Lawn Making and Maintenance

LAWN MAKING

and Maintenance

A discussion of the
problems involved

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O. M. SCOTT & SONS CO.
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CONTENTS

MAKING NEW LAWNS

LAWN MAINTENANCE

Part One. Making New Lawns

Lawn problems naturally fall into two classes; first, the construction of new lawns and, second, the care of lawns already established. New lawns are first considered, beginning with a discussion of clearing and grading, followed by a consideration of soils and how they may be improved, seed bed preparation, seed selection and planting, and, finally, by suggestions as to the after treatment of a newly seeded lawn until it is developed into turf.

CHAPTER I

CLEARING AND GRADING

Better lawns can be had at lower cost if the work is planned and begun several months ahead of the time of seeding. There will then be opportunity for improving soil conditions, and otherwise preparing a more favorable seed bed. Tile drainage should be installed early so that the trenches will settle and the tile will be actually functioning by the time the lawn is seeded.

Clearing the Land. The work to be done in clearing depends upon the number of large trees, stones, and other obstructions to be removed. It is usually not necessary to cut many trees, as only those should be removed which interfere with the general plan. Trees are one of the most beautiful features of any landscape, and as many as possible should be retained. A dense growth of trees, however, adds to the difficulty of maintaining turf, as the best grasses will not grow in shade because of the absence of sunlight and because trees take moisture and plant food from the surface soil.

In clearing land the removal of tree roots is quite a problem. One method is to pull the entire tree over by the use of power equipment so that some of the roots will be pulled out of the ground at the same time. This is generally less satisfactory than cutting the timber and then removing the stumps. The larger stumps can be more easily removed by first loosening them with a small charge of powder or dynamite. Powder is usually preferred because combustion takes place more slowly and tends to push rather than shatter the stumps. The size of the charge is determined by the type of soil and the size of the stump.

Unless a large tractor is available stumps must be lifted with a stump puller and then hauled away on stone boats. Large stones or anything else that might interfere with grading should be removed at the same time. Usually all clearing can be done during winter except, possibly, the pulling of stumps from deeply frozen ground.

A rank growth of weeds and underbrush should be burned off during late fall and winter.

Using Unbroken Sod Land. Pasture land with a good tough sod can often be made into a good lawn turf without the expense of plowing. From such areas stones and other debris should be removed. Sod land is improved by regular mowing, fertilizing and reseeding, and by rolling in the spring. If the turf is ridged and uneven it can be levelled by cutting in various directions with a sharp disk harrow, set straight. It is then to be seeded at the rate of 50 to 75 pounds per acre.

Grading. After clearing, any large holes should be immediately filled so that they will not collect water. Before grading, good topsoil should be removed so it will not be covered. Topsoil is too valuable to be covered with subsoil. It should be set aside by means of scoops, and replaced just before the final seed bed preparation.

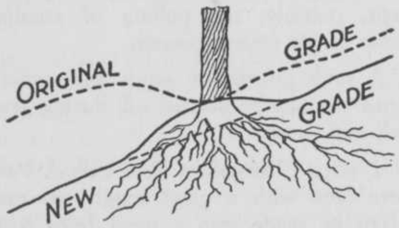
Lawns should have pleasing slopes that conform to the natural contours of the ground. If possible, flat, uninteresting surfaces are to be avoided, as well as those graded regularly up to a few high points. Grading must be done so that no holes or pockets are left to collect water during heavy rains or winter thaws. *Standing water is the cause of much winterkill.* It is best to grade lawns so that most of the water will be absorbed where it falls and not develop into a wash.

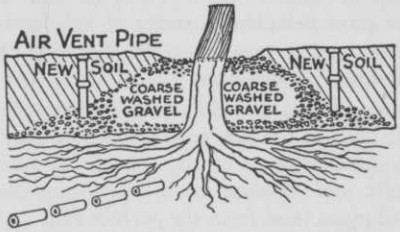
In bringing the soil surface to grade it should be remembered that there will be a certain amount of settling. An allowance of one to two inches for this is usually enough.

Abrupt grades and terraces with a southern exposure increase lawn maintenance difficulties. On steep slopes rain water runs off so rapidly that the soil cannot take up sufficient moisture for the needs of the grass. Such slopes should be avoided if possible. It is particularly difficult to keep good turf on southern slopes as the direct rays of the sun increase evaporation losses so that the soil is not able to furnish the moisture needed by the grass.

The eye cannot be relied upon in establishing surface grades. On large areas, surveying instruments are needed to set grade stakes, while on smaller lawns line levels are satisfactory. The ground surface will look more natural if the grading is done by horse or tractor-drawn scoops, as, by their use, it is more nearly possible to approach nature's gentle undulations and pleasant slopes.

Tree roots must be protected during grading. If the new grade is decidedly lower than the old one a low spreading mound of soil should be left over the roots. If the grade is to be raised by a large amount of fill, the trees must be protected by a fill of coarse gravel, with installation of vent pipes to insure air and water circulation. *(See illustration.)*





SAVE THE TREES WHEN RE-GRADING.

The illustration to the left shows how to leave a sloping mound of soil around tree roots when the grade is being lowered. Note the low sloping mounds which should extend out as far as the spread of the roots.

Whenever an extensive fill is required around trees precaution is necessary to prevent smothering. The above drawing suggests use of gravel, vent pipes and tile drains to insure proper air and moisture movement.

CHAPTER II

THE SOIL

Soil provides the lodging place for grass. Strong, healthy turf will not develop unless good lodging is furnished. Like animals, grass requires food, air and water, as well as suitable temperatures and sufficient light. Unlike animals, however, grass is not able to move about to alter its environment. It is anchored to the soil and must obtain from a very limited space all that it needs for its existence. It is not sufficient to provide for a part of the needs and not all of them. If one is lacking the others are of no avail, even though they be supplied in abundance.

The ability of a soil to support a luxuriant growth of grass depends upon several physical and chemical factors.

Physical Characteristics

In a physical sense, a soil consists of a mixture of mineral grains of all shapes, sizes and colors, intimately mixed with organic matter. Coating these mineral grains are gluey jelly-like substances called colloids. The relative amounts of the different sizes of mineral grains, organic matter and colloidal material in a soil determines its tilth, its ability to hold water, its texture—in short, all its physical properties.

Soil Texture. Casual examination of a number of soils will show that they contain particles of many different sizes. In some soils coarse particles predominate and the soil is sandy. In other soils the smaller particles are most numerous and the soil is clayey. Coarse sandy soils contain approximately two billion or less particles per gram (roughly one thirtieth of an ounce) of soil, while the same weight of a clay soil may contain twenty billion or more particles. Between these extremes are the loam soils, in which neither large nor small particles predominate.

The physical nature of a soil depends, then, upon the proportions of the different-sized particles which the soil contains. The term *texture* is commonly used to designate the degree of fineness of the soil mass. Thus, the texture may be coarse, medium, fine or very fine, depending upon the size of particles that are present in the largest amount.

Clay. This is the term used to designate the smaller of soil particles. A given volume of clay often contains 7000 times as many particles as the same volume of fine sand. This characteristic enables the potter to work wet clay into shapes which it will retain when dried. By puddling, or working when wet, he forces the clay into separate particles, and these particles are so small that he can form the clay into any desired shape. What he does is to destroy the aggregate or granular arrangement and expel the air. A similar thing happens in the field whenever clay is worked when wet—it becomes more clayey and sticky than before.

The tiny size of clay particles also increases the water holding capacity of this soil type. In an equal volume of clay there is 500 times the amount of exposed surface as in fine sand. In one cubic foot of clay there are over 3000 *acres* of exposed surface area as compared to about six acres in the same volume of fine sand. As moisture is held as a thin film around the soil particles, it naturally follows that the greater the amount of exposed surface the more water will be held.

Sand. The main characteristic of sand is the lack of ability of its particles to stick together and retain a form, especially when dry. Its moisture holding capacity is very low, in some cases only about five per cent. The content of humus and of plant food elements is also usually low. Plant food is leached excessively because of the rapid drainage of sandy soils.

The difference in size of clay and sand particles must always be kept in mind. Since sand particles are many times larger than clay particles a given volume of clay will have a greater modifying effect upon a sandy soil than will the same volume of sand on a clay soil. Twenty to thirty per cent of clay will serve to classify a soil as clay, whereas at least fifty to sixty per cent of sand is needed to classify a soil as sandy. In other words, a soil of 80 per cent sand and 20 per cent clay can be changed from a sandy soil to a clay soil by the addition of ten or fifteen per cent of clay. Conversely, to change a soil of 80 per cent clay and 20 per cent sand to a sandy soil would require the addition of at least 60 per cent of sand.

Soil Classes

Since the particles in soils are not of uniform size and shape, certain terms are used to indicate their texture and physical character. The easily recognized physical properties of various classes of *soils* are as follows:

Sand. Loose and single grained. The individual grains can be seen and felt. Dry sand, when squeezed in the hand, will fall apart when the pressure is released. Squeezed when moist, it will form a cast which crumbles when touched.

Sandy Loam. Contains much sand, but enough silt and clay to make it hold together to a greater degree than does sand.

Loam. Contains about equal amounts of sand, silt and clay. It is somewhat gritty, yet, when rubbed between the fingers, seems fairly smooth. The ball formed by squeezing the moist soil can be freely handled without breaking.

Silt Loam. Contains only moderate amounts of the finer sands, and only a small amount of clay. Over half of the particles are of the size called *silt*. When dry it may look quite cloddy but the clods can be easily crushed. When pulverized it feels soft and floury. When wet it cannot be rolled out into a ribbon, but will break up.

Clay Loam. A soil in which the fine particles predominate. It forms hard lumps or clods when dry. When moist it is plastic, and if the wet soil is kneaded or rolled in the hands it works into a heavy compact ball.

Clay. Made up of very fine particles. It forms very hard lumps or clods when dry and is sticky and plastic when wet. When moist clay is rolled between the hands it will form a long flexible ribbon.

Muck. Soil consisting of thoroughly decomposed organic matter mixed with 40 per cent or more of mineral matter. It contains very little fibrous material.

Peat. Soil consisting chiefly of organic material, highly fibrous. The plant-remains in it can easily be recognized.

With a little experience, one can place a soil in its proper class by its appearance and feel. The texture can be determined by rubbing the soil between the thumb and forefinger.

Soil Structure. It is evident that not only the size but also the arrangement of the particles must exert some influence on the physical properties of soils. The term "structure" refers to the arrangement of the soil particles. Some soils like sands are loose and open and allow the easy movement of air and water through them. Others, especially clays, are very tight and compact, a condition which seriously interferes with the movement of air and water. Not all clay soils have such an undesirable physical condition. If the individual particles of a clay are clumped or grouped together so as to produce a granular condition, the soil, even though it be a clay, may be loose and open, due to the space between the granules. The method of handling a clay soil largely determines its structure. Improper handling causes the fine particles to run together and a tight soil, very sticky when wet, will result. The physical condition of heavy clay soils may be much improved by proper methods of cultivation, exposure to alternate freezing and thawing, and by the addition of organic matter and, sometimes, lime.

Chemical Characteristics

The wide difference in the ability of soils to support plant growth is everywhere evident. Two adjacent soils lying in the same field and farmed by the same man may show extreme differences in their crop producing power. Often these soils show little difference in appearance. Only by a detailed chemical analysis can it be shown that one soil is rich in those chemical elements used by plants, and the other lacking in one or more of them, or holding them in a form not readily available to the crop.

Of the ninety or more chemical elements of which the earth is composed, not more than twelve are needed by plants. Seven of these are supplied by the soil.

What's in a Soil? The greater part of mineral soils consists of three elements: silicon, aluminum and iron. Two million pounds of average soil, the weight of an acre to plow depth, contains silicon equal to six carloads of sand, enough aluminum to make an ingot weighing seventy tons, and enough iron to build 250 feet of railroad track.

The most needed elements, like nitrogen and phosphorus, are present in soils in quantities that are small as compared with the quantities of elements like aluminum and silicon, which the plant does not need. A statement of the total quantity of all the elements present in a soil gives little or no indication of its ability to support the growth of plants. Soil composition is only one of the many factors necessary for plant growth.

Soil Acidity. Plant growth on soils is influenced not only by the amounts of the needed elements in the soil that are available to the plant but also by the reaction, that is, the degree of acidity or alkalinity, of the soil. While highly acid and highly alkaline soils are not uncommon, the reaction of most soils is from only slightly acid to very slightly alkaline. The degree of acidity or alkalinity of a soil is usually expressed in terms of its "pH" value. On the pH scale the number 7 indicates neutrality. pH values less than 7 indicate increasing acidity, while values greater than 7 indicate increasing alkalinity. The pH value of soils of the humid regions lies between 4 and 8, the great majority of such soils having pH values between 5 and 7.

Soil Water. Growing grass is composed of sixty to ninety per cent water. A soil must therefore supply enormous amounts of moisture at all times if grass is to be kept from wilting. At the same time, this moisture must be in such form as to be available to the grass. As will be shown later too much moisture in a soil may cause greater damage than too little moisture.

Soil Organic Matter. Fertile soils contain varying amounts of decaying organic matter which comes from vegetable or animal residues. These materials gradually decompose into a dark colored substance called "humus." The color of a soil is a fair indication of the humus content, as the more humus the darker the soil. Humus acts as a sort of sponge, improving the physical condition of soils and increasing the water and plant food holding capacity.

In order that organic matter may be broken down into humus, certain bacteria are necessary. Every cubic inch of good soil contains literally billions of these friendly bacteria which are constantly attacking and breaking down organic matter into humus. During this process they liberate nitrogen and other chemical elements and make them available to the grass. When given suitable climatic conditions and organic matter, bacteria are almost ceaseless workers.

The production of humus is closely related to air circulation and temperature. With enough air, bacteria will completely decompose humus into simple substances somewhat similar to those produced when organic matter is burned. Thus, humus is more rapidly exhausted from light, sandy soils than from heavier clayey soils. Similarly, less humus is found in cultivated soils than in soils under grass, because of the amount of air admitted in cultivation.

All Soils Complex

From previous statements it may be seen that any soil is a most complex substance. Many factors determine its suitability for grass, all of which are closely allied. Thus, poor texture is improved by good structure or arrangement of the soil particles. Organic matter must be present to furnish material for breaking down into humus. Also, soil bacteria cannot thrive or work unless organic matter is provided them, together with other food elements, and unless the soil is of a texture and structure suitable to give the necessary conditions of air, moisture and temperature. The whole process is an endless chain. If one factor is absent the cycle is broken and plant life cannot be sustained.

The Ideal Soil

Although at first thought the requirements set forth in the preceding pages may seem to indicate that suitable grass growing soils are very scarce, this is not the case. Fortunately good turf can be produced on soils having moderately favorable physical and chemical characteristics. No one type of soil can be considered as best for lawns. It is probable that heavier soils are better than lighter ones. Generally speaking, they will have a greater moisture holding capacity as they are usually better supplied with humus. This is because the lighter soils permit a rapid circulation of air which tends to decrease the supply of humus. In addition, heavier soils are composed of smaller particles, which expose larger surface areas, and therefore hold more water.

A good soil is made up of about 50% solid matter, 25% air space and 25% moisture. It should contain a liberal amount of decaying organic matter. Soil should be friable and mellow in order to encourage rapid removal of excess water, allow free circulation of air, and enable a rapid extension of grass roots.

Improving Soil

While it is hardly practicable to change the texture of a heavy soil to any appreciable extent, it is possible to make it better for grass in several other ways. On limited areas, the texture can be improved by adding soil of opposite texture. Materials such as sharp sand, very fine cinders, ground slag and the like will improve the texture of heavy clay, although enormous amounts are required.

As explained before, a relatively small content of clay particles classifies soil as clay, whereas a soil must contain practically all sand before it is classified as sand. For that reason, proportionately large amounts of sand are needed to change a clay soil, but small amounts of clay will change the texture of a sandy soil.

Under Drainage. The structure of heavy soils is more easily improved than their texture. Under-drainage aids greatly in the formation of soil granules whereby small particles are grouped together forming units that function like individual large particles. The alternate passing of moisture and air through the soils which results from underground drainage is one of the important factors in soil granulation. Under-drainage, therefore, tends to make soils more loose and mellow, while standing water or a near state of saturation tends to cause compactness.

