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Use of Peat and Other Organic Materials on Golf Courses

By John Monteith, Jr. and Kenneth Welton

The value of peat and muck for soil improvement has been a subject of much interest and discussion for many years. These materials have been extensively used on golf courses for a long period. In many cases the results obtained have been favorable but in all too many instances damage to turf has resulted from their use. The contradictory reports of results have clearly indicated that further information is needed on this subject before uniform benefits can be expected from these materials. There has been ample evidence that the contradictions have been largely due to some improper use of the material, or the selection of the wrong type of material. American golf clubs have no doubt wasted many thousands of dollars during the past two decades in the application of peats and mucks, or their supposed equivalents, to courses. On the other hand, during this same period huge quantities of these materials have been profitably used on golf courses. It is the purpose of this article to briefly summarize available information on this subject in order that some of the large waste of the past years may be avoided and that the materials may be used to better advantage and with more uniform satisfaction.

A number of years ago an entirely wrong impression of peat generally existed among golf clubs. Clubs purchased large quantities of this material at fancy prices and used it for some purposes for which peat was unsuited and in a manner which caused harmful results. With the widespread disappointment following its use it fell into general disrepute and it has only been in recent years that its proper use has been generally realized.

In past years a great deal of peat was sold to golf clubs for the purpose of providing a moisture-retaining layer in putting greens. Clubs were induced to put layers of peat several inches thick in the greens. These layers, laid from 6 inches to over a foot below the surface, were supposed to be for the purpose of conserving moisture. This practice for various reasons produced bad results and greens thus constructed had to be rebuilt at considerable expense. Peat was also used in pure form as topdressing sometimes because it was considered to be rich in plant foods and sometimes in an attempt to soften the surface of hard packed greens. These layers of peat became buried under subsequent topdressings of soil and, even though the layers were thin, caused trouble, especially at certain seasons. The troubles arising from these methods of using peat were due to the manner of using the material, and they largely could have been avoided by using peats in soil mixtures as clubs are learning to do today.

Peat was also sold to golf clubs as a valuable fertilizer material. As a fertilizer, peat has never been able to produce results on turf that would justify its purchase, even at prices much lower than those usually demanded. Therefore when it was sold on the basis of its fertilizer value it could not long continue to compete successfully with the many commercial fertilizers on the market.

The widespread interest in peat and the rather general impression that it has unusual plant food value are not based on the performance of peat itself but upon the productivity of certain rich soils that are confused with peat. River bottom land is usually the richest in any district. Likewise reclaimed land resulting from drainage of ponds or lakes is usually found to be highly productive. Such soils are usually dark in color and contain an abundance of organic material, so it seems only natural to assume that all soil materials that are water-borne or are deposited under water will be extremely productive when made available to growing plants. This assumption is not justified, however, because there is an important difference between water-borne silt or mucks and peat. The rich black soils that are so commonly referred to as peat are in reality classed as silty peats. These soils have been made by clay or silt being deposited in peat beds. The mixtures of mineral soil and peat, upon cultivation, are capable of producing extremely heavy crops. Some golf courses have been built on this type of soil and invariably when properly fertilized have soon been covered with a heavy growth of turf which has been easily maintained. In some instances soil of this type has been used for topdressing putting greens for a number of years with entirely satisfactory results. Such experiences have led to the belief that all dark colored soils or peats are desirable for golf course turf in their natural condition.

Peat, Muck, and Humus Defined

To the layman the terms peat, muck, and humus are usually regarded as synonymous. To one acquainted with these materials the terms are by no means interchangeable. There is, however, a close relationship between them, for the origin of all three is the same, namely dead organic material. Peat is past centuries' accumulations of wood, sedges, mosses, and similar material which are packed together and preserved, under water or near the water level, through the ages in a partially decomposed condition. When peat is further decayed it breaks down into a finer form called muck, in which form it is usually found mixed with clay or silt. Still further decomposition changes the material into what is commonly referred to as humus. It has been estimated that 2 to 6 parts of organic material may break down in soil to form 1 part of the residue commonly referred to as humus. Since peat, muck, and humus represent various stages of decay there are no sharp dividing lines between them, and since they originated from many different types of vegetation, it can be readily understood why there should be such striking variations in the material classed under these names.

Peat and muck may be derived from any vegetation, including large trees or delicate mosses, which means that the texture varies according to the relative proportions of the coarser or finer constituents. Also the texture varies with the stage of decomposition. The color, mineral content, and other characteristics vary in different peat and muck deposits. All these variations make it impossible to predict with any degree of certainty just what results can be expected from the use of peat or muck on a golf course.

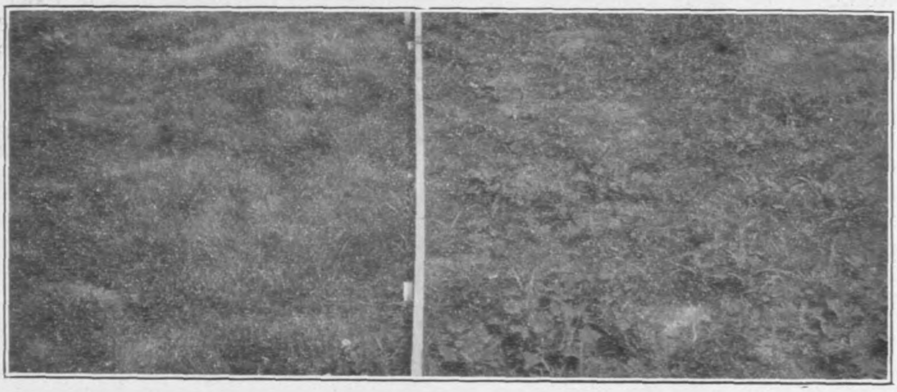
Peat and muck may be black and in general appearance resemble well-rotted manure. Rotted manure is full of organisms, including bacteria and molds, which are helping the decay of the manure, and changing the plant foods contained in the manure so that they will be readily available to roots of plants when applied to the soil. In the case of peats there are relatively few organisms present and no decomposition of the material in the natural state. They contain some plant food but it is chiefly in a form that is not available to plants for many months, or even years, after it is applied to soil. Therefore in spite of the general similarity in appearance and in some chemical characteristics of peat and humus to well-rotted manure, it should be recognized that they behave differently. Since the final stage in the decomposition of peat or muck is humus, just as in the case of animal manures, it follows that ultimately they will all have some similar effects on soils. Most soils to encourage best plant growth require an ample supply of humus, and any material that will supply this humus to golf course soil is desirable provided it does not at the same time introduce harmful factors.

Organic Material Required in Soils

When most of our agricultural land was first put into cultivation it contained ample supplies of organic material. Organic matter is necessary for the activity of the microorganisms in the soil which are responsible for maintaining the supply of nitrogen. Hence soil fertility is nearly always associated with organic matter and under suitable conditions, and up to a certain extent, the higher the organic content the higher the nitrogen supply. The constant cropping of much of this land with faulty agricultural methods has gradually reduced the organic content of many of our soils. The gradual loss of organic material combined with the losses of mineral plant foods through cropping and leaching have resulted in the impoverishment of many soils that were once highly productive. In recent years the need for the replacement of organic material and mineral elements to soils has been generally realized. Golf courses because of certain topographical advantages or monetary considerations frequently have been built on properties where the soil has long been exhausted, and therefore the problem of restoring the organic material and fertility of soils is one that is presented to a large number of golf clubs throughout the country. Organic material decomposes and is lost more rapidly in sandy soils than in clay soils. It also is lost from soils in the South more rapidly than from similar soils farther north. Therefore on some courses organic material must be constantly replaced even though there may have been no great deficiency at the time of construction.

Many golf courses are built on land which had been exhausted by years of faulty farming methods, and many other courses are built on land so poor that it was never worth farming. The fertility and organic content of such soils are woefully deficient. On many other golf courses faulty methods of construction resulted in the burial of good topsoil in making fills and the covering of large areas with subsoil or extremely poor grades of topsoil. Some of this poor soil has even been used for the surfacing of putting greens. Since organic material is an essential ingredient of a productive soil, it naturally follows that the problem of supplying even a minimum of organic matter to the soil is an important problem on the large number of courses where the surface soil is insufficiently supplied to provide for even the normal requirements of turf. Many desperate and costly attempts have been made to provide the essentials of plant growth on golf courses handicapped by poor soil.

In the early days of golf courses in this country the usual method of restoring both fertility and organic matter was by the use of animal manures. In more recent years, however, the animal manures have been more difficult to obtain and more expensive than in years gone by. It also has been recognized that animal manures are badly contaminated with the seeds of weeds that are troublesome in golf course turf. The objection of weed seeds can be overcome by proper composting, by sterilization, or other methods to destroy the weed seeds, but all these methods add to the cost of using manures.



Manure is usually badly contaminated with weed seeds whereas peat is practically free from them. The plot at the left contained peat and soil; the plot at the right contained manure and soil. Since the source of that soil was the same in both cases it is evident that the large number of weeds in the plot on the right was due to the manure.

Commercial fertilizers have been extensively developed in recent years and have been rapidly gaining in favor among both farmers and greenkeepers. More efficient production methods have resulted in a gradual reduction of the cost of commercial fertilizers, so that now fertilizer elements can be applied on most golf courses more economically in the form of commercial fertilizers than in the form of animal manures, especially the bulky types. It has been found that in many soils manures rapidly disintegrate. Even where an abundant supply may have been worked into the soil before the turf was planted there may be little of its organic matter left in the soil in the course of relatively few years. Tests with manure applied to the surface of established turf have left serious doubts as to its greater effectiveness in raising the organic content of the soil as compared with corresponding quantities of fertilizers applied in commercial form. Consequently there has been a constant increase in the interest in replacing the organic matter of manure for golf course use with some other form of material that is weed-free, more economical, and most lasting. All sorts of organic materials have been used in an attempt to restore the organic material to golf course soils, and peats and mucks have been in common use for this purpose. Efforts to build up relatively high organic contents of soil have been especially concentrated on the putting greens, where the best turf on the course is demanded.

