California Turfgrass Culture

FORMERLY, SOUTHERN CALIFORNIA TURFGRASS CULTURE

VOL. 17 - NO. 3 JULY 1967

Root Tip Degeneration Of Turf Grasses, Natural And Induced

R, M. Endo
Department of Plant Pathology. University of California. Riverside

One of the most imp or t an t factors determining the growth, vigor, and survival of turfgrasses in California is the condition of the root system. During summer the roots of cool-season turfgrasses and Dichondra are frequently reduced in number and length, eg. roots of ryegrass, bentgrass, and bluegrass commonly measure only one-half to one inch in length. Plants with abundant, vigorously growing roots tend to be associated with green, healthy, productive plants, whereas sparse, stunted, slow-growing roots tend to be associated with light green, dwarfed and stress susceptible plants. Plants with reducedroot systems are especially susceptible to drought during hot weather and require special care in watering.

The most commonly cited causes of this reduced root system are insufficient aeration (low oxygen, excess carbon dioxide), high soil and air temperatures, salinity, excessive accumulation of grass residues, unfavorable mowing practices, unfavorable nutrition and various diseases. Just which factor is most important is not known. One obvious beneficial effect of aerification is increased root growth. The problem is complex because several factors may beoperative at the same time, and the actual causal factors may vary depending upon the particular situation and conditions. Further progress in diagnosing and correcting the various types of root troubles will depend upon the following: 1) the development of rapid and simple tests to determine the levels of salinity, carbon dioxide and oxygen present in soils and 2) microscopic studies to determine whether or not distinctive, diagnostic, pathological symptoms can be detected in roots treated with excess carbon dioxide, insufficient oxygen, high temperatures, salinity, toxic decomposition products arising from mat and thatch, etc.

We have been conductingresearch on troubles affecting turfgrass roots for three years. Our findings can be summarized as follows: 1) stunted roots collected from plants in the field frequently show symptoms of root tip degeneration (see question and answer No. 1 for definition); 2) a toxin or toxins produced by the dollar spot fungus, *Sclerotinia homeocarpa,* in the laboratory also causes root tip degeneration of bentgrass roots; and 3) certain sugars and sugar derivatives that occur naturally as structural components in the cell walls of plants,insects, bacteria and fungi cause a degeneration of the root tips of bentgrass and ryegrass in the laboratory at concentrations between 2040 ppm in 12 hours or less. Examples are D-galactose, D-mannose, 2-deoxy-galactose, and glucosamine.

QUESTIONS AND ANSWERS

1. ***What is root tip degeneration?***
It is a deterioration of the structure and function of the immature cells and tissues of the root tip.
2. ***Can root tip degeneration be diagnosed without the aid of a microscope?***
No, not usually, but its presence can be suspected if the root system consists of very short, abundantly branched roots. However, this particular pattern of root development is rare.
3. ***Why does this pattern of root development sometimes occur?***
Because the factors which cause root tip degeneration affect only the immature cells and tissues of the root tip, mature cells are unaffected. When a root tip is killed, secondary roots form within the mature, unaffected tissues of the root. These new roots remain unaffected by the degenerative agent until the secondary roots emerge from the parent root. The affected secondary roots may then form tertiary roots which. are also affected in the same way.
4. ***What does a normal healthy root tip look like?***
Figure 1A (page 18) shows a photograph of a healthy root tip of Seaside bentgrass. Note the large, cone-shaped group of cells (filled with starch grains) that comprise the root cap. The double layer of brick-shaped cells (see black arrow) at the base of the root cap is made up of meristematic mother cells. These mother cells divide to form the new cells of the root cap to replace those that are lost by sloughing (see loose cells). The root proper can be seen immediately above the root cap. The few brick-shaped cells, immediately above the mother cells of the root cap, are the meristematic mother cells of the root proper. These cells are important since they divide to form the new cells of the root. The remainder of the root that can be seen consists of the zone of differentiation and a portion of the zone of elongation. Finally, note that the cells of the root proper are filled with fine granular material (protoplasm) and are either brick-shaped or rectangular with straight sided walls.
5. ***What does a degenerated root tip look like?***
Examples of whole roots affected with root tip degeneration caused by a poison produced by the dollar spot fungus are shown in Figures 1B-D. Figures 1B and 1C show the same root in an advanced stage of degeneration focused at different levels. Figure 1B was focused so as to show effects on the surface cells of

the root. Note that these cells are considerably enlarged, the cell walls are no longer straight and the cells lack contents. The root cap is reduced in size with cells lacking protoplasm, nuclei, and starch grains. The meristem mother cells (black arrow) of the root cap and root proper are also greatly enlarged and are totally lacking in cellular contents. Since these meristem cells can no longer divide, root elongation has stopped. Figure 1C shows similar characteristics of the internal cells of the same root. Figure 1D illustrates a root in very advanced stage of degeneration. Note the total absence of a root cap and the greatly enl arged cells of the root proper which are being sloughed off (black arrow).

