President's Message

ROMANCING THE SOIL

My wife and three daughters know that if there was a worldwide competition for a "Cornball of the Year Award" I would for certain finish in the top 10. And all of the corny suggestions of my past notwithstanding, they think I've outdone myself with the title of these paragraphs. I'll admit to borrowing and amending the title of the popular movie, but no more than that. Love is romance, and if one loves the soil like I do, then the title fits, perfectly.

A youth spent on a farm in the rolling hills of southwestern Wisconsin instilled a love of the soil in me. I'll forever feel lucky to have spent my childhood in this unglaciated area of the state. Although farming on hillsides is difficult, it was made easier and more productive by the Soil Conservation Service and the UW Soil Science department when they introduced contour farming and strip cropping some fifty years ago. These practices not only preserved precious soil, they added immensely to the beauty of the countryside. And they drew a lot of deserved attention to the soil and its importance. This is where my romance with the soil began.

Each spring rekindles fond memories of the soil, memories made by helping prepare fields for planting. Plowing is a primitive art, one that began when man first planted a crop instead of depending on a wild harvest for his food. It is the beginning of the chain of most of all that goes on in this world. The soil is where, I think, all nations ultimately seem to draw their power. There is something very special about being at the beginning of this chain. Springtime is when strong feelings about the soil are passed on, subtly, as son watches father walking plowed fields, pausing for a closer look and occasionally reaching for a handful to see if it has the right feel. All of these things left a lasting impression and a love of the soil that I will never lose. It is, it has been, and it always will be a pleasure to be a husbandman and a romantic of the soil.

Truly great literature and poetry deal with profound themes and my favorite poet, Robert Frost, felt strongly enough about the soil to compose a poem entitled "Build Soil." His poem points this way:

"What is more accursed
Than an impoverished soil,
pale and metallic?
What cries more to our kind
for sympathy?"

Horace and Vergil held the same view of the soil. President and farmer Thomas Jefferson once wrote, "Tillers of the Soil are the Chosen of the Lord." I'm surrounded by the thoughts of other soil romanticists, and they are powerful company indeed.

Soils are beautiful and colorful and fragrant and alive. Soil has a subtle fragrance and an "earthy" aroma. It is the aroma of millions of years gone by, of all living things past. The color of soils are those the artist can describe only as "earth tones," soft and subdued. The soil is teaming with the life of earthworms and animals, bacteria, protozoa and many other microscopic organisms.

Although the study of the soil is a true science requiring the use of highly specialized, detailed, precise and technical words, it also includes a language that is descriptive and romantic in sound. Few sciences can lay claim to such pleasant words as friable, tilth, fertile and loam — words that simply roll from your tongue.

Strong sentiments about the soil were nurtured and developed and matured by the Soils Department during the six years I studied at Wisconsin's Land Grant College in Madison. Justin Smith Morrill introduced legislation during Lincoln's term as president creating a land grant institution in each state — a piece of legislation as useful as almost any ever introduced, in my view. I've felt so strongly about it that I visited Senator Morrill's homestead in Vermont last year, just to have a better feel for the man who created these landmark institutions across America. Nowhere in the country, since the beginning of these colleges that deal with American agriculture, has a Soils Department done more than Wisconsin's. It was, in fact, the first Soil Science Department in our country, established in 1905. Any discipline that leaves its mark does so with its people, not buildings or laboratories or equipment. So it was with the professorial staff during my generation. By accomplishment, personality and example, this marvelous group gave grads and undergrads alike a sense of the miracle and wonders of the science of soil. I know hundreds of students left those classrooms with the same love of soil that I have.

There's not a person alive who wouldn't forever remember an evening at Dr. S.A. Wilde's home, a world renown expert in Forest Soils. He came to America early in the century as a refugee from Russia, forced to leave his homeland at the time of the revolution. Educated in Russia and Europe, he was an accomplished musician on the cello, violin and piano. He spoke several languages, was widely read and authored standard texts found in Soil Science. He was more than a scientist; he truly was a Renaissance and cosmopolitan man. And beyond that, he loved both the soil and young students of the soil. That staff included Leo Walsh, who at one time during my stay in the department was president of the **International** Society of Soil Scientists and chairman of the department. Subsequent to that time he has advanced to the position of Dean of the entire College of Agricultural and Life Sciences. Dr. Champ Tanner seemed never to leave the building and has devoted his life to the study of water use by plants and soil-plant-water relationships. His investigations led to his election to the National Academy of Science and he currently chairs the Department. Few people have walked this earth who possessed more exuberance for the study of the soil and geology than Dr. Francis Hole. His influence on students is legend, and he is the man who finally persuaded the legislature to declare the Antigo Silt Loam the "State Soil," the first state to do so.

