Structural Requisites of Putting Green Soil

By Kenneth Welton

Cultural practices influence to a large extent conditions which affect the growth and vigor of grass plants and hence the quality of the turf produced. In common with most plants, grass requires, among other things, a suitable substratum in which the roots may obtain anchorage and find a reserve of plant food, air, and moisture with which to carry on the life processes. The physical condition of the soil affects the development of roots and tops as do the cultural practices.

It has been shown that the restriction of the top growth of grasses by constant cutting reduces the root system of the plant in a corresponding degree, due to the depriving of the plant of a certain amount of food which is manufactured in the leaves under the action of sunlight. The root systems, then, are limited in development not only by soil conditions but also by the amount of food which the plant is able to manufacture through the medium of its leaves. Some grasses which provide excellent fairway turf can not be maintained for any length of time under the comparatively close cutting to which they are subjected on the putting green. As a consequence certain species and strains of grasses have been developed which are better adapted to the unusual cultural conditions found on putting greens. Even these species and strains are weakened by frequent close cutting and are rendered more susceptible to turf ailments to which they might be resistant if allowed to develop under more normal conditions.

It is through the root system that plants are able to absorb moisture in which the fertilizer and other salts are dissolved. These salts play an important part in the manufacture of plant food in the leaves. A restricted root system is limited in its ability to supply the plant with the necessary elements. Efforts to give it assistance by supplying fertilizers become increasingly difficult, since the proper concentration of fertilizer must be maintained in the comparatively thin layer of soil surrounding the roots During hot weather, when transpiration and evaporation are rapid, more water is needed by the plants than at any other time. A dense root system concentrated in an inch or two of the surface soil tends to deplete the soil moisture in the top layer more rapidly than does a root system drawing its water supply from deep in the soil. Evaporation also adds to the loss, necessitating frequent watering to supply the required amount of moisture. Frequent and excessive watering further complicates the scheme of things, because water in the soil, in excess of the optimum amount, displaces from the pore spaces of the soil the air which is indispensable to plant growth.

Soils Must Contain a Supply of Atmospheric Oxygen

The microscopic plant and animal life in the soil is usually referred to under the general term of microorganisms. These are of importance in the soil for a number of reasons, but the extent of their importance in putting green soils is not yet fully understood. Their activities are greatly influenced by changes in conditions. A normal supply of air in the soil favors those forms of microorganisms which are of actual benefit to plant growth by their action in decomposing organic matter and building up soluble plant foods. When, however, water is present in excess for any length of time, the development of a group of microorganisms which are not beneficial to plant growth is favored.

The condition of the soil for satisfactory grass growth should be such that free or gravitational water will drain from it. The plants therefore depend mostly upon capillary moisture, which remains in the soil against the pull of gravity. Capillary moisture exists only as a film surrounding the individual soil particles and leaves space in the soil for the presence of air. A heavy rain or watering displaces the soil air and a new supply is drawn into the soil when the excess water drains away. Part of the water which has drained to lower depths is available to plants by capillary attraction, which brings it within reach of the roots. This action is best likened to the manner in which ink creeps through a blotting paper.

Soils in good tilth have their individual particles grouped or flocculated into crumbs or granules. This arrangement increases pore space and provides a more satisfactory medium for the development of plant roots. Under putting green conditions the soil is often puddled much as bread dough is kneaded. The excessive watering and trampling while the soil is wet help to bring about this condition. The crumbs or granules are broken into the single grains of which they are made, and the resulting structure is much more compact and sticky. Such a condition hinders the percolation of water through the soil, excludes the air to a large extent, and renders the penetration of roots more difficult. Puddled soils become hard upon drying, and excessive watering is required to bring them to the resiliency demanded by the players, and thus a vicious circle is developed. All these related conditions which tend to further restrict normal root development combine to weaken the grass plants so that a period of extreme weather conditions or an attack of disease may prove too much of a strain and the plants will succumb.

A study of the influence of soil conditions on plant growth emphasizes the desirability of providing a topsoil for putting greens which will allow moisture to penetrate to the lower levels in the soil and encourage the maximum growth of roots which the restricted top growth will allow. Such a soil when dry should retain the required resiliency or "give" to hold a reasonably well-played pitch shot.

