

USGA GREEN SECTION RECORD

A Publication on Turf Management
by the United States Golf Association

MARCH/APRIL 1979





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Cover Photo:

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1979 GREEN SECTION EDUCATION CONFERENCE

Arthur A. Snyder, 19th Recipient of USGA Green Section Award

ARTHUR A. SNYDER, of Phoenix, Arizona, a pioneer in the American turfgrass industry, became the 19th recipient of the annual USGA Green Section Award for distinguished service to golf through work with turfgrass. The Award was presented to Mr. Snyder by Frank D. Tatum, Jr., of San Francisco, California, President of the USGA, and William C. Campbell, of Huntington, West Virginia, Chairman of the USGA Green Section Committee. The ceremony took place during the 23rd Annual Green Section Conference on Golf Course Management, which was held in New York City on January 26.

In accepting the Award, Mr. Snyder stated:

"I am extremely happy to receive this Award, and I thank the USGA Green Section and everyone who had a voice in my selection. But I must readily admit that I have never done anything outstanding enough to merit this Award. My only claim might be that I have spent a lifetime in doing my very best to help the golfer enjoy golf to the utmost while playing at the course at which I was serving as superintendent.

"You are all aware of the work now being done by the Green Section — financial assistance for turf research, the advisory service by its staff of agronomists, the publication of the *Green Section Record*. But the Green Section's history goes back a long, long way. Its work has covered many facets.

"It was shortly after the close of World War I that, in an effort to improve the quality of turf on golf courses, the USGA gave birth to the Green Section, which, in turn, gave birth to the world's first, and for a number of years, the world's only fine turf research station, the Arlington Turf Garden.

"Beginning in January, 1921, the results of the work being done at this station were published in what was called *The Bulletin of the United States Golf Association Green Section*. It was mailed each month for the next 13 years to the greenkeeper at USGA Member Clubs. The Depression forced the discontinuance of the *Bulletin* at the end of 1933. During those 13 years, it became the greenkeeper's bible, and we eagerly awaited its arrival each month. It contained reports on the results of their research, articles on every phase of golf course maintenance, and a question and answer section of great value.

"I well remember planting stolons of a creeping bentgrass while I was an employee of the Westmoreland Country Club, near Pittsburgh, in 1921 or 1922. These stolons were furnished by the Arlington Experiment Station to any USGA Member Club that desired to try out this new method of planting putting greens.

"But to get back to the *Bulletin*, it was by seriously studying the material published in it

that I and hundreds of others gained our education in greenkeeping — turf management, as it is called today.

"Finally, I want to thank the USGA Green Section for recognizing the value of capable golf course superintendents to the game. They have shown this by honoring a number of golf course superintendents in the past.

"Very few other golfing organizations have done so! There are exceptions, of course. One such group is the Arizona Golf Association, which, in 1975, went so far as to induct a golf course superintendent into its Hall of Fame!

"In closing, let me say that the Green Section has always been very helpful to me, and I am very grateful."

Snyder was born in Pittsburgh, Pennsylvania, in 1898. He began his career as a caddie in 1909, and later became a golf professional. In 1927, after several years of apprenticeship, he became the golf course superintendent at the Longue Vue Club, in Verona, Pennsylvania. Later, he moved to the Alcona Country Club, near Pittsburgh.

During these years he helped to develop the turfgrass research program at Pennsylvania State University. Through his capacities in various Pennsylvania turfgrass organizations, he significantly contributed to the research programs of Professor H. B. Musser, Dr. Fred V. Grau, and Dr. John Monteith. He served on the Board of Directors of the Golf Course Superintendents Association of America. He has spoken at many GCSAA Conferences and Green Section meetings.

In 1953, Snyder moved to Phoenix, where he began a commercial sod nursery from which he developed one of the earliest selections of an improved fine-leaved bermudagrass. It was designated A-53 and became known as "Snyder's Bermuda." Today, several southwestern golf courses still use A-53.

He was instrumental in founding the Arizona Cactus and Pine Golf Course Superintendents Association and the Arizona Turfgrass Council. Through these organizations and his efforts, the University of Arizona renewed its interest in turfgrass education and research. He trained several men who are now golf course superintendents in the Southwest. Several members of his family are engaged in golf. Two sons and a grandson are golf course superintendents, a third son is a golf course architect, and another grandson is a technical representative for an organization engaged in the turfgrass industry.