Peat and other forms of organic material have been used on golf courses for many years for mixing in the soil during the construction period, and for topdressing established turf. Many of the results obtained have been entirely satisfactory, but there are many instances where these materials have not only failed to give the desired results but where their use actually has proved to be harmful. Such contradictory results clearly indicate that something is wrong in the use of these materials. In some instances it has been apparent that the wrong materials have been used, in other cases the methods of using them have been at fault, while in other cases the cause of the disappointing results have not been apparent. In spite of the extensive use of materials of this kind and the obviously great wastage of club funds due to their haphazard use there has been little experimental work done with them to help furnish the information needed to determine the proper kinds of material to use under different soil conditions and the best method for using them. These attempts have too often given little or no benefit or at least only a temporary benefit. One of the outstanding needs of modern turf culture is more information as to methods for permanent improvement of these extremely poor soils.

Experiments With Peat and Other Organic Materials

In order to obtain more information on the subject of improvement of the soil for golf courses with the aid of organic materials, especially peat, some experiments were undertaken at the Arlington turf garden and the Mid-West turf garden by the Green Section in cooperation with the Bureau of Chemistry and Soils, United States Department of Agriculture. The results of these tests to date will be referred to briefly throughout this discussion. These tests were designed primarily with the purpose in mind of permanent soil improvement, and therefore the observations that shall be made several years hence should be of much more interest and practical value than these preliminary observations. There are many methods known to give rapid and economical stimulation to turf. In the case of peat and some other forms of organic matter, however, the Green Section feels that the added cost involved can be justified only by greater permanence of benefits than can be obtained by the well-known cheaper treatments that are now available.

Peat, muck, charcoal, and certain waste products have offered possibilities for the replacement of exhausted organic matter in soil. Some of these materials are distinctly more economical to use than manure, are free from weeds, and have indications of great permanence. Unfortunately some of them have possibilities of causing harm to turf; others, although not actually harmful, may be of little value, either temporary or permanent. It was the purpose of the tests to determine some of these advantages or disadvantages.

Series of plots were prepared at the Arlington turf garden and at the Mid-West turf garden to test the value of sand and various kinds of peat and other forms of organic matter when mixed in the top few inches of soil used for putting green turf. Some plots were included also to test the use of peat in the pure form as a surface mulch. The mixtures were used in surface layers of different depths. To accomplish this the soil was removed to the desired depth and the subsoil graded at the same slope as the surface of the finished plots. The required amount of soil for each plot as well as the peat or other materials were screened, with a suitable sized mesh to break down aggregates and to put the material into its typical finely divided condition. The soil and other materials were put in a large mixing box and turned over several times as in mixing concrete. Boards were placed around each plot to keep the mixtures separate and each mixture was then put in the plot and leveled, rolled and prepared for planting in the usual manner of planting putting green grass.

The materials tested at the Arlington turf garden included two samples of sedge peat from different sources, two samples of reed peat from different sources, a sample of reed muck, imported moss peat, leaf mold, cottonseed hulls, buckwheat hulls, manure, and charcoal. The materials tested at the Mid-West turf garden included two samples of sedge peat from different sources, a sample of raw reed peat, two samples of cultivated reed peat from different sources, a sample of kiln-dried reed peat, one sample of imported moss peat, one sample of domestic moss peat, manure, and charcoal.

It is recognized that peat and other organic materials may be of much value in improving fairway and tee turf. The greater interest in their use for putting greens and the decided limitation of facilities for the tests, made it seem desirable to restrict the tests chiefly to putting green conditions. The general application, however, of some of the observations obviously can not be limited to putting green turf.

How Organic Matter Helps Soils

Organic matter performs several important functions in the improvement of mineral soils. One of the most important of these functions is to improve the structure of the soil by making the soil more granular and preventing its tendency to become hard and baked. Sticky clay soils are particularly benefited in this manner. The surface of putting greens having a plastic clay soil is especially undesirable, since such a soil gives a soggy surface when wet and unusually hard surface when dry. This condition is decidedly undesirable from the standpoint of play, and it is also likely to be troublesome from the standpoint of grass growth. Some form of organic material in conjunction with sand is generally used in changing the structure of clay or fine silt for golf course purposes. Various methods have been devised for measuring the plasticity or cohesion of soils. Some of these methods, together with suggestions for the use of different materials for changing an undesirable soil structure, are discussed in the Bulletin for February, 1932.

On fine textured soils peats exert a most striking effect by improving the structure of the soil. In this respect they are much more effective than sand. In fact on certain soils the addition of even as much as one-third sand has been observed to make the soil harder when dry. Peats improve the granular structure of fine soils and seem to lessen their plasticity. Fine soils to which sufficient peat has been added offer better growing conditions for the plants and improve playing conditions by giving the soil a certain resiliency even when dry. Tests conducted by the Green Section showed that a clay loam soil became puddled under fine turf conditions and became very firm and hard when dry. The same soil treated with peat two years previously was twice as easy to penetrate with an implement for testing the firmness or tenacity of the soil.

Peats also may be used to good advantage on sandy soils although for a different purpose than on finer soils. The comparatively coarse sand particles form a soil that is too loose and porous. The peat has a binding effect and retards percolation, and increases the water retention.

Another important function of organic material in soil is to increase the water-holding capacity. The water-holding capacity of a soil is a measure of its ability to retain water against the pull of gravity. Since water drains away from sandy soils rapidly they have a low water-holding capacity. Clay soils, on the other hand, are able to retain much larger quantities of water than the sandy soils. Many forms of organic material are able to retain huge quantities of water, and when mixed with soil these materials generally increase the water-holding capacity of the soil. It has long been known that the water-holding capacity of a soil is not an accurate measure of its ability to supply moisture to plants, for the reason that much of the water so retained is held in such a condition that it is not available for use by plants. The amount of this water that is available to plants varies decidedly with the different types of soil and especially with the different types of organic material contained in the soil.

For many years much importance has been attached to the large water-holding capacity of peat. It has been pointed out that some peats will hold as much as 30 times their own weight of water. Large figures representing the water-holding capacity of some peats have been frequently misinterpreted to indicate that such materials will provide ample reservoirs of water in the soil which will provide plants with moisture during dry periods.

TABLE 1.—EFFECTS OF DIFFERENT KINDS OF PEAT ON THE PHYSICAL PROPERTIES OF A CLAY SOIL.*

Type of peat added to clay soil in equal proportions by volume	*Weight per cubic foot*	*Loss on ignition*	*Moisture content air-dry*	*Maximum water-holding capacity*	*Moisture retained per cubic foot air-dry soil*	*Maximum water per cubic foot*
	Pounds	*Per-centage*	*Per-centage*	*Per-centage*	*Pounds*	*Pounds*
Moss peat, poorly decomposed	38.63	14.1	2.22	104.6	.86	40
Sedge peat:						
Poorly decomposed	48.75	16.1	2.09	76.0	1.02	36
Partly decomposed	45.62	24.4	2.81	88.1	1.28	39
Reed peat, partly decomposed	55.74	17.2	2.52	72.4	1.40	39
Reed muck:						
Largely decomposed	58.54	20.4	3.38	67.9	1.98	38
Well decomposed	60.92	24.4	4.07	76.0	2.48	44
Untreated clay soil	79.26	3.7	.76	42.1	.60	33

* Analytical data by I. C. Feustel.

The relative importance of the water-holding capacity of peats in connection with improvement of soils for putting green purposes has undoubtedly been much overrated in the past few years. There have been many tests made under control conditions which indicated some decided benefits from peat in the growth of grass primarily from the standpoint of the increased water-holding capacity of soils containing peat. Some of the experimental work conducted by the Green Section, together with observations on golf courses, has indicated that in a practical way a large increase in the water-holding capacity of soils by the addition of extremely large quantities of peat may not be as great an advantage on putting greens as has been claimed. An excessive retention of water in the surface layer of putting greens may be decidedly detrimental, for it keeps the surface soggy and in a condition that can be easily marred by footprints, which result in unsatisfactory putting surfaces. It has often been observed that, in some cases where the water-holding capacity of the soil has been increased by the addition of excessive quantities of certain peats, some other factor is involved, which leads to a rapid escape of the water from the surface layers during dry weather. Undoubtedly there are many instances where the additional water-holding capacity of peat is an advantage on putting greens even though many of the present opinions as to the value of this particular characteristic of peat are greatly exaggerated.