Soil is made up of weathered fragments of rock and organic material. It may be considered under three general categories: (1) the physical, which includes the size of the particles (texture) and their arrangement in the soil (structure); (2) the chemical, which includes the composition of the particles; and (3) the biological, which concerns the activities of the minute forms of life with which the soil is teeming. The physical properties are important in the building and maintenance of putting greens, for without the proper texture and structure of the soil the chemical and biological processes can not be maintained in a condition most beneficial to the growth of the grass. With suitable soil structure the chemical and biological processes can be influenced by superficial soil treatments, but it is difficult, if not practically impossible, to improve soil structure in a putting green after it is in play.

Soils to be used as top soil, or for top-dressing material, on putting greens, are too often chosen with no appreciation of the qualities which are essential in putting green soils. The origin of the soil has little to do with its suitability, since in some cases subsoils are superior in this respect to some topsoils. The color, the feel, and the fertility of a soil may have little to do with its suitability, since there are other factors which have a greater influence. Color is an indication of varying amounts of materials which may or may not have a decided effect. The fertility is the potential productivity of a soil, and this can not be fully realized except under ideal structural and climatic conditions. The feel of the soil is the most accurate guide of those mentioned, but is useful only to those who have some knowledge of the physical properties of the soil and understand and appreciate the unnatural conditions under which putting green soils must be productive. The skilled worker is able, by the feel of a soil, to place it as to class and to estimate, to some extent, its behavior under various conditions.

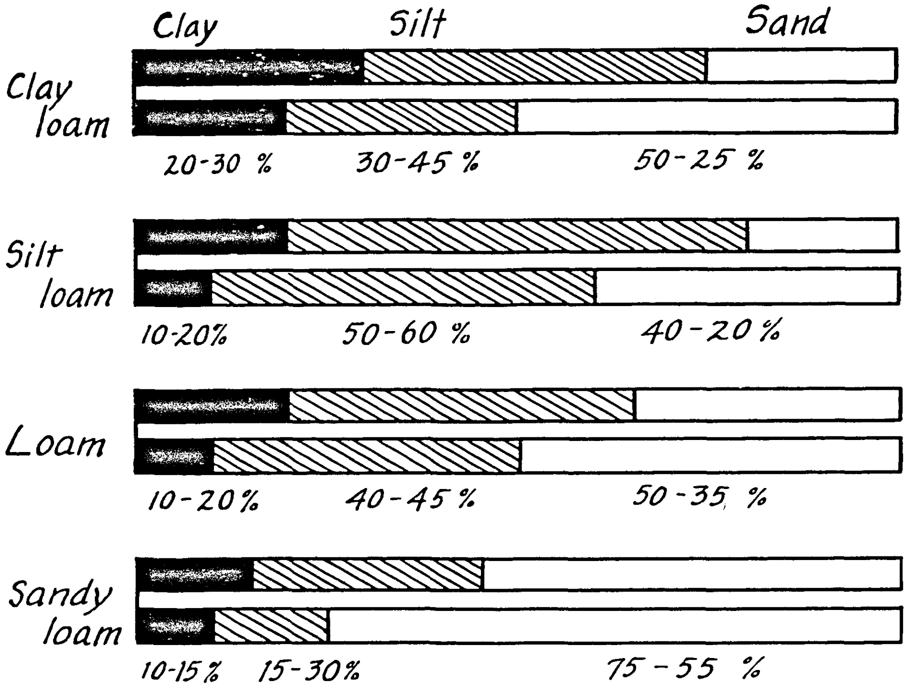
Detrimental layers may be formed on a putting green by the improper use of top-dressing materials. The six clearly-defined layers of soil were formed in as many seasons of top-dressing. A highly plastic soil was used for top-dressing purposes throughout the growing season and each winter a heavy dressing of sand was applied. Satisfactory results would have been attained had the soil and the sand been mixed together for use during the growing season