The staff included Dr. Dick Corey, one of the finest teachers in the entire University, not just the Department or the College. Dr. Dennis Keeney assumed a major role in the study of pollution problems of soils and sediments, and taught a terrific course that brought together the two disciplines of chemistry and soils. At one time I shared an office with Dr. Jaya Iyer, a native of India who came to this country with an M.S. and Ph.D. and promptly earned another of each in Soil Science. M.L. Jackson conducted much of his research in Soils at the atomic level of soil minerals and made extensive use of electron microscopy. Many of you now know John Harkin and the diverse and interesting background he brings to the Department and its students. And so it went with the ever friendly Art Peterson and his almost unrestrained good spirits, and with Emmett Schulte and his dry wit and sense of humor that made him a favorite of students.

But for all of these professors and their strengths and brilliance and influence among students, no one has left a greater mark on so many that passed through the Department than Dr. Jim Love. He has, over the past thirty-plus years, touched thousands of UW students as a teacher. He has been, for hundreds of Soil Science students, the surrogate father they may have needed, an advisor helping point the way through the University, and a trusted counselor and true friend when the need was present. His door was always open to a student needing special help with course work. He never will be replaced as a teacher in that Department, and many of us are sad to think that in just one short year he is going to retire.

I cannot imagine a group as distinguished as the one I knew will ever again be assembled. But generations before have probably felt the same way, and generations to follow most likely will too. This shows the strength of the Department and the University and their attitude about quality teachers and researchers.

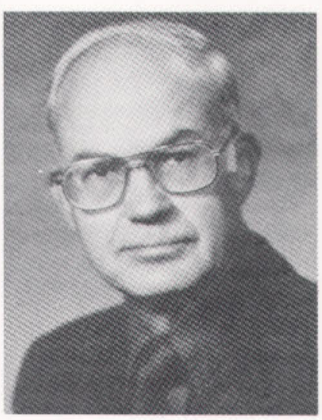
Every Golf Course Superintendent should not only be a student of the soil, but should join me in the ranks of the romantics. Soil is, after all, the stuff golf courses are made from.

Monroe S. Miller

Wisconsin Pathology Report

Recent innovations in elm injections for DED control

By Dr. Gayle L. Worf



We still have some valuable American elms on many Wisconsin golf courses—not as many as we used to, but we'd still hate to lose the remaining ones. I've seen the data and listened to discussions of improved injection techniques and modified application rates. I'm impressed with their possibilities, and want to pass them along to you.

Two major changes have occurred in recent years: (1) a **modification in injection technique** that places the chemical through root flares (just below the soil line), and (2) **use of Arbotect 20S at three times the former rate.**

These have been made possible through the research of Mr. Mark Stennes, a former graduate student at the University of Minnesota, and EPA label expansion that permits legal injection at the higher rate. Although other chemicals and low trunk-site injections are still possible, considerably improved uptake, distribution, and retention of active ingredient results from the newer system, and in turn results in much greater protection and greater survival. If you've injected elms previously—or even if you haven't—the modifications are relatively simple and easy to follow. I've offered a general summary below:

1. Timing. For preventive treatments—anytime during the growing season (June-September) after leaves reach full size. Do not inject defoliated trees until they are refoliated.

Therapeutic treatments can be made with good chances for success on trees that develop symptoms after July 1. Injections on trees showing earlier symptoms rarely work—the fungus is too far advanced and widespread in the tree. Also, trees infected via root grafts (including those showing epicormic branch wilting) won't respond for the same reason.

2. Equipment and chemical. Materials required are the following:

a. a corrosion-proof injection container that will hold 30 gallons or more:

b. a pressure system to deliver 5-12 psi constant pressure; (gravity units will do for this, but other systems may be better.)

c. a leak-proof "harness" consisting of high quality polyvinyl tubing of sufficient length, and with a sufficient number of tapered injection tees to surround the "root flare" base of the tree. A tree with a DBH of 30 inches will require from 45-60 injection sites. There should be 12 inches of tubing between each injection tee on the harness. Best tee size is 3/16 to 5/16 inch diameter. Introduce the chemical into the harness at two locations on opposite sides of the tree for uniform pressure.

d. An electric hand drill equipped with a sharp, high quality wood-boring bit to make clean, snug-fitting holes.

e. A chemical solution. Arbotect 20S is the most persistent and effective chemical. The amount needed is determined by multiplying the DBH (tree diameter at 4.5 feet above the soil line) by 12/5 (12 ounces per 5 inches DBH). This is the "3 year treatment" rate as it appears on the label. (Chemical cost is about $1.30 per ounce.)

After equipment and chemical are assembled, follow these steps:

1. Excavate around the base of the tree, out a distance of 2-3 feet, and 8-18 inches deep, depending on the accessibility of root flares. Avoid tree damage.