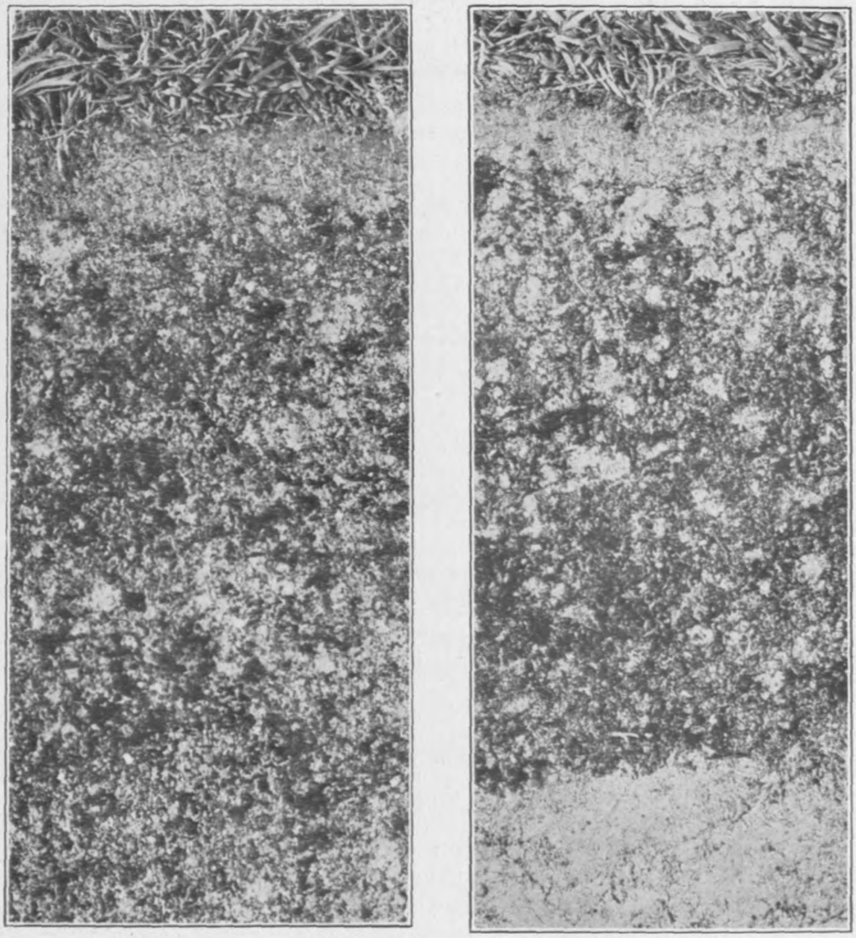
Table 1 shows the effect of some of the peat materials, used in the tests at the Arlington turf garden, on certain physical properties of the natural clay soil. Samples were taken a year after the plots were planted. It shows the effect of peat and muck in reducing the weight of the soil samples. This is partly due to increasing the pore space of the soil and partly due to replacement of soil with an equal volume of a lighter material. "Loss on ignition" indicates the amount of organic matter contained in the mixture and shows that the poorly decomposed materials add less organic material to the soil than do equal volumes of materials that are decomposed.

The moisture content of the air-dry samples represents a measure of the amount of water that would be maintained in the soil mixtures if the plots were allowed to thoroughly dry out in a natural manner at average summer temperatures. These figures show the relative amounts of moisture retained by the different samples. When the weight of a cubic foot of the soil or the mixture, shown in the first column, is multiplied by the moisture content, shown in the third column, the result represents the total amount of water retained in a cubic foot of the soil or mixture when exposed to the air for natural drying. These results are shown in the fifth column. It will be noted that the moss peat mixture when air-dry retained little more water than did the clay soil of the check plot. The more thoroughly decomposed peats retained more moisture than did the others. The small amount of water retained in the peat and poorly decomposed sedge peat mixtures, in spite of the large water absorbing capacities of these peats, may help to explain the tendency of these plots to dry out to such an extent that they fail to take water as readily as the other plots.

It will be noted that the water-holding capacity of the moss peat mixture was much greater than the reed or sedge mixtures and that these latter were much greater than the check plot. However, since the water-holding capacity is based on the weight of the mixture, it is apparent that the figures do not represent the actual difference in amount of water. In order to show the approximate amount of water contained in each cubic foot sample the oven-dried weight was calculated from the data in the table and multiplied by the figures in the fourth column. The sixth column contains the figures so calculated. They represent roughly the total amount of water contained in a cubic foot of the material when it contains all the water it will hold against the pull of gravity. This means the amount that is contained in soil when it is thoroughly wet but when all excess moisture has drained away. It therefore represents the maximum amount of water held in these soils, but plants can not use all of this water. It will be noted that in spite of the great variation in the water-holding capacity figures for these different materials, the actual amount of water they hold in soil does not vary as much as is ordinarily supposed. Thus in the case of the reed peat the water-holding capacity is 72.4 compared with 104.6 for moss peat. The actual difference in the amount of water held in a cubic foot is only one pound. A comparison of the well-decomposed reed muck with moss peat shows a water-holding capacity of 76 as compared with 104.6. The mixture with the lower water-holding capacity, however, holds four pounds more water in a cubic foot than does the moss peat mixture. It is recognized that there are other factors that should be considered to give accurate data for such comparisons. Nevertheless, the above calculations are sufficiently accurate to justify serious questioning of some of the claims as to superior qualities of certain peats for golf course use primarily because of high water-holding capacity of the materials.

Organic material in the soil has an important influence on the activities of microorganisms that inhabit the soil. Many of these microorganisms have an important influence on the growth of plants. They play an important part in the breaking down of plant and animal refuse in the soil, including the dead roots and leaves of the plants that are living on the soil. Directly or indirectly they are responsible for many of the chemical changes that take place in the soil, and are constantly changing some unavailable plant foods into forms that are available for use by the higher plants, such as those that form turf. Some of the microorganisms in the soil cause diseases in plants and therefore are undesirable. The big majority of them that occur in soils are organisms that are beneficial. Rotting manure is full of organisms that cause decay, and when such manure is added to soil it stimulates the activities of soil bacteria and other soil organisms. Peat, on the other hand, is usually not a favorable medium for the growth of microorganisms, and when it is applied to soil without fertilizers, especially those containing ample nitrogen, it usually does not result in the decided stimulation of microorganisms, as in the case with manure. When a sufficient supply of fertilizer or lime is added with the peat to soil there may be a decided increase in microorganisms. This activity may result in a complete utilization of available plant foods by these microorganisms and a resulting apparent starvation of higher plants such as grass.

Certain forms of organic material when added to soil greatly increase the pore spaces and result in better aeration and facilitate the movement of air and other gases through the soil. Adequate aeration of soil is considered essential for proper plant growth. It is necessary for free circulation of air in the soil to provide the plant roots with oxygen. It is necessary for the work of the many microorganisms in the soil which produce decay of organic matter and supply the nitrogen and carbon dioxide which is necessary for plant growth. Oxygen in the air also effects chemical changes which produce soluble mineral nutrients in the soil. Peat is most beneficial in fine soils by increasing the porosity of the soil and thus allowing the plant roots to easily penetrate the soil and grow to greater depths in their search for moisture and plant foods. Constant trampling of soil, such as occurs on putting greens, tends to reduce the pore space and seriously affects the aeration of the soil. In some cases it may be possible to increase the pore space too much for the welfare of the plants. In some of the plots at Arlington, particularly those where peat moss was used in excess or where buckwheat hulls and cottonseed hulls were used, the moisture seemed to escape too rapidly. This may have been due in part to excessive pore space. The effect of peat in increasing the pore space may be seen in the illustration of sections of soil and a soil-peat mixture taken from plots on the Arlington turf garden.

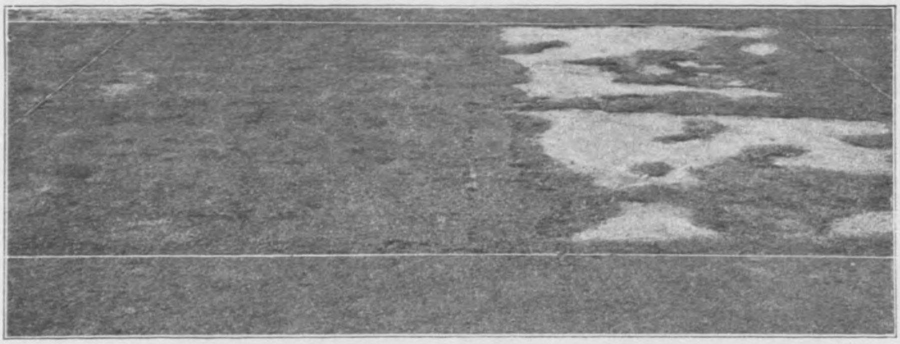


Effect of peat and sand in improving the soil structure. At the left is a cross section of turf growing on a mixture of 1/3 clay, 1/3 moss peat, 1/3 sand. At the right is a section of turf on a 4-inch layer of ½ clay, ½ moss peat. Beneath this layer is the natural clay soil used in these mixtures.

Organic material in soils generally is an aid to root penetration. This may be a mechanical aid due to improved soil structure, or the indirect aid of better aeration, drainage, or other factors. Whatever may be the cause, it is generally found that better root development occurs where the soils are well supplied with humus, provided there is no toxic material present to inhibit root penetration.

Organic material in the soil also has the capacity to absorb certain chemicals in solution and may at times prevent some chemical injuries. In some instances this may be due to a chemical change; in other instances it may be due to the movement of water through the soil. It has been observed at the Arlington turf garden that peat in surface soils checks the harmful concentration of salts at the surface.

Soon after the seedlings were well established on the series of peat tests at Arlington, an attack of brownpatch occurred and injured much of the turf in all of the plots. Dry weather followed and it was observed that the grass recovered from the brownpatch in the plots containing peat but that in the check plots the grass failed to recover. These dead areas were raked lightly and reseeded. Some



Effect of peat in preventing concentration of salt at surface. The turf in the damaged plots on the right is growing on bare clay and the healthy turf on the left is growing on similar clay to which peat has been added; moss peat in the front plot and sedge peat in the rear plot. All the plots were given similar heavy rates of fertilizers before planting and all had received similar cultural treatment. The soil in the dark patches is frequently covered with a thin incrustation of salts.

seed germinated but was soon killed. This reseeding process was repeated several times with equally poor results, even in the fall when conditions were decidedly favorable for seeding. It was noted that during the dry summer months the dead areas gradually enlarged. The soil in the dead areas was examined and it was found that there was an excessive concentration of salts in the surface layer of soil. The highest concentration was in the center of each dead patch. At times salts were deposited in a thin crust over the surface of the soil. In all of these plots an excessive amount of fertilizer was added at the time of mixing the soil in order to make sure there would be no deficiency of plant foods. All the plots, however, received the same amount of fertilizer, and it was all thoroughly mixed in the soil, just as it was in the soil-peat mixtures. Therefore the concentration of salts in the check plots represented a movement of the salts to the surface rather than any concentration due to careless mixing. Where the concentration of salt in these injured areas was sufficient to check grass growth it probably increased rapidly, due to excessive evaporation from the bare soil. The nature of the injury is shown in the illustration.