There is a general understanding among greenkeepers of the proper use of the terms sand, silt, and clay to designate soils of different textures. Briefly, the term sand designates the predominance of coarse material; silt, the predominance of material which is finer than sand and coarser than clay; and clay, the predominance of fine material. The term loam designates a more or less balanced mixture of both coarse and fine materials. It has been found, however, that these terms are used to designate different classes of soils in different localities. For example, farmers in an area where clay soils predominate are apt to class soils which are somewhat coarser than their average soils as sandy loams, when in reality they are silt loams. Likewise, in sandy areas there is a tendency to class silt loams as clay loams. Soil specialists can judge with surprising accuracy the class to which a soil belongs by rubbing a sample of the soil between the fingers. However, some soils which are similar in texture can not be accurately classified by field methods, and it is necessary to subject them to a mechanical analysis in order to determine accurately their class. There are practically no pure silt or clay soils, and seldom is a soil found which contains more than 80 per cent of silt or 65 per cent of clay. These materials are usually found in mixtures, and the terms sand, silt, and clay are used to describe qualities which may be easily determined in the field. To avoid misunderstanding, the terms sand separates, silt separates, and clay separates may be used to designate these classes of soil particles. The limits in size of the soil separates, as designated by the Bureau of Chemistry and Soils of the United States Department of Agriculture, are given below. The estimation of the number of particles in similar weights of the various separates shows the tremendous differences in fineness of particles.

SIZE OF SOIL PARTICLES

Separates	*Limits in size* Millimeters	*Calculated approximation of No. of particles to each gram* (453.69 *grams equal* 1 *lb.*)
Fine gravel	2.00-1.00 (.078-.039 in.)	200
Coarse sand	1.00-0.5 (.039-.019 in.)	1,700
Medium sand	0.5 -0.25 (.019-.01 in.)	13,500
Fine sand	0.25-0.1 (.01 -.004 in.)	132,000
Very fine sand	0.1 -0.05 (.004-.002 in.)	1,700,000
Silt	0.05-.005 (.002-.0002 in.)	35,000,000 to 65,000,000
Clay	Less than 0.005 (Less than .0002 in.)	45,000,000,000 and over

The proportion of soil separates, or of soil particles of various sizes, in some of the more common soils is shown in the following list and accompanying chart:



Differences in composition of normal loam soils are shown in this chart. It also brings out the possible variation in percentage of clay, silt, and sand in soils of the same class

Sandy loam contains less than 20 per cent of clay, from 20 to 50 per cent of silt and clay, and from 50 to 80 per cent of sand.

Loam contains less than 20 per cent of clay, from 30 to 50 per cent of silt, and from 30 to 50 per cent of sand.

Silt loam contains less than 20 per cent of clay, 50 per cent or more of silt, and less than 50 per cent of sand.

Clay loam contains 20 to 30 per cent of clay, from 20 to 50 per cent of silt, and from 20 to 50 per cent of sand.

Clay contains 30 per cent or more of clay, less than 50 per cent of silt, and less than 50 per cent of sand.

Peat contains 30 per cent or more of relatively poorly-decomposed organic material, sometimes mixed with much sand, silt, and clay.

Muck contains from 25 to 65 per cent of well-decomposed organic material with much clay or silt, and some sand.

There are several methods of making mechanical analyses of soils, such as sieving value and measuring the settling velocity. In the sieve method the soil is put through sieves of various-sized meshes. The meshes, however, can not be made small enough to separate the finer grades of soil particles, and hence some other method is usually used supplementing the sieve method. Finer particles may be separated by suspending the sample in water, since the rate of settling of the soil particles is in proportion to their size, and each successive grade of particle may be determined as it slowly settles. Soil is classified according to the percentage proportion of each soil separate present. The soil classes have been arrived at through the analyses of many soils which are regarded as typical.

The classes of soils have various characteristics which must be considered in cultural practices. The characteristic property of soil which should concern the greenkeeper when selecting or mixing a soil for putting green topsoil is the structure which it will form under putting green conditions. Soil structure is the term used in reference to the arrangement of the various particles, which determines whether it is loose or compact. The choice of a soil for its structure is more complicated than the simple choice of a soil class. The structure depends, apart from proportion and size of particles, upon the factors of plasticity and cohesion, which vary in soils of the same class, especially in fine-textured soils.