2. Dilute the chemical required into water containing low salts such as rain, deionized or distilled water. Lake or river water might do. Check water quality by adding one teaspoon of Arbotect to 12 ounces of water, stir, and let sit for 3 hours. If cloudiness or settling occurs, the water is not suitable. To mix, first place the required amount of chemical in the tank, then add one gallon of water for each 2 ounces of chemical.

3. Drill injection holes perpendicular to the root surface, and not deeper than one inch into the sapwood. Space them 4-8 inches apart in the root flares all around the tree, spacing farthest apart on widespreading buttress roots and closer together where there are no flares. Where sidewalks disrupt, place as low as possible on the trunk at 2-4 inch intervals. Then use a lower dosage rate (8 ounces/5 inches) to minimize phytotoxicity.

4. Insert the tees all around the tree by tapping in place as promptly as possible to avoid drying out the tissue. Allow an extra tee on each side of the tree—replace these with ordinary connecting tees for attaching the supply tubes.

5. Connect the supply tubes to the two sites of the harness and also the tank.

6. Evacuate the air from the system by pulling out two injection tees from opposite sides of the tree and away from the supply lines. Then open the supply valve. After air bubbles stop coming through, re-connect tees to the tree, and allow injection to continue.

7. When the tree has taken all the solution, or uptake has stopped for several hours, remove the harness. Allow 30 minutes for drying before replacing the soil. Wound dressings are not necessary.

8. Dispose of leftover chemical according to directions, or save to use on another tree.

9. Clean and sanitize tees and drill bit before using on another tree.

10. If it is a therapeutic treatment, remove wilted branches within a month.

Another injection should not be necessary for two to three years. When needed, drill holes 2-3 inches above or below and to the side of previous sites.

Red elms should not be treated as they may be injured by the chemical. Some epicormic branches and mineral bark splitting of American elms has occurred, but damage has generally been minimal or none at all, and results have been good. I hope they will be for you, too!

Editorial

A NIGHTMARE

By Monroe S. Miller

I had a bad dream last night. No, it was worse than a bad dream; it was a nightmare, and a very sad nightmare. Although my mind is filled with details, as so often happens with dreams, it seems strange the person centered in this dream is unknown to me. Unknown, yet familiar. It **could** have been me, or it **could** have been you. Morbid subjects don't make good essay topics, but this one had a deep, serious and long lasting lesson for me. It may have been a subconscious message. Maybe you will react the same way I have.

My sad dream was about death, the death of a good and kindly man. He was a man who worked hard and conscientiously and probably too much. He touched many lives and had many friends. He had a heart the size of a locomotive and if asked for help or almost anything else, he was right there. His work? Like most of us, he managed a golf course and managed it very well.

The quiet conversation at the funeral home seemed to center on how unbelievable it was that he should pass away at such a young age. He was only 52 and appeared to be in the pink of health. Most felt there was some special meaning in the fact that he died at the golf course, doing what he loved most. After all, wasn't he always at work?

The shock of his death got some to thinking why he had died. Healthy (or so he seemed), yet like me and too many others, he was 15 pounds overweight. And he was a worrier. He worried constantly, throughout the year, about the golf course. He worried about every little and insignificant complaint he heard from the members of the Club. He worried about his employees and their personal problems. He worried about his irrigation system, although it was new, and even about whether or not machines would start on the first try. He worried needlessly about his job and if he would be able to keep it. He worried and worried and worried.

And he worked too hard, far more hard than was necessary or desirable. He worked 7 days a week from opening day to Thanksgiving. Only during the winter months did he slow down and go home at noon on Saturdays. He had made it impossible for anyone to ever fill his shoes. The members had come to expect to see him at any time they were at the Club. He readily came to help those whose cars wouldn't start at 1:00 A.M. in the winter. He plowed snow the same way he prepared for a golf tournament. He simply worked too hard at everything.

Everything, except living. He played golf once a month because he felt obligated. And he hated it and always tried to find some way to escape from it. After all, he had too much work to do. Three days into a vacation, his wife told me, he was ready to go home. "I've got work to do," he said. He had no hobbies or extracurricular activities. Work was what mattered most in his life. He didn't even take time for lunch, unless you count the 5 minutes spent gulping down the brown bag lunch he carried for as long as he had worked. "No time for lunch — there's work to do."

He was, in fact, a typical Type A personality. You've read about the Type A personality, the person who is a classic workaholic. Although the doctors said he died from a massive heart attack, his friends and acquaintances immediately knew he had worked himself to death.