When Snyder retired in 1974, Paradise Valley Country Club, in Scottsdale, Arizona, where he had served as superintendent since 1956, made him an honorary member. Many other clubs have held "Art Snyder Day" in appreciation of his contribution to their golf courses.

Water - U.S.A.

by J. R. WATSON

AS I PREPARED this paper, I thought it might be interesting to know the number of hours I spent during the past five or 10 years in attending conferences, meetings, seminars, and various other turfgrass related and non-related gatherings, where the subject of water was discussed or was of concern to those who attended.

This was futile. I counted 700 hours in less than two years, the equivalent of more than three months of 50-hour weeks for *one* person. Obviously, if that is multiplied by the hundreds of people who are involved in such meetings, it is apparent that the subject of water receives a great deal of attention.

Rightly so, because water is important; it is one of our most vital natural resources. And it is an *exhaustible* resource.

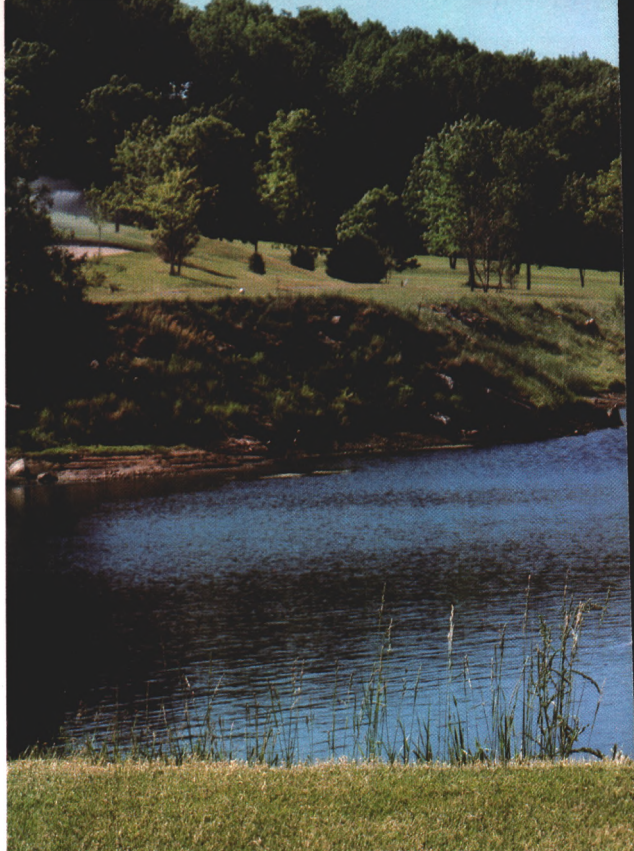
Three common themes ran through all the meetings:

1. There is a vital need, a desperate need, for everyone who uses water for beneficial purposes to use it more wisely. To practice water conservation every day.

2. There is a need to impress upon *everyone* that the use of water to grow healthy turfgrasses for a golf course, or for any other recreational purpose, is a very important beneficial use of water. We must not overlook the key role turfgrasses play in our communities.

3. It is time to recognize that wastewater — sewage effluent — is an important source of water for turfgrass irrigation, including golf courses and that use of this "recycled" water is in reality water conservation.

Water is really a very serious subject, but we don't treat it with the seriousness it deserves. None of us does — not those of us involved in turf management; not the farmers, who account for about 80 percent of the total amount of water consumed in the U.S. each day; not the people in industry, even in those industries that could not exist without access to large quantities of water: the utility companies, the food processors, the beverage makers, the paper manufacturers. And certainly not the average householder, whose total waste



of water — that's waste, not beneficial use — each day amounts to millions of gallons.

I suppose the main reason we don't regard water more seriously is that we have not been convinced that we're dealing with a scarce commodity. In my home state of Minnesota, it's hard for anyone to believe that water is scarce when he can look out over the countryside right now and see it covered with two to three feet of snow.

Under the snow are more than 15,000 lakes containing many billions of gallons of water. How can water be scarce under those conditions?