6. *Is the type of root tip degeneration seen in the field the same as that caused by the dollar spot fungus and the various sugars and sugar derivatives?*
If we study whole unsectioned roots under the low powers of the microscope, the effects look strikingly similar: 1) suppression of root elongation, 2) increased thickness of the root apex, 3) decreased root hair formation, 4) stimulation of adventitious and lateral roots, and 5) disappearance of starch grains in the root cap cells.

7. *What is the cause of root tip degeneration in the field?*
We know that root tip degeneration of turfgrasses occurs commonly in the field but we do not know its cause as yet. Fungi infecting the roots do not seem to be involved. The dollar spot fungus only rarely attacks the roots: infection is usually confined to the leaves and the toxin does not appear to be translocated to the roots. Inadequate aeration, salinity, high temperatures, and excessive removal of foliage during periods of environmental stress are all possible causal factors. Unfortunately, no one has determined whether these factors cause root tip degeneration.

8. *Certain sugars and sugar derivatives have been shown to cause root tip degeneration of turfgrasses. What relationship does this have to root tip degeneration problems that occur in the field?*
We don't know, However, we suspect that they play a very important role because turfgrass debris is always present in turf sod, and the microorganisms that break down plant cell walls may release sufficient quantities of these toxic cell wall compounds to cause root tip degeneration. This appears possible because these compounds act very rapidly in 6 to 12 hours and at very low concentrations from 20 to 40 ppm. Additional research is necessary since we must show that these compounds are present in soil, that they may be present at certain times in toxic concentrations, and that they induce root tip degeneration symptoms in the field that exactly match those obtained with these compounds in the laboratory.

9. *Since only the tip of the root becomes degenerated, bow could such limited injury cause damage to turfgrass plants?*
The question is difficult to answer because information is lacking on the exact water and salt absorbing regions of the root. Most investigators agree, however, that youngroots and the youngest portions of old roots are most active in absorption. Degeneration of the meristem mother cells is important because it would halt the formation of new cells, tissues, and root hairs. Prolonged and continued production of compounds toxic to root tips would result in a sparse, shallow root system ill-equipped to tap the soil for nutrients and water.

If a turfgrass plant is growing vigorously, degeneration of a few root tips would cause little harm since such loss would be compensated for by the formation of adventitious and branch roots. Thus, appreciable plant injury might be expected to result from root tip degeneration only when cultural or environmental conditions favor the production and continued longevity of the degenerative chemicals over a prolonged period and environmental conditions are unfavorable for plant growth and root growth. Such conditions could readily develop in turf sod since grass clippings are abundantly and continuously present. The wet, anaerobic conditions which apparently favor the production and persistence of toxic chemicals readily develop in turf that is overwatered and compacted by foot traffic and maintenance machinery. It is also possible that degenerated root tips might be more readily infected and invaded by root-attacking pathogens than normal healthy roots because of lower host resistance and leakage of nutrients.