His wife, although grief stricken, seemed less surprised than friends did that he had died. She knew all too well of his nervousness. She knew he was overweight. And, like other Type A personalities, she knew he worked too hard. Club members all said to her, "We know you'll miss him terribly." She wanted to say that she already had missed him for too many years. His kids mirrored the feelings of their mother. A good father he was, and they loved him dearly, but they were wishing they had known him better. "He worked too much."

Maybe the saddest part of this dream for me was that already, at the funeral home, there were quiet discussions about replacing him. Oh, they were discreet and tasteful, for sure, but it was too soon for such talk. "How's his Assistant as a manager?", one member wondered to another. "Is he a hard worker?", asked another. Life goes on, we all know, but couldn't these practical and necessary matters wait a few days? It bothered me tremendously.

I awoke with a start. My hands were cold and clammy, and there were beads of sweat on my forehead. Although I was prayerfully grateful it was only a dream, I wondered who the person in this dream was. I didn't know, and the question still haunts me. It wasn't me, was it? It wasn't any of my friends that I could recognize. Granted, we are guilty of many of the characteristics of the deceased man, but can we not usually rationalize and justify the worst of them?

Was it you? Could **you** be the man who worked himself to death too early in life? The fact is, unfortunately, it could have been any one of quite a number of us.

There is a lesson for me in this bad dream. I absolutely must look carefully at my work style. The benefits of excessive hours of work at the golf course have to be measured against the potentially dreadful cost the person in my nightmare paid for his work habits. You may work hard (and smart), but when you are gone the memory of you and your work is short; the thoughts almost immediately move to "who will we replace him with?"

I feel for the subject of my dream. May he, finally, rest in peace.

Amen.

THE PHYSICAL PROPERTIES OF SOIL

By James R. Love, Department of Soil Science, University of Wisconsin-Madison

As an introduction to the discussion of soil, it might be well to ask, "What is soil?" The answer to this question depends largely on who is doing the asking. To the mother it is the dirt that gets on the child's clothing; while to the gravel quarry operator it is the overburden which must be removed to get at the gravel. A soil scientist working for the conservation service considers soil as a naturally occurring body on the landscape consisting of genetically related layers formed by the combined efforts of climate and vegetation acting on a particular parent material over a long period of time. To anyone in production agriculture, like the farmer, gardener or turf manager, the soil is that material (organic or mineral, synthetic or naturally occurring) which serves as the support medium for the growth of plants.

Regardless of the way people look at it, however, each soil possesses certain chemical and physical properties; and an understanding of these characteristics is essential if the soil is to be used wisely no matter what the purpose. The chemical properties of soil will be discussed by Drs. Kussow and Schulte. In this article, the emphasis will be on the physical properties of soil. By physical properties we mean those which can be sensed by the user, that is, felt or measured (like weight, depth, temperature, etc.). *It should be noted that it is quite common to find soils in which the physical properties are more limiting to plant growth than the chemical conditions of the same soil.*

Physically all soils are composed of solids (or particles) and spaces (voids or pores) between them. The first part of this discussion will deal with those physical properties related to the solid phase of soils, while the second part concerns those physical properties which are related more to the pore spaces in the soil.

Part 1. Physical Properties Associated With Solid Phase of Soil

A) Composition of soil solids. The solid portion of soil consists of organic and inorganic material having the following composition:

1. Soil organic matter can be dead or alive animal or plant material and may range in size from macroscopic to microscopic. Thus, it includes such diverse things as earthworms to bacteria and from roots to humus particles so small they can be seen only with the aid of an electron microscope. Humus is the colloidal and very active fraction of organic matter manufactured in the soil by many of these same organisms. Soils consisting largely of fibrous organic matter are termed Peats, while those composed mainly of non-fibrous organic matter are called Mucks. About 8% of Wisconsin's land surface (or approximately 2.8 million acres) are classified as organic soils. Peats are named according to the plant material from which they formed. Thus, there are woody, mossy (sphagnum and hypnum), reed-sedge peats, etc. In turf management peats are often used to condition soils and are applied at the rate of 10-20% by volume (foot printing generally occurs as values exceed 20%).
2. Soil inorganic matter consists of mineral particles derived from the weathering of parent rock. These particles are classified on the basis of size into one of three groups, called soil separates.[1/]

B) Soil separates. The three soil separates and their size limits are:

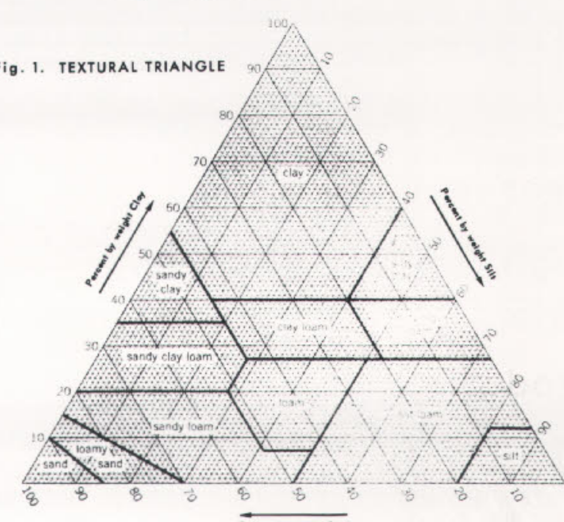
1. Sand (2 to 0.05 mm in diameter). In the metric system, 25 millimeters are approximately equal to 1 inch.
2. Silt (0.05 to 0.002 mm in diameter)
3. Clay (less than 0.002 mm in diameter)

Note: Particle size is important because it determines the surface area exposed by the various soil separates, which in turn determines their physical and chemical activity. Thus, clay is more active than silt which is more active than sand, and the degree of activity is related inversely to particle size. For example, 4 lbs. of a typical sand will expose approximately 40 sq. ft. of surface area. For the same weight of silt the area increases to 4,000 sq. ft., whereas, 4 lbs. of clay exposes about 40,000 sq. ft. (nearly 1 acre), and in the case of colloidal clay the value is approximately 10 times this or 10 acres of area.

C) Soil texture. The relative proportion of the three soil separates impart to each mineral soil its distinctive feel or texture. There are 12 mineral soil classes as seen in the textural triangle in Fig. 1. Depending on their texture, these 12 classes can be arranged into three groups: coarse, medium and fine, as given below:

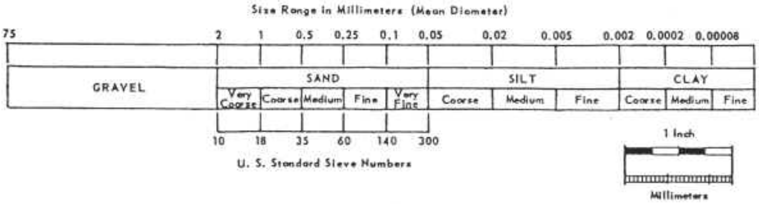
1. Coarse textured soils (CTS) are sand, loamy sand and sandy loam.
2. Medium textured soils (MTS) are loam, silt loam and silt.
3. Fine textured soils (FTS) are clay, sandy clay, silty clay, clay loam, sandy clay loam and silty clay loam.

Fig. 1. TEXTURAL TRIANGLE



1/Mineral particles greater than 2 mm in diameter (gravel, pebbles, etc.) are not considered unless they exceed 20% by volume of the soil. Then the soil's name reflects the modification, for example, gravelly loam.

COMPARISON OF PARTICLE SIZES IN USDA SYSTEM



Note: In Wisconsin approximately 33% of the surface mineral soils are CTS (of which sands and loamy sands predominate), while about 50% are MTS (with silt loams dominating) and the remaining 17% are FTS (of which clays, clay loams and silty clay loams dominate). The distribution of these soils in Wisconsin is given in the accompanying map and shows that in the southern part of the state silt loam soils are the most common textural class, while in central Wisconsin sands predominate. Clayey soils are found along the coastal areas of both Lake Michigan and Lake Superior.

Fig. 2. Textural distribution of surface soils in Wisconsin.

D) Soil structure. If soil texture is defined as the feel imparted to the soil by the relative proportions of the soil separates, soil structure refers to the arrangement of these same separates in the soil. Structure is classified according to grade, type and class.

1. Grade of soil structure refers to the degree that the soil separates are aggregated (that is, clumped together) and varies from strongly through weakly aggregated to no aggregation or structureless.
   a) Aggregated grade. The aggregation process involves two steps. First, the soil particles must be brought together. This is done chemically by flocculation and physically by drying, root growth, tillage, earthworm activity, etc. Secondly, the clumped particles are then cemented together to form an aggregate or ped, which is characterized by lines of weakness (called cleavage) between adjoining surfaces and by many different pore sizes within and between the peds. Humus, iron oxides, clay materials and carbonates are excellent materials that serve as cementing agents in soils.
   b) Non-aggregated or structureless grade. Two kinds exist, they are:
      i — Single grained. This is seen in CTS which do not contain sufficient cementing agents to bind the soil particles together and, as such, they occur as non-coherent, single grains. Loose sand is an excellent example of this grade.
      ii — Massive. This is seen in medium to fine textured soils (M-FTS) in which the aggregated structure has been ruined either physically by puddling or chemically by defocculation. The latter occurs in soils high in exchangeable sodium, such as coastal regions along oceans or other bodies of salt water. The physical abuse or puddling of soil is by far the more common, especially in Wisconsin, and occurs when the soil is worked or walked on when it is too wet (in the plastic form of soil consistence, to be discussed shortly). In the massive state the soil particles adhere to one another in masses, which upon drying are referred to as clods. These differ from peds in that they have no cleavage lines of weakness and exhibit few if any large or medium size pores. Soils in the puddled condition have been likened to concrete. This is an apt comparison because plant roots, tillage implements, air and water have a difficult time penetrating them, which makes growing plants in these soils something less than enjoyable.
2. Type of soil structure refers to the shape of the individual soil aggregate. Some of the more common structural types and their relative shapes are:
   a) Granular and crumb (spheroidal shapes). This is the ideal type of structure to have in the surface layer of M-FTS.
   b) Blocky and nuciform (cubic shapes). Typical structure seen in the subsoil of M-FTS.
   c) Platy (plate-like shape). Some M-FTS will have this type in their subsoil which causes internal drainage problems, since plates behave like shingles and impede downward movement of water in these soils.
3. Class of soil structure refers to the size of the aggregate or ped. It is an important consideration when planting seed. Small seeds (like bentgrass) require a finer seedbed than do large seeds, like ryegrass.