Organic Matter. Heavy soils are much improved by the incorporation of manures and other organic materials. However, these must be added in relatively large amounts to appreciably affect the soil texture. Often thirty or forty tons of barnyard manure to the acre are required. Sometimes substitutes for manure, such as sewage sludge, peat, muck or other vegetable matter, are used. Consideration of organic matter is given more fully on pages 12 to 15.

Green manure crops are excellent for improving heavy soils. Their root and top growth, when decomposed, will bind together the finer soil grains and form larger aggregates. The resulting humus will improve moisture holding capacity.

Several fall and spring sown farm crops make the heavy growth desired for green manure.

No matter what green manure crop is used, it is important that it be plowed under while the leaves and stems are green and succulent. In such a state they will decompose more rapidly than when ripe and woody. Generally speaking, fall sown cover crops should be plowed in April and spring sown crops during early August.

Early Cultivation. Heavy soils are also improved by cultivation. A good plan is to plow the land in late fall, thereby subjecting it to alternate freezing and thawing, and wetting and drying, during the winter. Such action will make the soil more crumbly. Spring plowing enables the surface layer to dry out slowly and crumble into a condition suitable for making a good seed-bed. Disking and harrowing during spring and summer will further improve the mechanical condition, and, at the same time, destroy successive weed crops as they germinate.

Regardless of what is being done, a heavy clay soil must not be worked when wet. Plowing or cultivating wet clay will cause the formation of lumps which will later dry and bake into hard, compact clods. Those working with heavy clay will soon learn that there are only a few times when such soil is in proper working condition. If too wet it puddles and packs; if too dry it works up into dust which compacts into a tenacious mass after the first heavy rain. There is nothing more discouraging or ruinous in lawn making than trying to establish a seedbed in a clay soil during a wet season.

Sandy Soils. While a proportionately small quantity of clay will change a sandy soil into a better mechanical condition, this method of improvement is not practical for large areas because of the expense.

Under-drainage is seldom needed. In fact many sandy soils are often over drained.

Like heavy soils, lighter soils are improved by embodying liberal quantities of partially decayed organic matter. If manure is used it should be free from weeds. The use of leaf mold, sewage sludge, peat, muck and other organic matter is explained on pages 12 to 15.

Green manure crops also help to add body to sandy soils. Vetch especially makes a good growth on light soils.

Use of Lime. Lime is usually considered as a soil amendment. While used chiefly to neutralize soil acidity, it at times aids in improving the physical condition of heavy clay soils and helps to release and make available plant food elements held in unavailable form in these soils.

Fortunately, the more important lawn grasses thrive better on slightly acid soils than do most weeds. By keeping the soil moderately acid, the growth of weeds is to some extent restrained. For this reason lime should be applied with caution to soils on which turf is to be grown. Before any lime is applied a determination of the reaction of the soil and of its need for lime should be made. This, with a recommendation of the amount of lime needed, can usually be obtained by sending a sample of the soil to the State Agricultural Experiment Station.

Organic Matter

The turf producing ability of a soil depends largely upon its organic matter content. The outstanding function of such organic matter, often referred to as humus, is to improve soil texture and structure. The presence of humus improves soils by providing better drainage, better aëration and a greater capacity to hold the needed capillary water.

If properly used humus will make stiff clay friable and loamy, permitting greater aëration and drainage, as well as a greater extension of plant roots. Humus will also improve light sandy soils. It acts as a weak cement binding the separate particles together, giving a better moisture retaining capacity and firming the soil.

A most important function of humus is to provide food and a home for beneficial soil organisms. By the action of bacteria on organic matter nitrogen is made available to the plant. Plants cannot thrive in a medium wholly devoid of decaying organic matter.

Humus vs. Commercial Humus

Agricultural authorities have long applied the word humus to that portion of the soil organic matter which has undergone decay to the extent of losing its identity. The loose application of the term humus to all forms of soil organic matter has resulted in the loss of its true significance. One reason for this has been the exploitation of some natural peat and muck deposits in various sections of the country. Notwithstanding the fact that these materials are advertised and sold as "humus," the organic matter contained has not reached the proper state of decay to be properly so designated.

Source of Humus-Making Materials

Humus is produced from decaying animal or vegetable matter, although little actually comes from animal matter. Probably the most common source is ordinary barnyard manure. Humus is added to the soil in the form of partly decayed vegetable matter. For example, the humus supply in turfed soils is constantly supplemented by decaying grass roots.

If organic matter is to yield humus certain favorable environmental conditions are necessary, such as light, temperature, air and moisture. Otherwise the bacteria and molds causing decay are not active. It is because of unfavorable air and moisture conditions that peat and muck in their natural locations are not transformed into humus.

Barnyard Manure

If barnyard manure were sufficiently plentiful no other source of humus materials would need to be considered. Properly rotted, it makes almost perfect humus. It is a wonderful soil conditioner, carries numerous beneficial organisms and their products, and some plant food. The only objection to its use is the possible introduction of weed seeds, but this can be avoided by using only well rotted manure. The actual plant food in manure is almost negligible. The average manure contains about 1% nitrogen, 2% phosphoric acid and a trace of potash.

Spent Mushroom Soil

Spent mushroom soil consists of the remains of good horse manure and soil after the mixture has been in a mushroom cellar for a year or so. It has all the advantages of good barnyard manure, including freedom from weeds and good texture. Unfortunately it is not available in large quantities except in the East, where it is a most economical humus-forming material.

Peat and Muck

Peats differ widely in form, texture, and chemical composition. However, all types of peat consist of vegetable materials in a partially decomposed condition, and their value as a humus forming material is similar.

In discussing its value and utilization, Mr. A. P. Dachnowski-Stokes of the United States Department of Agriculture defines peat as follows:

"Peat is the general name applied to the remains of plants which at one time formed an aquatic vegetation, or a marsh of coarse sedges or tall reeds, a bog of mosses and heaths, or a swamp of shrubs and trees. A peat deposit is therefore the result of the accumulation of many generations of plants from one or several groups of vegetation and in all cases contains at least one or more layers of different kinds of material. On that account the term 'peat' is restricted in its meaning to a compact and well-shrunken mass of organic material which accumulated in water or under conditions of a rising water level and varies in thickness from about 8 to 10 inches upward. Muck, on the other hand, is the finely divided plant debris on any surface portion of peat land which has been cleared and cultivated for farming purposes. The term 'muck' is applied correctly to disintegrated organic matter which contains more than 40% of mineral material."

It is difficult to make a definite distinction between peat, muck, and commercial humus. The term peat is ordinarily limited to that material which still retains the form of the vegetation. In its natural state peat is rather coarse, and somewhat flaky and usually dark brown in color.

Muck represents an advanced stage of decay. It is found as the top layer above peat deposits. Because of further decomposition it is darker and much finer. In addition it contains considerable clay and sand particles which have been blown or washed into the deposit.

"Commercial humus" is the name given to either peat or muck which has been cultivated, inoculated or otherwise so treated as to change its form. For example, beds of peat or muck may be used for some cultivated crops for a time and then offered for sale as "humus." Sometimes they are even artificially inoculated with nitrifying bacteria, but any such treatments make the materials too expensive, considering their actual value. They may hold several times their weight of water but usually it is locked up so tightly in the peat particles as to be entirely unavailable to plants.

If either peat or muck or both together are cultivated or changed in any way and offered for sale they become commercial humus.

Peat Often Toxic. In its natural condition peat is often highly acid in reaction and so may be toxic. Because of the exclusion of air in its natural habitat peat contains practically none of the nitrifying bacteria or the beneficial organisms needed for decomposition of organic material into humus and for liberation of plant food.

While peat and muck may serve to improve the mechanical condition of soils special treatment is required before they are of much real value. Toxicity must be dispelled, if present, and bacteria for decay must be introduced, and conditions changed so that they will multiply rapidly. This can be done by thorough weathering and composting with manure and lime before use, or by cultivation.

Peat can hardly be considered in lawn-making unless it can be secured at a cost little more than is incurred in handling it. Even then it should be used only when good barnyard manure or other decaying organic matter can be had to mix with it and to introduce the necessary bacteria. In no case is peat the equal of manure, ton for ton, even if it has a low moisture content. Agriculturists estimate that one ton of good manure is worth as much as three to five tons of peat.

If it is not practicable to cultivate a peat deposit it may be prepared for use by composting with manure. This is accomplished by mixing the peat with about one half its volume of manure. Twenty-five to fifty pounds of finely ground limestone should be included with every ton of the mixture to neutralize the acidity.

A COMPARISON OF SOIL HUMUS AND PEAT OR MUCK

Humus.	Peat or Muck
Definition	
Decaying organic matter in the soil.	Organic matter in arrested condition of decay.
Bacteria	
Abundant bacteria available to break down organic matter and liberate plant food.	Absent because of location of beds in excess water so that air is excluded. Temperature not favorable to growth of bacteria.
Moisture Retaining Capacity	
Hold enormous amount of water in capillary form which grass can use.	May hold several times its weight of water but retains it so tightly that grass cannot make use of it.
Plant Food	
Bacteria release plant food as they break down organic matter into humus.	Arrested decay therefore no plant food released. Unavailable.

In the United States peat is usually classed as domestic or imported, a large part of the latter coming from Germany. Domestic peat is mostly from sedge and forest litter, while the imported has been derived largely from sphagnum moss. Domestic peat is darker in color, contains more moisture, and is not so uniform as the imported product.

When purchasing peat certain factors should be kept in mind. In the first place, some peats have a high moisture content, sometimes as much as 60 to 70 per cent, while others contain as little as 20 per cent. Obviously, if peat is bought by the ton there is a vast difference in the actual amount of organic matter secured, depending upon the amount of moisture contained in the peat. Even at two or three dollars per ton water is rather expensive. Imported peat is sold largely in bales containing a certain number of cubic feet. This may be the better way to buy.

Toxic peats should be avoided. An easy method of determining the presence of toxic materials is to plant a few seeds of redtop in a sample of peat and subject it to conditions of moisture and temperature similar to those of good growing weather. If the seedlings thrive it is safe to assume that the peat is not toxic, but if they turn yellow and sickly after a few days' growth the peat is unsafe to use.

Leaves, Leaf Mold

A good source of organic matter is destroyed every fall in the burning of leaves. While it takes some time for leaves to rot sufficiently for incorporation into soils, this process can be hastened by certain treatments. The addition of mineral fertilizers and lime to the pile will hasten bacterial decomposition. A commercial 4-12-4 fertilizer to which has been added an equal weight of sulphate of ammonia or nitrate of soda, together with about 25 pounds of finely ground limestone, should be added to a ton of leaves or other organic material. The addition of a small amount of manure will assist the decomposition. After the fertilizer and limestone have been mixed with the organic material the pile should be kept moist enough to prevent excessive heating.

Other miscellaneous organic refuse such as grass clippings, sod and straw, may be added to the leaves.

Leaf mold is often available in large quantities in wooded areas. Most of it gives a relatively high acid reaction. It is well to aërate it before using, and to add a little manure to increase the bacterial content.

Green Manure Crops

The use of green manure crops to improve soils by addition of organic matter was discussed on page 11. Here it may be added that such material will decompose more rapidly after plowing if a liberal quantity of commercial fertilizer is worked in at the first disking.

CHAPTER III

MOISTURE SUPPLY AND DRAINAGE

The importance of moisture in the development of turf grasses is very great. Grass uses water from the time germination begins until the plant dies and decays into its original elements. After germination, plants first develop roots for the absorption of water. Mineral elements are dissolved in the water and carried by it through the roots and to the very tips of the blades where it helps in the actual manufacture of plant food in the leaves. This food is also carried throughout the plant by water wherever needed. Protoplasm, cell walls, roots, leaves and stems can only develop with abundant moisture. When soil fails to furnish sufficient moisture for these processes the first noticeable result is wilting, due to an actual loss of water from the plant.

As moisture is of such importance in the growth of grass it naturally follows that grass growth will be largely influenced by the soil moisture supply. This supply is dependent not only on rainfall or irrigation, but also on the capacity of soils to absorb and hold this moisture after it has been provided.

To make a soil effective for turf production the right amount of moisture must be presented and in the *correct* form. Soil moisture is of three forms, namely, *gravitational*, *capillary* and *hygroscopic*. These will be considered briefly.

Gravitational Water. Gravitational water is the excess existing in soils after heavy rains or irrigation. It is free to move about in the soil according to the pull of gravity, when conditions permit. Gravitational water should be removed as quickly as possible. It occupies pore spaces and thus displaces the air which supplies turf roots with the much needed oxygen. Excess gravitational water also prevents the normal development of beneficial organisms in the soil and prevents the soil from warming up rapidly in the spring. Soil containing excess water becomes packed and puddled when tramped over or worked. After puddling has occurred, the soil when dried out, is apt to harden and form clods.

A soil should not be saturated too long. If the surplus water cannot drain away naturally artificial drainage must be installed.

Capillary Water. The second form of soil moisture and the only one available to grass is capillary moisture. It is that moisture remaining after gravitational water has drained away. Capillary water is present as a film of moisture around each soil particle. Besides being the only form that grass can use, capillary water is also that form from which soil bacteria derive their moisture and in which the mineral nutrients are dissolved.

There is an optimum moisture content for grass soils. It exists when the plant is able to absorb sufficient moisture to prevent wilting, when there is enough pore space to promote the desirable root growth and activity, and when the desirable bacteria are most active.

Hygroscopic Water. When soil is dried in the air it will retain a certain amount of moisture which cannot be driven off except by artificial means. Even then, if it is again exposed to moist air, it will take up a quantity of moisture equal to that driven off. This form is called hygroscopic or unavailable water. It is never available to grass and will not keep it from wilting. Certain special types of soils have a high percentage of hygroscopic water as for example peat or commercial humus. Although such water is not available to plants, it is often referred to misleadingly in recommending peat and muck, because of their so-called high water holding capacity.

Maintaining Optimum Moisture. To determine how to maintain optimum moisture, it is first necessary to learn what happens to the water that is added to soil by rain or by irrigation. Water may be disposed of in the following ways:

1. Be lost by run off, or surface drainage.

2. Pass immediately through the soil as gravitational water.

3. Evaporate from the surface or through cracks.

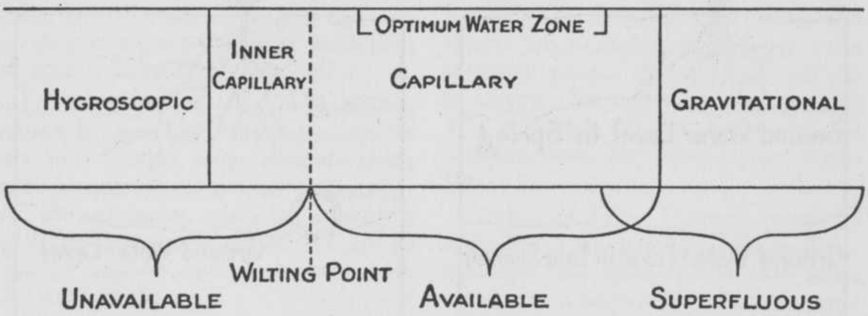
4. Be taken up by the soil for later use of the grass.

In some soils it may be advisable to avoid at least part of the loss by run off, percolation and evaporation. Steep slopes and hard surfaces which water cannot penetrate speed up surface run off. Elimination of such conditions is the only satisfactory solution. Except in very loose sandy soils, percolation need not be checked. In fact in most soils this process needs to be assisted so that excess water will be removed more rapidly. Loss from evaporation is largely a matter of weather conditions, but the process can be slowed somewhat by avoiding heavy clay-surface soils, which bake and crack open during dry periods.

Drainage

Contradictory as it may seem, drainage is probably the most important feature in maintaining the moisture content of soils, having in mind, of course, the optimum moisture content. If surplus moisture is not readily removed it will hamper turf development because of the exclusion of air, will make an unfavorable environment for the soil bacteria, will puddle the soil and will retain injurious salts. On the other hand, if percolation or drainage is too rapid, sufficient moisture will not be held in reserve and the excessive drainage will leach out valuable mineral plant food elements.

Drainage is of two kinds, surface and subsurface or underground. The prin-



FORMS OF WATER. Soil moisture is divided into three forms. Unavailable water is so closely held that plants cannot make use of it. Capillary water is that from which plants derive the necessary moisture. Superfluous water is that excess present after heavy rains or irrigation. It should drain off in a short time. (After Lyon and Buckman.)

