JULY 1977

USGA GREEN SECTION RECORD

A Publication on Turf Management
by the United States Golf Association

It Plays Well. It Looks Well.

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It's the Rub of the Green

by WILLIAM G. BUCHANAN, Mid-Atlantic Director, USGA Green Section

Some thoughts from an Agronomist . . . who also happens to be a scratch golfer. Editor

In the United States today, according to figures compiled by the National Golf Foundation, 12 million people play golf 15 or more times during each year. Other information provided by the NGF tells us we have approximately 12,000 golf courses in this country. Of these, about 42 per cent are private clubs. The remaining 58 per cent are either daily fee or municipal-type operations. No matter where the game is played, a tremendous amount of golf is going on today.

Every round presents some form of challenge to the individual golfer. The setting may vary from a wooded, mountainous golf course to a wind-swept links or a lighted par-3 in a metropolitan area. Although the location may change, each course, each hole, and each shot presents a challenge to each golfer. I am not at all sure, however, that each golfer realizes the role good golfing turf plays in his enjoyment of the game.

The golf course superintendent, the golf professional and the manager can and do affect the quality of the challenge of the golf course. This is not to say that every golf course should be set up to the standards of the United States Open. However, they should be set up to require a certain amount of skill in playing the game. Richard S. Tufts, former President of the USGA, has said,

> "A golfer must expect variations caused by terrain, by constant use, and the changing conditions of the growing things. That's all a part of the challenge, it's the rub of the green aspect that makes golf the challenging and exciting game that it is."

It is the job of the superintendent, the golf professional and the manager to educate the golfer, not only on how to play the game, but about the surface on which the game is played. I feel it is just as important for the golfer to understand and appreciate good playing surfaces as it is to be educated on the proper etiquette of the golf game.

How many times have you heard "the greens are getting hard; what you need to do is water them more," or "the rough is getting too high; I had a shot that went into the rough the other day, and I had no chance to reach the green," or "that fairway bunker has to be redesigned; if you hit the ball into it, you have no chance to get it to

Marking the course properly helps the players.

Golfers improving lie on fairway, and riding the carts that make it necessary.

the green," or "the pin placement on No. 7 green was illegal. There was no way that I could hit the ball at the flag because, if I miss the shot just a little, I would be in the water"? These are all comments that are heard time and time again by golf course superintendents and green committee chairmen. These comments all refer to elements of the game that are part of the "rub of the green" to which Tufts referred.

There is nothing in the Rules of Golf that says you have to be able to reach the green if you knock the ball into the rough, or that you have to be able to shoot straight at the flagstick, or that every "good" shot hit onto the green must hold the green. These are factors that are influenced by the conditioning of the golf course and the quality of the challenge. The USGA had the foresight to recognize these types of challenges and has established a USGA Golf Handicap System. The system is based on a course rating and is used to handicap players so that, although the players differ in ability, they should be able to play on an equal basis.

Many of the nation's 12 million golfers are not as familiar with the reason behind the handicap system as they might be. They are playing the game at a time when "preferred lies" or "winter rules" are the rule as opposed to the exception to the rule. Everything the new golfer has been exposed to at the golf course is geared to improve his game. He has been exposed to all the new improved equipment that makes the ball supposedly fly straighter or go farther than any other ball. The golfer's entire way of thinking has been changed to where the equipment and the course should be maintained to suit his game, not that, heaven forbid, he should have to adjust his game to suit the course's conditions. Today's golfer has come to believe, "If it's green, it's good, and a lush golf course is a prerequisite to a good score."

Many golfers today believe course conditioning and their own expensive equipment should and will compensate for their playing deficiencies. The 20 handicapper stands at the 150 yard marker (placed there by his request) with a downhill lie. He not only expects his ball to hold the green (just like Johnny Longknocker's ball did when he hit an 8 iron from the same position), but also expects it to stop immediately. If the high handicapper's ball does not hold the green, it is not because of any fault of his — it's because the greens are too hard. Of course, the club's professional staff will hear about this as soon as he returns to the clubhouse.

Unfortunately, Mr. High Handicapper's complaints are often taken too much to heart. Surely, all members' complaints, no matter how small, are to be listened to, but if the greens are going to be watered more often just to make them hold, the quality of the turf will suffer. I have yet to observe a golf course that has a good quality playing surface that has lowered its standards to appease the higher handicapped golfer.

The putting greens are generally the first to receive criticism. It is the nature of the way golf is played. Approach shots are hit to every green and, according to par, two putts are allowed on every green. This means the putting surface has to be of good quality. The majority of the strokes in the game are taken there. However, and this must be kept in mind, the putting green is not so much a landing area as it is a putting surface. To provide the best possible putting surface, every effort must be made to keep the green firm and the putting surface fast and true. Any break of the green must be influenced solely by the contours of the green and not by top growth. Therefore, a good putting surface does not display the characteristics of a good landing area. Mechanical operations, such as spiking and top-dressing, will greatly assist in developing a true putting surface. They will also assist in providing a surface that has some resilience to it, so that the properly played golf shot will hold the green.

Invariably, the height of cut will enter into a discussion on the quality of the putting surface. The frequency of cut can do just as much or more to improve the quality of the putting surface as the

height of cut. By mowing greens daily, they can be groomed and the growth on the surface controlled. Of course, the amount of nutrition and the amount of water the greens receive also have a tremendous effect on putting quality. A green that is slow but consistently growing is much easier to maintain. By controlling nitrogen on greens and keeping them on the hungry side, a better quality putting surface can be realized. There is no great secret that a turf maintained under light but frequent fertility causes far fewer problems than a green with a fast, lush growth.