Very Plastic and Cohesive Soils are Troublesome

The plasticity of a soil is its ability to allow a change in form without breaking apart. Plastic soil may be compared to putty which has been mixed with the proper proportion of oil for use. The cause of plasticity of soil has long been under discussion, but it is generally accepted that the fineness of texture, along with the colloidal content, affect the soil most vitally in this respect. Soil colloids are usually defined as soil particles which are finer than one micron (1/27,000 inch) in diameter. They are complex substances, usually gelatinous in nature, which tend to bind the soil particles together. There are certain fine-textured soils which are neither cohesive nor plastic. In general, the more finely textured the soil the more colloidal matter it contains and the more plastic it becomes. The more plastic a soil the more likely it is to become puddled by working or trampling, particularly when it has a high moisture content.

Cohesion is the tendency of soil particles to stick together and to conserve the mass intact. It is closely related to plasticity. The cohesion of soil might be made a rough measure of its plastic properties, and vice versa, because, in general, the greater the plasticity of a soil the higher is its cohesion. When a soil is dry its cohesion is developed for the most part by the drying and shrinking of the gelatinous colloidal matter, and to a lesser extent by the interlocking of its grains and the development of cementing salts. Fine-textured soils, such as clay and silt loams, may be handled in such a way in farming that they may be kept porous in spite of their plasticity and cohesion. By proper cultivation at times when the moisture content is correct, the soil may be maintained in a granular condition. With the putting green, however, cultivation is impossible at any time, and the frequent watering and trampling soon destroy the granular structure and increase the plasticity and cohesion so that the soil becomes puddled. When fine-textured soils are in this condition they are likely to become exceedingly hard upon drying. A coarse or sandy soil, on the contrary, may be worked or trampled while wet, and its structural condition will remain unimpaired, since it has little or no plasticity.

Organic Matter Corrects Many Defects in Soil Structure

Organic matter also plays an important part in soil structure and in the fertility of the soil. Most soils do not contain sufficient organic matter for putting green topsoil. The effects of organic materials on soil and plant conditions are numerous and complex. Since the water-holding capacity of partially-decayed organic material is relatively high, soils which are rich in humus usually possess a high water-holding power. Although the addition of organic materials to soils increases their water-holding capacity, such additions do not necessarily increase the tendency of the soil to become saturated. Organic matter exerts a beneficial action on soil structure. Its water-holding capacity makes possible greater changes in volume both on drying and in the presence of excessive moisture. This action is somewhat similar to the action of freezing and thawing on the soil in opening the soil and increasing its granular structure and porosity. The organic matter also tends to spread the individual particles farther apart, especially in clay and silt soils. There is considerable difference in organic materials and not all of them are suitable for the purpose of improving soil structure. Some muck soils, although high in organic matter, may tend to increase rather than decrease the plasticity of certain soils when mixed with them. Usually the mixing of such peat or humus materials which are now on the market and available to the greenkeeper will tend to lower cohesion at any moisture content ranging from a saturated to a dry condition. Tests have shown that these materials will decrease the plasticity of the finer soils more effectively than will an equal amount of sand.

Texture must play an important part in determining the extent of cohesion which soil is capable of showing. In general, the finer-textured soils, such as clays and silts, show great cohesion, since, whether dry or wet, the forces that tend to hold the soil together are stronger than in coarser or sandy soil. As finer-textured soils dry there is a great increase in the binding capacity of the colloidal matter, but in coarse soil this binding effect is small or entirely absent. The addition of organic material to a soil, by hastening and increasing granulation, will also tend to lower cohesion. Therefore if it is desired to avoid hard-packed soils on putting greens it is necessary to avoid plastic soils and either to select a suitable natural soil or to mix materials, such as sand and organic material, with finer soils to reduce their plasticity and cohesion.