Certain forms of organic material have been used as a mulch to prevent the excessive evaporation of moisture from the soil. Different types of peat have been used for this purpose. They have been used in a general way for many years as a mulch on flower beds and are used in this manner on many golf courses. They have also been used as a mulch on turf immediately after seeding, and even on established turf. The chief objection to the use of peat as a mulch on golf course turf lies in the fact that it is likely to be blown off the bare areas, where it is most needed, in periods of drought, and at times of heavy rains it is washed from such areas and piles in ridges which may be a great inconvenience to play. In the experiments at the Arlington turf garden where peat was used as a mulch after seeding, there was evidence of a stimulation of growth, which appeared due to the effect of the peat layer in aiding the retention of moisture in the germinating layer of soil.

Peat Should Not Be Considered As a Fertilizer

As previously stated, peat at one time was used extensively on golf courses under the misapprehension that it was a good fertilizer. It is now realized that peat does not take the place of fertilizers. In fact, chemical analyses of peats show that most of them are decidedly deficient in fertilizing elements and certainly do not furnish these elements in sufficient quantity to justify their prices. At times when they are added to soils they not only fail to provide the stimulation expected of a fertilizer but they may actually serve to reduce the effectiveness of fertilizers for a time at least. When they are used on turf, therefore, peats should be supplemented with an adequate supply of fertilizer, especially one containing plenty of nitrogen. When so supplemented they can be expected to produce beneficial effects in soil improvement that may well justify their use independent of any fertilizer effects. Peat is sometimes used as a filler or a base for mixed fertilizers and as such is satisfactory for turf purposes.

In one test at the Arlington turf garden moss peat was mixed in the top four inches of soil just before planting in early September with Kentucky bluegrass and redtop. The plot received a complete inorganic fertilizer of the same kind and at the same rate as did the adjoining plot where no peat had been used. Germination in the two plots was about the same, but the young grass in the plot having no peat grew much more rapidly than in the plot containing peat. During the entire fall and until May of the next year, the grass in the plot containing peat appeared yellow and unthrifty, as if suffering from a fertilizer deficiency, especially nitrogen. In the adjoining plot of the same soil, receiving the same application of fertilizer as did the peat plot, the grass continued to grow vigorously and had all the appearance of a well-fertilized turf. In May the grass in the peat plot began to grow more vigorously and by midsummer the turf in this plot was entirely satisfactory. In later series at both the Arlington and Mid-West turf gardens the same retardation of growth was observed in many of the peat plots, especially in the period between late September and early May. Some of the plots where the grass appeared decidedly poorer than the check plots were divided and part of each plot received a heavy application of some form of quickly available nitrogen fertilizer. Wherever sufficient nitrogen was added there was soon a rapid growth of the grass.

The above observations throw some light on some of the contradictory results obtained with peat on golf courses. In many instances large quantities of peat have been used to improve soil for golf courses without at the same time adding an ample supply of fertilizers. In some cases the peat has been used under the misapprehension that peat itself was a good turf fertilizer. In many such instances only detrimental responses were observed in the grass, and it has been often assumed that the harmful results were due to toxic substances in the peat. The above tests demonstrated that harmful results can come from using peat with insufficient fertilizer wholly independent of any toxic action. It is probable that the peat simply locks up much of the plant food in the soil by chemical, physical, or biological means. Regardless of the cause, however, it is evident that large quantities of peat can not be used without taking into account the fertilizer requirements of turf. This unfavorable response where insufficient fertilizer is available is especially important in regions where golf courses are used extensively during the cool seasons.

In the case of the plots in which as great a volume of organic matter in the form of manure was used, as was used in the peat plots, there was an excessive growth of grass which was too soft and succulent to withstand adverse conditions of summer. This rapid growth was probably due to the more immediate availability of the plant foods in manure than in the peat plots, even though they had been supplemented with commercial fertilizers to make them correspond to the manure plot. In the case of the cottonseed hulls the growth of grass was at first retarded but there was some stimulation the second year which apparently was due to the sudden release of its plant food when the lint and hulls were finally decayed. In the buckwheat-hulls plot there was a decided retardation in growth which was probably due to some other factor than its effect on fertility.

Different kinds of fertilizer were tested in two series of plots, one series containing European moss peat and the other series containing American sedge peat. These tests were to determine the effect of different types of nitrogenous fertilizers on soil and peat mixtures. Some types of peat are decidedly acid in reaction and have a tendency to increase soil acidity. It has been assumed that under acid conditions these peats are likely to be preserved longer than in neutral or alkaline conditions. For these tests three plots were used for each fertilizer. One plot contained the natural clay loam soil, the second plot contained a four-inch surface layer composed of 50 per cent of clay loam soil and 50 per cent of moss peat. The third plot contained a similar four-inch surface layer of clay loam but with 50 per cent of sedge peat instead of moss peat. All of these plots received equally heavy applications of superphosphate and muriate of potash thoroughly mixed through the top four inches. Into one of these sets of three plots there was well mixed a heavy application of sulphate of ammonia. Another set of three plots was similarly treated, but instead of the sulphate of ammonia these plots received an equal amount of nitrogen in the form of nitrate of soda. Three other plots were treated in the same way except that they received the same amount of nitrogen in the form of urea. The fourth set of plots was an exact duplicate of the third set, but it had added to it a heavy application of lime. All of the plots were planted in May, 1930. After the first year additional applications of nitrogenous fertilizers were added whenever the grass seemed to be in need of additional nitrogen. No further applications of superphosphate, muriate of potash, or lime were added. The effect of these fertilizers on the acidity of the soil is shown in table 2.

TABLE 2.—EFFECTS OF MOSS AND SEDGE PEAT AND CERTAIN FERTILIZERS ON THE PROPERTIES OF THE ARLINGTON CLAY SOIL*

Treatment of plot	*Weight*	*Loss on ignition*	*Moisture content*	*Maximum water-holding capacity*	*Total nitrogen (N)*	*pH*
	Lbs. per cu. ft	*Per-centage*	*Per-centage*	*Per-centage*	*Per-centage*	
Check-urea	74.27	3.8	.83	41.2	.06	4.6
Moss-urea	46.19	12.0	1.44	92.8	.12	4.4
Sedge-urea	56.17	15.7	1.78	72.6	.23	4.2
Check-lime-urea	76.77	3.3	.76	40.3	.04	6.4
Moss-lime-urea	51.18	10.7	1.45	84.6	.12	5.8
Sedge-lime-urea	59.29	14.4	1.72	72.2	.22	5.3
Check-sulphate of ammonia	76.15	3.4	.76	38.7	.04	4.1
Moss-sulphate of ammonia	44.31	12.1	1.55	93.0	.13	4.1
Sedge-sulphate of ammonia	56.17	15.1	1.66	68.4	.23	4.2
Check-nitrate of soda	74.90	3.4	.82	37.3	.05	6.0
Moss-nitrate of soda	46.19	12.1	1.64	93.8	.14	5.1
Sedge-nitrate of soda	54.92	15.5	1.85	74.9	.26	4.7

* Analytical data by I. C. Feustel.

The table shows the effects, in two years, of the different fertilizers on the acidity of the soil and mixtures of peat with soil. The urea check plot was distinctly acid, pH 4.6. The lime with the urea changed the soil reaction to pH 6.4 which is the least acid plot. The sulphate of ammonia changed the soil to a more acid reading of pH 4.1. The nitrate of soda reduced the acidity to a reading of pH 6.0. The peat made little change in the degree of acidity in the two sets receiving urea and sulphate of ammonia. Where the fertilizers used tended to correct the acidity the peat checked such changes. In these plots the peat was used in a 50-50 mixture by volume, so changes may be regarded as extreme for all practical purposes. It will be noted also in the table that the moss peat, which is ordinarily more acid than sedge peat and is supposed to have a more acidifying effect on soils, actually was far less effective than sedge peat in these tests.

In the above table the column headed "Loss on Ignition" represents the measurement of the organic content of the soil. It will be noted that the sedge peat produced a greater increase in the organic content of the soil than did an equal volume of moss peat. This column also serves to emphasize the fact that a large volume of peat is required to make any substantial change in the organic-matter content of the soil. These figures represent also the organic matter contained in the root systems included in the samples.

In the column of the table showing the maximum water-holding capacity of the samples it will be seen that there were large increases due to the addition of peat. In all cases the moss peat figure is larger than that for the sedge peat plots. The moss peat more than doubled the maximum water-holding capacity of the natural soil. It is interesting to compare these figures with those in the moisture content column, which show more moisture in the sedge peat mixture than in the moss peat.

The figures in the column of the table showing the total amount of nitrogen show approximately twice as much nitrogen in the sedge peat plots as in the moss peat plots, which in turn contained two and three times as much nitrogen as did the natural soil. All of the plots had received the same amount of nitrogen.

Selecting Peats and Mucks

The large assortment of peats and mucks that are available for golf course use serves to complicate the task of selecting the best and most economical types for any particular course. In some instances golf courses have paid good prices for peat materials which have been hauled in from distant points, while they have had in some out-of-the-way corner of their property an equally good grade of material in ample quantities that has been available simply for the cost of digging and handling. On the other hand some clubs have been using peat deposits found on their properties which, because of certain unfavorable characteristics, cost the clubs far more than would a good grade of commercial peat shipped hundreds of miles to the course. Before a wise selection of peat or muck can be made one should have an understanding of some of the fundamental characteristics of peats and mucks and should have at least a casual acquaintance with some of the factors that should be considered in comparing the relative values of different peats or mucks. The different types of peat are described and classified elsewhere in this number of the Bulletin.