It might be well to consider the benefits of slow but steady growth for grass on the greens. Number One, if the grass is growing slower and we mow it more frequently, there will be fewer clippings with which we must deal. Number Two, a slow-growing turf will have a more rigid blade and will be easier to groom into upright growth. Number Three, a slow-growing plant will have a thinner blade which will stand up under traffic stress. And Fourth, it will provide a better playing surface.

Maintaining a firm, true putting surface may not win for the superintendent the neighborhood badge for the greenest green, but more than likely it will put your club in the position of being known as a club that has a golf course. Please understand, I am not trying to leave the impression that the putting greens alone make a golf course. That is not so. We all know they are only a portion of it. The fairways, roughs, bunkers and other hazards, as well as the tees are all part of the whole. The condition of these areas must also be maintained with a high degree of professional skill if one is to have a challenging course.

With the inception of "preferred lies," the new golfer has come to think of a fairway as that area between the roughs where the ball may be moved, teed up and made ready for the next shot. Harry W. Easterly, Jr., President of the USGA, refers to them as "those insidious Winter Rules." How many of today's golfers realize the tremendous improvement in the quality of fairway turf over 20 years ago? With the strides that have been taken and the amount of money spent today on maintaining the fairway, the professional staff at the club should be doing everything in its power to convince the members that they have excellent fairway playing surfaces. Again, winter rules are only another step in the direction of eliminating the "Rub of The Green" from the game.

If today's golfer insists on preferred lies, a great deal of money could be saved in golf course maintenance. This could be done with minimal fertilizer on the fairway, no water, and mowing fairways twice a week whether needed or not. This would greatly reduce the maintenance costs and give the golfer a reason to move the ball.

A quality golf surface that is well-groomed can be maintained with a reasonable budget and will provide an excellent quality playing surface. There is no need for preferred lies. On the other hand, a lush, highly manicured layout can give the appearance of a quality playing surface, but still not provide the essential ingredients of a good golf course.

The club's professional staff can make a significant contribution to golf by providing leadership for the members in determining what constitutes a good golf course and good playing conditions. They should focus on the individual golfer's talent. They should stress that good course conditioning complements those talents and should not be expected to compensate for a deficiency in them. And then, after all is said and done, that single most exciting and challenging quality of the game will be preserved; "The Rub of The Green."

"That'll teach that bunker to make me miss a shot."

A Scoopful of Soil . . .

Pail of soil with scoop conveniently attached to the golf cart.

by TOM MASCARO, Turfgrass Products Corporation

Riviera Country Club, located in Coral Gables, is one of the old, well-established clubs in the area. When the site for this club was selected it was part of the old Biltmore Club, which was established in 1926. In 1930 the 18 holes of the present Riviera Club were abandoned and much of it grew to weeds. In 1946 the Riviera Country Club was formed. Through the years many changes and improvements have taken place.

It has always been difficult to grow good turf at this club. One of the basic problems is that topsoil is practically nonexistent. When Lou Oxnevad, the present superintendent, came to Riviera, he began a long-range plan of improvement. Anyone who knew the course in former years can attest that Lou has done a great job. His efforts have ranged from improved parking facilities and landscaping to complete renovation of the fairways. Our story centers on Lou's fairway improvement program. The common bermudagrass on the fairways provided poor playing conditions. Lack of soil also contributed to the problem. The course is built on a solid coral rock base. Topsoil ranges from as little as one inch to three inches. Lou felt that the only solution was to plant a hybrid bermudagrass and hope for the best. Any other approach, such as hauling in topsoil, would have been too costly. He selected 419 bermudagrass, which was cut and sprigged into the existing turf. Paraquat was used to burn back the common bermudagrass. The renovation program was successful. The limited topsoil, however, is still a problem — especially when divots are taken.

Lou tackled this problem in a rather unusual way. Buck Luce, the club professional, mentioned that he had played a course where some of the members carried a pailful of soil on their golf cars and put a handful down instead of replacing divots. Lou latched onto this idea in his usual dynamic way. First, he reasoned that replacing divots was detrimental because they smothered new healing growth. Second, he knew that replaced divots only remained in place until the next mowing, which knocked them out and chopped them up. However, as a good golfer himself, he knew that replaced divots also made for a fair lie for following golfers.

Filling divot holes would do a number of things that would please the golfers and be good for the grass. Placing soil in divot holes would provide a fair lie for the following golfers. Placing soil in the divot hole would be good agronomically, since grass would be stimulated for regrowth and not be smothered. Best of all, much needed topsoil would be put down. However small, over a period of time this could become significant.

The plan was simple. Provide every golf car with a bucket of good soil and a small scoop. At first the membership was cool to the idea. After a while, however, they found that it was no trouble

at all to place a small scoopful of soil in the divot holes. As membership enthusiasm (and pride) increased, everyone got the fever. Today almost all the members use the system.

