken in other kinds. The others at best are but substitutes. Good barnyard manure properly rotted and com-

minuted comes more nearly filling the requirements of a humus-producing material than any other form of organic matter that is commonly available. In the form of spent mushroom soil it is nearly ideal. In this condition it is well decomposed, of good texture, easily broken up, free from viable weed seeds and disagreeable odors, and usually all it needs is to be put through a screen to make it ready for mixing with the other constituents of compost. Spent mushroom soil is what remains of a good quality of horse manure after it has been in a mushroom cellar for a year. It has lost little of its fertilizer value and is highly desirable for the golf course.

It is not a difficult matter to convert barnyard manure into a form suitable for topdressing turf. All that is necessary is to pile it in ricks and give it time to decompose. Surplus straw should be removed with a fork or screen. For incorporating with the soil of fairways, manure should be used alone unless the soil is very sandy, and little attention is necessary in preparing it for this purpose. For topdressing fairways, it should also be used alone, except on very sandy soils, where clay should be mixed with it. But as a topdressing it should be free from undecomposed straw and from large lumps. As a topdressing for putting greens, loam and sand may be mixed with manure to advantage. The charge that manure is unsafe to use on turf because of the weed seeds it contains is not well founded; and besides, it is entirely possible to determine whether or not it contains viable weed seeds, by putting a representative sample in a box and giving it conditions of heat and moisture favorable for the germination of seeds. No conjecture on this point is necessary. If seedlings appear, weed seeds are present; if seedlings do not appear, weed seeds need not be feared. Seeds of the most troublesome weeds are soon killed by composting.

The fertilizer value of barnyard manure can not be reckoned from its nitrogen, phosphorus, and potash content, nor from the organic matter it contains. In addition to available nitrogen, phosphorus, potash, and organic matter, it carries numerous beneficial organisms and their products. Very probably there are also other beneficial agents in it, all of which are valuable; but their importance can not be directly measured.

The duty of a limited quantity of barnyard manure can be greatly increased by composting it with peat, sod, or other decaying plant material. A little manure will inoculate a large compost heap.

Peat or Muck

The terms peat and muck are very often used interchangeably. Peat, however, is the more comprehensive of the two, and is applied to the remains of plants decomposed or partly decomposed in the presence of water. In consistency, it varies from scum to a solid substance in which the texture of the plants has almost if not entirely disappeared. All muck soils are of peat origin. Peat deposits are numerous, especially along the seacoast and in the vicinity of large lakes. The color and texture of peat and its availability have suggested its use as a material to add to soils to increase their productivity, but results from its use have been far from consistently good.

There is a wide diversity in the texture and chemical composition of peat deposits in the United States, as they represent hundreds of years of plant accumulations, often of different kinds, and it is only

to be expected that there should be considerable variation not only between peat deposits but also between different portions of the same deposit. It is said that deposits vary widely in percentage of nitrogen, and it is often claimed that those with a high percentage are much more valuable than those with a small amount of nitrogen.

As it occurs naturally, peat is very frequently toxic to plant growth, and some of it is highly acid in its reaction. It is also practically free from nitrifying bacteria and other beneficial organisms. Because of its probable toxicity and freedom from organisms, peat should be thoroughly weathered and composted with manure and probably lime before it is used for topdressing. Lime has a tendency to correct the toxicity, and manure inoculates it with proper organisms for nitrification.

As a fertilizer or a topdressing on grass or other crops, the value of any peat is very slight. The nitrogen or other elements found by chemical analysis in peat are in a very inert condition. Indeed, as compared with manure or commercial fertilizer, the elements in peat are practically unavailable to plants. During the past few years peat has frequently been advertised for sale as "humus" to be used as fertilizer or in place of fertilizer or manure. Special processes, such as the bacterization of peat, occasionally are alleged to give to it unusual power to improve soil conditions and to aid plant growth. In general, extensive investigations show that peat as well as muck and similar materials, whether bacterized or not, are distinctly inferior to stable manure or mineral fertilizers for increasing crop production. The use of some kinds of peat, like straw or other low-grade or surplus material, may often be desirable in stable manure or in compost. Composting a suitable peat with stable manure increases the quantity without very materially lowering the manure value.

Where peat can be procured cheaply and where good barnyard manure is not abundantly available, it may be used advantageously on greens and fairways if it is composted with manure and lime to correct the toxicity. Golf clubs can not afford to pay good manure or mushroom soil prices for raw peat even if it has a low moisture content and is non-toxic. Compost containing peat should not be used as a topdressing for putting greens without first being tested by putting a sample in a box or tray and sowing grass seed in it. If the young seedlings thrive, it is safe to assume that the peat is not toxic.