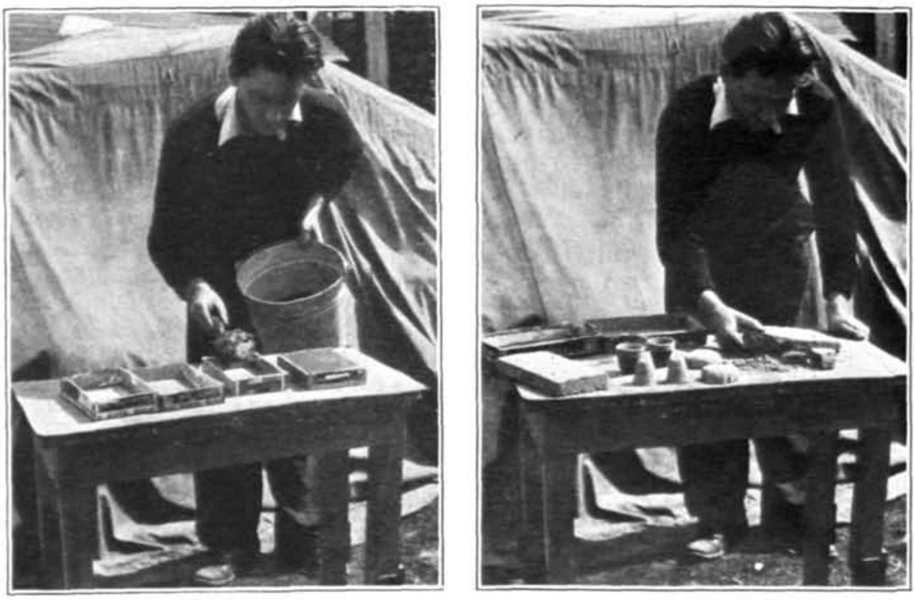
In general, topsoils are more fertile than subsoils, due largely to the oxidation to which they have been subjected, to their greater content of organic material, and to the greater activity of micro-organisms. The greenkeeper should select a topsoil, if possible, which requires the minimum addition of materials to increase or to decrease its plasticity. Since expert soil men may be mistaken on the actual plasticity of soils not in the sandy class, the greenkeeper should not be content with judging a soil merely by its structure or feel, under the conditions in which he finds it. The greenkeeper's choice of the soil to use for mixing might be accurate enough to decide upon the most suitable type available; but before putting either natural or prepared soils on the green, samples should be tested to discover the ultimate cohesion of the material.

Putting Green Soils Should be Tested for Plasticity and Cohesion

A number of laboratory methods have been devised for determining the cohesion of clays and other soils. Considerable difficulty has, however, always been encountered in measuring natural cohesion of either wet or dry soil. The chief difficulty has been in controlling physical conditions, since the cohesion of the soil depends largely upon the manner in which it has been handled, the amount of water that has been added, the length of time of drying, and the moisture content at which the determinations are made. As a consequence, most tests of cohesion have been made with samples worked to a maximum plasticity and then brought to a required moisture content, or with samples which have been uniformly compacted and then allowed to take up water by capillarity. For accurate determinations of an exact numerical expression of plasticity of various soils it has been necessary to develop a highly-specialized technique. It is possible for the greenkeeper, however, to make more or less rough comparisons of the cohesion of various soils and mixtures at his disposal.

Equal amounts of the various soils to be tested should be procured while in such a condition that they can be handled without adhering to the hands or the equipment. The samples should be put through a 1/16-inch mesh screen in order to granulate the soil and to remove large bits of organic material or rock which might complicate the results of the test by forming lines of weakness through the samples. All except a small amount of each sample should then be placed in similar containers and water added slowly while stirring the soil with a stick. Each sample should be brought as closely as possible to a paste-like consistency. Soil in this condition will not readily flow from the container. It contains less than its maximum water-holding capacity and yet contains enough water so that in clay and silt loams the soil has lost much of its sticky toughness; and although it will coat the fingers if they are thrust into it, it will not stick in large irregular clots. If a furrow is cut through the mass, the soil will just flow together if jarred slightly, leaving a distinguishable line of contact. If too much water has been added and the sample has become too thin, enough of the remainder of the soil should be added to thicken it to the required consistency. After a few trials it will be possible to prepare each sample of approximately the same consistency with about an equal amount of stirring.