The selection of peat for a golf course may be decidedly influenced by the use for which it is purchased. Peats have a lower content of decomposable constituents than many other organic materials such as manure, straw and vegetable matter in cover crops, and in this respect reed and sedge peat contain comparatively more residue that resists further decay than does moss peat. A coarse fibrous and even a woody peat, if available at a favorable price, may be used to advantage in the construction of a course where the material is to be thoroughly disced into the soil and the coarser particles will be left to undergo gradual decomposition. On the other hand, the same coarse or woody material is entirely unsuitable for mixture with soil for use in topdressing putting greens. Coarse material may be used in compost piles or soil beds with manure or with other fertilizers to aid in the decomposition, and after a sufficient time has elapsed these materials will provide the necesary organic component to make a suitable topdressing mixture. Many cases have been observed where golf courses in the interest of economy have purchased a coarse grade of peat containing a large proportion of woody fragments. This material before being used for immediate application to greens in topdressing material has to be sifted. The total bulk is greatly reduced when the coarser fraction is removed. The actual cost of the usable material obtained in this manner after deducting the cost of the discarded fraction and the cost of labor in removing it may be greater than that of material sold at a higher price. In purchasing peat, therefore, it is important to consider cost of the actual material that is usable for the special purpose for which it is purchased.

Peat and muck have large water-holding capacities. In comparing prices of peats or mucks one should take into consideration the amount of water contained in each lot. In many cases golf clubs have purchased peat on a weight basis when as a matter of fact they have actually been purchasing largely the water obtained in the peat. When clubs buy fertilizers wisely they purchase on the basis of the percentage of nitrogen, phosphoric acid, and potash that the fertilizer contains. These three materials can not be obtained without obtaining some inert materials; likewise, in the case of peat, it is impractical to obtain the organic material without purchasing at the same time some water, because all the water can not be driven out of peat without destroying some of its important characteristics. Nevertheless, allowance should be made for the amount of water each sample contains.

Some peats and mucks contain substances that are toxic to plants. In some instances these toxic substances can be removed or converted by proper handling. Before any peats or mucks are extensively used on a golf course it is well to make sure that they do not contain any of these toxic substances. In some instances the excessive quantity of acids that may occur in peat may be detrimental to turf development. In some instances, particularly in California and certain other western states, deposits may contain alkalies which are decidedly detrimental to plant growth, particularly when added to soils which already contain too high a concentration of alkalies. Excessive quantities of iron or other elements or combinations of elements may occur in peats or mucks and make them unsuitable for turf use until such chemicals are removed.

In the experiments at the Green Section turf gardens no toxic materials were encountered in the peats and muck tested. At the Arlington garden, however, one of the samples of charcoal which was tested proved to contain sufficient toxic material to prevent the establishment of turf.

A set of plots was established for testing the effects of charcoal mixed with soil for turf production purposes. A surface layer four inches in thickness was prepared by mixing 50 per cent of clay loam soil with 50 per cent of granulated charcoal. Charcoal from different sources was used for the tests.

One of the plots containing charcoal failed to produce a stand of grass even when reseeded several times. Much of the seed germinated but the seedlings soon wilted and died. An examination of the soil showed that it contained excessive quantities of alkali. The toxic chemicals were traced directly to the charcoal. The amount of charcoal used in these tests was more than is ordinarily used on golf courses, but the excessive amount was used in order to bring out in a striking manner any advantages or disadvantages in its use. It is possible that the moderate use of this charcoal on a putting green would have given no such strikingly harmful results as was experienced on this plot. Nevertheless, a decided injury undoubtedly would have resulted from the use of even small quantities of this particular sample of charcoal. It was material that had been recommended by the manufacturer for golf course use, and probably much of it has been used on golf courses, where it no doubt has caused damage even though this damage may not have been recognized. The other plots containing other samples of charcoal showed no signs of injury and produced a turf equal to that produced in the adjoining check plots. In these tests there was no evidence of the beneficial results that are so often claimed to be associated with the use of charcoal in soils for putting green turf.

Regardless of whether charcoal produces more beneficial results under certain conditions than has been observed at the Arlington turf garden, these results clearly indicate that whenever this material is used special precautions should be taken to avoid obtaining a charcoal that is a by-product of certain industrial processes which are apt to contaminate it with toxic chemicals which may be a detriment to turf and if used in sufficient quantities may entirely prevent any growth of grass.

In purchasing mucks one should make allowance for the amount of mineral soils contained in them. In adding these materials to soils the chief objective is to add organic material. Some of the muck that is purchased by golf clubs actually contains comparatively little organic material. It is chiefly clay or silt with a relatively small proportion of well-decomposed organic material. Where muck is used for the improvement of sandy soils there undoubtedly is some advantage in the addition of clay or silt together with the organic material to make a sandy loam soil. The relative difference in the cost of organic material and of clay or silt justifies a careful consideration of what proportion of the muck that is purchased represents organic material and how much of it is simply silt or clay. In some cases, particularly with some types of sedimentary peats or mucks, there apparently is little relative structural benefit derived from adding the material to plastic soils. In some instances a black soil is purchased under the assumption that it is peat, when in reality it contains no peat whatever and may actually be extremely deficient in organic material, for the black color may be due to mineral coloring. In the purchase of peats or mucks allowance should be made for the differences in weights for a given volume. Moss peat, which is poorly decomposed, weighs only 10 to 15 pounds a cubic foot; and peat varies from 20 to 35 pounds; cultivated and kiln-dried reed peats vary from 35 to 45 pounds; and sedge peat varies from 18 to 30 pounds to a cubic foot. These weights are influenced by the state of decomposition and the moisture content.

Suggestions for the Use of Peat on Golf Courses

It has been found that one of the most effective ways of using peat or muck on golf courses is to work it thoroughly into the soil before planting. This applies not only for turf purposes but also for use on flower gardens and for the planting of trees. For this purpose it is well to have the material shredded or pulverized and spread over the surface to the desired depth before plowing and discing thoroughly.

When using peat it usually requires the addition of about 15 to 30 per cent of peat by volume, depending on the organic contents of the soil and the peat, to bring the soil up to an organic content of approximately ten per cent. Observations and tests indicate that this amount of organic matter in putting greens is not too much, although somewhat less is probably sufficient for fairways, lawns, and flower gardens. If the soil is to be prepared to a depth of five inches a one-inch layer of peat should be spread and mixed with the four inches of underlying soil. It requires three cubic yards of material to spread a layer one inch thick over 1,000 square feet.

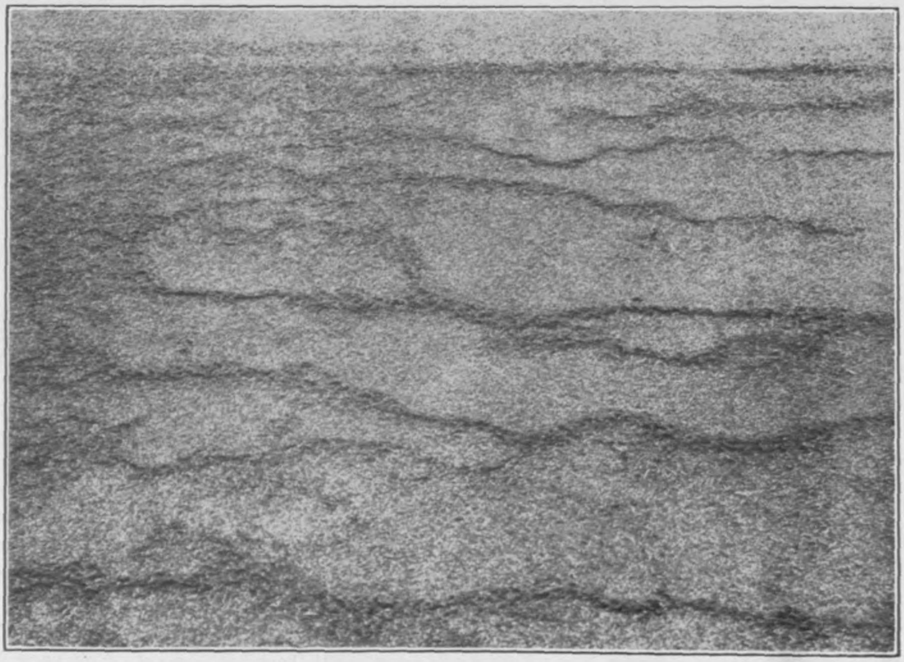
On some clay or silt soils the addition of 15 to 30 per cent of peat does not break down the stickiness or cohesion of the soil sufficiently, in which case the addition of sand may be made until the desired texture is reached. Seldom is it necessary, with the most compact of soils, to add more than one-third sand when the amounts of peat mentioned above are also added.

Use of sand and peat in improving the structure of a clay soil on the course of the Augusta National Golf Club. The area to be improved was first covered with a layer of sand (above) and this in turn was covered with a layer of peat (below). These layers were then thoroughly worked into the surface soil.

The layers of peat or peat and sand can then be thoroughly disced into the soil. Before the discing operation is completed it is well to add an ample supply of fertilizers containing phosphoric acid and potash and to apply lime wherever the soils are distinctly acid. These materials are not soluble and it is much better to work them into the soil rather than to apply them later when they remain on the surface for some time before reaching the plant roots. It has been found that it is worth while to take some trouble if necessary, in order to thoroughly mix the added layers with the soil and thus avoid any layers or pockets which may be decidedly detrimental to the turf in later years.

If the area is to be planted immediately the large moisture requirements of the peat should be supplied as much as possible by watering the area thoroughly a day or so before planting. Also, as the peat may reduce, for some time, the supply of available nitrogen to the plant, a good application of some organic nitrogen carrier should be mixed in the top inch or two of soil or soluble nitrogenous fertilizer should be raked into the surface just before planting. Later, the planted area should not be allowed to become too dry and should receive nitrogenous material whenever the plants show some signs of being starved.

If it is practical to do so, it will be found decidedly helpful in improving the soil structure in areas to be prepared in advance, or in preparing soil to remove elsewhere, to plant a cover crop on the land after the peat, fertilizer, and lime have been worked into the soil. This cover crop can be turned under and thoroughly worked into the soil. The addition of tops and roots of this cover crop will not only add further organic material to the soil, but will greatly stimulate the activity of microorganisms in the soil, which will be a distinct aid in getting the soil into good condition for the planting of turf.