E) Soil consistence. To have a well aggregated soil is one thing; to maintain it is another. Soil consistence is the ability of an aggregated soil to withstand deformation and it varies with the texture, moisture and organic matter content of each soil. Some of the more common forms of soil consistence are:[2/]

1. Dry state. M-FTS are most resistant to deformation when soil is dry.
2. Friable state. The soil is moist. This is the most desirable form of soil consistence in M-FTS for tillage, root penetration, walking on the soil and improving its aggregation through aerification.
3. Plastic state. In this form, M-FTS are most susceptible to deformation. Working or walking on an aggregated soil in this state (water content between moist and wet) results in the destruction or puddling of the aggregates, leaving the soil in a massive (cloddy) condition upon drying. M-FTS in the plastic state of consistence should not be worked or walked on but rather should be allowed to dry out until the friable state of consistence is reached. An exception to this rule is when the intent is to puddle the soil, as in the construction of seepage barriers in earthen dams or to seal the bottom of man-made lakes, ponds or land-fill sites.
4. Liquid state. In this condition the soil is wet and behaves like a liquid. That is, it will tend to flow under an applied force. It is in this state that soil on a slope is subject to landslides. Also, it is at this form of soil consistence that cave-ins occur in tunnels or ditches.

F) Soil conditioning agents. These are mineral or organic materials which are used to improve the physical condition of soils. *It is interesting that these materials are equally as effective in CTS as they are in M-FTS, although for entirely different reasons.* In CTS the soil conditioning agent contributes the medium to small size pores these soils (as we'll see shortly in Part 2), are lacking, whereas, in puddled M-FTS the conditioning agent supplies the large pores which these soils need. Some common examples of these materials are:

1. Mineral conditioning agents. Calcined (fired) clay, diatomaceous earth, perlite and expanded vermiculite.

Note: Do not use the latter two materials on soils subject to traffic. Their best use is for flower beds and potting mixtures.

2. Organic conditioning agents. Rotted sawdust, compost, rotted manure and peat. With regard to the latter, it should be noted that experts prefer woody to mossy peats (and hypnum over sphagnum), with reed-sedge a poor third for conditioning turf soils. *In no case should one use sedimentary peat for this purpose due to its high content of fine mineral material.*

Table 1. Sand sizes by turf use.*

SAND PARTICLE SIZE CLASSIFICATION TABLE

	*ASTM Mesh		Sieve Opening Millimeter	Sieve Opening Inches		
	4		4.76	0.187		
	5		4.00	0.157		
	6		3.36	0.132		
	7		2.83	0.111		
	8		2.38	0.0937		
	9		2.00	0.0797		
	10		1.68	0.0661		
	12		1.41	0.0555		
	14		1.19	0.0469		
	16		1.00	0.0394		
	20		.84	0.0331		
RANGE	24		.71	0.0278	COARSE	
FOR	28		.59	0.0234		
BUNKER	32		.50	0.0197		
USE	35	RANGE	.42	0.0165		IDEALLY –
	42	FOR	.35	0.0139	MEDIUM	MINIMUM
	48	SOIL	.30	0.0117		OF 75%
	60	MIXES	.25	0.0098		MEDIUM
	65		.21	0.0083		SAND
	80		.18	0.0070		
	100		.15	0.0059	FINE	
	115		.13	0.0049		
	150		.11	0.0041		
	170		.09	0.0035		
	200		.07	0.0029		
	250		.06	0.0025		
	270		0.5	0.0021		
	325		.04	0.0017		

*Quality Sand Bunkers, Stanley J. Zontek, Vol. 2, May 1984 The Grass Roots.