Lou experimented with various size buckets and scoops until he found the most practical and convenient sizes. After trying inexpensive buckets and scoops, he has gone to good substantial plastic buckets and metal scoops. He drills two ⅜-inch holes in each bucket about three inches from the top and one inch above the bottom for drainage in case of a sudden downpour. The buckets are fastened to the golf cars at a convenient height. They are out of the way and in no way inconvenience the golfer. They are easy to fill, easy to use. All 58 golf cars at Riviera are equipped with buckets of soil. Every morning the buckets are refilled. About three wheelbarrow loads of prepared soil mix are required each day on the average. In other words, approximately one-third of a yard of soil is added daily. This may not sound like much, but Lou estimates that the golfers have put out about 25 yards of soil since the plan was started in July. The great thing about this effort is that everyone is serious and conscientious about it.

One weekend they ran out of top-dressing and there were so many demands by the golfers for full buckets that the crew had to use almost pure sand with whatever soil they could mix with it. On another occasion, one group came back five times to refill their buckets in one round.

This effort at Riviera Country Club demonstrates and proves many things: The golfer's pride and concern for his golf course, good communications within the club organization, good communications with the members, and equally as important, a superintendent like Lou Oxnevad is tuned in to the needs of his club.

Lou Oxnevad, the golf course superintendent at Riviera Country Club, Coral Gables, Fla., shows simple step to repair divot.

TEE ALIGNMENT: Don't Overlook It

by STANLEY J. ZONTEK, Northeastern Director, USGA Green Section

In reading through the various golf course trade magazines, a substantial amount of copy is spent on maintenance procedures, management programs, and various problems relating to construction, grasses, putting greens, drainage, etc. This is fine. However, this article will concentrate on one small but important aspect of tee construction and how it affects the play of the game and how we, as turf managers, may or may not improve this situation.

Golf is a unique sport. Every golf course is unique and different from the next. Each requires a vast assortment of shots to fit the particular situation of where the ball lies. Up to 14 different clubs may be used. Any number of shots are taken from fairways, bunkers, roughs and certainly any number of putts are taken on greens. However, there is one particular aspect of the game where all courses are the same — never less than 18 shots are played from the teeing grounds to complete 18 holes of play. Therefore, somewhere in the neighborhood of 20 to 25 per cent of all golf strokes during a par round originate from tees. It is somewhat surprising that with so many strokes played from tees, these important play areas can be as neglected as they are. In the usual scheme of priorities, the greens come first, the tees second, the fairways third, and bunkers and roughs come in fourth and fifth. Even though high on the priority list, tees usually are one of the weaker turf areas on the golf course. They usually require much work to keep them in good playing condition.

In my travels as a USGA Green Section Agronomist, I see many different types, shapes and sizes of tees. I often find one important aspect of tees often overlooked; i.e., tee alignment. The direction the tee is pointing in relation to the designed direction of play for that particular hole is important to the golfer. *Figure 1* pictures a par-3 tee that is actually pointed directly at a clump of trees and not at the green. When setting up to play the shot, this misdirection can certainly affect the player's stance, alignment, and the end result of his shot from the tee.

Why Is This Alignment So Important?

The alignment of the tee whether good or bad can affect the play of the hole, especially for the higher handicapped golfers. They usually make up a majority of club players. Teaching golf professionals often state that one of the most common problems with higher handicapped golfers is aligning themselves correctly to play the golf shot. If they are properly aligned and they hit the shot

Figure 1. *The alignment of this tee can make the shot played to the green very interesting.*

Figure 2. *Superintendent Jack McCarthy of the Old Westbury Golf and Country Club, Old Westbury, N.Y., contemplates what to do with this tee pointing play directly into the woods.*

correctly, then the ball should go where initially aimed. If the golfer is poorly aligned, a properly hit shot simply has no chance of going where it was expected to go.

The better golfers, and perhaps this is one reason why they are better, usually realize the importance of alignment, and they make certain they are properly set before hitting the ball. The point is, tees can either make alignment for play easy or difficult; there seems to be a psychological correlation between the way the tee is pointed and how the golfer tends to line himself up with the edge of the tee and not necessarily the tee markers.

Why Poorly Aligned In The First Place?

Experience seems to indicate that improper tee alignments are really no one's intentional error. Golf course architects usually lay out a course with the center line for each hole running through the center line of the planned tees. Construction contractors usually intend to properly align the tees according to the architect's plans. Construction equipment operators usually try to do the job as directed by the contractor. Finally, the golf course superintendent usually inherits the end result — good or bad. So, by the time the tees are in play any number of situations could have caused the tee to be pointed improperly. Once constructed, it is usually difficult to justify completely rebuilding a misaligned tee, especially if the importance of tee alignment is not appreciated. If not initially constructed correctly, any realigning work usually must wait until later when the tees are renovated for whatever reason.

Once a tee is misaligned, as in *Figure 2*, there really is nothing the golf course superintendent can do other than to try to square off the tee by cutting the grass in the desired angle of play, and by instructing his crew to properly align the tee markers when changing them during the week. This all helps. However, in a bad situation all that really can be done is, when the tee is renovated, enlarged, rebuilt, etc., to realign it according to the play of the hole. This is the point where the golf course superintendent has an excellent opportunity to actually do something to improve the play of the course. When tee renovation work is scheduled, be sure to realign the tee to the hole. Little extra effort is involved.

One point should be stressed. Square, rectangular, or free-formed tees all can be aligned to the hole. Shape and design really do not matter; it is the sense of direction that counts.

Figure 3 illustrates a common occurrence. A tee is being rebuilt, but is not being aligned with the hole. Rather it is being aligned with the ladies' tee in front. This is not to say that it was done intentionally, but that perhaps few people really realize the importance and the value of properly aligned tees. This, in a nutshell, is the purpose of this article . . . to show that tees, no matter what shape they take, can be so constructed as to aid the golfer as opposed to unintentionally making things more difficult and complicated.