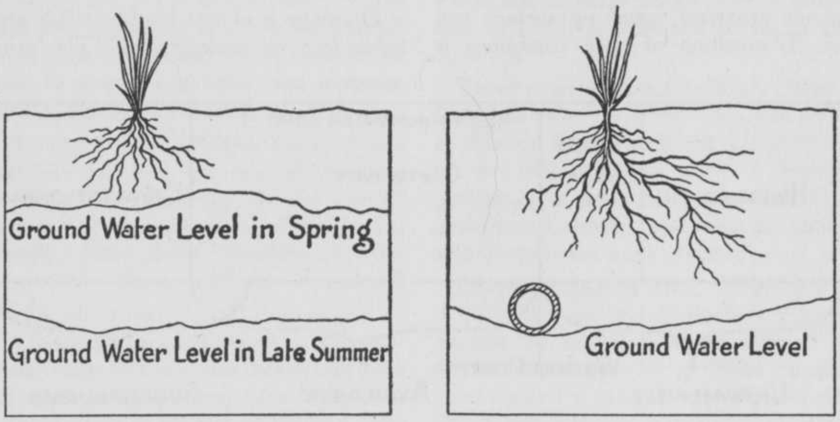
ciples of surface drainage are well understood and usually well taken care of. It consists of having slopes and grades sufficiently steep to carry off water that cannot be readily admitted to the soil. It is most important that surface drainage be provided for over the entire property, so that there will be no basins or pockets in which water can collect and stand.

The principles of underground drainage are not generally understood and cannot be adequately set forth in a booklet like this. So many factors enter into the matter of proper drainage that it is really a job for an engineer trained in soil technology and hydraulics.

What Drainage Does. One of the most important advantages of underground drainage is the improvement of the physical and mechanical condition of the soil. The rapid passage of water and air produces an alternating wet and dry condition that aids in soil granulation. The finer soil particles are grouped together so that they act as coarser grained particles. If satisfactory drainage is not provided, the finer soil particles float about in the saturated soil and move into spaces between the coarser particles. This tends to make the soil compact, and eventually a puddled condition results.

Underdrainage improves aëration for two reasons. The better physical condition, as explained, means larger pore spaces for the circulation of air. At the same time removing the surplus water leaves the soil pores open for the passage of air. This helps the grass directly and, also, aids in the decomposition of organic matter by bacterial action.

Some authorities feel that the greatest benefit of underdrainage is that it increases the supply of available plant food and moisture. It was shown at the beginning of this chapter that plant food was made available to grass by being carried to it in solution and that the only moisture which roots can absorb is in the capillary form. Capillary moisture is present only after the surplus water has been removed. Working the other way it is quickly apparent that (1) after removing surplus moisture there is left



GROUND WATER LEVEL. Poor soil drainage means scanty root development. Roots encounter difficulty in penetrating undrained soil as shown at left. They occupy only the upper layer of soil and are likely to be injured in periods of drought. Turf in a well drained soil withstands drought better because of a more extensive and farther reaching root system.

(2) capillary moisture, which (3) takes up plant food in solution and which (4) the grass roots can take up only when they are present in capillary moisture. At the same time underdrainage improves the granular structure, thereby providing more capillary moisture which increases the food supply.

Underdrainage is closely allied with the availability of plant food, in making conditions more favorable for soil bacteria. Saturation inhibits the development of bacteria which are needed to break down the organic matter and release plant food.

Turf on well drained soils withstands drought better than on poorly drained soils, because the physical condition of a well drained soil is such that it can hold more reserve moisture. This better physical condition will enable the grass roots to extend more deeply into the soil, thereby providing a large area from which they can obtain moisture in dry periods.

A well drained soil will warm more quickly in the spring, and hence induce earlier germination of seed or growth of grass than a poorly drained soil, and this growth will continue later in the fall. Roughly speaking, it takes five times as much heat to raise one degree the temperature of a given volume of water than an equal volume of air dried soil.

Drainage reduces the winterkilling caused by heaving. Heaving occurs in wet soils because water expands about one eleventh of its volume in freezing. As this expansion must be upward it pulls the grass roots out of the soil so that the exposed roots are broken off or dry out and die.

Summarizing: Better drainage (1) improves the physical condition of soils which in turn insures better air circulation and provides a greater moisture reserve for periods of drought, (2) makes available a larger amount of plant food and moisture, (3) warms the soil earlier in the spring, and (4) reduces winterkilling.

Mechanics of Drainage

Since soils vary in nature the depth and placing of tile lines on a property cannot be definitely prescribed. To determine the drainage characteristics of a soil it is necessary to do a certain amount of experimenting. No more drainage should be installed than is necessary to dry the soil in spring as soon as other well drained soils in the neighborhood become dry.

If possible, all parts of the property should be drained during construction so that they may be worked alike. It is best to install tile drainage in the summer or early fall. If the work is done in the spring when the ground is saturated, soil around the tile becomes puddled due to being dug and handled while wet. Several seasons of freezing and thawing weather may be required to undo such damage and make the entire line function satisfactorily.

Outlets for tile vary greatly with different properties. Sometimes small runs or creeks are available, where only short lines of tile are needed. Open drains and ditches are satisfactory if they are made to appear natural and to blend with the landscape. Subsurface drainage is usually connected with the outlets for the driveway, road and other surface drainage.

Types of Tile. Common porous or agricultural tile is most often used for drainage. As most of the soil water enters drains between the joints, the type used does not matter much as far as the water absorbing capacity is concerned.

While three inch tile is satisfactory for laterals up to 400 feet in length, four inch tile is generally used for everything up to a length of 1000 feet. The water carrying capacity of tile varies according to the square of the diameter of the bore. Therefore a three inch tile will carry only about one half the amount of water as a four inch tile, while a six inch line of tile will carry more than twice the amount of a four inch.

Sufficient allowance in the size of the tile should be made to take care of several laterals entering the main line. The points of entrance of the laterals should be staggered so that no two enter opposite each other.

Tile should be laid with at least one fourth inch between joints to allow for expansion and entrance of water.

It is not safe to establish the grade of a tile line with the eye. Some kind of a mechanical leveling device should be used. A fall of at least three inches in 100 feet is considered necessary. If the fall for 100 feet is doubled the water carrying capacity is increased about one third.

The depth for laying tile depends upon the type of soil. The deeper the tile is laid the farther apart the laterals may be placed. In clay soils it is not safe to put them in deeper than two feet, with twenty feet between the lines. In light sandy soils tile may be placed considerably deeper and farther apart.

Laterals should always enter the main line at an angle of 45 degrees with the drop or fall of the water, and never at right angles to it. When a sudden decrease of grade which would check the flow is necessary, the junction should be made by a stone lined or cement catch basin, with the bottom at least a foot below the lower tile. This will serve to collect sediment. The tile outlets must be well protected to keep them from being clogged, cracked or crushed.

The general advice is to cover tile with gravel, cracked stones or cinders to a depth of several inches before the dirt is replaced. This procedure is not always followed on large lawns because of the expense. When tile is laid in sand the tops of the joints are sometimes covered with strips of tar paper to prevent the fine sand from working into the lines. Tile must be well packed and firmly set to prevent their shifting when being covered.

Hillsides are frequently not included in the tile drainage program because, from casual observation, it would seem unnecessary to drain such places. However, drainage is often badly needed, particularly if there is much higher ground in the vicinity. Seepage water coming from higher levels may appear on such hillsides, and this is apt to keep the soil saturated during the late fall, winter and early spring. A quickly apparent result of this condition may be the growth of moss which is often found on such hillsides. When this condition exists there is only one remedy, and that is the correct installation of tile lines.

CHAPTER IV

GRASS VARIETIES AND SEED

One of the most important phases of lawn building is the selection and use of the proper varieties of grass. In the United States alone there are many hundreds of different grasses, but only a very few that are really adapted to the turf requirements of lawns.

Different grasses have different climatic requirements. Happily, however, the more desirable varieties will thrive over a wide range of climatic conditions. For the whole of the United States and southern Canada only two distinct divisions are required, namely, grasses for the North and grasses for the South. Roughly speaking, the dividing line runs through the state of North Carolina and west through southern Missouri and southern California.

The best classification of turf grasses for lawns is probably the one made by Professor L. S. Dickinson of The Massachusetts State College, in his book, "The Lawn." He classifies all turf grasses into four groups as follows:

(1) *Basic Grasses.* The permanent and desirable turf grasses, which, because of soil environment, will predominate as the lawn ages and give the kind of turf wanted.

(2) *Special Purpose Grasses.* These grasses are adapted to peculiar locations such as shady places, terraces, unusual soil conditions and the like.

(3) *Nurse Grasses.* These are quickly germinating grasses which serve as shock troops against weeds. They grow rapidly and die as soon as the permanent grass requires their space.

(4) *Filler Grasses.* These are not adapted to turf purposes, "but used to increase the bulk of the package or lower the cost per pound."

Basic Grasses

By far the most important of the four groups, yet withal the one with the fewest number of varieties, is the *basic* group. In this are the grasses that should predominate in a seed mixture, as they are the only ones that will make permanent and desirable turf. For the North, members of but four species can be regarded as basic grasses. These are Kentucky Bluegrass and Poa Trivialis of the bluegrass family, most of the bent grasses, and Chewings (Creeping Red) Fescue of the fescue family.

Southern grasses will be named and discussed later.

(In the bent grass family are many fine and desirable turf varieties. As the planting and care of bent grasses differs considerably from ordinary kinds, there is a special Scott publication on bent which will be sent free to anyone interested.)

Special Purpose Grasses

The largest use for special purpose grasses is in shaded locations. Besides the exclusion of sunlight, shade usually offers the problem of a very wet or very dry soil. In wet shaded places Poa Trivialis seems to be better than any other variety. This is its natural home as the seed of Poa Trivialis is harvested in the dense forests of Denmark. Poa Trivialis makes a soft turf, though a good looking one, and does much better if not trampled or abused, or cut too closely.

For dry shaded locations Chewings Fescue is apt to be superior to Poa Trivialis. It has a lower moisture requirement since less water is lost by transpiration from its leaves. Chewings Fescue also seems able to thrive in places where trees take nearly all plant food, as well as moisture, from the soil.

Terraces offer many problems. Rain washes plant food from the soil and also washes the soil from around the grass roots. Southern and western exposed terraces dry out excessively. Many terraces are subject to seepage water in wet seasons, which finally results in an unsatisfactory soil condition. Moss often comes in, particularly on northern slopes.

No grass can possibly overcome all of these bad features. However, Chewings Fescue does well in many instances because of its low plant food and moisture requirement, and its tendency to form thick, close turf, which prevents washing. Next to Chewings Fescue, Kentucky Bluegrass is probably best.

Another special use for Chewings Fescue is on sandy soils. It succeeds there again because of its low moisture requirement, and its ability to form a thick close turf, which probably reduces evaporation of soil water. Fescue and clover work well together in sandy soils north of the 40th parallel.

Nurse Grasses

Many and varied are the nurse grasses used in lawn mixtures. Quick germinating grasses must be planted with the slower growing basic grasses for protection and to act as shock troops against weeds.

Filler Grasses

Of the many species of grasses, most are filler grasses. They are not suitable for turf purposes but are used to increase the bulk of the package or lower the cost per pound.

Most fescues are filler varieties. In fact all of them might be included except Chewings New Zealand Fescue. The list includes Sheeps, Hard, Meadow, and many others. To be safe avoid any but pure Chewings Fescue.

English Bluegrass (Meadow Fescue) is often sold for its connection of sound with fine English lawns and the word Bluegrass. Actually, it is one of the poorest varieties for lawns, as it grows in tufts and will not form a solid uniform turf.

Another common filler grass is Orchard Grass. While it may grow in the shade it is entirely too coarse for lawns. It grows only in heavy clumps.

Canada Bluegrass must be termed a filler grass in most cases. However, in some instances it serves as a special purpose grass for extremely dry and poor soil.

In excessive amounts, any of the nurse grasses are also filler grasses. This includes Redtop, Ryegrass, Timothy and the others, if they make up the bulk of a lawn mixture. In large quantities they are filler grasses, because they will not make permanent turf.

In addition to filler grasses there are several kinds which might be called "misconception" varieties. They may be put in mixtures to make them look better, or because of a mistaken idea of their value as lawn grasses.

Crested Dogstail is such a variety. It is very good looking seed but the grass is worthless in lawns. The same is true of Wood Meadow Grass, often used in shady place mixtures.

Why Seed Mixtures

To make good lawns it is necessary to use a mixture of grasses, for three distinct reasons. In the first place, the basic grasses, which are defined as those making the permanent turf, are very slow in becoming established, so other grasses must be planted with them. These grasses act as a nurse crop and provide turf while the basic grasses are establishing themselves. They also protect the young seedlings of the basic grasses from injury by the hot sun.

The second reason for planting a mixture of grasses is that the different varieties have different periods of maturity. For example; bluegrass matures comparatively early in the summer, and goes through a long semi-dormant period during the midsummer when the grass may not be very vigorous and often is brown and dead looking. In contrast, the bent grasses mature later in the season, so that they furnish a green covering for at least a part of the period when bluegrass is not thriving. In contrast, bluegrass recovers very early in the spring, whereas the bent grass recovers more slowly, as it requires a very warm soil to arouse it to vigorous growth.

Differences in soils supply the third reason for the use of mixtures. Certain grasses will thrive better on one kind of soil than other grasses, and, as a single property may contain different kinds of soil, it is safest to use a mixture of the various grasses in order to be sure of a uniform turf.

Seed Quality

Granted that a mixture of different grasses will make the best turf, the next question is, "What is a good lawn mixture?" Several factors determine this. (1) The kinds of seeds that make the mixture, (2) purity and germination of the seeds, (3) the weed seed content.

At the beginning of this chapter basic grasses were defined as the permanent and desirable turf grasses which will predominate as the lawn ages, and give the kind of turf wanted. Obviously, if basic grasses are to predominate in the lawn they must form the bulk of the seed mixture. Unfortunately, this condition is not found in all mixtures. The basic grasses named are more expensive than other varieties, and so filler or nurse grasses are frequently used in overabundance to lower the cost of the seed. Such seed mixtures cannot make good lawns because of the absence of permanent turf producing varieties. A cheap mixture is more expensive in the end.

Next in importance to the varieties of seed in a mixture is their quality. Basic grasses *cannot be recleaned to as high a state of purity as some filler and nurse grasses.* Nevertheless a mixture of the right grasses should be at least 92% to 95% pure and should have a germination of 85% or more.

Most important is freedom from weeds. A weed content of 1% is often considered low, and two or three per cent permissible. However, even a 1% weed content may mean adding 100 to 125 weeds to every square foot of seeding surface. Obviously, this should be avoided. Unless a mixture contains less than ¼ of 1% of weed seeds, it is unwise to sow it.

Every seed mixture therefore should be carefully judged from three angles. (1) Is it composed largely of basic grasses? (2) Is it better than 92% in purity and 85% in germination? (3) Is it free from weed seeds?

Southern Grasses

Amost every conceivable type of soil is found in the South, from sandy loams to the stiffest of red and white clays. The situation that is conducive to a rapid growth and a permanent stand of grass is a granulated subsoil that will readily absorb and hold the winter and spring rain. Such soils are ordinarily found throughout that section lying north of the Mason and Dixon line where the soil freezes in winter to a depth of six to ten inches. This freezing improves the physical condition of clay subsoils and promotes their water holding capacity. As such climatic conditions do not exist in the South, other means of improving the physical condition of subsoils must be resorted to in order to secure a permanent and drought resisting stand of grass. Of course, in some sections, this heavy subsoil is not found. On the contrary, the soil may be sandy in nature. In such cases the problem is to increase the amount of organic matter, and so increase the amount of water available to the turf.

The grasses adapted to the cool moist climate of the northern states are not best suited to the hot, dry weather occurring in the South during the summer months. This necessitates the use of other varieties of grass, as well as different methods of soil preparation and seeding.