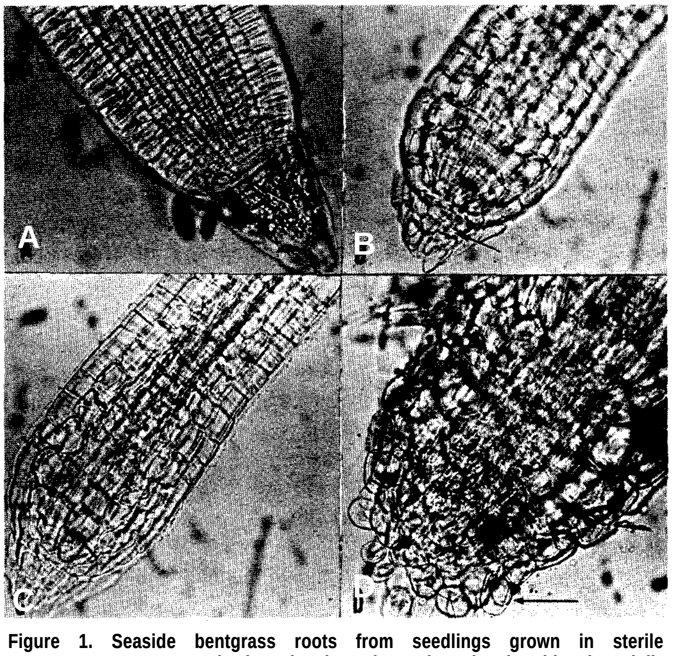


Figure 1. Seaside bentgrass roots from seedlings grown in sterile quartz sand, inoculated and noninoculated with the dollar spot fungus, *Sclerotinia Homeocarpa*. A) A healthy, normal root tip. Note the large, cone-shaped root cap that protects the root proper, the brick shaped meristematic cells (black arrow) that divide to form replacement root cap cells and the abundant starch grains contained in the root cap cells. Note also the brick-shaped and rectangular-shaped cells of the root proper that are densely filled with granular protoplasm. B) Fungus affected root which is damaged by the fungus toxin although no root Infection is present. Note cell enlargement, somewhat polygonal shape of cells, the lack of starch rains in root cap cells (arrow) and the lack of protoplasm and nuclei. C Same root as B but focused at amedian position. Again notegreatly enlarged cells and the total lack of cell contents, indicating that the root tip can no longer elongate. D) A very advanced stage of root tip degeneration. Note corn lete loss of root cap and the sloughing off (arrow) of the enlarged cells.

TURF AND SOIL WATER- AIR RELATIONSHIP [1]

F. K. Aljibury
University of California Agricultural Extension Service
Orange County

Soils are a combination of soil particles, air and water. The spaces between the soil particles are called the soil pores or voids. The amount, size and arrangement of these soil pores are of considerable importance to soil water movement and retention. These pores are much larger individually in the coarser soils than they are in the finer textured soils. Figure 1 illustrates the pore size distribution for different soils. Water in the larger pores drain freer and faster than through the small pores of the finer textured soils. The pore space is of vital importance to plant roots. Soil pores accommodate both water and the gases required by the plants. The balance between air and water in the soil system must be maintained so that no one should overcrowd the other.

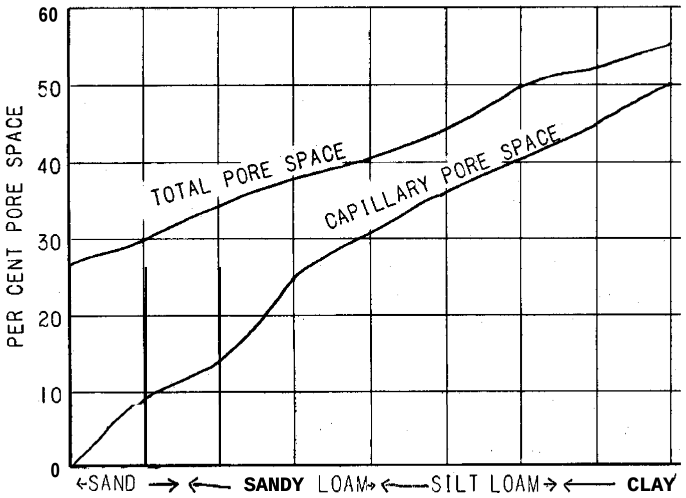


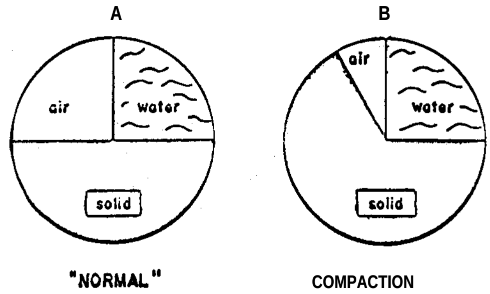
Figure 1. Pore size distribution for various soils

In a well-drained soil the water which is held in the larger pores drains away rapidly leaving the retained water as a film around the soil particles. The pore space from which water has drained away immediately after irrigation is of extreme importance to soil oxygen. Kunze and his associates (1) have shown that when water has drained away from 10 to 15 per cent of the larger pores a few hours after irrigation, the aeration would be sufficient for good grass growth. A practical and simple method to evaluate soil aeration is to observe the tensiometers. Within 12 hours after irrigation the soilmoisture suction should advance above 5 c.m. (centibars). Prolonged wetness of the soil around the grass roots can damage the turf.

A gradual compaction of the soil can be detected by the use of tensiometers. When the reading remains below 5 c.b. within 12 hours after irrigation pore aeration occurs. The effect of compaction on the soil system is illustrated in Figure 2. Due to compaction, the soil becomes denser and the amount of the large pores decreases. Although compaction does't reduce the amount of soil moisture retention, it certainly creates drainage and aerification problems.

[1] **Talk presented at Southern California Turfgrass Field Day, 5-10-67.**

Figure 2. Soil conditions under normal and compacted states.



The performance of common bermuda turf was observed under compacted and noncompacted soil in Grange County and is illustrated in Figure 3. Poor aeration causes a weak and shallow root system although sometimes the top growth is hardly affected. Shallow and poorly developed roots require more frequent irrigations. Such a turf continues to weaken. The best method to correct soil compaction and to improve soil porocity is by deep aerification and avoidance of traffic immediately after irrigation.