If you wish to test this thesis, look at the direction of the divots taken from any of your tees and

Figure 3. *When reconstructing a tee, don't underestimate the importance of tee alignment to the play of the hole.*

see if they point out of play. If in the majority of cases they do, then the tee's alignment is actually adversely affecting the play of the hole and thus inadvertently penalizing the unknowing golfer. Therefore, when planning tee work, don't forget the tee's alignment.

A good tee should be firm underfoot . . . not hard or mushy; level . . . not uneven and bumpy; adequately sized . . . so that good turf can be maintained on it; and finally, pointed in the desired direction of play. In practice, all of these points are essential for a good tee. Certainly the importance of a good-sized, firm and level tee is appreciated. But tee alignment, although perhaps a smaller point, can be a very important quality to an already struggling high handicap golfer.

Turfgrass Bibliography **NOW AVAILABLE**

A bibliography of turfgrass literature from 1672 to 1972 has been completed and is now available. It was compiled and edited by James B. Beard, Harriet J. Beard, and David P. Martin. For the first time, the turfgrass literature has been assembled in an organized reference format in one single publication. The *Turfgrass Bibliography* contains more than 16,000 references listed alphabetically by author. These references are then cross listed in a subject index containing more than 40,000 entries. Included are scientific, semi-technical, and popular writings covering all phases of turfgrass science, culture, and management.

The bibliography was compiled over 10 years while the senior author was writing the textbook, *Turfgrass: Science and Culture*. It should be a valuable reference source for scholars of turfgrass culture, private and commercial turfgrass researchers, teachers, adult extension workers, students of turfgrass culture and management, golf course superintendents, and other practicing professionals involved in the preparation of articles and talks concerning turfgrass culture and management.

A limited edition of 1,500 copies has been published by the Michigan State University Press, a nonprofit organization. Financial assistance in publishing the book was given by the O. J. Noer Research Foundation, United States Golf Association Green Section Research and Education Fund, Inc., The Michigan Golf Association, and The Michigan Seniors Golf Association. Turfgrass professionals interested in purchasing a copy should contact Lyle Blair, Michigan State University Press, Room 25, Manley Miles Bldg., 1405 So. Harrison Road, East Lansing, Mich. 48824. Price per copy is $35.00 plus 45 cents shipping charges in the United States. Allow two weeks for delivery. Add 4 per cent tax for Michigan residents.

Principles of Soil Preparation for Drained Golf Greens

by L. ART SPOMER, Associate Professor of Plant Physiology in Horticulture, University of Illinois, Urbana

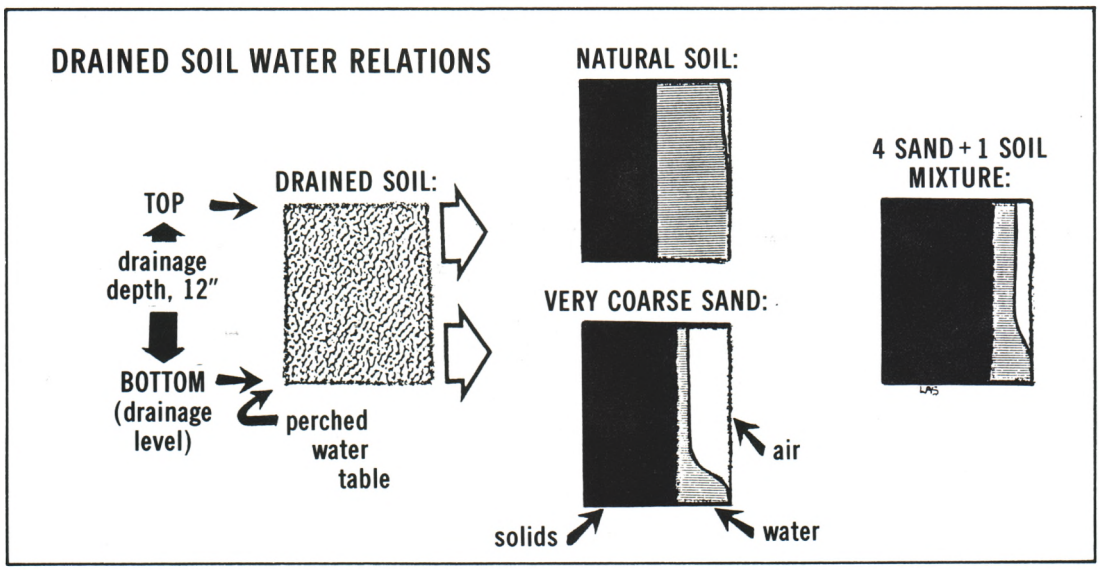
INTRODUCTION

Plants grow by accumulating raw materials (carbon dioxide, water, minerals, and energy) from their environment. Our cultural practices for golf green turf maintenance are therefore oriented toward providing an optimum supply of raw materials to the turfgrass community.