The truth is that the amount of water on this planet is constant. Just like land, it's not being made any more. The amount of water available for the use of everyone on earth for all purposes — industry, agriculture, golf courses, and our individual needs — is the same today as it was at the beginning of time, and it will be the same in the year 2000 and in the year 3000.

The amount of water available for our use is less than one percent of the total in existence. The rest is tied up in the polar ice caps and in the oceans — essentially unavailable to us. Not only is what remains a limited, inelastic supply, but we are doing things to it. We are finding new uses for it constantly, and we're polluting it faster than nature can purify it.

I attended the National Conference on Water held in May last year in St. Louis. A great deal of information came out of that conference, but one

J. R. WATSON is Vice-President of the Toro Company, Minneapolis, Minnesota.



The amount of water on this planet is constant . . . no more will be available for human needs regardless of population growth.

thing that stuck in my mind was transmitted to President Carter in this statement:

"Overall most parts of the nation are short of water now, and consumptive use nationwide will increase by 33 percent by the year 2000."

We had better recognize we are dealing with a scarce commodity, and we had better begin treating it with more respect.

What are we going to do about it? What are you and your golf club going to do about it?

I said a little while ago that even those of us involved in the turfgrass industry are guilty of misuse of water. That's true, but to a far less degree than for most of the other major water users. The golf courses in this country, by and large, have for years had better management than any other type of recreational turf. That management includes, of course, the use of water.

As you know, I was the fortunate recipient of a Fellowship sponsored by the USGA Green Section. Dr. Fred Grau, Director of the Green Section at that time, and Professor Burt Musser, my major advisor, considered watering practices to be one of the important areas needing evaluation. That was in 1947.

My dissertation was entitled, "Irrigation and Compaction on Established Fairway Turf." The following conclusions resulted from this study:

1. Moisture levels exerted a greater influence on turf quality during the experimental period than soil compaction.

2. Moderate use of supplemental irrigation seems necessary to produce high-quality playing turf that will remain green throughout the growing season.

3. Unwatered plots were brown and in poor condition for play over an extended period of time.

4. Moderate use of supplemental irrigation on intensively managed turf will favor development of bentgrass at the expense of the slower growing species (Kentucky bluegrass and red fescue) so that eventually the turf will consist largely of bentgrass (and *Poa annua*).

5. Supplemental irrigation in quantities great enough to maintain a soil at approximately field capacity is unnecessary and encourages disease and the subsequent invasion of crabgrass and clover.

6. Excessive watering creates a soggy soil condition, promotes shallow rooting of the turf, encourages disease and the invasion of crabgrass and clover. And, if *Poa annua* had been present or the height of cut lower, I am confident it would have increased.

That was 1950. Since then others have investigated other aspects of water — its application and use on golf course turfgrass. Have we made progress? Yes, we've made a great deal of progress in all phases of golf course management in the past 30 years. One of the reasons is that, aside from agriculture, nothing that grows has received as much attention as golf course turf-

grasses. Research — private, industrial, and university — and all kinds of extension activity have helped the industry make enormous strides. Knowledge, technology and management techniques relating to golf course turf have all advanced dramatically. Despite those gains, however, water and water-related problems are still with us.

As an example, Dr. John Hall, of V.P.I., published an article in the 1978 proceedings of the Rocky Mountain Turfgrass Conference.

"We killed more golf greens in Virginia in 1977 by improper irrigation than by any other management factor." Dr. Hall also said that, too often, greens were irrigated when the intent was to syringe, and when this happens at 90-degree temperatures, damage is likely to occur. Automatic irrigation systems offer many advantages, but too few have the capability to "mist" water. Only a limited number of manufacturers have equipment capable of properly syringing (misting) and too few system designs incorporate this feature. It costs extra, but there are costs involved in replacing greens! We must learn to distinguish between maintenance watering — that applied to meet the water requirements of the plant — and water applied to regulate or control temperature, or syringing.