Part 2. Physical Properties of Soil Associated With Pore Spaces of Soil

A) Soil porosity. Two aspects of this physical property are most important to plant growth, namely, the amount and size distribution of soil pores.

1. Amount of soil porosity determines the storage capacity of the soil for air and water, in addition to serving as the space through which roots penetrate the soil. Contrary to popular belief, CTS generally have the least amount of pore volume of all soils (about 80% as much as M-FTS). The reason they give the appearance of being "light" soils is due to their lack of aggregation, which gives them a loose, single-grained effect. On the other hand, M-FTS have about 25% more pore volume than CTS, yet they are commonly referred to as "heavy" soils, due to the fact that they contain sufficient fine material to cause the soil particles to adhere to one

---

[2/]It will be noted that these forms of soil consistence apply essentially to M-FTS. Soils like sands do not contain enough fine material to be aggregated and hence have a single grained structure. Now this can be both good and bad. The latter occurs, as we'll see in Part 2, due to the sand's limited porosity (both in amount and size distribution) which makes these soils droughty. The beneficial effect of a single grained structure, however, lies in the fact that these soils, with their lack of aggregation, can't be ruined even under severe physical (or chemical) abuse. This explains why sand is used in the construction of USGA Spec Greens and why it's preferred for topdressing and in bunker or sand trap use. In this regard, it should be emphasized that a well sorted sand of medium to coarse size is recommended, as given in Table 1.

another (either as peds or clods, depending on the soil condition as we have seen) and this produces greater friction or drag.

Note: The terms "light" and "heavy" in connection with soil refers to the amount of draw bar pull required in tilling the soil. CTS require less power than M-FTS, hence they are referred to as "light" soils whereas M-FTS require more power and are called "heavy" soils. In terms of actual weight (or mass) per unit bulk volume, one can quickly see from Table 2 that the CTS typically have the greatest bulk density and the least amount of pore space of all the soils.

Table 2. Typical values for some soil physical properties.

Soil Texture	Bulk Density g/cm³	Bulk Density lbs/ft³	% Soil Porosity
Sand	1.6	99.8	40
Silt loam	1.3	81.8	50
Clay	1.2	74.9	55
Muck	0.4	24.9	65
Peat	0.2	12.4	85

2. Pore size distribution. In CTS the majority of pores are large, which also helps to give these soils their "light" appearance. Large pores are ideal for taking in water and draining away the excess. However, they do not hold water very well and, therefore, CTS tend to be droughty. On the other hand, M-FTS which are puddled tend to have mainly very small pores (like concrete), thus causing them to be poorly drained. In the aggregated state, however, M-FTS have the ideal pore size distribution. That is, they have all pore sizes. . .small to medium sizes within and between the smaller peds and large size pores between the medium to larger peds.

B) Soil water. From the standpoint of water efficiency, a good soil is one which takes in water easily, drains away the excess readily and stores sufficient water between rains or irrigation to supply the needs of plants growing in the soil.

1. Infiltration is the entry of water into the soil. It is important because water that doesn't enter the soil obviously is not much use to plants growing in the soil. Moreover, water that doesn't enter the soil may be ponded on the surface, where it induces toxic reactions in the soil by preventing air exchange and destroys soil aggregates by softening the cementing agents. Also, if soil is on a slope water may runoff the surface and unless controlled can cause erosion and pollution problems. As stated earlier, soils with large pores have good infiltration rates. Thus, the importance of maintaining a well aggregated condition in M-FTS.

Note: CTS like sands, with their preponderance of large pores, have excellent infiltration rates. For this reason coarse sand (or fine to medium gravel) is often recommended for use in the construction of slit trenches; however, it should be emphasized that the effectiveness of these materials will be severely impaired if one then covers them with a layer of M-FTS as a means of inducing grass to grow over the slit.

2. Water storage. Water is held in soil by the forces of adhesion and cohesion. Water is attracted to the surfaces of soil particles by the force of adhesion (and the finer the particles the more surface area that will be exposed to this force as we've seen earlier). The force of cohesion is responsible for holding water in the pore spaces between these particles due to the attraction of one water molecule for another, creating a bridging effect in the water. Approximately half of the water stored in soil is available to plants growing in the soil (the other half is held so tightly to the soil particles and in the very fine pores as to make it unavailable for plant use). M-FTS generally have about twice the available water supply as CTS. In terms of plant use this means that in each foot of M-FTS, there exists about a two week or more supply of water, whereas, a foot of CTS holds about one week or less supply. The importance of soil depth favorable to plant roots becomes readily apparent, as does the rooting depth of plants. Thus, a soil may be deep and contain a good supply of available water but if the plant (like **Poa annua**) is shallow rooted, especially when cut at green height, it will soon be subject to desiccation.