Poorly decomposed peat is unsatisfactory for topdressing putting greens. The turf shown here had been topdressed with a mixture of topsoil, sand and peat. A heavy shower floated the peat out of the mixture and deposited it in ridges which were extremely difficult to remove.

Peat or muck is sometimes used in the pure form for topdressing putting greens, tees, and occasionally fairways. Such topdressings in time build up a soft, spongy surface layer which may be difficult to keep true for putting surfaces. Also on fairways or other areas where the turf may be thin, topdressings of pure peat are usually unsatisfactory because of the tendency to wash and to form into ridges which interfere with the mowing and playing conditions. When used for topdressing putting greens, peat or muck should be used mixed with loam and sand. For most soils a satisfactory combination consists of one-third peat, one-third clay, or silt loam, and one-third coarse sand. Where possible, this mixture should have manure or other fertilizers added to it and prepared in a compost pile or in a soil bed for a couple of years to assure the proper breaking down of the coarser particles of peat. Peat, unless thoroughly decomposed, will float out of topdressing during heavy showers and accumulate in ridges, which will completely destroy the trueness of the putting surface. This condition is shown in the illustration.

Peat or muck can be satisfactorily used in compost piles and soil beds to add the necessary organic material to the soil. When using it in this manner the material should be used in conjunction with some fresh manure or should have added to it sufficient fertilizer and lime to aid decomposition. For more detailed information on the preparation of compost, the reader is referred to the September, 1930, issue of the Bulletin.

Organic matter is more effective in improving the physical condition of clay and silt soils than is sand, and if the organic matter of the pile is brought up to 15 or 20 per cent, the need for sand is cut down. Tests may be made to determine the exact mixture of soil, organic matter, and sand needed. Methods of testing are described in the Bulletin for February, 1932. It usually requires the addition of at least 50 per cent, by volume, of organic materials to make the percentage of organic matter in the pile as much as 15 or 20 per cent after it has undergone some decomposition. This is because the organic content of soils is figured on a dry-weight basis, and many organic materials, such as manure, clippings and other vegetable refuse, and some peats, contain as much as 50 or 60 per cent of moisture.

Manure, clippings, and the organic matter in sods frequently break down so quickly that very little is left by the time the compost is ready for use. Peats, however, strongly resist further decomposition and tend to keep up the organic contents of the compost even though the compost has been well heated. It is desirable to have a certain amount of manure in compost piles to create bacterial action, but the manure may be replaced by at least 50 per cent of peat. Peat alone may be used in the pile, and some organic nitrogen carrier such as a sewage sludge, cottonseed meal, or a pulverized poultry manure may be used to aid decomposition and heating of the pile. The inclusion of 5 to 10 per cent, by bulk, of these materials is usually sufficient.

Using Peat or Muck Deposits Found on Golf Courses or Near-by Property

The Green Section frequently receives samples of peat or muck representing deposits found on golf courses or somewhere nearby and which represent materials that can be obtained at a low cost. These samples may prove to be high-grade materials quite suitable for the purpose in mind. Many of the samples, however, are of little or no value, and if used, would undoubtedly do more harm than good. Therefore, before one utilizes any local materials it is well to make sure that the deposits under consideration are suitable for turf-culture purposes.

As a general rule, the first step in the utilization of a local peat deposit should be to drain it adequately by means of open ditches or by tiles. When the deposit is drained it is well to plow it and keep it in cultivation for at least a year. The area can be well fertilized and limed when necessary and can be planted with a cover crop or some cultivated crop. This process of cultivation should last at least a year and preferably two or three years, and then the top layer to a depth of two or three inches can be removed and stored for further use.

Material that is obtained in this manner from local deposits can be used for mixing in soil or for the preparation of topdressing material just as has been suggested above for the use of commercial peats.

Toll from Plant Diseases—The average mind can hardly conceive of the enormous loss sustained in the United States from plant diseases. The plant pathologist in charge of the plant-disease survey of the Bureau of Plant Industry, reports that $1,500,000,000 annually is lost in this country alone and that losses in other countries are proportional. Plant diseases are of three classes—nonparasitic, parasitic, and virus diseases. Nonparasitic diseases are caused by unfavorable environment, condition of soil, or air or mechanical influences, but are not contagious or infectious as is the case with the parasitic diseases. Parasitic diseases are caused by the attacks of living organisms, plant and animal, and may be transmitted from plant to plant by a transfer of the agent. The exact cause of virus diseases has not been determined, but these diseases are increasing rapidly and have assumed considerable importance among the plant diseases of the world.

Control methods, such as preventing the introduction of diseased plants into the country, the eradication of the disease, quarantine of states and territories, and the selection and development of plant varieties which will resist the attacks of the diseases, are used to combat their spread.

The development of a strain of grass which will resist the attacks of dollarspot, brownpatch, spotlight, snowmold and the other turf diseases seems to be the solution of the disease problem with respect to golf course turf. In addition to its resistant qualities, the strain must of course have the necessary requisites of good turf. Until such a turf has been tried, proved, and accepted, we must use such control methods as are now in general use if we are to have desirable greens.

The migratory locust of northern Africa, western Asia, and eastern Europe is a large, long-winged grasshopper that flies in swarms so vast as to darken the sun. When a swarm settles on a field or orchard it often wipes out every trace of green leaf and stem in 15 minutes or less. Fortunate it is that golf courses in the United States are troubled with insects no more voracious than the Japanese beetle, June beetle, May beetle, mole cricket, and a few others.

A Classification of Peats

The increasing interest in peat for soil improvement during recent years has led to the utilization of numerous deposits in different parts of the country. Golf clubs which contemplate purchasing peat find that there are numerous kinds of peats sold under various names which are decidedly confusing. Claims of superiority are made for many of these special kinds of peat and the consumer has had little information to indicate to him the relative merits of the different types of peats. The new Circular No. 290 issued by the United States Department of Agriculture contains a description of different types of peat. Since this circular should be of interest to all clubs that plan the purchase of peats, we are extracting freely from it such parts as are of chief concern to golf clubs.

It is pointed out in the Circular that the peat importations from Europe are increasing and now reach an annual value of nearly $1,000,000, while the domestic production in 17 states is reported to be greater than the imports. This estimate does not include the large amounts of peat and muck that are obtained and used locally on golf courses or similar areas wherever small deposits of this material occur on the property or nearby.

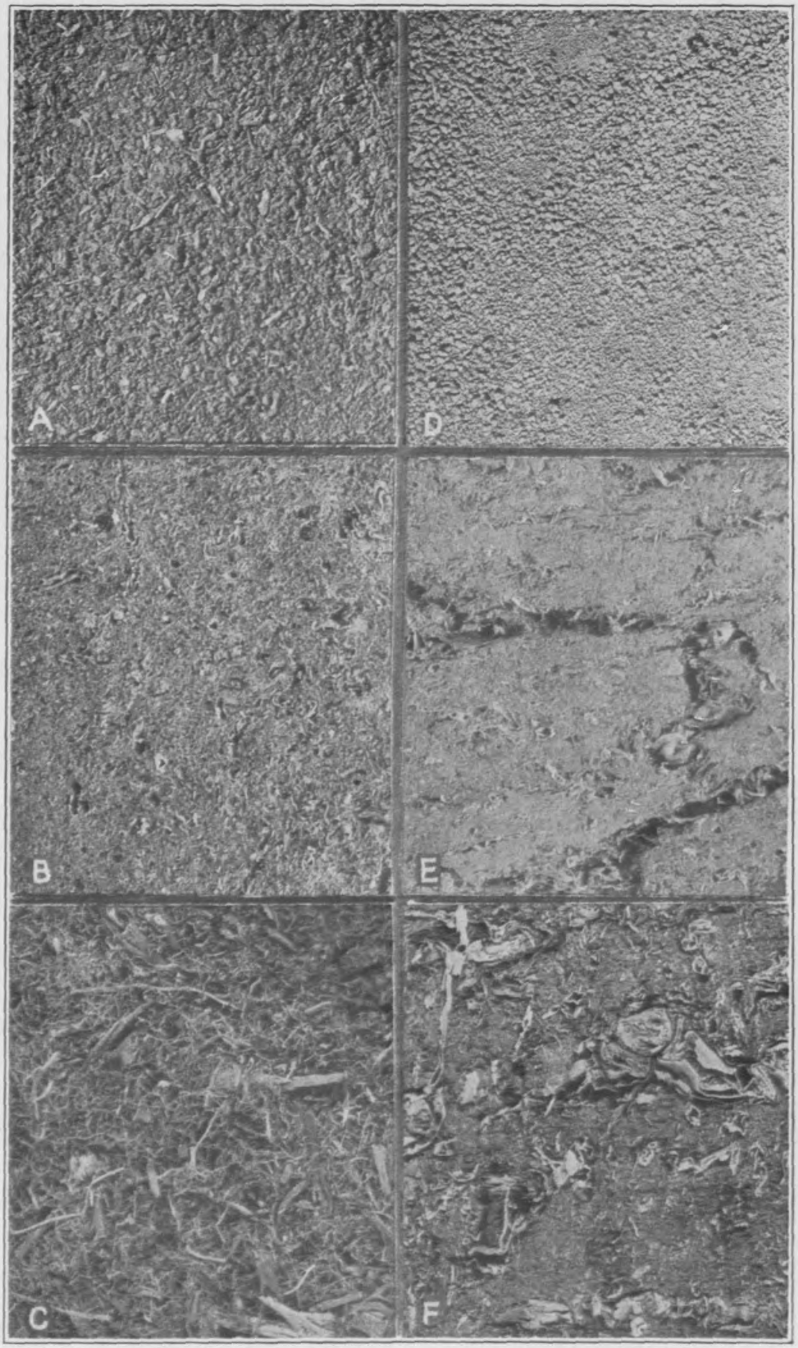
Under natural conditions peat deposits as a rule consist of different layers of peat which vary in composition.