The map shows the range of Bermuda Grass, the most commonly used Southern grass. Another common variety is Carpet Grass. This is particularly adapted to sandy soils, although it will do well on heavier types of soil. Both of these grasses, like bent, have a creeping habit of growth, and produce a quick and dense turf from rapidly spreading overground runners. The objection is that they are both summer grasses and turn brown after frost. Such lawns are unsightly during the winter, and so they are frequently seeded to other grasses in the fall, in order to furnish a green covering during the winter months. Ryegrass and Redtop are the varieties generally used for this purpose.

The best Bermuda grass seed comes from the state of Arizona. The strain grown there makes a finer type of turf than the ordinary Bermuda, and the seed is usually of excellent germination. Seed produced in other sections is sometimes so low in viability as to be almost worthless. Since Bermuda grass is killed by frost, it is necessary to plant it in the spring, before the rains of April and May.

Grasses generally used for winter turf in the South include Redtop, Ryegrass, and some of the clovers, especially White Dutch Clover and Bur Clover. Japan Clover is an annual that is often seeded with Bermuda grass in the spring because it grows quickly and makes a fair turf while the Bermuda grass is getting a start. Bur Clover, on the other hand, goes through the winter in a green state and dies in the spring. Under ordinary lawn conditions, however, it will reseed itself so that there is a fresh crop each year. Clovers are worth while, as they take nitrogen from the air and store it in the soil. The decaying roots also add humus.

A few other grasses used in the South and generally planted vegetatively are Centipede, Buffalo, Manila and St. Augustine grass.

MAP III. Bermuda Grass Range. The double hatched area is that in which Bermuda Grass succeeds best. The single hatched that in which it competes with bluegrass and other grasses.

CHAPTER V

PREPARING THE SEED BED

Final Working. Preparation of the seed bed should be started as far in advance of the time for seeding as possible. Fall, rather than spring, is the best time to seed. Soil preparation may be begun even as much as a year prior to the actual seeding. In such case, the soil should be plowed in the fall or winter, and allowed to remain fallow until spring. The alternate freezing and thawing of the soil during the winter makes it more mellow and of better tilth. If a green manuring crop is to be used, it is sown in the spring, plowed under in August, and the seed bed then prepared. If no green manuring crop is used, the ground should be disked frequently enough in the summer time to destroy successive weed growths.

Land should be plowed fairly deep, but not so deep as to bring up any subsoil. If the soil is shallow it can be disked, instead of plowed, thus avoiding the turning up of subsoil. A new implement now can be had, called "killifer," which cuts up heavy soils without turning them over. The knives of this machine can be set to go as deep as eighteen inches if desired.

The fact that clay soils must not be worked when wet cannot be over-emphasized. It is better not to work any soil unless it is reasonably dry.

After plowing, the land should be disked and cross disked. If fresh manure is to be added it is best put on after disking, then harrowed in. A spring tooth harrow is better than a disk harrow for this purpose. Well rotted manure will be more economically put on during the final seed bed preparation. The amount of manure to use depends upon the soil, usually 30 to 40 tons per acre; the more the better.

At this stage in soil preparation it is advisable to remove roots, sticks, stones and other debris. If there is some definite method of doing this it can be done better and cheaper. A few men sent out occasionally to pick up stones seldom do economical work.

After disking, any top-soil that was removed before grading should be replaced. Final grades will also be established, and the land cultivated regularly to destroy successive weed crops. It is important that these be destroyed before seeding, so that the young grass will not need to compete with them.

Fertilizing the Seed Bed

Not so many years ago the only fertilizer used was barnyard manure. The supply was plentiful and the demand limited. Such is not the case now, as the supply is limited, and the demand is great. The use of commercial fertilizers in lawn making and maintenance has become so widespread that a whole chapter is devoted to the problem later in this book. For an explanation of the fertility requirements of grass, and the composition and properties of different fertilizing materials, the reader is referred to page 35.

The main advantage of fertilizing new seedings is a quicker growth and a dense uniform turf. Small grass seeds contain very little reserve food, hence, sufficient fertilizer materials should be put on the soil before seeding to supply the needs of the young seedlings. It is not very expensive to fertilize a large area before seeding, and this investment usually insures better turf with lower final cost.

The first few weeks following seeding are most critical. The young plant is not able to forage for food owing to its limited root system. Unless the soil is abundantly supplied with food there may not be enough for all plants. Many weak seedlings will succumb, and a thin turf results.

Complete Fertilizer Needed. Of seven chemical elements which soil must supply to grass, all but three are abundant in most soils. These three, in the order of their importance, are nitrogen, phosphorus and potassium.

Nitrogen, sometimes spoken of as ammonia, promotes vigorous blade growth, and gives grass a dark green color. Nitrogen is leached rapidly from most soils, and so it is better to supply it in small quantities, as needed.

Phosphorus is important in development of roots and stems. It gives frame and shape to the grass. Unlike nitrogen fertilizers, phosphorus fertilizers do not readily move downward in the soil; hence, surface applications after turf is established, are not as satisfactory as if incorporated in liberal amounts into the original seed bed. This is a safe practice, since phosphorus is not lost from the soil in the drainage water, but is held there until the grass actually needs it.

Potassium influences the general tone and vigor of the plants. Those having an ample supply of potassium are more resistant to disease. Like phosphorus, potassium application can be made before seeding.

A fertilizer containing nitrogen, phosphorus and potassium, (usually expressed nitrogen, phosphoric acid and potash) is regarded a complete fertilizer, as it contains the three elements ordinarily supplied. The amount of actual plant food is commonly expressed in the analysis in the order of nitrogen, phosphoric acid, and potash. Thus a 10-6-4 fertilizer contains 10% nitrogen, 6% phosphoric acid and 4% potash.

Sources of Plant Food. These fertilizing elements are derived from many different sources, which are roughly grouped into two classes, i. e. organic, and inorganic materials. The organic sources are chiefly vegetable or animal matter, while the inorganic sources are either minerals or salts. Examples of organic materials are soybean meal, cotton seed meal and animal manures. Examples of inorganic materials are sulphate of ammonia, nitrate of soda, superphosphate and muriate of potash.

Generally speaking, any inorganic fertilizing material supplies but one plant food element. For example, sulphate of ammonia furnishes only nitrogen; superphosphate only phosphorus, and muriate of potash only potassium. In contrast, most organic materials contain at least traces of all three necessary elements, although they are seldom present in the correct proportion for feeding grass. To make a balanced food ration, therefore, two or three inorganic materials are mixed together to make a complete fertilizer, or, sometimes, they are mixed with organic materials to make a complete fertilizer containing both organic and inorganic matter. The latter combination has several advantages. It provides quick stimulation to the grass as well as a slowly available and lasting supply of plant food. Most inorganic materials are quickly available for the use of grass, while the organic materials must be broken down or decomposed before the elements which they contain become available. Usually, it is best to apply a complete fertilizer before seeding. This insures a readily available supply of plant food to the seedling plants which are not able to forage for their food. As phosphorus is the important element at this time, a fertilizer containing a large amount of phosphoric acid is advisable. Phosphorus needs to be worked into the seed bed, because it moves downward very slowly. For this reason surface applications are not as efficient as application prior to seeding which are thoroughly mixed with the soil. The fertilizer used should contain a rather high percentage of phosphoric acid. A 4-12-4, or better still, a 4-24-4 is recommended. On sandy soils deficient in potash a 4-24-8 or 4-24-12 is more suitable. The rate of application depends upon the soil condition, and varies from 500 to 1000 pounds per acre.

Fertilizing established turf involves somewhat different principles than fertilization before seeding. This problem will be considered later.

Applying Commercial Fertilizer. In applying fertilizers prior to seeding, thoroughness of distribution is essential. If put in too deeply they will be beyond the reach of the grass. It is, therefore, advisable to work them into the soil with a smoothing or spike tooth harrow after the soil is practically ready for seeding. They should be thoroughly mixed with the upper three to four inches of soil. Evenness of distribution is important in order to avoid burning the tender seedlings. If possible, at least a week should elapse between the fertilizer application and seeding.

Fertilizer is best applied over large areas with a regular fertilizer, or lime spreader. For smaller lawns special hand operated distributors may be secured, or the fertilizer applied broadcast. In the latter case it is wise to divide the fertilizer to be used into small amounts and broadcast on areas of corresponding size.

Final Seedbed Preparation. The cultipacker is excellent to prepare soil for seeding as it firms the soil without destroying the surface mulch. Other tools used include drags, smoothing and spike harrows, brush drags, and the like. For fining and smoothing the seed bed a Meeker harrow is a good implement. This tool consists of four series of straight disks set in a frame.

On small lawns these tools cannot be used. There hand rakes, rollers, and leveling boards may be employed to prepare a fine and even seed bed.

The upper inch of surface soil where the young grass will get its start, should be as fine as sifted ashes. The upper inch acts as a blanket for the coarse soil beneath, prevents the escape of moisture through cracks, and assures quick germination.

The topsoil should be mellow, but made firm by rolling. Rolling both ways reveals inequalities of the surface that may afterwards be easily adjusted by the use of rakes. Hollows are likely to hold water, and so prevent germination, drown out the young plants, or cause the mature grass to be killed by alternate freezing and thawing in winter. Rolling makes a firm seed bed and permits the soil water to be brought up by capillary attraction.

CHAPTER VI

SEEDING

Best Time. Except in the extreme North the ideal seeding time is fall. The exact date will depend upon climatic conditions, and will vary from August 20 to October 15. At that time temperature and moisture conditions are most favorable, and weed competition is at a minimum. In fall, the weather is usually cool and there is sufficient rainfall to keep the ground moist. Grass grows best in such weather, and tends to develop a strong root system, and stool out, instead of an excessive blade browth. Weeds are much less serious in fall because only a few sprout and most of these are killed by early frosts.

In contrast, conditions in spring are not so good for seeding, nor for later turf development. In early spring the ground is usually too wet to be worked, and too cold to germinate seed. A little later, weed competition is most severe. Even if the grass seedlings are able to get started, many soon perish during the hot, dry summer months. Spring seeded grass grows so fast that only a weak root system develops, which is unable to get to the reserve soil moisture and food supply. A large proportion of spring seeded lawns result in either partial or total failure.

Rate of Seeding. To insure a thick, even turf a comparatively heavy seeding is necessary. A light seeding may be responsible for a thin, spotted stand, an excellent harbor for weeds.

The amount of seed needed depends upon at least four factors: variety of seed, quality of the seed, soil fertility, and cultural loss.

Light, chaffy seed, containing considerable inert matter, will not go as far as heavy re-cleaned seed with a high purity. Then, too, less is required of a seed high in germination than of one in which the germination is low. It is not economy to buy cheap seed, as it only necessitates planting more seed.

Strange as it may seem, less seed should be used on poor soils than on good soils, if no fertilizer is added. There is not sufficient fertility in a poor soil to support a heavy seedling growth. If there is not enough food available for young plants they quickly perish.

The "cultural loss" also affects the rate of seeding. This loss is due to some seed being covered too deeply or to seed blowing away, or being eaten by birds. The average cultural loss on a well prepared seed bed is over 20%. On a poorly prepared seed bed it may be over 30%.

In general, with good seed and a carefully prepared seed bed, planting should be at the rate of 100 to 150 pounds per acre. For smaller areas 4 to 5 pounds per 1000 square feet will suffice.

Methods of Seeding. A skilled workman can distribute seed evenly by hand, although this method is usually wasteful of seed, and is likely to result in an irregular distribution. A mechanical seeder of some sort is preferable, as it does a better job and saves seed. One of the best types is the wheel barrow seeder. This has a long narrow hopper into which the seed is placed. It is mounted on a single wheel which operates the distributing mechanism. It seeds a strip 14 to 16 feet wide. Regular grain drills are unsatisfactory. They put the seed in rows, and it takes a long time for the turf to fill in between.

Regardless of the type of seeder used, or if the seed is sown by hand, it should be divided in half, and one-half sowed in one direction, and the rest at right angles to it.

It is not easy to sow evenly in a heavy wind, but a faint breeze is sometimes helpful. If there is a little wind the seed should be sown only with the wind, even though the walk back is idle. Unless this is done, thin strips will be noticed after the grass starts coming up. This is due to the fact that much seed will be blown back on the sower.

Covering and Rolling. After the seed has been sown it should be mixed immediately with the top half-inch of soil, but not deeper. In doing this it is better to have horses pull the implements. The drag will partially eradicate the horses' hoof prints, but if a tractor is used its weight packs the soil too much, and young grass has difficulty in getting established in the wheel tracks.

On heavy soils a smoothing harrow should be used to cover the seed. The spikes should be set at such an angle that they will not dig too deeply. On light soils with a very fine mulch, a brush harrow is often used to distribute the seed through the surface soil. Brush harrows are made by laying bundles of fine switches between planks. A clevis is balanced in the center so that the team will pull the harrow evenly.

On small areas it is more satisfactory to rake the seed into the soil. A wooden rake is suitable for this, but the operator must use it lightly.

Immediately after covering, the seed bed should be rolled with a light to medium heavy roller, the weight depending upon the type of soil. Rolling not only presses soil about the seed but also compacts the soil, thus permitting the rise of soil water by capillarity. It will also prevent some loss of seed by blowing. The evidence in favor of rolling after seeding is preponderant. Sometimes, in a dry season, when the seed is not carefully rolled but simply harrowed, the grass may come up only in places where the soil has been compacted by horses' hoofs or tractor wheels.

Watering. On large areas without facilities for irrigation, it is necessary to rely upon nature for the required moisture. This is probably the best plan to follow, even if irrigation is possible, unless the soil is very dry, or a drouth is anticipated.

After a newly seeded lawn is once watered it must be kept continually moist until the young grass is well established. The small amount of water supplied by sprinkling will germinate the seed quickly, but unless plenty of moisture is afterwards supplied the small seedlings will die. Sprinkling forms a crust on the surface of the soil that the seedlings cannot penetrate unless the soil is kept moist. This demands careful attention, as the bright sun and high winds dry the surface rapidly. A single day's neglect may mean the drying and hardening, or crusting of the soil surface, with the consequent destruction of a large proportion of the tiny grass plants.

It has often been pointed out that the most critical periods in the life of a grass plant are those during and just after germination. Water is needed to promote germination, and a continuous supply is necessary to keep the young shoots alive. As grass is planted shallowly it is difficult to keep sufficient moisture available for it. A stand of seedlings may be destroyed by a few days of dry weather.

A dry soil condition may be more disastrous after, than during, germination. Sprouting seeds may not be harmed by drying for short periods, but after the first leaf emerges even a severe wilting may prove fatal.

The most desirable sprinkler to use on a newly seeded lawn is one that will deliver the water as a fine spray, and not as a pelting rain. Sometimes it is not a bad idea to sprinkle a lawn after seeding if a rain storm seems to be in the offing. Such a sprinkling may prevent excessive washing of the surface soil.

Sodding. It is often necessary to sod steep slopes, or other areas in new lawns, which might wash badly before seeded grass could become established. Success with sod only follows careful preparation of the seed bed and handling of the sod during and after the laying.

Before laying sod the surface soil should be as carefully prepared as it is for seeding. When dry, the soil should be so compact that footprints are not readily made. Adequate amounts of fertilizer should be applied during soil preparation.

Sod cut about one inch thick is convenient to lift and lay. The roots of such sod will establish themselves in the new soil quickly. The sod should be cut in true squares, or other regular shapes. It can be made of an even thickness by trimming in a cutting box. This is simply a table on which there are two sides or guides of even height. The sod is laid grass down and a sharp blade drawn over the sides of the box. The back stop holds the sod in place.

The pieces of sod should be placed close together, but not crowded or bulged. The sod should be raised or lowered so as to provide a level surface without heavy tramping.

After laying, the sod should be thoroughly watered immediately. As soon as the water has soaked into the soil the sod should be rolled with a fairly heavy roller.

Later Treatment. The care given a newly seeded lawn during the first two or three months after seeding will have a great deal to do with the stand of turf during the following years. The careful work done in preparing and seeding a new lawn must not be rendered useless by carelessness or neglect later on.

Mowing. A newly planted lawn must be mowed the first few times very carefully. There should be no hurry about doing this. The new growth should reach a height of at least three inches before mowing is begun. One or two inches more height is not too much so long as the grass is in no danger of falling over and lodging. For the first cutting, the mower should be set as high as possible so that it simply clips off the tips of the blades. A necessary precaution is to see that the mowers are sharp, as otherwise the young plants are very tender, and may be pulled out. The intervals between mowing depend upon weather conditions, and rapidity of growth. Some authorities feel that in general practice lawns are cut too closely. It is much better for the grass, especially new grass, if clipped at a height of two or two and a half inches, and mowed more often, rather than cut close only occasionally.