In relation to these cultural practices, the plant and its environment may be divided into above ground (shoot and aerial environment) and below ground (root and soil environment) portions with the growth of the whole plant depending upon the interaction between them. Shoots absorb energy (light) and carbon dioxide while roots absorb water and minerals. The turfgrass shoot is well-exposed to its energy and carbon dioxide supply; however, the root exists in a relatively unfavorable supply environment where replacement of absorbed water and minerals near the root's surfaces occurs very, very slowly. Plants therefore have evolved tremendously extensive root systems which often have over a hundred times as much surface as the shoot (even though the shoot may actually be two or three times heavier than the root). The development of an extensive, functioning root system is therefore essential for proper turfgrass growth and survival.

The proper development and functioning of turfgrass root systems necessitate an adequate soil environment. Unfavorable soil environmental factors will inhibit root development and functioning. Many biological, chemical, and physical factors directly and indirectly affect plant root growth and function. These factors affect either soil water retention and movement or plant root growth and function. The most important soil physical factors directly affecting plant water absorption are soil water content and soil aeration. Water content, the amount of water in the soil, is important because it directly indicates how much water is potentially available for plant use and indirectly how tightly it is held in the soil. Soil aeration, the exchange of oxygen and carbon dioxide between the soil and above-ground atmospheres, is important for maintaining a constant supply of the oxygen required

Figure 1. *Drained golf green soil water relations. A perched water table forms at the bottom of the soil (drainage level) and any soil in the green will be saturated at the bottom. Most natural soils are saturated throughout their entire depth following drainage. Very coarse-textured materials such as sand are saturated at the bottom and dry at the top. An ideal green soil is a compromise between these two extremes and is achieved by mixing sand (or other amendments) with soil. The amounts of solids, water, and air in natural soil, very coarse-textured sand, and a mixture of soil and sand are illustrated in this diagram.*



for good root growth and absorption. Soil water content and aeration both depend upon the amount and size distribution of the soil pores which, in turn, depend upon the size and packing of the soil particles. We can therefore control the physical environment of the soil by controlling soil porosity with special soil mixes.

This article briefly considers the principles for optimizing the golf green soil physical environment through the use of soil mixes.

DRAINED GOLF GREENS

Drained golf greens are different from other golf course turf sites, and they therefore must be backfilled with special soil mixtures during construction in order to avoid excessive water retention (poor aeration) and compaction. The relatively shallow drainage and heavy traffic on these drained greens render natural soils unsuitable for these sites. The purpose of these special media is to insure the proper balance between water retention and aeration through control of the pores.

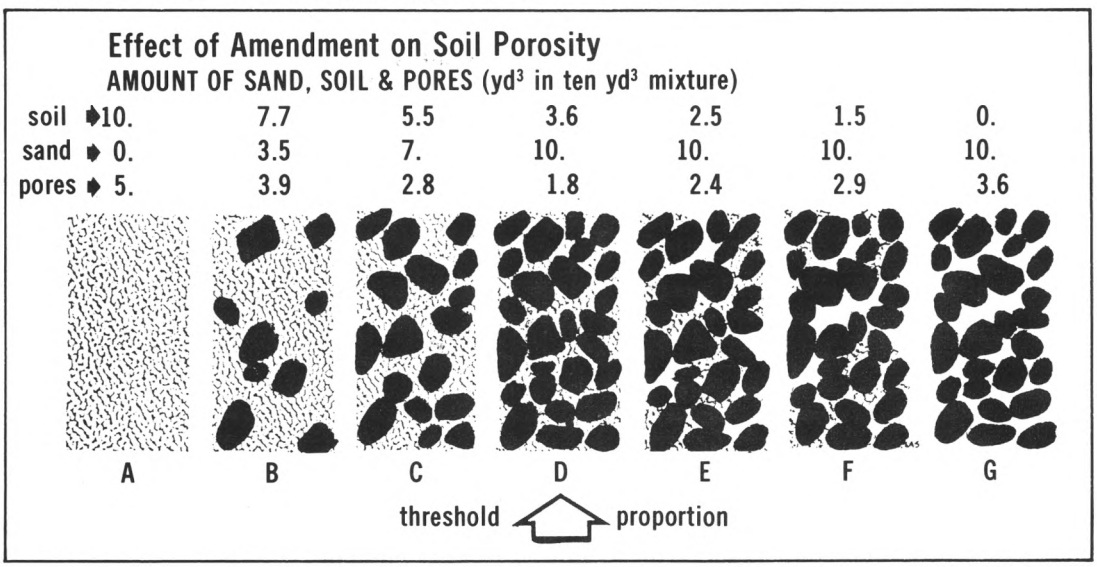
Most drained golf greens have two important features which distinguish them from other golf course turf sites: (1) they are subject to severe foot and mower traffic and (2) they are drained. The effects of the traffic are obvious (soil compaction, poor root growth and absorption); however, the effects of the shallow drainage (excess soil water content and poor soil aeration) are less obvious but are generalized in *Figure 1*. A perched water table forms at the bottom (drainage level) of a drained green soil following irrigation and drainage. Any media in such a site will be saturated at the bottom and water content will decrease with height above the bottom. Almost any medium of fine-textured natural soil will be saturated throughout its entire depth and grass growing in such natural soils will likely suffer from poor aeration. At the other extreme, a very coarse-textured medium will have excellent aeration but will retain insufficient water for growth, especially when the plants are young. The main difference between these two media is that the soil contains primarily small, water retention pores which remain water filled under the influence of the water table, whereas the sand contains primarily large aeration pores which drain despite the water table at the bottom. An optimal medium for a drained golf green would be a compromise between these two extremes. It is usually attained in practice by mixing very coarse-textured amendments such as sand, calcined clay, perlite, etc. with soil in order to provide sufficient large aeration pores while at the same time retaining sufficient water retention pores to insure adequate growth.