There obviously is a gap between what we know and what we practice. Sometimes I think it's a chasm. To date, we seem to have been incapable, or at least unsuccessful, in bridging that gap. Why? Perhaps it's an economic factor, perhaps improper dissemination of information, perhaps resistance to change, and probably some of all these reasons, plus others. Certainly, I don't have an answer, but I firmly believe that one of the major challenges facing the turfgrass industry in the next few years is to find a way to narrow this gap. We simply must find a solution to this problem. We need to learn more about such things as drought tolerance and rooting characteristics of grasses, water requirements, watering techniques — water application and efficiency — water conservation, soil-air-water relationships, leaching and weeds and their ecological relationship in the golf course environment. Also, we must find ways to avoid pollution and to use recycled water.

And, of course, we have not learned to use water with the kind of efficiency that we must if we are going to play a significant role in helping to keep this planet from running out of water.

In addition to recommending that we find a solution to the information gap, I should like also to suggest that we do everything we can to generate more knowledge, more new information, better technology, better products, better equipment — so that golf course turfgrass management will continue to advance.

That can be done in a number of ways. One is with college scholarships. Another is to sponsor research, basic or fundamental research, as my company is doing in support of a four-year study of water use rates for turfgrasses at Texas A&M University. We believe knowledge of water use

rates is basic and will be of immense value in determining overall water requirements of a particular region, as well as for the water-efficient turfgrasses that grow and will grow on golf courses in the future.

Another recommendation I should like you to consider is that we all act as if we really believe we face a water crisis. To do that, we must stop wasting water in our personal use of it. It also means golf courses must be managed as though we are in a severe drought right now and will continue to operate under drought conditions for the rest of our lives.

There are some eight or nine steps for conserving water under drought conditions. To conserve water, consider the following:

1. Treat every day as if you were in a period of severe drought.
2. Establish watering priorities. This means giving highest priority to the most intensively managed areas; for example, on a golf course, the greens, the most valuable part of the course and where the most critical play takes place.
3. Follow sound irrigation practices.
4. Reduce, or avoid where possible, all causes of stress, such as salt build-up.
5. Alter mowing and cultivation practices. This includes raising the height of cut for all areas and mowing less frequently.
6. Expand use of mulch. This is very important.
7. Erect wind barriers, especially where there are large expanses of open spaces.
8. Experiment with anti-transpirants and surfactants.
9. Aggressively seek additional sources of water.

Among the alternative sources are wells and ponds, collections of marginal water and, the most abundant and most often wasted supply, treated sewage effluent.

At my company we are convinced that wastewater will become a major source of irrigation water in the future. We would like to see it used widely for all types of irrigation, especially for large turf areas and in agriculture.

We expect to play a strong role in the research and product development necessary to make certain the equipment and the resources will be available for expanded use of wastewater for irrigation.

As many of you are aware, the USGA Green Section, the American Society of Golf Course Architects, the Golf Course Superintendents Association, and the National Golf Foundation sponsored a two-day conference in November in Chicago to deal exclusively with the subject of wastewater use for irrigation of turf on golf courses and other sports fields.