Usually, it is preferable to allow the grass clippings to remain on the lawn. In the case of a very large lawn this is of course necessary, but it is good practice even on small lawns, because the clippings return to the soil some of the fertility that has been taken out by the grass. They also act as a surface mulch and as a protection for the roots. In very wet seasons, however, clippings may cause a rotting of the grass.

Rolling. On sandy soils several light rollings as the grass is becoming established may be found helpful. This will compact the soil around the roots and help to firm the turf generally. Heavy clay soils should be rolled with discretion, especially when they are wet, as rolling under such conditions tends to compact the soil.

Re-Seeding. After the first sowing of new lawns some spots will be found where the grass, for some reason or other, did not catch. These areas should be raked lightly and immediately re-seeded as, otherwise, they will soon become infested with weeds.

Weeds. Weed seeds are present in practically all soils everywhere, even though the land has been cultivated and cropped for a number of years. Most weed seeds have the ability to lie dormant for many years and then germinate whenever conditions become favorable. Some of these seeds will germinate during the preparation of the seed bed. Many are seeds of annual plants that will not give any permanent trouble. These will usually disappear as soon as the lawn is mowed regularly. Other bad weeds may show up if weed infested manure or topsoil is used in construction. These will be more difficult to eliminate.

Fertilizing New Seedings. If a new lawn has been properly prepared, and a sufficient amount of fertilizer worked into the soil before seeding, it should not be necessary to fertilize again during the first season. However, if the grass has come up unevenly, and appears weak and has a yellowish green color, a lack of available plant food, and a need for a stimulant or tonic is indicated. Usually a light application of a nitrogen fertilizer such as sulphate of ammonia, at the rate of 2 to 3 pounds per 1000 square feet, will correct the difficulty. Heavier applications than this should be avoided because of the danger of burning the young grass.

Winter Protection. An established lawn seldom requires any special treatment to carry it through the winter. The important thing is to stop mowing early enough in the fall to give it a chance to develop a growth of four to five inches before winter sets in. This means that lawns will be mowed all through September in the northern states, where they usually develop enough growth in October to carry them through the winter. A long growth increases the storage of food in the roots, and slows up the growth of the grass in early spring, thus preventing injury from heavy spring freezes. Long grass is also less likely to be damaged by trespassers.

Quite often it is the practice to cover lawns in the fall in order to protect them against winterkill, and to add fertility to the soil. Manure, straw, leaves, tobacco stems and similar materials are most often used for this.

There is no evidence that grass is benefited in any way by a mulch. It not only makes the lawn look unsightly, but may even smother the turf during the winter. Contrary to general opinion, only small quantities of plant food are added to the soil by manure or other materials put on during the winter, because most of this leaches out during the winter, or runs off in surface drainage during the early spring thaws. If manure is procurable, it should be allowed to rot under conditions which will conserve the nitrogen supply and kill the weed seeds. Later it can be put on as an early spring or summer top-dressing. Winter mulching with straw or fresh manure may introduce a horde of weed seeds.

Part Two

Maintenance of Lawns

Lawn maintenance includes such practices as fertilization, mowing, rolling, watering, the eradication of weeds, the control of fungous diseases and of insect and animal pests; in short, any treatment that makes for a permanent improvement of the turf.

CHAPTER VII

GENERAL LAWN MAINTENANCE

Rolling. Early spring rolling presses into the ground roots and grass crowns which have been heaved by the alternate freezing and thawing of winter. An occasional compacting of most soils insures proper capillarity, and presses the soil around the grass roots, so that they will be able to draw on the supply of moisture and plant food.

Proper moisture conditions for rolling occur for just a few days every spring. One must watch carefully, as lawns are drying out, to be sure that the soil is in the right condition to roll. Light or sandy soils may be rolled when wet without injury. If a heavy clay soil is rolled when wet it becomes puddled and packed, with consequent injury to the turf. A well drained soil is in condition to roll earlier in the spring than one poorly drained.

Greenkeepers determine the right time to roll by walking across the turf. If water seeps into the footprint the soil is too wet to roll.

The proper type and weight of the roller to use depends upon the kind of soil. A sandy or light soil can stand a much heavier roller than a compact clay soil. The general rule is to use a roller weighing about 100 pounds per foot of length.

Lawns seldom need be rolled at any time other than early spring.

Raking. An occasional vigorous raking, especially in early spring, removes dead grass and weeds, leaves, papers and other things that tend to choke or smother the growing grass. A sharp-toothed iron garden rake is good for this, as is also the newer type of steel lawn broom. An established lawn should be vigorously raked before re-seeding to scarify the surface soil, thus providing a better seed bed.

Re-Seeding. The best time to re-seed is in the fall, except in the extreme northern sections, and in the South, in case Bermuda and Carpet Grass are to be used.

If winter killing has left the turf thin and bare in spots, it may be necessary to do some re-seeding in the spring. This should be done immediately to prevent weeds from coming into such areas.

This spring re-seeding should be done very early, even at the risk of losing some of the young grass by freezing. It is better to risk a loss in this way than to take the greater risk of loss from weeds and drouth that may occur if seeding is delayed. One method of spring seeding is to sow late in February, or early March, when the ground is honeycombed with frost. Subsequent freezing and thawing will cover the seed. It is easy to broadcast seed evenly over snow as it shows up so plainly. This method is not satisfactory on hillsides or other places where the melting snow may develop into a wash and carry the seed with it.

Weather conditions will of course affect the time of seeding to a certain extent, but it should be the aim to have all grass seed sowed by the first of April or or soon thereafter as possible.

If spring seeding is delayed beyond the first of April the soil should be loosened by raking, especially if there are many open bare places in the turf. If the grass is thin a general broadcasting of seed over the entire lawn will aid in obtaining a thick luxuriant turf. The seed used for re-seeding should be selected with care. Money and effort spent on poor seed is wasted. Careful preparation of the seed bed and a good maintenance program may be entirely nullified by the use of seed infested with weeds.

The spring seeding mixture may contain White Clover if desired. It is better to seed White Clover in the spring rather than in the fall, because of the possibility of young plants freezing out during the winter.

The amount of seed needed will depend upon the condition of the turf. If a good chaff-free mixture is used, 2 pounds per 1000 square feet of area, or 50-75 pounds per acre, should be sufficient.

Mowing. Experience continues to accumulate in favor of higher clipping of grass. If mowed regularly, lawns look just as well with a longer growth, and longer mowing will insure better turf. It is a proven fact that root growth is closely related to top growth. Close mowing, therefore, limits the development of roots, and in turn the food and water supply of the plant is limited. The lesser leaf surface also hinders the actual manufacture of food in the plant. The longer growth of grass, by acting as a sort of mulch, reduces the evaporation of water from the soil, and thus the grass stays green longer during a period of drouth.

Longer grass also aids in weed control, by choking out the weeds, and by shading them. The leaves of some weeds are held erect by the grass, so that a larger portion of them are cut in mowing, thus tending to starve the roots.

Watering. The desire to maintain a luxuriant growth of green grass throughout the summer months has led to the installation of irrigation systems. Some of these are entirely automatic while others combine hand and automatic features.

Water does not act as a "cure all" for every summer turf ill. It cannot overcome unsatisfactory soil conditions, such as lack of humus, poor drainage, or the absence of sufficient plant food. In fact, artificial irrigation may even aggravate such unfavorable conditions.

It is usually nature's plan that grass should go through a period of rest after the maturing season. Watering does away with this resting period by forcing the grass to grow throughout the summer. It is unwise to attempt to keep grass green all summer if the soil is not abundantly supplied with humus and plant food. Irrigated lawns must have frequent applications of plant food to sustain the extra growth and to replace the elements leached from the soil by constant watering.

Water should be applied in heavy amounts at infrequent intervals. Occasional light sprinkling is harmful. It forces the roots to the surface, to draw upon this moisture, where they are exposed to the hot sun and where a sufficient moisture supply prevails only immediately after watering. Sudden heavy waterings then do little good, as the roots are unable to reach the moisture in the lower zones.

Over-watering may result in injury to turf from moisture deficiency, as it fills the soil with hygroscopic water so that the grass roots cannot secure sufficient capillary water. See page 18.

The ideal watering method is to moisten the soil to a depth as great as desired for the root system. Irregular sprinkling to a depth of 4 or 5 inches is much better than a daily light sprinkling.

CHAPTER VIII

FEEDING LAWNS

In time grass, or any other plant, tends to exhaust the food supply in the soil. Under natural conditions, this plant food exhaustion may be extremely slow, but in lawns where the grass is kept clipped it is rather rapid. Food elements are removed from the soil in grass clippings and by leaching. Only a small amount of the plant food removed is restored when the clippings are left on the lawn.

Grass Requirements Not Same as Farm Crops. Careful consideration should be given to the purchase of fertilizers for turf. Past studies of the fertilizer needs of plants have been confined largely to crop plants and not turf. With most crop plants, it is grain or seed, and not vegetative growth, that is desired. No person tries to produce a crop of seed on a lawn, but he does endeavor to increase the production of grass leaves to make a closely knit turf. Not all of the experimental work and sales literature on increased crop yields is necessarily applicable to turf production. Many of the mixed commercial fertilizers on the market are prepared for the requirements of field crops, or for flower and vegetable gardens, and not for grass.

Authorities now agree that the requirements of grasses are better served by the use of complete fertilizers, which furnish a balanced plant food ration.

Kinds of Plant Food Necessary. Any fertilizer containing quantities of the three elements most often lacking in soils, namely, nitrogen, phosphoric acid and potash, is called a complete fertilizer. However, the ratio in which these elements are present varies greatly in different kinds of fertilizers and fertilizing materials.

Nitrogen. Of the three elements usually supplied in fertilizers, nitrogen is the one used in the greatest amount by grasses. It is responsible for the deep green color of healthy turf, and for blade growth. A deficiency of nitrogen is easily recognized. A thin, light green, slowly growing turf is almost certain to be suffering from nitrogen starvation.

Frequent top-dressing of a turf with a fertilizer high in nitrogen is recommended. There is a great loss of nitrogen in the clippings and it leaches rapidly from most soils.

There seems to be a close relationship between the lack of nitrogen in the soil, and the amount of white clover in a turf. Often a large amount of clover indicates a deficiency of nitrogen. As clover is a legume it is able to take nitrogen from the air, and use it for its own growth. It can do this by virtue of the nitrogen fixing bacteria contained in the nodules on the roots. There is an inexhaustible supply of nitrogen in the air, but grasses cannot draw upon it directly, as can clover. As a result, in nitrogen poor soils clovers predominate because they are able to draw upon the air for their nitrogen supply. They thus take the place of other grasses where a lack of nitrogen curtails growth.

Paradoxical though it be, this ability of clover to grow on soils deficient in nitrogen may lead to its own destruction. It often happens that clovers store too much nitrogen in the soil for their own good, and, as a consequence, the overfed plants die. This additional nitrogen encourages the growth of other grasses, and they gradually take the place of clover. In many instances a turf may consist largely of clover one year and of bluegrass the next due to soil conditions becoming less favorable to clover and more so to bluegrass.

Phosphorus. Phosphorus is next in importance to nitrogen in turf development. It is responsible for stem and root development, giving frame and shape to the plant, not unlike the bony skeleton in the human body. In contrast to nitrogen, phosphorus is not readily leached from soils. It is relatively insoluble. When phosphorus does dissolve, it is usually chemically fixed in soils, that is, it is taken up by the soil particles and held until needed by the plant. As a result, there is practically no downward movement of phosphorus in soils, so that the effects of surface applications of phosphorus on turf growth are not as evident as applications of nitrogen. This fact indicates that phosphorus is more important in the original construction of lawns than in the subsequent maintenance. Heavy applications of phosphorus alone seem to promote the growth of clover. In commercial fertilizers phosphorus is supplied in the form of phosphate of lime, known commercially as super-phosphate.

Potassium. Formerly, it was not believed necessary to apply fertilizers containing potassium to a turf, as there seemed to be a sufficient supply of this in most soils for plant growth. However, in recent years, authorities have realized that in many cases a turf may need additional potash, particularly, when regular applications of nitrogen are made. There seems to be some direct relation between the availability of nitrogen to plants, and the amount of potash present. In a sense, we may say that potash controls the living functions of the plant. It is claimed that an abundance of potash in a soil makes plants more resistant to disease.

The Proper Grass Fertilizer

It should be evident from the short description given above that the proper fertilizing program for grass calls for regular applications of a complete fertilizer containing first, nitrogen; second, phosphorus (phosphoric acid); and third, potassium (potash). Moreover, many experiments indicate that of these three elements, nitrogen should be supplied in greatest abundance. Many agricultural authorities recommend for turf a complete fertilizer containing 10% nitrogen, 6% phosphoric acid and 4% potash, as being suited for turf. In any turf fertilizer the nitrogen should be present, in a quantity equal to at least the sum of the other two elements, with phosphoric acid and potash in a 3:2 ratio.

Kinds of Fertilizing Materials

While the different elements and their proportion in a complete fertilizer are most important, other factors should be considered when deciding upon a fertilizer for lawns. The main difference in the types of fertilizing materials is that they supply plant food, especially nitrogen, in both organic and inorganic form. A thorough understanding of the difference between organic and inorganic nitrogen fertilizers is necessary for their intelligent use.

Organic Materials. The chief source of organic fertilizers is waste animal or vegetable material. One of the first of these that comes to mind is ordinary barnyard or stable manure. Manure has a very low percentage of plant food, ordinarily carrying less than 1% of nitrogen, and even smaller quantities of phosphoric acid and potash. It is therefore necessary to make heavy applications of manure to supply an appreciable amount of plant food.

In former years one of the commonest organic fertilizers was bone meal.

Bone meal by itself is not particularly adapted for use on turf as it contains a relatively small proportion of nitrogen. On the average it contains approximately 2% nitrogen and 28% phosphoric acid. It also contains just a trace of potash.

Two very fine organic fertilizing materials are cotton seed meal and soybean meal. Both contain plant food in the proper proportions for grass, as they contain about 6% nitrogen, 3% phosphoric acid and 2% potash. Both are rather slowly liberated and feed grass over a long period of time.

There are many other organic fertilizing materials, such as dried blood, tobacco dust and castor bean pomace. These should be used only with a full understanding of the content of nitrogen, phosphorus and potash they carry, and a price according.

Advantages in the Use of Organic Materials. The supply of plant food in organic fertilizing materials is but gradually delivered, as these substances must decompose before the food can be released. In most instances this process extends over a number of weeks. Plant physiologists have discovered that it is particularly advantageous to have nitrogen supplied in small, regular quantities. Apparently there is a definite connection between the quantity of nitrogen available for grass and development of grass roots. If it is ready in abundance root growth is retarded, and an excessive and soft growth of leaves results. In most organic materials the quantity of nitrogen usable at any one time is small and so unlikely to upset the balance between root and blade growth.

The objective in lawn maintenance is to keep grass growing vigorously and steadily throughout the growing season. This is more nearly possible, of course, if plant food is in moderate and constant supply, rather than being present in large quantities at one particular time, as when inorganic fertilizers are used. Organic fertilizers are also more safely applied. Having a slower chemical action there is less danger of burning the grass.

More food elements of inorganic than of organic fertilizers are lost from soils by leaching.

Inorganic Materials. Inorganic fertilizing materials are derived from two sources; mined and manufactured salts, and refuse materials. In the list of mined and manufactured salts are muriate of potash, nitrate of soda, sulphate of ammonia, and the various superphosphates.

Inorganics Have Advantantages. At certain times, particularly after a period of unfavorable weather, grass needs to be stimulated to quick growth. Inorganic fertilizers whose food elements are available to plants almost as soon as applied, provide this stimulation if weather and moisture conditions are suitable.

Inorganics are also cheaper per unit of plant food. The extensive use of inorganics is probably due to belief in their greater effectiveness because of their quick action.