SOIL AMENDMENT: SOIL PHYSICAL CHANGES

Soil or root growth media suitable for turfgrass growth in drained greens are therefore prepared by amending soils. Unfortunately, too little amendment reduces both soil aeration and water retention without increasing the soil's resistance to compaction. Too much amendment reduces water retention excessively. The optimum amount of soil amendment should maximize soil compaction resistance while at the same time provide soil aeration and soil water retention which closely match those required for good turfgrass growth and water absorption.

Figure 2 pictures what happens as a coarse-textured amendment is mixed with soil in increasing proportions. Beginning with 100 per cent soil, mixture porosity first decreases, then increases

Figure 2. *Effect of increasing amounts of amendment on soil porosity. The sand is a very coarse-textured river sand and the soil is a silty clay loam. Mixture component proportions are shown as mixing or bulk volumes. Mixture total bulk volume was kept constant.*



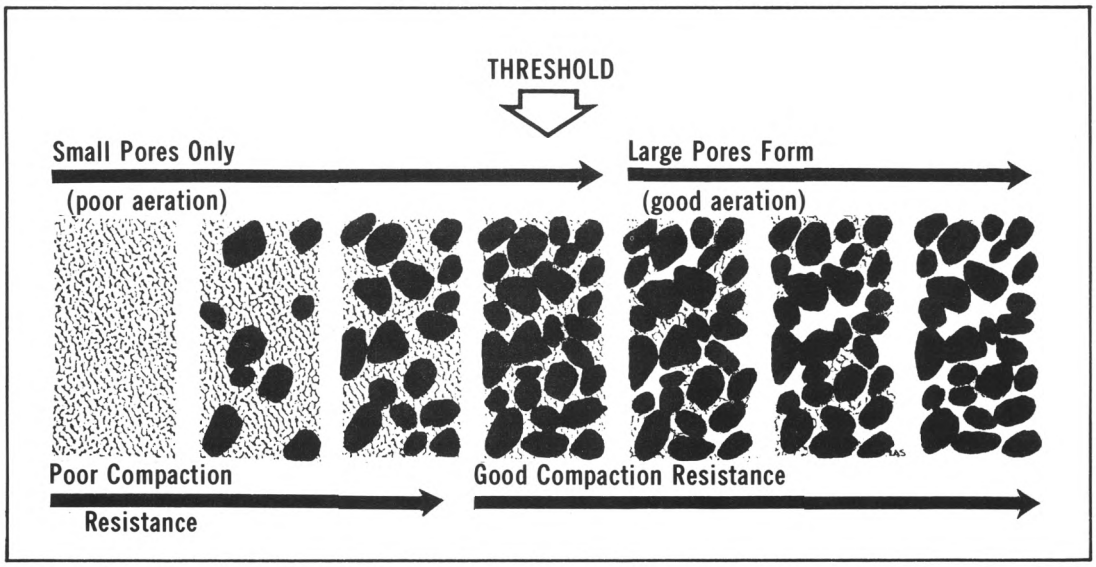
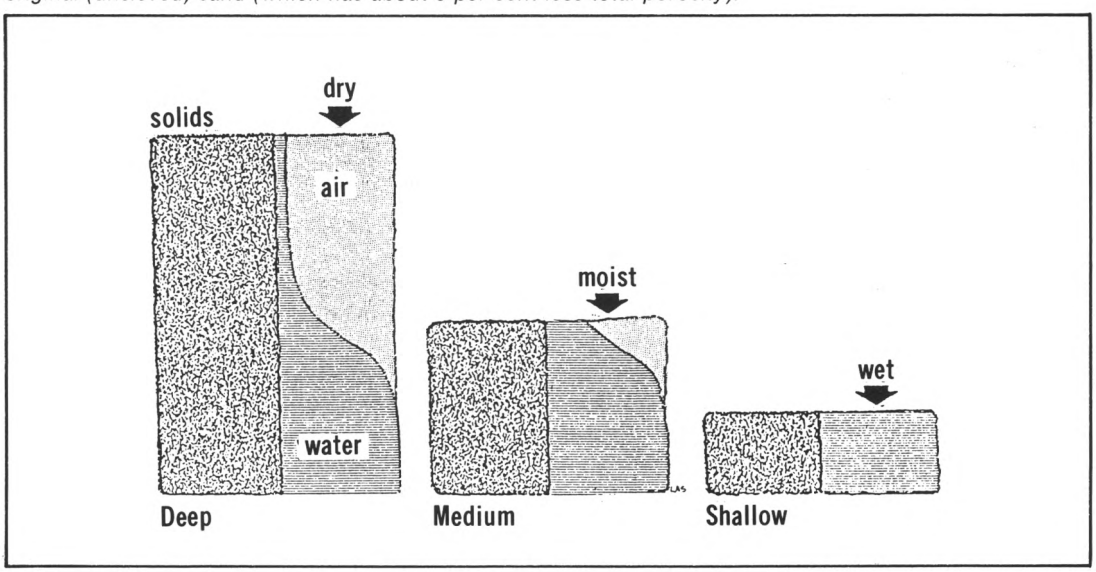