"Areas of peat represent different stages in a process of development which in many instances has proceeded since the close of the ice age and is still in progress. They vary in size and depth, in the number and thickness of layers, and in such characteristics as color, reaction, height of water level, and the features with which each layer is preserved, making identification possible."

Distribution of Peat Deposits in the United States

Peat and muck deposits are found widely distributed in the United States. "The peat deposits of the United States have been broadly divided into three major groups, differing in important characteristics and regional relationships to surface vegetation, climatic conditions, and time relations. The geographic limits established for each group must necessarily be arbitrary, and each group unit includes areas of peat of a transitional character."

"The first main group comprises areas that contain a surface layer of moss peat varying greatly in thickness and in amount of woody material. It includes flat and raised bogs, heaths, and coniferous swamp forests, as well as peat areas of an intermediate character. The deposits are generally acid in reaction, more or less poorly decomposed, and deficient in plant nutrients. The group is confined chiefly to the cool and humid northern portion of the New England and the Great Lakes States and along the Pacific coast from northern Washington into Alaska. The peat materials are more or less leached, lack available nitrogen and mineral salts, notably lime, but have a moderately high content of decomposable organic matter. They are of relatively recent origin and do not appear to have undergone decomposition to so great a degree or to so great a depth as in the more southern states.



Varieties of Sedge and Reed Peat

(A) sedge muck; (B) radicellate sedge peat; (C) coarsely fibrous sedge peat; (D) reed muck; (E) partly fibrous reed peat; (F) coarsely fibrous reed peat. Each variety is shown here in natural size from air-dry sample. (From Bulletin 1419, U. S. Dept. Agriculture)

"The second major group includes areas of peat from New Jersey westward to Ohio and toward South Dakota. It comprises continental deposits that have a more or less complex structural development. The various layers consist of fibrous peat derived from reed and sedge marshes and of woody materials from swamp forests of mixed conifers and hardwoods. Some of the layers of peat are darker in color and partly decomposed. Lime, phosphorus, and nitrogen may be present in varying quantities owing to the greater depth at which decomposition has taken place favored by a modifying influence from the underlying mineral soils of the region, by evaporation and warm summers. A belt of peat deposits, represented by the Dismal Swamps along the Atlantic Coastal Plain from Virginia to Georgia, has been included in this main group. These peat areas are predominantly woody and acid in reaction. Their relationships and possible uses are not well known, but their basic economic utility is that of timber production.

"The third major group consists of deposits of peat containing fibrous material derived from saw grass, cane, tule, and other marsh vegetation subject to periodic flooding. They are generally neutral to alkaline in reaction and show varying degrees of decomposition. Outstanding members of this group are the subtropical Everglades of Florida, the areas of peat in the valley of Mississippi River, the semiarid peat lands of California, and the deposits in the valleys of the Klamath and Willamette Rivers in Oregon."

Principle Classes of Peat

Peat deposits have in the past been classified in several different ways. Like all classifications these have had certain advantages and disadvantages. The chief classes now used by the Department of Agriculture are based largely on the origin of peat.

Sedementary Peat.—"In any shallow lake or pond, such as may be seen rather generally in the Northern and Central States, the history of a peat deposit begins with a stage of vegetation associated with the open water.

"It consists of microscopic organisms, submerged plants, pond weeds, waterlilies, and similar forms of plant life. The yearly addition of decaying bodies of such organisms, deposited in depressions and basins, accumulates in the form of a soft, oozy, structureless peat. It contains plant remains that are recognizable and material which has lost all traces of its origin and has become changed into an amorphous residue. With these variations are associated gases such as methane, hydrogen, carbon dioxide, and others produced by the activity of certain (anaerobic) microorganisms that decompose the organic matter.

"Sedimentary peat is fine-textured, plastic, and often gelatinous when wet, but hard and horny when dry. In some localities it occurs compacted into a dense, impervious organic sediment; in other places it contains bits of tissue from roots and leaves, a variety of seeds, wind-blown pollen, quantities of shells from mollusks, diatoms which have siliceous skeletons, or sand, silt, and clay. Some varieties of this organic material are nearly alkaline in reaction and comparatively high in lime but others range from acid to neutral.

"The significant feature of the organic content of sedimentary peat is that in a plastic colloidal state it performs the function of a binding material with a soil. It is the seat of important chemical reactions and absorbs and exchanges dissolved substances from solution. When air-dried it shrinks greatly and becomes relatively inert. Owing to this tendency to unfavorable compaction and hardening, sedimentary peat with a high content of organic matter of the size of colloidal particles does not offer a satisfactory material for decreasing the cohesion or plasticity of certain soils when mixed with them. The evidence available at present indicates that, in general, the characteristics of sedimentary peat do not have the value for imparting changes in granulation, aeration, and other desirable properties."

Reed and Sedge Peat.—"The second stage in the development of a peat deposit is generally associated with the encroachment of marsh vegetation upon the lake or pond in which the free water surface is disappearing by the filling process of the aquatic plants. In this case the dominant vegetation consists either of sedges such as wire grass, saw grass, tule, rushes with cattail and others, or of reeds, canes, and reedlike grasses. The plants make little demand for nutrients. They can grow in water containing considerable proportions of mineral salts in solution, tolerate partial submergence, and root themselves into the soft, miry ooze. They possess a habit of excessive root growth, which in time builds up a firm, coarse-to-felty fibrous and porous peat layer, made of an interwoven network of underground stems and roots. The plant remains restrict the movement of water, and this in turn raises the water level, excludes air to a large extent, prevents oxidation, reduces microbial activity, and thus preserves the accumulation of roots, rhizomes and residue.

"Poorly decomposed plant remains generally form a considerable proportion of the fibrous layer; but in certain cases it may contain dark-colored, structureless residue, derived from more easily decomposing leafy tissue by a complex series of microbiological and chemical changes. Fibrous types of peat are often designated as fen peat, low-moore peat, and high-lime peat. They are here separated and classified either as sedge or reed peat, depending on the nature of the flattened rootstocks that predominate in the organic material, and can be recognized by the eye or under the microscope.

"Characteristics which meet the requirements of a good grade of reed or sedge peat are based on degree of decomposition, color, reaction, low ash content, and absence of objectionable matter such as coarse woody fragments and injurious mineral salts of iron and sulphur.

"A poorly decomposed grade of reed or sedge peat is reddish to yellowish brown in color, acid or neutral to slightly alkaline in reaction, and distinguished by its more or less porous, coarse-to-finely fibrous structure. When air-dried, the mass is brittle and the finer root material tends to break into powdery particles that absorb air and become almost impervious to water. Under moderately moist or drained conditions reed and sedge peat favor the activity of an appreciable number of micro-organisms, especially fungi. They decompose more or less rapidly when their moisture content is favorable, and the recognized nutrient deficiencies are remedied by the addition of potash and phosphate fertilizers. Applications of nitrogen and lime are not always required, but should vary according to climatic conditions and soils.

"When reed or sedge peat is in a moderately advanced state of decomposition or has undergone cultivation, the material is partly fibrous, and the residual organic matter is dark brown to black in color, fine-grained in texture, and slightly acid to neutral in reaction. This grade crumbles easily and is generally referred to as reed or sedge 'muck.' It shows marked transformations in comparison with the original parent material. The changes are characterized by an increase in the content of ash and organic complexes that are more or less resistant to further decomposition. There is present also a higher content of nitrogen, mainly as a result of the activity of microorganisms, but phosphorus and potassium are found in small amounts and should be reinforced by the use of commercial fertilizers.

"Fairly definite inferences may be derived from the information presented above. Grades of reed or sedge peat that are fibrous and poorly decomposed, when prepared by shredding and sieving, and well mixed with a mineral soil, may be expected to improve the moisture relations, to be more effective as a source of organic matter for microbiological processes, and to develop an organic complex that possesses the characteristics of soil humus. They may thus render possible the development of a crumbly structure in sticky or hard-packed, clayey soils and to that extent exert desirable physical influences. On the other hand, partially decomposed and cultivated grades of reed or sedge peat should be valuable primarily for supplying a relatively inert, organic residue; they may be used more effectively for improving the physical condition of any mineral soil in need of structural changes."

Woody Peat.—"The final stage of native vegetation that establishes itself upon a layer of reed or sedge peat under natural conditions is a swamp forest of conifers, together with deciduous trees. The gradual accumulation of peat above the water level of the original lake, moderate aeration, and a vigorously active population of microorganisms, as well as differences in evaporation and shading through tree growth, modify the character of the surface of the marsh and eventually result in new peat-soil features.

"The invasion of shrubs and trees into a marsh reaches its greatest development with the subsequent segregation of the swamp forest vegetation into dominant deciduous trees and subdominant trees of conifers, a diversified undergrowth of shrubs, and a ground cover of perennial herbs, ferns, some mosses, wood-destroying fungi, and the like.

"Under forest conditions the principal source of organic matter is an accumulation from fallen logs, branches, and roots varying in size and degree of decomposition. Additional marked effects of the influence of a swamp forest are indicated by the litter from leaves and needles, by a considerable contribution of bits of twigs, bark, cones, and fruiting bodies, and by an appreciable amount of crumbly, granular residue (duff or leaf mold) matted together by a meshwork of roots and the mycelium of fungi. This type of organic mixture is classified as woody peat.

"Coniferous woody peat derived from spruce, tamarack, cedar, evergreen shrubs, and others has a marked acid reaction, and transformation of the organic matter is very slow. Decomposition changes are mainly the work of fungi, and the peat material remains as a more or less sharply defined, coarse, woody layer, brown or dark brown in color, correspondingly poor in mineral nutrients and basic constituents. In the presence of a sufficient supply of lime and other mineral bases to maintain a neutral to slightly alkaline reaction, changes result mainly through the agency of bacteria, earthworms, and similar organisms. The dark-colored, granular woody residue may extend to considerable depth, and the peat deposit is then in its final phase, in which the principal trees are maple, ash, elm, and to a less extent conifers such as tamarack and cedar.