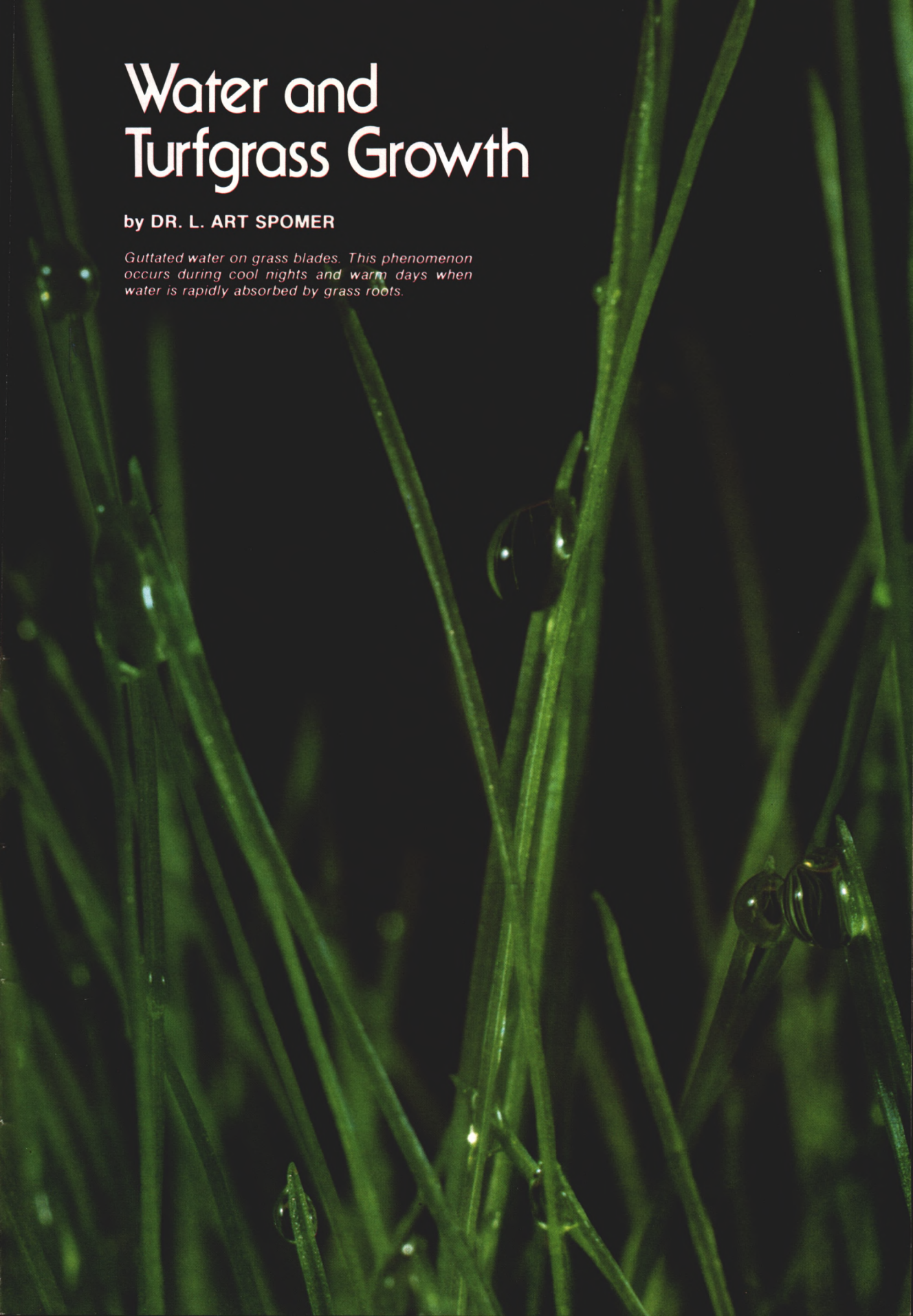
It was a conference that was long overdue. It will, I predict, encourage significant expansion in the use of effluent for irrigation.

The proceedings will be printed and will be available within a matter of weeks. I urge everyone to obtain a copy of the proceedings and to read them carefully and thoroughly.

Water and Turfgrass Growth

by DR. L. ART SPOMER

Guttated water on grass blades. This phenomenon occurs during cool nights and warm days when water is rapidly absorbed by grass roots.



BOTH QUANTITATIVELY and qualitatively, water is probably the most important nutrient necessary for turfgrass growth and survival, and because of its importance, a shortage is probably the most common limiting growth factor.

Most actively growing turfgrass tissues (leaves, stems, and roots) consist of about 90 percent water by weight. This is a lot of water! To demonstrate just how much, weigh a heavy cardboard container (such as a mailing tube), cap one end, fill it with water, and reweigh it. You will find that when it is full of water, it also consists of 85 to 90 percent water by weight. So plants are literally living, growing containers of water. Even woody tissues often contain 40 to 60 percent water.

If plants really contain this much water, why isn't it readily apparent? A bluegrass plant, for example, consists of about 90 percent water, yet it has a solid appearance and feel. When it is mowed, water does not run out freely as it would from other containers. The only noticeable water is a slight moistness at the cut surfaces. Why? The plant is not a single large container; it is composed of billions of microscopic containers, called cells, cemented together to form the plant body. When a stem or leaf is cut, relatively few cells are cut open and only a little water leaks out. If all the plant's cell walls and other solids could somehow be made transparent, the plant would appear as the continuous, nearly solid body of water it actually is.