Sod, Leaves, and Leaf Mold

In making compost, sod is very useful. It is composed of the dead leaves and roots of grass, and the soil in it is usually of very good texture and quality. Some soil is needed in compost, and almost an ideal combination can be made by mixing sod and manure. Equal parts by volume of sod and manure are about the right proportion for compost; but the matter of proportion is indeed very flexible. Six months to a year in a compost pile is necessary for sod to rot properly. The pile should be worked over and screened considerably in advance of the time the compost is needed, and the coarse material put aside for further composting.

The term leaf mold is applied in a very general sense to leaves, twigs, roots, and similar vegetable matter in various stages of decay. Much of the leaf mold that is used is made up largely of leaves only

partly decomposed. Such material is useful for supplying humus if it is well composted with manure, but alone it does not make a suitable topdressing for turf. Darwin says earthworms play a very important part in the making of leaf mold—much greater, in fact, than is ordinarily supposed. Leaf mold commonly gives a relatively high acid reaction, the degree of acidity depending somewhat on the stage of decomposition, the kind of leaves, and the kind of soil underlying them. Well-decayed leaves often give a neutral or even an alkaline reaction, because of the lime they contain. Red oak leaves have higher acidity than maple leaves, and leaves that have fallen upon acid soil produce leaf mold that is more highly acid than that produced from leaves decomposing on an alkaline soil. Like sod, leaf mold contains an appreciable proportion of soil, which is useful in making compost. Equal parts by weight of leaf mold with the soil that usually goes with it, and manure, make a desirable combination.

Street Sweepings

At one time street sweepings were quite extensively used as a fertilizer. Now they are not so much in demand. With the advent of the modern asphalt pavement and the automobile, street sweepings are not what they once were; in fact, sweepings from an asphalt-covered street are very likely to be toxic to grass and other plants, because of the asphalt and oil that are collected with them. It seems advisable, therefore, to issue a warning against their use, especially for topdressing turf. Where they have been used and injury to the grass has resulted, it is suggested that a light application of pulverized limestone be added. Calcium is known to unite with asphalt, and it is believed that it will neutralize the harmful effects of the latter on vegetation.

Pulverized Sheep Manure

As a source of humus, sheep manure as it is put on the market is an expensive product and is not considered very satisfactory. While it is in a very convenient form to use and is free from viable weed seeds, it falls far short of producing the results that are necessary to justify the price that is asked for it.

Barnyard Manure Made Artificially

The Rothamsted Experiment Station, in England, has found that straw may be converted into a good quality of manure by treating it with a soluble nitrogen compound, such as ammonium sulfate or nitrate of soda. The former has been used at Rothamsted and is preferable where golf courses are concerned. The method involves the composting of fresh straw with ammonium sulfate at the rate of 100 pounds of ammonium sulfate to one ton of dry straw. As straw takes up moisture slowly, it should be moistened thoroughly two or three days before adding the ammonium sulfate. Where the sulfate is put on dry straw and then watered, there is danger of considerable loss through leaching unless extreme care is used. After applying the ammonium sulfate, the straw should be kept well moistened until fermentation or decay is well under way, and then mixed with loam or clay loam, as in making compost with manure. The Rothamsted investigators advise the addition of lime to the ammo-

nium sulfate and straw, since straw breaks down more rapidly in a neutral or alkaline solution of nitrogen, but experiments conducted here in a crude way indicate that lime is not necessary, and where compost is to be used on putting greens it is not desirable. At least one concern is attempting to commercialize the process, but doubtless the method used by this concern involves some modification of the simple one here described.

COMPOST

Barnyard manure, sod, leaf mold, and peat—in fact, almost any vegetable matter that will decay readily—may be used in making compost. Clay, loam, and sand may also be included, and probably some lime, where peat is used, to obviate any possible toxic effect; likewise organic and inorganic commercial fertilizers—the fertilizers especially if the compost is not rich. Composting is an old practice of gardeners and florists. It brings about changes in the materials involved—some well known, others only slightly if at all understood. The final result, however, is a product very beneficial to plant growth.

Mixen was the name by which compost was known several generations ago, but it is obsolete now. Nevertheless, the term has good features. It is simple, euphonious, and descriptive. However, it smacks of common origin and lacks the pedigree of its successor, "compost." This is probably responsible for its demise.

There are no very hard and fast rules to lay down for the making of compost. The materials to be used necessarily depend to a considerable extent on what is available. Barnyard manure, however, should always be a conspicuous constituent of every compost pile. No commonly available material will take its place, especially in supplying the various organisms that are highly important in bringing about proper decay.