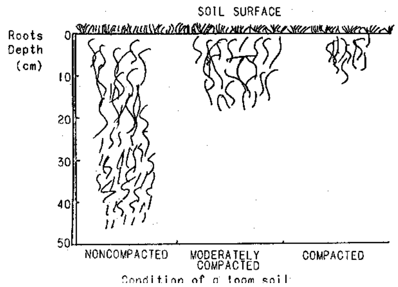


Figure 3. Schematic diagram of bermuda root penetration

Another method to check aeration was suggested by Letey and his associates (2) using platinum electrodes. This procedure measures the oxygen diffusion rate (ODR) the soil. Compacted and wet soils have a low ODR reading. A reading between 20-30 x 10^{-8}gm. cm^{-2}, min^{-1} was proposed to be a critical level for many plants.

While air flows through the soil pores, the moisture is retained as a film around the clay and colloidal particles of the soil system. Good moisture retention property of the soil system is essential to provide the plant water needs between irrigations. A minimum value of 10% of retained water was suggested for soil media. Alowretention property causes irrigation problems to the turf manager. Soil can be amended with organic matter to improve permeability and the retention capacity as shown by Richards and his cooperators (3) as illustrated in Table 1.

Amend. Amount By Volume	Permeability cm/hr	Water Released Vol. fraction O-3 0 c .b.
Soil	0.5	0.13
Soil & 30% R.W. Shavings	2.2	0.18
Soil & 60% R.W. Shavings	10.0	0.24
Soil & 30% Pine Shavings	2.8	0.19
Soil & 60% Pine Shavings	9.0	0.22
Soil & 30% Peat	0.6	0.18
Soil & 60% Peat	3.8	0.29

Table 1. Effect Of Amendments On Clay Loam Soil

Since turf soils go through constant physical changes, continuous evaluation of the soil system is essential for a successful turf management program.

1. Kunze, R.D., M.H. Fetguson and J.B. Page, The-Effects of Compaction On Golf Green Mixtures, USGA Journal 10: (6) 24-27, 1957.
2. Letey, J., L.H. Stolzy, O.R. Lunt and N. Valoras, Soil Oxygen and Clipping Height. Golf Course Reporter. 32 (2): Feb. 1964.
3. Richards S.J., J.E. Warneke and F.K. Aljibury, Physical Properties Of Soil Mixes, California Agriculture 18: (5): 12-13. May, 1964.

Turfgrass Research by the California Agriculture Extension Service

William B. Davis
University of California Agricultural Extension Service, Davis, California

Research in the University of California takes many forms and is carried on by several segments of the University. The Agricultural Extension Service has devoted a portion of its time to research in the past and will devote a greater amount of its time in the future. Primarily, we in the Extension Service are concerned with applied or adaptive research-that research which applies to problems encountered in the field and on which information is limited. Often more basic research has been done, but we need to make the information more useful in solving a particular field problem. Every day we have new chemicals, new soil additives, and new management techniques that need more thorough evaluation under field conditions. With the time, personnel, and funds available to us, we in the Agricultural Extension Service are engaging in research that we hope will be of importance to the turfgrass industry.

Our present research programs are divided into five major areas: (1) weed control, (2) water and soil management, (3) plant adaptability, (4) disease control, and (5) the value of the turf industry to California's economy. Thirteen farm advisors in nine counties are devoting some time to turfgrass projects. These projects are backed up or assisted by eleven statewide specialists, stationed on the Riverside, Davis and Berkeley campuses of the University of California. Most of these Extension people have assignments in other areas of agriculture, and so can devote only a portion of their time to development and extension of turfgrass information.

WEED CONTROL. At present we are engaged in or have just completed 18 different projects in 6 counties throughout the state. In most of these weed control projects we had the good fortune of having a Weed Control Technologist assigned to work on weed control problems in the ornamental industry. This gave us an opportunity for larger and more detailed programs so that we might develop better University recommendations on the use of many of our newer herbicides, particularly for the control of crabgrass, dallisgrass, kikuyugrass, spotted spurge, Australian brass button, English daisy, and annual bluegrass. One of our primary concerns is the phytotoxicity of these new chemicals on the various grass species. Some of these projects encompass relatively small areas on existing turf. We also are developing large, newly planted turf areas such as the one in Sacramento which will consist of 10,000 sq. ft. of new turf devoted to five different grass species solely for the purpose of developing phytotoxicity information. In southern California we are most concernedwith controlof spotted spurge, annual bluegrass, kikuyu, and dallisgrass. We make it a point in our weed control research work to not become too enthusiastic about information we obtain from one isolated experimental area. So that our recommendations are valid, we repeat experiments in different localities of the state under different climatic and management situations.