The samples should then be troweled into uniform receptacles in order that they may dry in a uniform manner. Small boxes or flower pots may be used, or, for somewhat less accurate results, mud balls or pies may be molded with the hands into uniform sizes and laid on a board. A record of the samples should be kept and the samples numbered to prevent error. The samples should then be placed under cover in a position where they may dry uniformly. As the samples become dry it should be noted whether certain ones remain moist longer than others, as this factor is important in determining the best sample for putting green topsoil purposes. A sample which remains damp abnormally long may contain too much organic matter. After several days, when it is apparent that the samples have become thoroughly dry, with the exception of any which may contain too much organic matter, they may be removed from the molds or, in the case of mud balls and pies, the samples should be turned. It is usually advisable to allow the samples to dry another day after turning or removing from the receptacles or molds.



In testing the cohesion of a soil, samples of the soil are puddled and then molded either by hand or in several receptacles of the same kind and size. The samples are then set aside until thoroughly dried. Cigar boxes or flower pots are convenient for use as receptacles. On the table at the right are seen also two "pies" molded by hand, and a sample molded in a cigar box being tested by crushing it between the thumb and fingers

By handling the dried samples, the relative cohesion, particularly in the case of extreme soils, should at once become apparent. Samples which are too sandy, or contain too much organic matter, will crumble and fall apart and will not retain their shape even with gentle handling. Samples which have too much cohesion will resemble brick and will retain their shape even when dropped some distance. There is no clearly-defined ideal sample; but by using this method greenkeepers and construction men can discover a mixture which they can use in the putting green with safety. A dried sample of over an inch in thickness, prepared as above, which can be crumbled by the pressure of the thumb and fingers of one hand, and which does not present a glazed, hard crust, may be judged as a suitable mixture for putting green topsoil, including material for top-dressing purposes.

With adequate fertilizing and watering it will be possible to maintain excellent turf on such a soil mixture without danger of turf injuries due to poor soil conditions. Such a soil will also have sufficient "give" or resiliency, without being spongy, to hold on the green a reasonably well-played pitch shot, and will have present the same qualities in this respect from day to day whether wet or dry.

When Is a Bent Grass a Creeping Bent?

There has been much discussion in the last few years regarding the inclusion of the word "creeping" in the common name applied to Astoria bent, a species of bent grass being grown in Oregon for seed which is a distinct strain of colonial bent that displays pronounced creeping characteristics in the place in Oregon where it is grown. The attitude of the Green Section in this matter is made clear in the article "Classification of Redtop and the Common Bent Grasses" commencing on page 44 of the Bulletin for March, 1930, especially on page 49 in that article. The difference in the points of view in this discussion is largely a matter of contention over the use of words, for both sides are in complete accord as to the character of the grass.

The name "creeping bent" has been handed down to us as a common name applying to a certain group of grasses which botanists have grouped into a single species which, as stated in the Bulletin for March, 1930, is known botanically as *Agrostis palustris.* Unfortunately in this common name the word "creeping" may be construed as an adjective, which is a construction not intended. If the name could acceptedly be hyphenated or compounded, thus appearing as creeping-bent or creepingbent, its meaning would perhaps be less open to misconstruction.

In the use of the common name "creeping bent," if the word "creeping" is to be construed as a descriptive adjective and not as a part of the noun, the confusion which exists in the case of Astoria bent would necessarily enter also into the case of many other grasses of the genus Agrostis. For instance, on many golf courses and experimental turf gardens there are areas of velvet bent turf (*Agrostis canina*) planted with stolons which have developed into thick turf by the creeping habit common to species of Agrostis. At the Arlington turf garden there are two plots of redtop (*Agrostis alba*) which were planted with stolons and which have developed by the creeping habit into thick turf. Using the word "creeping" as an adjective one could not deny that such turf consisted of species of Agrostis which had distinctly creeping habits. In that case therefore we should be obliged to call both velvet bent and redtop "creeping bent." However, no one acquainted with turf confuses redtop and velvet bent with creeping bent.