Note: The construction of greens according to USGA specifications utilizes two physical properties of CTS which we have already mentioned and another basic principle of soil physics as we shall shortly see. For example, USGA spec greens are constructed out of sand because of their a) excellent infiltration rates and b) resistance to compaction, even when heavily trafficked under wet conditions. However, as with all sands, they tend to be droughty and it is in this regard that use is made of a fundamental law in soil physics, namely that the flow of water from a smaller to a larger pore space only occurs under conditions of saturated flow. That is, water cannot drain from a medium to coarse sandy topsoil that is underlain by fine gravel until the overlying layer of sand adjacent to the gravel is saturated. Only then can any free water be drained. In essence what this does is to create a perched water table above the gravel layer that increases the water storage capacity of the otherwise droughty sand. In short, it can make the sand hold as much water as some loamy soil but without the danger of becoming puddled when the golfers walk on it or maintenance equipment is driven over it. Truly, this is the best of all possible worlds for golf (or any athletic) turf.

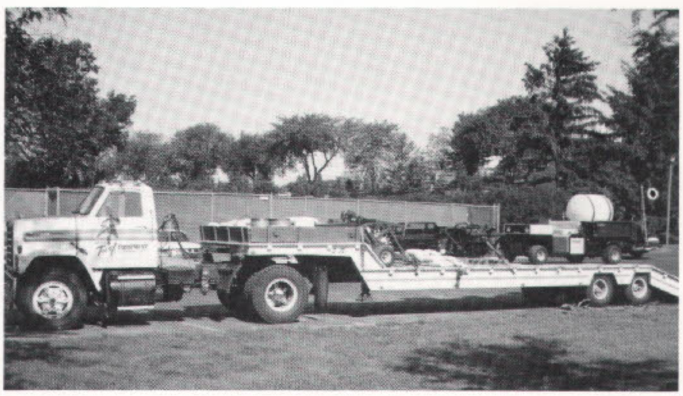
3. Soil drainage. As discussed earlier, surface draining is necessary for good plant growth (certain plants like paddy rice are exceptions). Equally important is the drainage of excess water that has entered the soil, because unless this water is removed, good aeration is impossible and plants which are unable to respire cannot absorb nutients, including water. It may seem paradoxical that plants in a waterlogged soil could actually suffer from lack of water and wilt. Yet such a condition was observed a few years ago on national TV during the U.S. Open when play

had to be stopped so that the maintenance crew could cool the desiccating turfgrass by syringing it, in spite of the fact that prior to the tournament the course was deluged with rain. This so-called condition of "wet-wilt" arises whenever the plant is unable to respire properly, as in a wet, compacted soil. Poor aeration can also lead to deficiencies of nitrogen, potassium and iron, any one of which can produce the chlorotic discoloration often seen in turf trying to survive in poorly drained, compacted soils. Soil drainage affects plant growth in yet another important way, namely through its effect on soil temperature.

C) **Soil temperature.** The specific heat of water is about five times that of a dry mineral soil. That is, the heat required to raise the temperature of water 1 °C is five times greater than that needed for an equal weight of soil. Thus, a wet, poorly drained soil is generally a cold soil and improving the drainage (either surface or subsurface) helps warm the soil. This also explains why plants growing in a CTS get off to a faster start in the spring than those in a M-FTS. Thus golf courses on sandy soils are the first to open in the spring, in northern climates, whereas, those on organic or clayey soils open later. Other ways of affecting soil temperature include irrigation or syringing, which produces a cooling effect when the water evaporates. In this regard it should be noted that a transpiring grass plant can be considerably cooler (as much as 10 °F) than one that is not. Thus well cared for lawns and shade trees, whether they be in the yard or a home or on a golf course create a more pleasant environment even aside from their aesthetic attributes.

UW TURFGRASS RESEARCH RECEIVES CUSHMAN TRUCKSTER AND ACCESSORIES FROM OMC/LINCOLN AND WISCONSIN TURF

The departments of Plant Pathology, Soil Science, Horticulture and Entomology recently received the free use of a Cushman turf vehicle for turfgrass research. The award was made possible by OMC/Lincoln and Wisconsin Turf Equipment Corporation. Dr. Bob Newman and Dr. Gayle Worf accepted the keys from Curt Larson, General Manager of Wisconsin Turf, on May 29. The unit is provided at **no cost** to the UW—Madison and has a total package value of over $12,000. OMC/Lincoln started the program in 1982, and company executives feel the student exposure and training will be beneficial to them as they pursue their turf management careers after graduation. This is the first year the University of Wisconsin received this important support.



The award is from OMC/Lincoln and Wisconsin Turf.

The unit is fully equipped and available for use for all of 1985.

Curt Larson presents Bob Newman and Gayle Worf the Cushman keys.