WATER AND SOIL MANAGEMENT. Successful turf areas in California must be irrigated during most of the year. We also are developing many of our turf areas on relatively poor soils or on completely artificial soils. Much information is needed to avoid early failures in many of our newer planting sites. We have 8 projects underway in this area. One of our most extensive irrigation projects is on the South Coast Field Station, Santa Ana, California where we are evaluating actual water needs of many of our important turfgrass species. The general tendency is either to overirrigate or underirrigate turf. Since water is expensive and often scarce, better information is needed in this area.

Irrigation management programs are underway in the Los Angeles Basin and the Bay Area. Of particular interest are the evaluation studies in the change of grass species in mixed turfs where irrigation is controlled by tensiometers. In Yolo and Alameda Counties we are studying low application rates of water for bowling greens and fairways where tight soils cause extremely low infiltration rates. New turf sprinklers, designed for lower precipitation rates, are being evaluated not only for their irrigation performance but also for their economic feasibility on our large turf areas.

In nearly all new turf installations we are modifying our soils with a variety of organic and nonorganic amendments. In many areas we are finding it necessary to develop a completely artificial soil for turf use. Of particular importance has been applied research work in Alameda County to ascertain the feasibility for sand soils for athletic areas. Many major stadiums must have turf adaptable for professional football, soccer and baseball. Many times the transition of the athletic area between these sports events must be made during inclement weather in a short period of time. In a long-term project in San Diego County, we are evaluating the value of modifying shallow, mesa soils for the establishment of permanent turfed areas.

PLANT ADAPTABILITY. In the past, many of our counties had rather extensive turfgrass plots to supplement the work of our research stations and to give us information on the adaptability of grasses to the varied climates and soil conditions throughout the state. Many of these plots are still in existence but are not carried as major Extension projects. The only active turf variety plot is located in Kern County. Many of our original plots are now part of the program of arboretums, schools, golf courses and parks. Our most extensive experimental programs in this area is located on five golf courses in San Diego County where we are evaluating different grass species for overseeding common and hybrid bermuda for year-round color. These golf courses were selected to give us a wide range of climatic conditions and yet maintain our projects within a relatively small area of the state. Much replication of the individual test areas has been made to further reduce natural variation. From this project we hope to gain information that will apply to most of the state where bermudagrass is a prominent fairway turf. Our other project is in the Santa Cruz area where different strains of bluegrass are being tested under actual fairway conditions at mowing heights of 3/4 inch. This 5,000 sq. ft. test area is located in the center of the No. 2 fairway of a newly established golf course. The predominant fairway turf is Highland bent.

DISEASE CONTROL. Perhaps one of the most difficult areas of adaptive or field research is in disease

Talk presented at Southern California Turfgrass Field Day, May 10, 1967.

control. Few turfgrass managers will give up their No. 1 green, even though it may be badly diseased, for an applied adaptive research program. On turf areas that can be utilized for disease control research we usually find it difficult to establish a disease. Fortunately, in the area of nematode control, we have had an opportunity to extensively study several chemicals reported to control nematodes which may be pathogenic on turf. In Los Angeles County, where high infestations of certain species of nematodes have caused considerable reduction in the total vigor of turfgrass, one or two chemicals have shown some value as turfgrass nematicides. In Alameda County we are establishing a new bluegrass area where we hope to evaluate the phytotoxicity of various fungicides on this grass species. We also hope to inoculate this new area with sufficient pathogens to establish diseased turf on which to evaluate the control potential of some of our new and standard turf fungicides.

SIZE AND VALUE OF THE TURF INDUSTRY. Perhaps this is one of the greatest unknown factors. How big is the turfgrass industry? What does it cost us to maintain various types of turf under varying conditions? What is its total value to California, based on what we pay to maintain it? We roughly estimate that the replacement value of the turf now existing in California exceeds $1 billion, and that to maintain this turf area we are spending in excess of $400 million per year. If these figures are anywhere near correct-this is big business. Unfortunately, turf is divided and segmented into many small parcels, which makes it difficult to get accurate estimates. The Extension Service repeatedly is called upon to furnish the turfgrass industry with information on just how big it is and how big it will be in the future. We presently have four projects underway in an attempt to get this information. By the end of this year we will have completed updating our 1963-64 golf course survey. Present figures indicate we will have approximately 600 golf courses with more than 70,000 acres under irrigation and regular mowing in 1968.

Perhaps one of our most important projects lies in Alameda County, where we are making a detailed study of the methods by which we might get an accurate turfgrass survey. Due to development of a rapid transit system in this area we hope to be able to use their aerial photographs to obtain some of this information. Various governmental agencies, chambers of commerce, cemetery districts, and other avenues are being explored in this one county to determine the best method of bringing together this information accurately and efficiently. Projects in two other counties are primarily concerned with gathering data on equipment and maintenance costs.

This report briefly sketches the type and extent of the Agricultural Extension Service's research program on behalf of the turf industry and the millions of California residents who demand year-round, green, recreational and aesthetic areas.