Figure 3. *Pictorial diagram generalizing the effect of increasing amounts of amendment on soil porosity, water retention, aeration, and compaction resistance (see Figure 2).*

with the addition of amendment in increasing proportions. Porosity initially decreases because the amendment floats in the soil or excludes soil solids and porosity without adding any large amendment pores (A, B, C). The minimum porosity occurs at the threshold proportion (D), which is the mixture in which the green excavation is exactly full of amendment and the large pores between the amendment particles are exactly full of soil. In other words, the threshold proportion is determined primarily by the amendment's interporosity (porosity between the particles). This mixture is called the threshold proportion because it delimits the minimum proportion of amendment required before further amendment begins to improve soil aeration. Total porosity is at a minimum at the threshold and aeration porosity is still nonexistent, so this is the worst possible soil mixture for plants. The threshold proportion is an excellent mixture for making a path, roadbed, adobe house, or earth-

Figure 4. *The effect of amendment particle size on water retention in a drained golf green. The amendment was a river sand which was sieved to obtain the various particle size fractions (USDA classification). Only the very coarse-textured sand and coarse-textured amendments would be suitable materials for drained golf greens (usually about 25 to 30 centimeters deep). The dashed line indicates the water retention of the original (unsieved) sand (which has about 6 per cent less total porosity).*



fill dam, but not for golf greens. Because the amendment particles also first exhibit particle-particle contact at the threshold, this mixture also delimits the minimum amount of amendment required for good compaction resistance. As the amendment proportion is increased above the threshold (E, F, G), aeration pores are emptied of soil and aeration and total porosity both increase. Looking at this in another way, at and below the threshold (A, B, C, D), amendment particles merely occupy volume in the green without adding any porosity. All we have done up to the threshold proportion (A, B, C, D) is reduce the soil volume (water and nutrient storage) without adding aeration, so any amount of amendment below the threshold worsens the soil physical environment. At and above the threshold proportion (D, E, F, G), the small soil particles fill in the large pores between the amendment particles to varying degrees. This effect of soil amendment on porosity and aeration is summarized in *Figure 3*.

The threshold proportion is the minimum amount of amendment which must be added to soil before any improvement in aeration can be expected. The threshold proportion depends on amendment particle shape and, to a lesser extent, size. It is directly related to the amendment porosity (about 25 to 35 per cent for most sands, 35 per cent for calcined clay and perlite). For a sieved sand or medium grades of calcined clay or perlite, the threshold proportion is about 10 volumes of amendment mixed with 3½ to 4 volumes of soil. A safe mixture for a drained golf green should therefore be about 10 volumes of sieved amendment (no fines) mixed with 2 to 2½ volumes of soil. If the fines have not been washed or sieved out of the amendment, a safe mixture for drained golf greens would be about 10 volumes of amendment mixed with about 1 volume of soil. Organic amendments such as peat, bark, and others generally require less amendment to reach the threshold proportion. Such amendments, however, are also less stable and tend to decompose or change with time and therefore may not be desirable for use in a golf green.

This picture of what happens when we amend soils is not a new concept; however, it has only recently been put into a potentially useful form for mixing soils on the golf course. In the past, golf green soil mixtures were developed through inefficient soil trials in which plants are grown in a series of media containing different proportions of various components. A simple mathematical and graphical model is being developed at the University of Illinois which can be used to produce mixtures having specific, predictable properties (total porosity, aeration porosity, water retention porosity). In other words, it is possible to control the soil physical environment in a predictable manner through the use of soil mixtures.

CONCLUSION

This article does not recommend any specific golf green soil mixture; rather it briefly describes what happens when an amendment such as sand

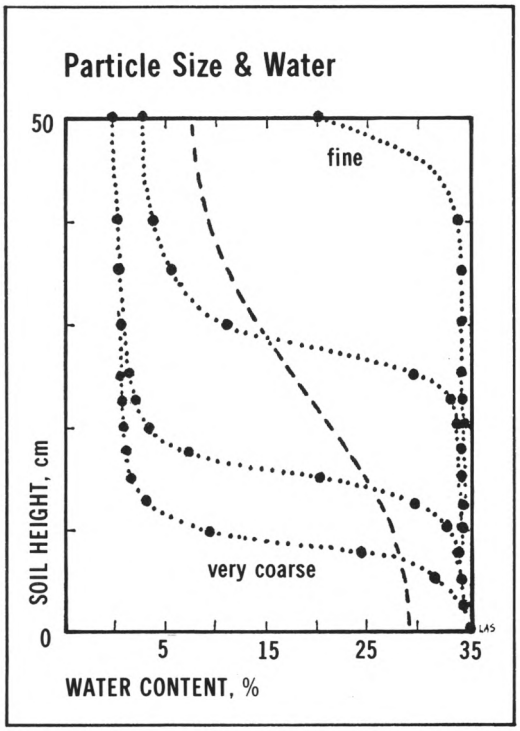


Figure 5. *The effect of drainage depth on the water retention of a very coarse-textured sand. The only difference between the three soils is their depth. A shallower drained green will always be wetter following irrigation and drainage than a deeper green using the same soil mix.*

is added to a soil. The take-home lesson is that drained golf greens are different from other turf sites and therefore require special soil mixes to maintain an adequate soil physical environment for continued root growth and function. Unless these mixes are designed properly, the results can be worse than if the original site soil is used. A certain minimum amount of amendment, the threshold proportion, is required before soil physical improvement is effected and this amount is usually quite high (75 to 90 per cent or more of the total bulk volume of the components). The optimum soil mixture depends on soil, climate, drainage depth, and plant species and is therefore difficult to determine without professional assistance and previous experience under similar conditions.