In addition to organic matter, soil of some kind should be added. Whether clay, loam, or sand, depends largely on the kind of soil with which the compost is to be incorporated or upon which it is to be applied. The common range of soil to organic matter is from one-fourth of the former to three-fourths of the latter, to equal parts of each. However, local conditions may call for proportions outside this range.

Two common and very satisfactory methods of constructing compost piles are illustrated by the following diagrams:

1

Sod
Manure
Sod or leaf mold
Manure
Sod or leaf mold
Manure

2

Sod
Manure
Peat mixed with lime
Soil
Manure
Peat mixed with lime

The piles may be built as high as desired. Six to eight feet is suitable for convenience. In diagram No. 2 the lime should be mixed with the peat at the rate of about 25 pounds to the ton; but it should not be mixed with the manure or allowed to come in direct contact with it until the compost pile is cut down and worked over for use. By varying the depth of the layers, it is easily possible to make compost of the desired consistency. However, layers exceeding 8 inches are usually too deep for the best disintegration.

If compost piles are built in sheds or are otherwise similarly covered, there will be less loss from weathering than if they are built in the open, but sufficient moisture must be provided to bring about the necessary decomposition and other changes.

It is said to be possible to inoculate peat with nitrifying organisms by composting it with bone meal, fish scrap, tankage, and similar fertilizers composed of animal products. However, the evidence indicates that they are not as satisfactory as manure for this purpose. If manure can not be had or is not sufficiently abundant, it is suggested that they be tried as a partial substitute for it. Five pounds of these fertilizers to a cubic yard is the approximate quantity which should be used. But, it should be distinctly understood that there is as yet no thoroughly satisfactory substitute for manure.

In making compost there are some important points to be borne in mind:

1. The compost pile should be so constructed as to bring about the proper decay of vegetable matter. This means that the materials should be laid down in layers about 6 inches thick or otherwise reasonably well mixed. This aids in decomposition and in the production of a uniform final product.

2. Covering compost piles protects them from loss by weathering; but considerable moisture must be present in the materials to promote proper decay and other beneficial changes.

3. Barnyard manure carries beneficial inoculating organisms and should be present in every compost pile, especially where peat is used. Bone meal and tankage and similar animal products are said to aid in the introduction of nitrifying organisms.

4. Soil of some kind improves the quality of compost, chiefly by giving it better texture, which involves, among other qualities, cohesiveness and water-holding capacity. It helps to unite the organic matter with the surface of the soil upon which it is applied.

Compost for Topdressing Turf

A rational system of greenkeeping involves the use of good compost as a topdressing. It should be followed in most cases as a matter of routine about once a month during the growing season. For topdressing sandy-soil fairways, compost should have a large proportion of clay. Even three parts of clay to one of organic matter is not excessive where the soil is nearly pure sand. For putting greens, such a large proportion of clay is not desirable, even where the soil is very sandy, and on clay-soil fairways it is questionable whether even a small percentage of clay or soil of any kind adds materially to the value of the compost. For putting greens on clay soil, compost should contain loam and sand rather than clay. A liberal proportion of sand will do no harm.

For best results ammonium sulfate should be mixed with the compost at the rate of 15 pounds of the sulfate to a cubic yard of compost at the time of topdressing. As is well known, care must be taken in applying ammonium sulfate alone, or otherwise burning of the turf will result. Even when mixed with compost the necessity of careful handling is not obviated. Applications of compost should ordinarilly be made at the rate of 1 cubic yard to 5,000 square feet, monthly, during the growing season. The compost should be worked thoroughly into the turf with a switch broom, a street broom, or any suitable implement. Flexible wire door-mats tied together lengthwise make an excellent device for this purpose.

Stink-Grass; A Putting Green Weed

Stink-grass (Eragrostis cilianensis), about two-thirds natural size; "a," single spikelet of seed-head, enlarged.

Stink - grass (*Eragrostis cilianensis*) is a slender, tufted, often decumbent grass with compact panicles of large spikelets, as shown in the accompanying illustration. The grass gives off a disagreeable odor, which is thought to be due to the glands found on the pedicles and spikelets. Being an annual, stink-grass starts from seed each year and dies in the fall. It occurs as a weed throughout much of the United States and at times invades putting greens in the eastern states. In the summer of 1925 it was reported as forming a solid patch on a putting green in eastern Pennsylvania. It was also reported on the course of an Ohio country club. Stink-grass is not likely to invade a heavy vigorous turf but may become a pest in thin turf. In such cases it should be weeded out by hand before it has a chance to produce seed. Heavily infested areas should be cut out and removed from the course.

Another species (*Eragrostis carolinia*), with open panicles of smaller spikelets, is also a common annual weed that is widely distributed in the United States.