California is a large state with a continuously growing population. There is a great need for more research for which we have insufficient time, personnel, or funds. Whether our activity is expanded or decreased depends largely on the support we receive from those persons interested in the turfgrass industry.

Peat Classifications

J. R. Watson
Director, Agronomy, Toro Mfg. Corp., Minneapolis, Minn.

Peat is an easily obtainable, relatively uniform source of stable organic matter. It is used in turfgrass culture to improve the physical condition of seedbeds and in top dressing mixtures. There are many classification schemes for peat. Those of significance in turfgrass culture relate to the original plants deposited-botanical compostition-and the stage of decomposition.

Three schemes utilizing all or part of both groupings are reviewed. In addition, other characteristics important in determining quality of the peat from the standpoint of soil improvement are listed.

Peat is the remains of plants that have accumulated and undergone partial or incomplete decomposition in water or excessively wet areas such as swamps and bogs.

Peat varies in a number of physical and chemical properties. Among the more important are botanical composition, water-holding capacity, state or stage of decomposition, organic matter content, nitrogen content and chemical reaction (pH). Peat is brown, reddish brown or black, depending on its state of decomposition and its moisture content. It may be fibrous or non-fibrous, depending on its botanical composition and, again, its state of decomposition.

Organic matter content-minimum of eighty (80) percent on a dry matter basis-and water-holding capacity-at least 400 percent on a dry weight basis, are of major importance in determining quality of peat. Reaction (pH) and moisture content are two additional criteria to be considered when purchasing peat.

Peat deposits occur throughout the world. Those in the United States, Canada and northern Europe are of commercial importance to the turfgrass industry. In 1963, the United States Department of Interior reported commercial production of peat in 23 states. Michigan producers accounted for 44 percent of the national production. Minnesota is reported to have the largest peat reserves but produces and markets only a fraction of the total.

Extensive areas of peat in Florida (Everglades), California and New Jersey are used for vegetable crop production. Turfgrass sod is grown commercially on peat deposits in a number of areas. In addition to these "In place" field soil uses, peat is harvested commercially

Reprinted from the Proceedings of the 38th International Turfgrass Conference and Show, 1967.

for use as a soil amendment or conditioner, as a mulch for ornamental plantings, shrub and flower beds and as a potting medium. Additional uses in some parts of the the world are as a fuel and as bedding or litter in stables and chicken houses.

The principal use of peat in turfgrass culture is as a soil conditioner or amendment. It is used as a source of stable organic matter in the preparation of seedbads and in the mixing of topdressing. Peat added to sandy soils will increase their water-holding capactiy and their nutritive supplying ability. It improves the air-water relationships of heavy soils. The beneficial effects of peat are comparatively long lasting. In tests at Pennsylvania State University, 70 percent of the original organic matter added to soil as peat was still present 10 years later.

Classification

A number of classification schemes for peat and for organic soils have been devised. They vary in accordance with the classification objective and the author's special field of study; for example, geology, botany or any one of several branches of agronomy. Thus, terms such as "marine marshes" and "fresh water swamps" with their various subdivisions used by Shaler (1890), a geologist, are found in peat literature.

Further contributing causes to diversity of classification are the various features and conditions used as a basis for establishing classes. For example, geographical and topgraphical features, surface vegetation, botanical origin and composition, chemical properties and others. Thus, terms like "low moor," "transitional moor" and "high moor" were used by Weber (1903), a German worker, to describe surface configuration of bogs. Low moor referred to the lower levels (below soil line) and would compare to the "sedimentary" classification discussed later. High moor referred to the raised portion of the bog and is synonymous with the term "raised bogs" used by Barry (1954) to describe the peat bogs of central Ireland.

Add this to the use of different terms for similar criteria and the lack of quantitative definition for terms describing a wide range of conditions, and it is easy to understand why confusion exists with regard to peat terminology and classification. Nevertheless, for the most part, all such schemes have served a useful purpose and have contributed to a better understanding of organic soils albeit classification confusion. Many of the classification schemes have been ably reviewed by Farnham and Finney in their excellent paper, "Classification and Properties of Organic Soils" *(Advances In Agronomy, Vol.* 17, 1965). Those interested in the more technical aspects of classification and survey or organic soils are referred to this article,.

Schemes important in classifying peat useful in turfgrass culture would include characteristics based on parent material, botanical composition, stage of decomposition, organic matter content, water-holding capacity and chemical reaction. Botanical composition and stage of decomposition are two of the most significant criteria. Schemes based on these factors and qualified on the basis of physicaland chemical properties that have direct bearing on soil properties would seem to be the more useful for turfgrass managers.