Not only is the amount of amendment important, but also the kind of amendment (primarily size) (*Figure 4*) and drainage depth (*Figure 5*). Other important factors are the length of time the green is in place, the effect of thatch and topdressing on the rootzone environment, and the chemical nature (pH, nutrient holding capacity, decomposition, etc.) of the amendment and soil used in the mixture. These effects are not entirely understood, but are currently under study by the USGA Green Section and others.

The Drought in Northern California

by JACK JAGUR, Superintendent, El Macero Country Club, El Macero, Calif.

The prolonged drought throughout the West is coming sharply to the attention of golf course superintendents in Northern California.

Now entering its third year, low rainfall along the Northern California Coast and in our inner valleys is only part of the water shortage story. The sparse snowpack in the Sierra Mountains last winter has led to very low water in all mountain reservoirs and hydroelectric power shortages may also be in the news later in the summer. Add to this the ever-expanding needs of municipalities and agricultural requirements and one begins to appreciate the great demand now being placed on our limited and precious supply of water.

To obtain maximum utilization of the water available to us, the Northern California superintendents must use it with the highest possible efficiency. Substantial water conservation programs on golf courses are now a necessity. This means very carefully regulating irrigations with no runoff. Just as with fertilizers and other costly chemicals and turf management procedures, there is no longer room for wasteful irrigation practices. Good management has never had greater meaning!

In the past the turfgrass manager has almost completely overlooked irrigation conservation. We have tried to keep our golf courses lush and green to please the golfer. This has led to overwatering, for there has always been an abundance of water available. It is an easy trap to fall into. Now the drastic water shortage in the West forces us to modify these old and wasteful practices.

We are coming to realize that overwatering has not only interfered with the playability of the course, but it is also damaging to the turfgrass itself.

During the past nine years at El Macero Country Club, my philosophy toward turfgrass irrigation has developed and I would like to share it with you. El Macero is located just west of Sacramento and prolonged daily summer temperatures in the high 90s and low 100s are common. I believe that if one can change the habitat of an animal and if one can modify his or her eating habits, modifying turf watering habits should also be possible. Conditioning turf to a new irrigation habit, however, means going through some stress periods.

Through my experience, springtime seems the best for turf to undergo stress. The strategy is to let the turf go unwatered until there is some indication of wilting. When wilting does occur, I apply sufficient water to fill the soil reservoir. Allowing the upper layer to dry out between irrigations enhances deeper penetration of roots. Deeper root systems enable the turf to better withstand adverse conditions. The longer intervals between irrigations also help minimize disease. I practice this method during the spring-to-summer transition period.

During the summer I water greens and tees three times a week. The fairways are watered 1.9 times a week. This program conserves water and brings about strong, healthy turf. It also minimizes syringing requirements during peak temperatures.

These practices have worked for me during past years and may be worth trying on other golf courses. During the spring we have had complaints from time to time about hard greens. However, we have not had a complaint about a wet golf course. I believe in this philosophy of irrigation. In the long run, I feel it leads to happier golfers, healthier grass and, whether in a drought or not, to conserving our precious resource — water!

Jack Jagur making a soil check.

USGA GREEN SECTION RECORD
JULY 1977

TURF TWISTERS

pH AND PESTICIDES

Question: Recently we have read that spray solution pH may have a bearing on the effectiveness of pesticide applications. Can you shed some light? (Pennsylvania)

Answer: Most pesticides, especially carbonate and organophosphate insecticides (except Servin and Proxol), do break down (hydrolyze) faster under alkaline conditions. However, when following the good standard procedure of applying the material as soon as it is mixed in the tank, little loss of effectiveness should occur. If this situation worries you, have your water analyzed both for pH and buffering capacity. In alkaline waters that are not also highly buffered, the rate of hydrolysis quickly slows down, with only minor (as little as 10 per cent) loss of active ingredient. For highly buffered alkaline waters, buffering agents are available commercially, with micronutrients included, to lower and maintain spray solution pH.

REDUCE EARTHWORMS

Question: Recently we have been troubled with large amounts of earthworms on the golf course. Do you have any suggestions how they can be minimized? (Wisconsin)

Answer: Earthworms come to the soil surface to pull leaves and other material into the soil. This feeding activity can help control the accumulation of thatch. Aeration of the soil, as well as improving water infiltration, are some of the desirable qualities of earthworms. As you mentioned, large amounts can be objectionable when they build small mounds of soil on the grass. The application of an insecticide material at the manufacturer's recommended rate will be very helpful in eliminating the worms. Recently the application of a systemic fungicide material has been observed to decrease the worm population. Research workers in Germany have made similar observations.

IN COMPACTED BUNKER SANDS

Question: Why is it some sands compact more easily and feel more stable in bunkers than others? (New York)

Answer: When a sand is uniform in particle size, it feels light, shifty underfoot and it does not set up as well as a sand composed of variable particle size. When you have a variety of particle sizes, the smaller particles integrate, become enmeshed and migrate into pore spaces between the larger particles. The end result is that the volume doesn't increase appreciably, but the weight certainly does. The weight is what helps create stability of a sand. Sharp angular sand particles contribute to a sand's stability also. Round particle-sized sands are not desirable for bunker use. All sand particles should range below 1 mm. Write for Green Section reprint "Sand for Golf Courses" for further details.