Combinations Satisfactory. Both organic and inorganic materials having certain proven advantages it would seem that a combination of the two in the proper proportion should work out well. This is indeed the case. The inorganic material provides a quick stimulation, and an early start in the spring, ahead of the weeds, or a quick revival in the fall, after a period of drouth. At the same time a long lasting food is supplied in the organic material, which generally does not become available until the inorganic material has been used. Such a fertilizer is not as likely to burn the grass as much as a straight inorganic material. A fertilizer having a combination of the two forms will cost less than one purely organic, and fit more readily into the budgets provided for lawn maintenance.

Best Fertilizer for Established Lawns

In considering the different phases of lawn fertilization several things stand out as important in the selection of a fertilizer for feeding established turf, as distinguished from that for making new lawns.

First, a complete fertilizer is necessary. Such a fertilizer should carry nitrogen, phosphorus and potassium. The material should contain these fertilizing elements in a certain ratio, as for example, 10% nitrogen, 6% phosphoric acid and 4% potash. This definite formula is not absolutely necessary, but the different elements should approximate this ratio. Other things being equal, a fertilizer carrying 5% nitrogen, 3% phosphoric acid and 2% potash would be just as suitable, provided that twice the amount were used. Besides having the proper plant food ratio, a good lawn fertilizer should be composed of a combination of organic and inorganic materials. It should supply a quick stimulation of the grass, as well as a long lasting source of plant food. A combination of inorganic and organic fertilizer applied regularly to lawns insures a quick growth in spring because of the inorganic materials, while the turf will revive quicker after drouth, and stay green longer in fall, because of the organic fertilizer. This has been demonstrated at various experiment stations.

When to Fertilize

It is generally agreed that best results will be obtained if fertilizer is applied in comparatively small quantities two or three times during the year.

Fertilizer may be applied either in April or September. Whether spring or fall is the better time depends upon whether the fertilizer used consists mainly of organic or inorganic materials.

For fall application fertilizer should be largely organic. This will provide food for the immediate use of grass, and what is left will remain in the soil for the roots to make use of in winter and early spring. Any inorganic material applied in the fall, not immediately used by the grass, is likely to leach out, and be lost during the winter months. Fall fertilization is not so apt to promote an excessively heavy and rank growth of grass as spring applications.

It is believed by some that spring is the natural time to revive grass with fertilizer. It is the better time to fertilize if a straight inorganic material is used, as the grass may be able to make use of it before it leaches away. However, inorganics may stimulate a heavy growth for a short period which the soil later will be unable to sustain. If a fertilizer containing both inorganic and organic materials is used the former stimulates the grass to an early growth ahead of weeds, while the latter will supply the later food requirement.

Fertilizer Applications

The amount of fertilizer to apply necessarily depends upon the condition of the turf and the kind of fertilizer. A complete plant food of 10-6-4 analysis should be applied at the rate of about 10 pounds per 1000 square feet of area, or 400 to 500 pounds to the acre. As shown before, the important feature in fertilizing established turf is the introduction of nitrogen. Therefore it is necessary to apply a complete fertilizer in accordance with the amount of nitrogen contained. If a material such as

4-12-4 is used instead of a 10-6-4, it will be necessary to apply 25 pounds per 1000 that is about three times as much in order to obtain an equal amount of nitrogen. Wisdom suggests purchase of a complete fertilizer on the basis of nitrogen content, as this determines how much must be used on a given area.

No particular method of applying fertilizer need be followed, as long as it is evenly distributed. On large areas a regular lime or fertilizer spreader that broadcasts the material can be used. Such a machine insures even distribution. On small areas hand broadcasting can be resorted to, or one of the small hand distributors on the market holding about 100 pounds of fertilizer, may be used. It is important to apply fertilizers only when the grass is dry. If it is damp or wet much of the fertilizing material will stick to the blades of grass and cause burning. This may not be a permanent damage unless very severe, but it makes the lawn unsightly for a time.

Even distribution insures uniform growth of grass avoiding the uneven growth which often follows fertilizer applications. It should be remembered that there is practically no lateral movement of fertilizers in soils. The movement is downward, and any areas missed in applying will not be reached by the fertilizing material.

CHAPTER IX
WEED CONTROL

According to a prominent writer on horticultural subjects, "Weeds do not make poor lawns! Poor lawns make weeds!" Weeds get started because of thin turf or bare places in the turf. This thin turf is the direct result of poor soil preparation, or neglect in maintenance, or both.

In making new lawns correct practice in soil preparation provides a seed bed from which the young grass plants can develop a strong root and top growth. Then, by selecting a high quality seed of grass varieties adapted to lawn conditions in the vicinity, and, after the lawn is established, taking care of it in the right way, it is possible to have a strong vigorous turf capable of withstanding the onslaught of weeds.

As weeds are a constant problem means of control are considered.

Control Methods

Weeds can be controlled by: (1) hand digging, (2) chemical sprays, or (3) by the development of a thick strong turf to crowd them out.

Over a large lawn, badly infested with weeds, hand digging is impracticable. But if some bad weeds get started in limited areas, hand weeding may be the only satisfactory method of getting rid of them. Many times dandelions and other weeds are dug by hand only to have two or three plants develop where but one grew before. This is due to the fact that the entire root is not pulled out or killed. When roots of weeds like dandelion are split in digging several new plants are likely to develop. After hand digging, the root remaining in the ground should be killed by putting on it a pinch of ammonium sulphate, common table salt, or a little gasoline or coal oil.

To aid in the control of weeds several tools have been designed in recent years. One of these is a special rake which pulls off the heads of dandelions and plantain not cut by the lawn mower. Such rakes are useful also in pulling up crab grass so that the long spikes will be cut in mowing.

Certain chemical materials can be sprayed or sprinkled on weeds for their control. Their use will be discussed later.

After destroying weeds by hand digging, or spraying, it is important to start immediately to develop a strong turf to prevent new weeds getting a foothold. Proper maintenance should be regularly followed.

Chemical Weed Destroyers

The use of chemicals to destroy weeds is comparatively new, though for some time they have been used to destroy such farm weeds as Canada thistle, quack grass, poison ivy or morning glory.

The chief objection to the use of such chemicals on lawns is that the most of them act upon all vegetation alike, killing both grass and weeds. However, the various State Experiment Stations, and the United States Department of Agriculture, have worked on this problem for a number of years, and have developed methods for the use of a few chemicals in diluted form to control certain lawn weeds.

One other reason for the rather limited use of chemical herbicides is that they cannot be applied economically in large quantities except with special spraying equipment.

Sodium Chlorate

Effective on Ground Ivy, Speedwell, Poison Ivy, Ironweed, Ox-eye Daisy, Chickweed.

Sodium Chlorate is a crystalline substance resembling fine salt. It can be purchased at most drug stores or chemical supply houses, but should not be confused with common table salt known technically as Sodium Chloride.

Like many other chemicals, Sodium Chlorate is destructive to all vegetation. Therefore it must be used in very dilute solution for lawn weeds. One or two applications may completely destroy the weeds mentioned above, and at the same time cause only a slight temporary burning of the grass.

The chief objection to the use of Sodium Chlorate is the fire hazard connected with it. A solution of Sodium Chlorate should not be allowed to come in contact with gloves, shoes, clothing, etc. If such articles become saturated with the solution and then are allowed to dry they become great fire hazards. If it is spilled on combustible material it should be promptly washed off. The danger incident to the weak solution here recommended is not much, but it should always be handled cautiously. Any solution not used should always be stored in a covered metal container, never in wooden containers.

For the control of the lawn weeds mentioned above, a solution is made by dissolving one to two ounces of Sodium Chlorate in one gallon of water. This will cover 100 square feet of turf if put on with a pressure sprayer. If the solution be applied with a sprinkling can a trifle more will be needed as this method is somewhat more wasteful of the solution. The leaves must be thoroughly covered, and the application made when rain is not likely to follow closely and wash the solution off the leaves.

One excellent feature of Sodium Chlorate is that it can be used to kill weeds in winter. Thus the objection to discoloration of the grass is reduced to a minimum. Besides being effective at any time during the winter when the ground is not covered with snow, Sodium Chlorate may be applied at any other season. There is more danger of injuring grass, however, in hot, dry weather.

A chemical similar to Sodium Chlorate is Calcium Chlorate. It has the advantage of being non-inflammable and recent work at several experiment stations indicates that it may serve as a substitute for the other material. However, as yet, there is not sufficient information to warrant its extensive use.

The scale of application is one to two ounces dissolved in one gallon of water and applied to 100 square feet.

Iron Sulphate

Effective on Dandelion, Plantain, Chickweed, Creeping Buttercup, Heal All

Other names for Iron Sulphate are Green Vitriol and Copperas. In the drug trade it is better known by the latter name. In purchasing it, the granulated form should be specified, as this is much easier dissolved than the ordinary coarser grade.

The chief objection to Iron Sulphate is that if any of the solution touches clothing, walks, buildings, or stone work it will leave a conspicuous rusty stain.

In using Iron Sulphate it is dissolved at the rate of 1½ pounds to a gallon of water. This solution should be strained through several layers of cheese cloth to remove grit. It is best applied with a pressure sprayer. One gallon of the solution is sufficient to cover 300 square feet of turf. The application is made on a quiet warm day when rain is not likely to occur for at least 24 hours. Iron Sulphate applications are much more effective if some implement is first employed to bruise the weeds, as the solution thus penetrates more rapidly. On large areas a chain drag can be pulled ahead of the sprayer, while on smaller ones a steel door mat may be used for the same purpose.

Iron Sulphate should not be used during hot, dry weather to avoid possible injury to the turf. In other seasons grass blades may be discolored but this damage will be removed by mowing, and no permanent injury will result.

While it is possible to apply Iron Sulphate with a sprinkling can, the spraying method is better. Any metal equipment used in the work should be carefully cleansed immediately after using, to avoid corrosion.

One application of Iron Sulphate will not completely rid a lawn of dandelions unless they are very small. Two or three sprayings are required, the first just as the plants come into bloom in the spring. Subsequent applications should be at intervals of about two weeks, or as the dandelions put out new growth.

Iron Sulphate may injure bent grass severely. It will kill white clover.

The rate of application is one and one-half pounds in one gallon of water applied to 300 square feet.

Sulphuric, Hydrochloric and Nitric Acids

Because of their acid properties these substances must be used carefully as they burn flesh and clothing almost instantly. They are best handled only in glass vessels. None can be utilized as a spray, but must be applied directly to the plant. They are often used to kill long, tap root weeds, such as dandelions and plantain.

A slow and tedious but effective method of controlling such weeds is to pierce their roots or crowns with a sharpened stick which has been previously dipped into one of the acids. Extreme caution must be observed to avoid getting any of the acid on grass. It is suggested that the bottle containing the acid be mounted on a board, or something of the sort, to provide a safe and convenient carrier.

Another chemical used in the same way is carbolic acid. However, it is not as strong as the other materials, and is not as certain to permanently kill the larger weeds.

Gasoline and Coal Oil

Both gasoline and coal oil are used in a manner similar to the acids described above except that large amounts must be used. These materials are preferable to acids because they are less dangerous to handle. Either one will destroy grass, even when used in very small quantities. Sometimes they are applied to weeds by means of a spring bottom oil can.

Common Salt

Common salt cannot be recommended as a weed destroyer except in those cases where it is desired to kill all vegetation, and where its sterilizing effect upon the soil is not objectionable. All vegetation can be removed from gravel walks or drives by applying dry salt, or by sprinkling with a solution containing three pounds of salt per gallon of water.

Arsenite of Soda

Arsenite of Soda is a very active poison and extreme care must be exercised in its use. No vapor or dust should be inhaled nor children or animals allowed near it. This material is not so convenient to purchase as only large wholesale druggists carry it. It is a whitish, gray substance. Since it hardens, if allowed to stand for any length of time, only strictly fresh material should be used. The formula for Arsenite of Soda solution is one pound dissolved into from three to nine gallons of water.

A less expensive weed killer than this is devised by mixing one pound of White Arsenic and two pounds of Sal Soda in three to nine gallons of water. These arsenical compounds are the chief ingredients of most commercial weed killers, and are used on walks, roadways, tennis courts and all places where the complete and lasting extermination of all plant growth is desired.

Do not use Arsenite of Soda, or the White Arsenic compound on any place where you want growth of grass or other vegetation.

Sodium Arsenite should not be confused with Sodium *Arsenate* which is less powerful.

Common Turf Weeds

Dandelion. Of all lawn weeds the dandelion is perhaps the most universally distributed.

The most common method of removing dandelions is to cut them out by means of a hoe, spud, or some other implement. Unless the entire root is removed the plant will sprout again. This can be prevented by placing a pinch of dry salt, or sulphate of ammonia on each root after it is cut off. Gasoline or coal oil may be used for the same purpose.

For digging out dandelions and other deep rooting perennial weeds an asparagus knife with a V shaped blade or one of the special dandelion knives helps to speed up the work. If the turf is infested with many small dandelions, spraying with iron sulphate is a more satisfactory means of control.

Crab Grass. Next to dandelions, crab grass is the worst lawn pest. Even with the greatest care taken in the preparation of the soil, and the selection of seed, crab grass springs up from apparently nowhere, and starts a vigorous growth.

Any annual like crab grass can be controlled by preventing seed production. However, this is not as easy as it sounds. The creeping stems of crab grass lie so close to the ground that the lawn mower passes over them untouched, allowing each plant to produce thousands of seeds on its many flowering spikelets. The seed produced in one season germinates in June of the following year. The plants develop rapidly, sending out spreading runners, which root tenaciously wherever they come into contact with the soil. The name, crab grass, is suggested by the flowering spikelets which somewhat resemble the claws of a crab.

In some sections crab grass is known as *finger-grass*. It is also called *summer grass*, and *fall grass* because it does not start growth until hot weather and is most noticeable in the summer or early fall. It is killed by the first frost, turning brown and leaving unsightly patches. Being particularly noticeable in hot, dry seasons, when much water must be artificially supplied, it is sometimes called *water grass*, and often seems to take possession of a lawn over night.

Control. Nearly everything has been tried in an effort to find some treatment to eradicate the pest, but so far nothing but hand pulling has been successful. This must be done when the plants are small, and before they have had an opportunity to mature seed. Perhaps the most satisfactory method of control is to rake the lawn with a steel rake after mowing. This pulls up the runners. These should then be removed by mowing. This is not complete eradication, but is better than allowing a patch of crab grass to re-seed itself entirely unmolested.

Closely knit turf will choke most crab grass plants before they can get a start. Every bare spot in lawns should be immediately covered with rich soil and planted with good seed. As mentioned before, "Weeds do not make poor lawns, poor lawns make weeds."

Goose Grass. Because of the same characteristic development of finger like spikelets, goose grass is often mistaken for crab grass. However, crab grass is larger and finer, and does not have the long, flat and dull green stems of goose grass. Control methods are the same.

Chickweed. Two varieties of chickweed, the common and the mouse ear chickweed, are common in lawns.

In spite of its frail appearance chickweed is probably the hardiest and most persistent weed on earth.

Common chickweed is an annual, and propagates from seeds only. Seed production should be prevented wherever possible. The roots of the plant are not deep and when the soil is moist it is not difficult to pull them out.

In contrast to common chickweed, *mouse ear chickweed* is a perennial. The leaves of this species are mostly oblong, sometimes lance shaped, and do not, as might be supposed, resemble the ears of a mouse. The entire leaf is covered with downy hairs giving it a dirty gray color.

Control. The iron sulphate spray which has been described is an effective means of control, particularly if the plants are young. A newer remedy is to burn the chickweed with ammonium sulphate. The infested area should be watered, and then a small amount of the dry sulphate of ammonia sprinkled on the patches. Some grass may be burned by this treatment, but the damage will not be permanent. Sodium Chlorate is also effective on chickweed. Two or three applications are necessary.

Plantain and Buckhorn. These two species are generally known as broad leaved plantain and narrow leaved plantain. The former appears in heavy, damp soils, and the latter in light, poor soils. They are most likely to give trouble where soil conditions are not ideal for the development of grass. The presence of either of them should be taken as a warning that soil conditions should be improved.

Control. Both types of plantain can be controlled by the methods suggested for dandelions. However, they are more easily dug out than dandelions and more easily killed by the use of an acid. Narrow leaf plantain is loosely anchored to the soil in August, and this is the best time to pull it out.

Moss. Contrary to general opinion, moss does not necessarily indicate an acid soil. Its presence usually means that soil fertility is low. Some authorities believe that a deficiency of potash is particularly favorable to the development of moss. They, therefore, suggest three applications of muriate of potash at the rate of 6 pounds per 1000 square feet of lawn.