Botanical Origin and Deposition

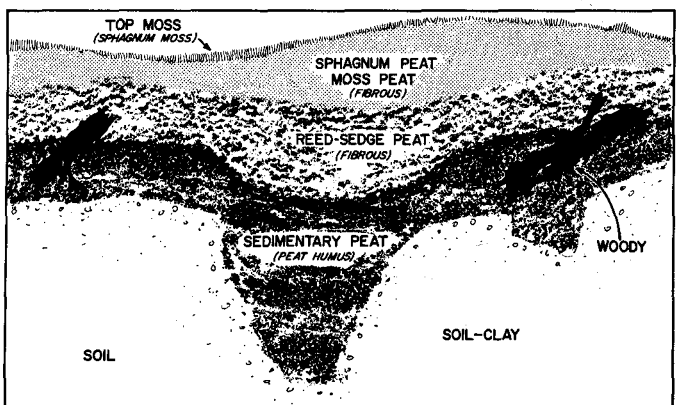
An initial grouping on the basis of the kind of original material, botanical composition, and its deposition is described by Lyon and Buckman in their book, *Nature and Properties* of *Soil.* This classification employs the terms sedimentary, fibrous and woody, reflecting the original parent material and, in part, its manner of deposition. They are applied without regard to stage of decomposition.

Sedimentary Peat accumulates on the bottom of the comparatively deep water zones of the swamp or bog. These peats are derived from algae, plankton, water lillies and various other pond weeds. Tissue from these plants decomposes rather completely. This, along with the type of decay, produces a highly colloidal, almost black, rubber-like peat. Because it accumulates on the lake bottom, this material often contains large quantities of soil mineral matter such as marl, slit and clay. Such material has very poor physical properties and is undesirable as a soil conditioner.

Fibrous peat accumulates along the edges and above the sedimentary peat zone. The fibrous peats develop from the deposition of reeds, sedges, marsh grasses, cattails, hypnum and sphagnum mosses. These deposits are normally subdivided into "reed-sedge" and "moss" peats. Generally, the moss layers are deposited over the reed-sedge zones. These are the peats with the highest commercial value and are the ones of most interest to turfgrass managers. They will be discussed in detail later.

Woody Peat results from the residues of trees-broadleaf and evergreen-shrubs and other woody type plants. Trees are the climax vegetation of a bog: however, "woody" peat may be found throughout the sedimentary and fibrous layers of zones. Woody peat is rather homogenous, loose and non-fibrous in character. It has a lower water-holding capacity than fibrous types and is generally considered unsatisfactory as a commercial product; however, soils derived from woody peat are considered excellent for the growing of crops.

The ecological succession of plants, as implied in the sedimentary, fibrous and woody classification, is not necessarily regular in nature. As a matter of fact, because only slight changes in climate or water level interrupt the sequence, layers or horizons varying in depth, degree of decomposition and botanical composition are characteristic of most peat bogs. (See illustration). It is estimated that from 100 to 500 years are required to build up a one-foot layer of peat. The variations possible over the thousands of years that some bogs have been in existence are obvious.



Stage of Decomposition

Musser in his book, *Turf Management,* groups peats primarily on the basis of their stage of decomposition. He uses the terms raw peat, cultivated peat, moss peat and sedimentary peat.

Raw Peat is described as the fibrous bog material processed only by drying, shredding and screening. It has undergone little, if any, decomposition. Musser indicates that, when used on the basis of dry, organic matter content, such materials have about equal value as soil conditioners. The acidity level (pH) should be requested when this material is being purchased.

Cultivated Peat is raw peat that has been broken up mechanically by tilling or cultivation. This hastens the rate of decay and stimulates the development of organisms responsible for decomposition. It is usually non-fibrous and approaches soil humus in physical properties. As such, the remaining organic matter decomposes very slowly. It is sometimes called decomposed peat and peat humus. Cultivated peat should be purchased on the basis of its organic matter content, its water-holding capacity, its water content at time of sale and its pH value.

Moss Peat according to Musser's classification is composed principally of sphagnum moss that has undergone partial decay. It is finely fibrous, light, fluffy and contains a higher percentage of readily decomposable organic matter than the raw peats. It is not as suitable as a soil conditioner as the raw or cultivated types.

Sedimentary Peat is characterized by Musser has about the same properties as mentioned earlier for this class. He describes these peats as being sticky and plastic when wet and compact and hard when dry. He points out that small local deposits have on occasion been used on golf courses with disastrous results.

Botanical Composition-State of Decomposition

Lucas, Rieke and Farnham, in their bulletin entitled, *"Peats For Soil Improvement and Soil Mixes,"* classify peats into three types-moss peat, reed-sedge and peat humus. In addition, they include sedimentary peat and muck in a separate group described as organic soils. Their descriptions follow:

Moss Peat is formed principally from sphagnum, hypnum and other mosses. Moss peat, sometimes called peat moss, is the least decomposed. It is derived mostly from sphagnum moss and is light tan to brown in color, lightweight, porous, high in moisture-holding capacity and highly acid. Hypnum moss peat is a darker brown color and possesses physical properties similar to reed-sedge peat. When moss peat is incorporated into a soil and lime is added, it will decompose at a moderate rate because of its high cellulose content.