"Because of the presence of tree stumps and many coarse, woody fragments, and the practical difficulty involved in separating the variable quantity of granular residue, woody peat does not constitute a suitable source of organic matter for soil improvement. The chief value of swamp forests and their woody peat seems to be in the tree growth which they are capable of producing."

Moss Peat.—"Many of the deposits from Maine to Minnesota illustrate a more northern type of peat, which differs markedly in character and composition from the kinds of peat previously described. It is formed predominantly by the small stems and leaves of sphagnum mosses.

"Layers of moss peat of varying thickness occur most commonly in the cool and moist northern region of the United States. Some of the peat areas are flat heath bogs, while others, especially those of northeastern coastal Maine, have a surface which rises from the margin of the deposit to the center, and on that account are known as 'high moors.' The native surface vegetation is made up largely of various species of Sphagnum and a scattered growth of sedges and small heath shrubs, principally leatherleaf, Labrador tea, laurel, blueberries, together with scrubby, dwarfed black spruce and tamarack. There is not much timber growth, owing to the very low amount of soluble mineral and organic constituents in the water retained by the mosses. A layer of moss peat generally overlies a layer of woody peat, but it may occur superimposed upon sedge and reed peat.

"The reaction of moss peat is strongly acid. The material is, as a rule, poorly decomposed, spongy-fibrous, light yellowish brown in color, and consists mainly of the remains of sphagnum mosses. It has a uniformly low content of mineral matter and nitrogen and supports a very limited population of fungi and other microorganisms. This is due in part to the high capacity of the tissue of stems and leaves of mosses to conduct and retain water in the meshwork of elongated, absorbing capillary cells.

"The chemical composition of these cells does not offer a favorable organic material to microbial activity. It cannot be utilized by them in the absence of oxygen and in a cold, acid, water-logged environment. These conditions account also for the heavy expense involved in reducing the moisture content of moss peat by artificial means. Similar considerations apply to the decomposition of the material when intermixed with a mineral soil. The rate of change is very slow unless the acid reaction is corrected by the use of lime, and its nutrient deficiencies are remedied by an application of nitrogen in an available form or by the use of a complete commercial fertilizer.

"Coarse-textured fibrous moss peat is supplied to the trade in several grades based mainly on the degree of fineness of shredding the material. It is customary to make a separation of the mechanically shredded moss peat by sieving. Moss peat for stable bedding and poultry litter is relatively coarse and lumpy, while particles of smaller size serve horticultural uses. The finely shredded fraction affords a more satisfactory material for soil improvement because it exhibits certain well-defined properties of organic matter that are most important from a soil standpoint.

"Moss peat which has undergone a moderate degree of decomposition is brown in color, partly fibrous, contains an appreciable quantity of dark-colored residue, small woody fragments, and coarse fibers from cotton grass; it is considerably more resistant to further decomposition than the less altered, younger material."

Classification According to Degree of Decomposition

Any of the above classes of peats may show considerable variation due to their stage of decomposition.

"To express the degree of decomposition that has taken place, it has been found practical to employ an arbitrary scale of five divisions. These represent certain more or less definite values to indicate grades of (1) poorly decomposed peat, (2) slightly decomposed peat, and (3) partly decomposed peat, and grades of (4) largely decomposed muck to (5) well-decomposed muck.

"Color is one of the important aids to the recognition and description of different grades of peat. There is generally a progressive darkening in color as peat material decomposes to muck. This can be well illustrated by comparing the material of a peat deposit exposed in an old open ditch with a freshly cut vertical section, or by examining portions of a peat area that have been under cultivation for different periods of time.

"The natural color of a peat material is a characteristic which assists judgment of quality and value. Light reddish- and yellowish-brown colors almost invariably predominate in poorly and slightly decomposed peat materials. These colors characterize grades that have a relatively low content of mineral matter and tend toward an acid reaction. Mottled yellow and red colors are indications of differences in plant remains and in the rate at which decomposable substances are developing a residue under fluctuations of water content. Mottling is rarely due to the presence of minerals such as iron or its oxidation products.

"Partially decomposed grades of peat are usually slightly acid to neutral in reaction, and brown. A shade of gray deserves closer consideration. A grayish tint indicates as a rule the prevalence of mineral matter and to a certain extent the presence of soluble salts. Black tints originate naturally from residual organic matter, but in some cases they are produced by anaerobic conditions and hydrogen sulphide.

"Very dark brown and black colors serve as the general basis for estimating grades of largely decomposed to well-decayed plant remains. They are the result of active oxidation of a high proportion of residual material contributed chiefly by the activity of microorganisms.

"Greenish colors may be attributed to the presence of compounds of sulphur and iron, such as marcasite, while a bluish color may be due to vivianite (phosphate of iron). Red colors may also occur in peat and muck containing varying proportions of iron compounds.

"Broadly speaking, it may be said that the most marked changes from dark to light colors are found in the peat material nearest the surface of a deposit. The differences in color are much less distinct in areas which have been subjected to drainage and in peat deposits of relatively greater age. The colors stand out sharply and are more strongly contrasted in deposits that are of recent origin or are water-logged and in which the active agents remove oxygen from the organic material."

QUESTIONS AND ANSWERS

All questions sent to the Green Section will be answered in a letter to the writer as promptly as possible. The more interesting of these questions, with concise answers, will appear in this column. If your experience leads you to disagree with any answer here given it is your privilege and duty to write to the Green Section. While most of the answers are of general application, it must be borne in mind that each recommendation is intended specifically for the locality designated at the end of the question.

Preparing putting green beds for spring planting.—The beds for our greens are now (November) plowed. What time in spring is best to start planting? Will it help to apply fertilizer in November? Our soil is black and heavy. (Vermont)

ANSWER.—Late summer or fall is the best time to plant putting greens. Frequently there is considerable trouble from weeds in connection with spring planting. For that reason you should apply fertilizer just previously to planting so that the seed or stolons may get a vigorous start and thus be able to compete better with the weeds. Since your soil is heavy it would be well to apply lime during winter, broadcasting it at the rate of 50 to 100 pounds to 1,000 square feet. If you can obtain some coarse sand it would also be well to disk that in during winter. Do not work the soil until it is free from moisture in the spring, and then apply 50 pounds of some good organic nitrogen carrier to each 1,000 square feet, raking it into the soil just before planting. Pulverized poultry manure, activated sludge, and bone meal are good fertilizers to use at the time of construction.

Injurious layers resulting from top-dressing with pure materials.—In planting our putting greens with stolons of the Washington strain of creeping bent we covered the stolons with about ½ inch of good soil, and when they began to come through the soil we covered them with ¼ inch of sharp sand. Is this a sufficient covering of sand? (Indiana.)

ANSWER.—The quantity of sand you have applied is too much for one application. Layers of pure sand or pure organic materials like peat and muck on putting greens are liable to cause injury in after years. In your further use of sand for top-dressing it should be mixed with sufficient soil to make a material having the consistency of a sandy loam.

Seed guarantees.—Our sample of South German mixed bent seed which you reported showed a purity of 80 per cent and a germination of 67½ per cent was from a lot which the seller guaranteed to be 90 per cent pure and to germinate 90 per cent. Do you consider that under the circumstances the seller could be asked to redeem this seed? (Ohio)

ANSWER.—It would seem that the seller of the seed in question simply guessed at its purity and germination, as it is extremely exceptional when the percentages of purity and germination of mixed bent seed are equal and when either purity or germination is 90. The average purity of lots of mixed bent seed is about 80 per cent, but a germination of 67½ per cent is somewhat low. On the whole, your sample is not much below the average. It does not contain much redtop. If a sample of German mixed bent seed should contain more than a small percentage of redtop, the redtop would be considered an impurity. It is a poor practice for companies to guess at the purity and germination of seed in making a guarantee, and we believe the company from which you purchased the seed would be willing to make an adjustment. Companies should either have their seed analyzed or else not make a point of high purity and germination of the seed. Your dealer, by guaranteeing 90 per cent purity and 90 per cent germination, is indicating that the seed is of very high quality, whereas it is found to be only ordinary.

Cocoos bent as compared with Washington bent.—What advantages, if any, has Cocoos bent over Washington bent? Is it true, as some claim, that Cocoos bent requires less water than other bents and is less liable to be injured by brownpatch? (Missouri)

ANSWER.—Cocoos is the trade name for seaside creeping bent grown in Oregon. It can sometimes be purchased more economically as seaside bent than by the trade name. Seed of Washington creeping bent is not on the market, but nursery stock may be purchased. The nursery stock is composed of vegetative material, or stolons, which are chopped up and planted the same as seed, except that the chopped stolons must be topdressed to a depth of 1/3 inch. Stolon planting is more expensive than planting by seed. There is not much difference in the winter requirements of seaside creeping bent and Washington creeping bent, nor is there much difference between the two in drought resistance. Washington creeping bent is more susceptible to dollarspot than is seaside creeping bent, but is more resistant to brownpatch. With either seaside creeping bent or Washington creeping bent you would have to use a fungicide to control fungus diseases during the summer months, and there would be very little in favor of either of these strains of creeping bent as far as resistance to both of these diseases is concerned.

Growing putting turf in greenhouse.—Will grass grow under glass thicker or less thick than in the open? How low a temperature would be sufficient to grow grass in a greenhouse satisfactorily for putting turf? (Illinois.)

ANSWER.—Grass grown in a greenhouse produces a much thinner and poorer turf than that grown outdoors. A temperature of 40 to 50 degrees would be sufficient to grow putting turf in a greenhouse.

Let us not pray for a light burden, but a strong back.

—Theodore Roosevelt.