Moss also develops in heavy wet soils in need of drainage. In such cases steps should be taken to improve the drainage.

Maintaining grass in a healthy vigorous condition by regular use of fertilizers keeps moss out.

CHAPTER X

PESTS AND DISEASES

Moles

In rich, moist soils the blind, furry little animals called moles are often a nuisance. Moles do not damage turf directly by eating the rots. They are carnivorous and live chiefly upon earthworms, grubs and ground insects. The injury from moles is from heaving the soil which causes the grass roots to dry out and leaves unsightly ridges in the lawn.

Moles may be destroyed by trapping, poisoning or asphyxiating them.

Kinds of Traps. Many types of mole traps are manufactured in this country, all of them depending for their operation on some sort of tripping device. The trigger pin is designed to rest upon an obstruction, such as a board, placed in the mole's runway when the trap is set. The trap is sprung when the mole follows its natural instinct to re-open the runway by burrowing through or upheaving the obstruction. The American traps are of three types: (1) choker loops, (2) clipping or scissor jaws, and (3) impaling spikes. No importance need be attached to the admonition that one should use gloves to prevent the animal's getting the scent of human hands. Experience has shown that this does not affect the catch in any way. A good strong garden trowel is the best tool to use in setting mole traps.

Poisoning Moles. So much satisfactory experience has been reported in the killing of moles by poisons that this method is recommended above trapping. Various poisons and methods of using are as follows:

CALCIUM CYANIDE. Open the burrow every five feet and place in it a teaspoonful of this poison and close the opening without stamping it down.

CARBON BISULPHIDE. Pour a teaspoonful into the burrow at points about five feet apart. Close the holes as indicated for Calcium Cyanide to retain the poisonous fumes.

STRYCHNINE. Insert a small crystal of Strychnine in the end of the shell of raw peanuts, then place a peanut every few feet in the runway.

Secure a solution containing sixty grains of Strychnine Sulphate to one ounce of water. Soak about a dozen grains of corn in this solution for 24 hours, then deposit 2 or 3 grains in runways at intervals of 6 to 8 feet.

PARADICHLORBENZINE. This chemical with the vicious sounding name is recommended by the Department of Agriculture for destroying the peach tree borer. It is commercially obtainable in the form of a powder which, when placed in the ground, gives off a heavy poisonous gas that penetrates the soil. About a teaspoonful should be dropped into the runways every six to ten feet, and the soil put back. The moles end their activities immediately.

POTASSIUM CYANIDE. Immerse small cubes of raw potatoes in a 20% solution of this poison, and place in the burrow at 10 or 12 foot intervals. There is no danger of injury to children or livestock in using the poison in this manner.

LYE. Apply a teaspoonful of flake napthalene, or household lye, in the runways at intervals of about 20 feet.

Asphyxiation. Attach a garden hose to the end of the exhaust pipe of an automobile. The connection may be made secure by using electricians' tape or by wrapping with an old inner tube. Insert the other end of the hose in the runway, and allow the motor to run for twenty minutes. The carbon monoxide in the exhaust gas will kill the moles if the runway is tightly sealed. Any openings should be closed with mud.

This treatment is more effective after a rain when the ground is wet, and therefore less porous.

CAUTION: Have the car out in the open in order to avoid accumulation of the gas in the garage.

After Treatment. Where moles have been at work the soil should be firmed down immediately with a roller or tamper. Thorough watering will hasten re-rooting of the grass.

White grubs and earthworms constitute the main food of moles. If these are kept under control moles will be less bothersome.

Gophers

Gophers are small burrowing rat-like animals. In large numbers, they become very annoying. Control with poison baits, as suggested for moles.

Ground Squirrels

There are several kinds of ground squirrels. The most common is gray, but not as large as the ordinary tree squirrel. Another common type is the 13-striped ground squirrel, having different colored stripes running the length of its back. Control with poison baits same as for moles.

Beetles and Grubs

Most persons are familiar with the common beetles, which at times infest certain sections of the country, but not many think of these as injurious to the turf of lawns. It is true that beetles themselves do not directly injure turf, but their larvæ do feed on grass and other vegetation. Certain types prefer to lay their eggs in moist, sod covered soil, and so lawns and putting greens are particularly inviting. From these eggs the larvæ are hatched. These grubs live in the ground until they develop into the pupæ stage, and finally into adult beetles, after which they emerge from the soil.

Damage to Vegetation. During their development, grubs feed on roots of plants, and any decaying vegetation that happens to be in the soil. At times they may be present in such numbers as to cause a tremendous amount of damage. The United States Department of Agriculture has published the results of some efforts at grub control. One instance in Iowa is given in which a 60 acre field of corn was entirely destroyed by the work of grubs. In another case a large field of timothy was laid waste by grubs, and by crows overturning the soil to get at the grubs. Skunks also are very fond of grubs and will do more damage in getting to them than crows. Many cases have been reported where skunks completely ruined a lawn in their search for the palatable, juicy grubs.

While grubs can do much injury to turf beetles can not. The latter feed on the fruit and foliage of trees and thus do considerable harm. Beetles do not attack all trees but have been known to completely defoliate large sections of hard wood forests, and to destroy large fruit orchards. In the eastern section of the country, particularly where the Japanese beetle is most prevalent, it is not uncommon to see an orchard of peach trees stripped clean of foliage and fruit, leaving only the stones of the fruit hanging on the branches.

Classification of Beetles

In general, beetles are divided into two groups; those having a three year life cycle, and those with a one year life cycle. The commonest type of the former is the May beetle, or June bug, while of the latter the Japanese beetls is representative. Because of the immense damage done by this beetle in the Eastern United States, certain agricultural departments, and the United States Department of Agriculture, spend millions of dollars each year in an effort to control it, and check its spread.

June Beetles. The June bug or beetle operates widely throughout the eastern and middle western portions of the United States. Scattered portions of West Virginia and Kentucky are infested with it, as well as parts of Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota and Iowa.

The life cycle of June beetles presents an interesting study. The adult beetles emerge from the soil in April or May, and feed on the foliage and fruit of trees. Soon after this the females deposit their eggs—each about 60 of them in the soil, after which they die. The males live longer, but cannot survive the cool weather of early fall. Eggs are ordinarily laid in the soil at a depth of some seven or eight inches. During June or early July these hatch into the grubs, which immediately start working toward the surface, where they feed on roots and other vegetation during July and August. In September they burrow into the soil to a depth of about a foot and make their winter cells. The following spring, the second year in the cycle, they come out of their winter cells in April, when the ground becomes warm, and again feed on the roots during the summer months. They again descend deep into the soil in September to pass the winter. The following spring, in the third year of the cycle, the grubs re-appear near the surface, and feed during April and May, but in June return to a depth of six or eight inches, where they make cells and evolve into the pupa stage. In the summer this pupa undergoes a final change to become adult beetles, which remain in their cells all winter, finally making their way to the surface the following spring to feed, mate and lay eggs for another generation.

Not all kinds of grubs go through this life cycle, it being particularly characteristic of only those species of greatest economic importance in the middle western states. Because of this three year period it follows that there will be three general broods of June beetles, each reappearing in the adult condition regularly at intervals of three years. For example, brood A appeared in the adult condition in the spring of 1929, brood B in 1930, and brood C in 1931. As these three broods do not necessarily infest the same area, there may not be a crop of beetles each year in any one locality. However, beetles may appear every year in a given locality, if the different broods overlap.

The Japanese Beetle. The Japanese beetle has thus far been found only in the Eastern United States. It is very common in New Jersey, New York, the District of Columbia, and other Atlantic coastal regions.

The life cycle of a Japanese beetle is completed in one year. The adult beetle appears later than the June beetle, usually in late June or July. Eggs are laid in the ground during July and August. These soon hatch, and the young grubs feed on decaying vegetation and grass roots in August and September. After this, the grubs go down to eight or twelve inches in the soil, wintering there, and re-appear in April of the following spring, when they feed again on vegetation until June, then emerge from the ground as full grown beetles to start a new generation.

While in general the Japanese beetle goes through the four stages of its existence—eggs, larvæ, pupæ and beetle—in one year, this is not always the case, and in the north especially the cycle may require two years.

The Japanese beetle had spread over a considerable area of this country before effective control measures could be devised. Recently, however, certain parasites have been brought from Japan and the Orient, and as time goes on there will be many more natural enemies developed or introduced which will aid in controlling this pest.

Control of Beetles and Grubs

The various species of beetles and grubs would cause much more damage to vegetation were it not for the tendency of nature to balance all things. Beetles are subject to attack by many natural enemies. Fungous diseases kill many of the larvæ, and bacterial diseases also aid in their destruction. Birds and skunks feed freely on the larvæ. Adult beetles are greedily devoured by poultry and birds. In addition, many insect parasites, and other enemies, aid in keeping down their numbers.

Until the invasion of the Japanese beetle no effective methods of destroying any beetles or grubs had been developed. In 1920 the National Bureau of Entomology demonstrated that arsenate of lead would kill both beetles and grubs. Since that time this poisonous material has been used to spray trees and other vegetation on which the beetles feed. After arsenate of lead was found to be useful in controlling beetles it was tried for controlling grubs. Arsenate of lead may be used with relative safety in treating fine turf, and has not so far shown any harmful effect upon the soil. By its means grubs established in a turf may be destroyed, and soils free from grubs may be kept free by "grub proofing" with arsenate.

Grub-Proofing New Lawns. In sections where grubs are known to do damage it may be worth while to treat the soil before seeding. A finely ground grade of arsenate of lead should be applied just prior to seeding, after all grading and smoothing, and contouring has been completed. The recommended amount to use varies from five to twenty pounds per 1,000 square feet of area. Under ordinary circumstances five pounds will protect turf for several years. It is best to mix the arsenate with enough sand or fine soil to prevent the blowing away of the light powdery material, and to insure an even spread. A proper mixture is five pounds of arsenate of lead to a bushel of soil. After being spread on evenly it should be lightly raked into the surface soil.

Arsenate of lead is used also to control earth worms, and some evidence indicates that it may discourage the growth of certain weeds, such as crab grass and chickweed.

Grub-Proofing Established Lawns. In case a serious infestation of grubs is present or expected in established turf, the arsenate should be put on as a top-dressing, at the rate of five pounds per 1,000 square feet of area. The arsenate should be mixed with sand or soil and applied when the grass is dry, to prevent its sticking to the blades and burning them, and worked into the turf with a broom or rake. It is well to water immediately though not absolutely necessary.

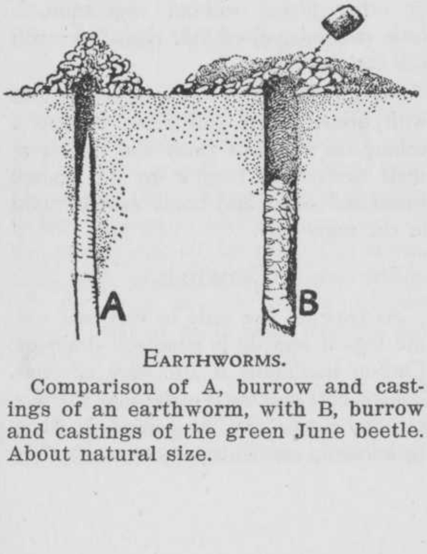
Earthworms

In limited numbers, earthworms are a benefit to lawns. But they become objectionable if the casts brought to the surface are numerous enough to smother the grass. If not too abundant they may be eliminated by occasional brushing or raking, without the necessity of killing the earthworms.

Holes made in the soil and the earth left on the surface by June beetles may appear to be done by earthworms, but grubs make larger burrows, and throw greater quantities of earth than worms. Besides, they loosen the roots of grass sufficiently to kill it over a space of several inches in diameter. Earthworms are not guilty of this, so that it is important to learn whether the damage is caused by grubs or by earthworms.

Earthworms are controlled by the use of such irritants as corrosive sublimate and Mowrah meal, or are poisoned by means of arsenate of lead.

Corrosive Sublimate. Two, or not to exceed three ounces of corrosive sublimate dissolved in 50 gallons of water is sufficient for 1,000 square feet. After applying the solution at least double this quantity of water should be used to wash it thoroughly into the soil. If corrosive sublimate is applied dry it should be mixed at the rate of two or three ounces to two cubic feet of dry sand, and the mixture scattered evenly over 1,000 square feet. Liberal watering should follow. When corrosive sublimate is applied in this way, at the rate suggested, no injury to the turf results. In very hot, dry weather, this treatment may cause a slight burning of the turf, but is seldom necessary, as earthworms are not then active. Any burning, from such applications, will not be lasting or serious.



EARTHWORMS.
Comparison of A, burrow and castings of an earthworm, with B, burrow and castings of the green June beetle. About natural size.

Mowrah Meal. Unadulterated fresh Mowrah meal is a safe and effective material to use. It should be applied at the rate of 15 pounds to 1,000 square feet of lawn, and well watered in. Use only fresh Mowrah meal, as it deteriorates rapidly, especially when stored in a damp place.

Arsenate of Lead. In some cases arsenate of lead has accomplished control of earthworms. However, it apparently is not effective on all soils, and must be applied in larger quantities than is required for destroying grubs. On established lawns the arsenate may be applied at the rate of 10 or 15 pounds per 1,000 square feet at any time during the growing season. Spring applications are best as established turf may be injured unless the arsenate is applied very carefully. It should be mixed with dry, screened soil, applied when the grass blades are dry and watered in immediately afterward. To insure constant and effective control against earthworms and grubs some green-keepers mix arsenate of lead with each topdressing at the rate of about 5 pounds per 1,000 square feet.

Ants

It is interesting to know how ants injure grass. The galleries which they form in the soil disturb plant roots and their earthen mounds cover low growing plants. Some species carry away germinating seeds. Ants' nests make unsightly spots in lawns.

Ants may be destroyed by fumigating their burrows, or by poisoning. The fumigant method is the one more commonly used.

Fumigants. Carbon bisulphide and calcium cyanide are the two fumigants generally used. If the burrows are so numerous as to form a mound holes may be made in the mound about a foot apart by driving in a stake an inch in diameter, to a depth of ten or twelve inches. About one fourth pint of carbon bisulphide is then poured into each hole, and the opening plugged with soil. The entire mound should then be covered with a piece of old carpet or burlap for twenty-four hours, to prevent the escape of the gas formed by the chemical.

Where the ants are not so numerous that they have formed mounds, carbon bisulphide may be injected in the openings by means of a spring bottom oil can. About a teaspoonful of the fumigant should be squirted into each opening. The openings should be plugged with soil after the treatment to keep in the fumes.

Instead of carbon bisulphide calcium cyanide may be used, provided the openings of the ants' nests are enlarged. One teaspoonful for each burrow. Care should be taken not to spill these chemicals over lawn areas other than those being treated. Injury may result if the material comes in contact with the turf. Carbon bisulphide is both poisonous and inflammable, and should be handled with care.

Poisons. Poisonous baits may also be used to get rid of ants. The so-called government formula is as follows:

1. Dissolve 2 pounds (1,000 grams) of sugar in 2½ gills of water, add 1/10 ounce (3 grams) of tartaric acid (crystals), boil for thirty minutes, and cool.

2. Dissolve 1/10 ounce (3 grams) of sodium arsenate in 4 teaspoonfuls (20 c. c.) of hot water. Cool and add 3 1/3 ounces (100 grams) of honey.

Mix the two solutions together thoroughly. Small pieces of sponge, cotton or wadded paper should be saturated with the poison syrup, and distributed where the ants work.

A more satisfactory plan, however, is to place the poison to a depth of a half inch in small covered cans, in the sides of which holes have been punched, from the inside out, with a ten-penny nail, about an inch from the bottom. A piece of sponge, cotton or paper placed in the can will prevent the ants from drowning in the syrup. This poison is not strong enough to kill the ants immediately, but they will carry it away to the nests, and feed it to the queen and the young, thus destroying the entire colony.

This and the other treatments suggested will be found most successful during warm, sunny weather, when the ants are most active.

Other Treatments. Two simple treatments which are sometimes successful involve the use of coal oil and Paris green.

Coal oil cannot be used on the lawn, as it will kill the grass. However, in drives, or other places without vegetation, a little coal oil poured into their holes will kill the ant colony.