Sphagnum moss or "top moss" is the young residue or live portion of the plant and should not be confused with the partially decomposed moss peat. Top moss is marked for packing, for use as a mulch and for starting cutting rather than for soil improvement.

Reed-Sedge Peat is formed principally from reeds, sedges, cattails and similar plants. Commercial lots of this peat differ in their degree of decomposition, acidity and in organic matter content. The partially decomposed lots are reddish brown to brown and are somewhat fibrous. Those in a more advanced stage of decomposition are darker in color. They are intermediate in their moisture-holding capacity and in their nitrogen content.

Peat Humus. Peat that is of an advanced stage of decomposition -none of the original plant remains are identifiable-is called peat humus by Lucas, et al. This compares to the cultivated peat classification used by Musser. Peat humus is dark brown to black in color, low in moisture-holding capacity and has a medium to high nitrogen content. Peat humus has a high lignin content because of its advanced state of decomposition. It is more resistant to further breakdown than the peat moss or reed-sedge types.

Organic Soil. Lucas et al place all other peat-like soils that are high in organic matter and that are offered for sale in the general category of organic soil. They include sedimentary peat, "black dirt," muck soil, topsoil and black humus. The authors caution against the use of such materials for soil improvement unless they have been tested for and have acceptable levels of acidity and mineral content. The sedimentary peat described is similar in characteristics to that given by others. Muck has undergone extensive decomposition and in comparison with peat is low in organic matter content.

Additional Characteristics

The significant features of the three schemes presented relate to the botanical composition and the stage of decomposition of peat. The peat analyses shows additional characteristics that need to be considered when purchasing peat.

Peats with a pH below 5.0 are called "low lime"; above 5.0, "high lime. " Low lime peats are deficient in calcium; whereas, high lime peats are said to have sufficient calcium. Very acid peats have a pH of 4.2 or lower. Many local peat deposits are often quite acid, and before they are used on golf course soil, they should be tested.

Reed-sedge and peat humus deposits may sometimes contain weed seed. The surface layers of such deposits, especially if they have been under cultivation, may be heavily infested. Care should be exercised to avoid bringing in such materials to a golf course. Subsoil peat and moss peat are usually free of weed seed.

RANGE IN ANALYSES OF COMMON HORTICULTURAL PEATS (AFTER LUCAS ET AL)

Type of Peat	pH	Water Absorbing Capacity*	Ash Content*	Volume Weights*	Nitrogen*
		Percent	Percent	lb. /cu. ft.	Percent
Sphagnum Moss	3.0 - 4.0	1500 - 3000	1.0 - 5.0	4.5 - 7.0	0.6 - 1.4
Hypnum Moss	5.0 - 7.0	1200 - 1800	4.0 - 10.0	5.0 - 10.0	2.0 - 3.5
Reed-Sedge (Low Lime)	4.0 - 5.0	500 - 1200	5.0 - 15.0	10.0 - 15.0	1.5 - 3.0
Reed-Sedge (High Lime)	5.1 - 7.5	400 - 1200	5.0 - 18.0	10.0 - 18.0	2.0 - 3.5
Peat Humus (Decomposed)	5.0 - 7.5	150 - 500	10.0 - 50.0	20.0 - 40.0	2.0 - 3.5

*** Oven-dry basis**

Bibliography

1 FARNHAM, ROUSE S. and FINNEY H.R. Classification and Properties of Organic Soils," *Advances in Agronomy,* Volume 17, 1965.
2. FARNHAM, ROUSE S. and GRUBICH, D.N., "Peat Resources of Minnesota."
3. LATHAM, J.M., "A Definition of Peat." Paper presented at the 36th Annual Minnesota GCSAA Conference, 1964.
4. LUCAS, R.E., RIEKE, PAUL E. and FARNHAM, ROUSE S., "Peats For Soil Improvement and Soil Mixes," Michigan State *University Extension Bulletin, No.* 516.
5. LYON and BUCKMAN, *Nature and Properties of Soils.* Macmillan Company, 1937.
6. MUSSER, H.B., *Tut/ Management,* McGraw-Hill, 1962.
7. "Soils and Men," *USDA Yearbook* of *Agriculture,* 1938.

CALIFORNIA TURFGRASS CULTURE
Department of Agronomy, University of California
Riverside, California 92502
Editor, Dr. Victor B. Youngner

CALIFORNIA TURFGRASS CULTURE is sponsored by the Federated Turfgrass Council of California and is financed by the regional councils and other turfgross organizations of the state. The Federated Council consists of officers and directors of the regional councils. Subscription to this publication is through membership in one of the councils listed below.