Paris green mixed in equal proportions with brown sugar will often destroy a colony, as the ants carry the poison to their nests, and feed it to the young. Powdered sugar and borax may be used in the same way.

Crawfish

As crawfish live only in very wet soil, the logical remedy is good soil drainage. Carbon bisulphide is also very effective. This is best applied directly into the burrows by means of a long nozzled oil can or kerosene can with a short nozzle. The nozzle in either case should be partially closed to allow the liquid to drop out slowly. Five or six drops of the liquid should be allowed to enter the burrow, and the hole of the burrow closed immediately by stepping on it with the heel. It must be remembered that carbon bisulphide is extremely inflammable, and it should be used with as great care as gasoline.

Skunks

As mentioned under the discussion of white grubs, skunks are likely to damage a lawn by making shallow holes in search of grubs and beetles. If this kind of damage is found in a lawn it should be a warning that white grubs are present, and that some day they may do serious damage. By eliminating the grubs with arsenate of lead there will be no further trouble from skunks.

Snails

Snail slugs occasionally attack grass roots, as well as the roots of flowers. Dusting with arsenate of lead at the rate of 12 ounces to 1,000 square feet, and afterwards watering in with a driving spray, will control these pests.

Sod Web Worms

Previous to the summer of 1931 sod web worms were little known to those interested in turf culture, although they had been recognized as agricultural pests for a long time. These worms wrought serious damage to turf in many parts of the central west at that time. The brown, dead turf, caused by the worms cutting off the grass at the surface of the ground, was in many cases thought due to the effects of the drouth.

Sod web worms are the caterpillars of small white and yellowish brown moths which fly mostly at night. When full grown the worms are about an inch in length. They are of a dirty gray color, with regularly spaced brown spots, and covered with small tubercles, each bearing a small tuft of hairs. When exposed they move rapidly backward or forward to shelter.

The moths usually lay their eggs in clusters on the grass blades. In a few days these hatch into small worms, which immediately begin to feed on the grass, cutting it off just at, or immediately under, the surface of the ground. As they grow they weave a sort of silken web in the form of a tube into which they sometimes incorporate small bits of grass. When full grown the worm pupates in this web, and after a week or ten days emerges as a full grown moth, to start the life cycle anew. It mates, lays eggs, and these hatch into web worms, to later pupate and develop into moths.

In ordinary periods these pests are kept in check by adverse weather, and by parasites and birds, which devour them greedily. When web worms appear in large numbers a lawn may be ruined by grackles, robins and other birds, as they scratch up the turf in search of the worms.

Control. If web worms are found in a lawn, measures for their control must be begun at once, or serious harm may occur. Prior to 1931 no satisfactory means of controlling them in lawns was known. All that time various insecticides were tried. Some proved partially effective, others had no value.

Arsenate of Lead. One of the most successful treatments was the use of Arsenate of Lead. This poison should be dusted on the turf at the rate of 6 to 7 pounds per 1,000 square feet. A hand dusting machine or a rotating fan duster is best although arsenate can be put on by placing it in a coarse burlap sack and shaking the sack up and down with a quick jerky motion.

After the lead has been distributed it should be worked down on to the ground by sweeping the lawn with a floor brush or broom. Following this it should be thoroughly washed off the grass blades by a heavy stream from a hose. A mechanical sprinkler is not satisfactory, but a heavy coarse stream of water should be applied direct from a nozzle.

Pyrethrum Extracts. Pyrethrum extracts are sold under trade names of Evergreen and Red Arrow. These are diluted at the rate of ¼ ounce to a gallon of water and sprinkled on one square yard of lawn.

Kerosene Emulsion. For large areas Pyrethrum is rather expensive. In such cases a Kerosene Emulsion will do if the necessary equipment is available. If improperly made or applied it will cause considerable burning. The United States Department of Agriculture, Farmers Bulletin No. 1258, suggests the following method of making a Kerosene Emulsion: "Dissolve ½ pound of hard or whale oil soap (or 1 qt. of soft soap) in 1 gallon of boiling water. Remove from the fire and add 1 gallon of kerosene while still hot. Churn with a force pump by pumping the mixture back into itself for five or ten minutes until the oil is thoroughly mixed, when it appears as a creamy mass, with no drops of free oil visible."

For control of web worms on lawns this solution must be diluted, using 1 gallon of the emulsion to 60 gallons of water, and 1 gallon of the dilute solution applied to one square yard of lawn area.

Brown Patch

The ordinary lawn is seldom attacked by fungous diseases or growths. However, brown patch and similar diseases do occasionally attack bent lawns, so they will be briefly discussed.

The disease, brown patch, is caused by the same fungus that attacks crop plants like potatoes, cabbage, and many others. Two types of brown patch, large and small brown patch, injure turf but they seldom do much damage to any turf except creeping bent.

Large brown patch affects areas of grass as large as one foot in diameter, or more. Not all of the blades are injured, so that a scattering of green remains through the patch. Ordinarily, the blades only and not the stem, buds or roots are attacked. The first indication of large brown patch is a fine cobweb-like ring that is visible early in the morning, before the dew disappears. After it has dried the area has the appearance of a "smoke ring" which later develops into browned turf.

Small brown patch affects patches of limited size, about as large as a silver dollar. There are a number of these spots scattered over the turf giving it a moth eaten appearance. *Small* brown patch kills the grass to the ground. The affected grass has a more bleached appearance than after an attack of *large* brown patch.

Large brown patch is likely to appear only during periods of hot, humid weather. *Small* brown patch, on the contrary, appears at any time during the growing season. Either disease may be checked by a change in weather conditions, or by the use of a fungicide which has mercury as its active element. Two common fungicides are corrosive sublimate (bichloride of mercury) and calomel.

Snow Mold

One of the common fungous diseases that attacks Bluegrass, Fescue and Bent, especially in the northern states, is snow mold. This disease is not caused directly by snow, the term being applied because it first appears after the snow melts. The disease develops any time during the winter, and is brought about by excessive moisture (in connection with low temperatures), from melting snow, heavy fog or rain.

The damage from snow mold is easily distinguished from other winter-killings, as the affected spots are covered with an aerial growth of mycelium which, when exposed to the sun, takes on a pinkish color, and the whole patch may have a pinkish cast. At this time the cobwebby growth is so abundant that the grass leaves are matted, and form a thick layer over the affected area. Some of these patches may not have this abundant growth, but appear a dirty gray instead. Damage from snow mold can be distinguished from damage due to other causes by the presence of the cobweb-like growth, and by its characteristic color.

Snow mold damage is not serious, and can be checked by the use of corrosive sublimate applied in late fall or early winter. On the average lawn, however, a vigorous brooming of the diseased spots as soon as they appear will check the spread of the disease.

Algae

Algæ, a growth which sometimes is found on poorly drained soils, forms a greenish scum that mats into a sheet when dry. This smothers and kills out the grass underneath, and indicates bad drainage or excessive watering. Correcting such conditions results in disappearance of the growth.

Fairy Rings

Fairy rings are caused by mushroom-like fungi that grow outward from a center to form a circle. They start from spores in manure which has not been thoroughly composted. There is only one cure and that is to cut out the affected turf to a depth of several inches, and at least 6 inches on each side of the growth.

Slime Mold

Another fungus occasionally damaging turf is known as "slime mold." This causes a grayish-to-dark colored growth over the grass, and shows up in warm, wet weather. It is entirely harmless to grass, as it lives only on decaying vegetable or animal matter in moist places, and crawls up the grass to form its spores.

Slime mold will develop in damp spots where an excessive amount of manure has been applied. As it is practically harmless no control measures need be considered, although its spread can be checked by spraying with dilute Bordeaux Mixture.

Toadstools

Toadstools generally are the result of an excessively wet soil condition, with an oversupply of partially decayed organic matter. Soaking the ground with Bordeaux Mixture is a remedy, or spraying with Iron Sulphate at the rate of one pound to a gallon of water.

CHAPTER XI

RENOVATING ESTABLISHED LAWNS

For one reason or another many lawns are in an unsatisfactory condition. If such lawns are in poor condition from neglect to follow an adequate maintenance program, the problem of improvement is not difficult. However, if their poor condition is the result of poor construction, improvement will be much more difficult. If the drainage is not adequate, the top soil lacking in humus, and of poor texture and structure, and soil conditions in general are bad, a complete rebuilding is the only satisfactory solution.

Renovating Lawns

When is it worth while to renovate a lawn? Only lawns on reasonably good soil should be renovated. Such soil should have the characteristics of good loam, and contain a fair proportion of organic matter. Then, too, the soil must be fairly well drained, if the remedial measures are to prove of lasting benefit. Poorly drained lawns tend to get worse as time goes on. Accordingly a lawn should have at least a 25% stand of permanent or basic grasses to be worth improving. Such a stand must consist of bluegrass, bent or fescue. These are the only permanent grasses for northern lawns.

If any of the above conditions are lacking it will probably be more economical to rebuild the lawn, rather than to renovate it. Then, too, if the grades and contours are not correct they may be changed during the rebuilding.

The best time to start a lawn renovating program is in the spring or summer, so that it will be ready for re-seeding in early fall. This applies only to northern lawns. For southern lawns early spring is the better time.

As with new lawns, old lawns should be re-seeded in the fall, rather than in the spring. Fall is the natural time to sow seed. Then nature sows her seed. During this period there is less competition from weeds and drought, and the cooler weather of September and October is favorable to a good development of the root system.

Preparation

The first step is to clean out dead grass and other debris by raking and sometimes by burning. Ordinarily, burning over a lawn is not desirable, but in some cases more may be gained than lost. This is particularly true if the lawn has not been kept regularly mowed, and has a growth of long, dead grass.

During this preparation any bad weeds should be destroyed as suggested in Chapter IX. Chemical weed destroyers may be used to advantage at this time as injury to the grass is of little concern.

If large lawns are being repaired, they should be harrowed with a disk harrow with the disks set straight. The lawn should be disked in two directions at right angles. Following the disking a weeder can be employed to advantage, as it tears out partially rooted weeds, and rakes the surface at the same time. Following this, the entire area should be hand raked to finish removing partially uprooted plants, and to get the surface soil in condition for re-seeding. On lawns too small for the use of disks or weeders, the work is done with hand rakes. The job should be thorough, even at the expense of losing some grass plants.

Following harrowing and raking, it is advisable to topdress with a good loam soil if procurable. Even as little as one fourth to one half inch will be helpful, particularly if the soil used contains a good proportion of well rotted manure or compost.

Special problems are frequently encountered in renovating lawns. One of these is hide bound turf, which results from excessive packing of the soil. Much used paths are illustrative of such a condition. Air and water are excluded from hide bound turf so that grass roots cannot function properly. As they fail to do their work, the leaves and crowns become weak, and the turf loses its vigor.

Such areas are improved by any process which loosens the soil. The hard surface soil is punctured with a spiker to permit air and water to enter. In the event the soil happens to be heavy and clayey, a dressing of sharp sand may be brushed into the holes made by the spiker to aid in opening the soil.

Low, wet spots offer another perplexing problem. Quite often these are difficult to drain. One suggestion is to open the subsoil of such places by the use of dynamite. The dynamite should be placed well within the subsoil, so that it opens it up thoroughly, and provides a channel for the escape of water to the lower subsoil.

Excessively dry spots may be the result of hidden rocks or stones under a thin layer of topsoil. The remedy in such cases is to remove the cause, and fill the areas with good soil.

Fertilizing

If this turf improving program is to be successful one of the most important requirements is the liberal use of good grass fertilizer. A few tons of manure per acre will not suffice for such fertilization. As pointed out previously, manure contains a rather small amount of plant food. Well rotted manure is an excellent material for improving the mechanical condition of soils, and increasing their water holding capacity. It cannot entirely take the place of commercial fertilizers. See chapter VIII.

Shady Places

Unsatisfactory soil conditions are often found under trees. The soil is pretty sure to be low in plant food because the tree roots use so much moisture and plant food. Such soils are generally in poor mechanical condition.

In spring, and during other wet seasons, shaded locations may be very wet for long periods. Such places are often low, with poor surface drainage, and evaporation is slow because the rays of the sun cannot reach the soil. In time excessive water puddles the soil.

Later on, in summer, these areas do not get sufficient water being hindered by the leaves on the trees. They also dry out rapidly because the puddled soil bakes hard, and cracks open, allowing valuable moisture to evaporate.

These conditions are not conducive to the growth of bacteria and therefore discourage the production of humus. In addition, such undesirable growths as moss, algæ, and toadstools may appear.

Drastic efforts are necessary to make such places favorable for the growth of grass. The mechanical soil condition must be improved by underground drainage, and by the addition of humus and good soil. If possible,the surface drainage should be improved. Often this cannot be accomplished lest some of the trees be damaged.

Sometimes ground limestone is of assistance to such soils. Lime is sure to help if the soil is excessively acid. Ordinary surface application of lime does but little good as it is usually washed off before any benefit results. In any event a little lime alone would not overcome moss, and other conditions brought about by a poor soil condition.

Another difficulty in maintaining grass under trees comes from toxic substances being exuded from the leaves of some trees, and then washing into the soil, eventually making it too toxic for grass. In such cases new topsoil is the only remedy.

After a suitable soil condition is provided the proper variety of grass must be used in seeding. If the place is moist, Poa Trivialis will probably be the best variety to use; if dry, Chewings Fescue.

It is best not to cut shaded lawns too closely but to leave as much blade growth as possible in order to utilize what little sunshine there is.

Re-Seeding

Long before the repair work has reached a stage that grass seed is needed, serious consideration should be given to its selection. In the first place, grass varieties known to make satisfactory and permanent lawns in the locality should be chosen. For best results it is necessary to use a mixture, but such a mixture as consists largely of permanent grasses.

Good seed should be used at about two thirds the seeding rate for new lawns, that is, three pounds per 1,000 square feet, or 75 to 100 pounds to the acre. On small areas the seed may be broadcast by hand, and on larger areas with a wheelbarrow seeder. It is best to divide the seed in half, and sow one part in one direction, and the other at right angles, to get a more even distribution, on a calm day with no wind.

After sowing, rake or brush the seed into the soil. Use a brush harrow or some improvised implement that will drag the seed lightly into the ground, and not pull it into definite rows, or ridges, as is sometimes done with a hand rake. Follow with a light rolling to compact the soil around the individual seeds.

Subsequent Treatment

After the expense and trouble of repairing a lawn it would certainly be unwise to use anything but the best maintenance practice. The correct program of mowing should be carried on and extreme care exercised in cutting the small and tender grass. Turf should be fertilized regularly with a special turf fertilizer and effort made to keep out weeds and prevent them against getting a foothold in the lawn.

Re-Making Lawns

As mentioned before, if the soil and drainage conditions of a lawn are poor, it will be wiser and more economical to rebuild the lawn completely from the beginning than to try to improve it without tearing it up. Then too, if the lawn does not have a correct grade, it must be worked over to make a new grade.

The method of re-making a lawn is the same as if a new lawn were to be built. Tile drainage should be installed if needed. This is probably the most important feature and demands the most careful consideration. Practically all soils of clay nature need underground drainage to make them suitable for a good development of turf.

Scott's Turf Products

Grass Seed

Standard weed-free lawn mixtures of permanent turf producing varieties. Special combinations for shade, terraces, unusual soil conditions and the like. In addition we can furnish separate varieties of all domestic and imported grasses.

Fertilizer

Because of the need of a special fertilizer for feeding grass we developed Scott's Turf Builder. It is a combination of quickly available and long lasting plant food analyzing 10% Nitrogen, 6% Phosphoric Acid, 4% Potash.

Scott Publications

LAWN CARE—A little bulletin issued five times yearly discussing timely problews of lawn making and maintenance. A complete file of back issues will be sent upon request.

LAWNS—This booklet contains a general treatment of lawn problems in condensed form.

BENT LAWNS—A complete treatment of the planting and care of this finest of all turf grasses—Creeping Bent. Tells how to plant bent with seed or stolons.

THE PUTTING GREEN—Forty pages of information on all phases of putting green planting and maintenance.

In addition to the above we have published books similar to *LAWN MAKING AND MAINTENANCE* for the benefit of those interested in producing turf for other purposes. These books are, *CAMPUS and ATHLETIC FIELD—TURF for PARKS—CEMETERY LAWNS.*

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