Plant water content averages about 80 or 90 percent. In general, the more actively growing the plant or plant part, the higher is its water content. Water content within a given tissue, however, can vary significantly over a short period, as evidenced by rapid wilting and recovery within a short period, sometimes within minutes.

Plants not only contain tremendous quantities of water, but they often use over a hundred times as much during growth. Why is so much water necessary? This large amount of water is more than just an inert filler. Probably every plant growth function is affected directly or indirectly by water.

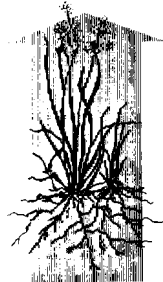
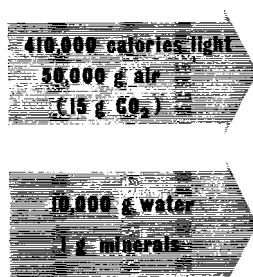
Water has at least four direct functions in relation to growth.

(1) Water is the hydraulic agent which maintains cells in the fully expanded or turgid condition necessary for the support of leaves and for growth of all plant parts. Water is drawn into the cells by its attraction to the salts and other materials found there. Since salts cannot readily move out of the cells, this absorbed water exerts pressure that stretches the cell walls, causing the cells to grow larger, like swelling balloons.

(2) Water is also a solvent and a transport agent in which all nutrients and plant products move into and throughout the plant.

(3) Water is the main constituent of the cell protoplasm where it is both a filler and a structural component. Most essential plant activities, includ-

100 g green plant
(90 g water, 9 g organic
1 g minerals)



Plants require and contain more water for growth than any other raw material.

ing the production and utilization of "food," occur in the protoplasm. The delicate structure of the protoplasmic machinery responsible for these activities is partially maintained by the water.

(4) Water in the protoplasm also functions as a raw material in the plant's chemical processes. The most significant reaction in which water is involved is in photosynthesis, which also directly or indirectly supplies all of the food consumed by humans.

Photosynthesis, by the way, is the most efficient and most significant means available for converting solar energy into usable energy. Not only is it a source of food, but photosynthesis is also the basic process responsible for the production of all of the fossil fuels (gas, coal, petroleum).

In addition to these direct functions of water in plants, it also indirectly affects plant growth by conditioning the plant's environment and buffering the plant from rapid or extreme temperature changes. Water affects the plant's physical, chemical, and biological environment above and below ground. Water has a high heat capacity, which simply means that it exchanges large amounts of heat energy per degree temperature change. It also has a high latent heat of vaporization, meaning it absorbs a tremendous amount of heat energy upon evaporation — has a great cooling effect. Their high water content gives plants a high heat capacity, allowing it to resist rapid temperature changes, while the evaporation or transpiration of water from plant surfaces cools the plant.

What happens when plants do not get enough water? Since water is so important for plant growth, a lack of water causes stress and affects growth. A water deficit occurs whenever the plant requires more water than it absorbs. The overall effect of a water deficit is reduced growth, injury, or death.

Most turfgrass plants experience frequent or nearly continuous water deficit or stress of varying degrees during growth. This is especially true during sunny daylight hours. (Well-watered turfgrass plants usually do not experience water stress at night; the exudation or guttation of water droplets

DR. L. ART SPOMER is associate professor of plant physiology in horticulture at the University of Illinois.

at their leaf tips, which is often usually mistaken for dew, is evidence of this.) The overall effect of this prevalent water deficit depends on its severity, duration, and frequency as well as on the plant species, growth stage and culture. The first effect of a water deficit is a loss of turgidity and the plant begins to wilt. Wilting causes expansion growth to slow or stop, and usually it also reduces photosynthesis. The first and most common effect of a water deficit, therefore, is reduced plant size.

As water stress becomes more severe or prolonged, more and more plant processes are affected until the plant is permanently injured. The injury shows by browning and dieback. Most plants, however, adapt in various ways and to varying degrees to survive repeated or prolonged periods of water stress. Some will even survive water losses of 30 percent or more. Plants that are highly resistant to water stress are called xerophytes and include cacti, succulents, and sagebrush. Many turfgrasses survive severe water deficit by becoming dormant. This usually means the leaves stop growing and turn brown. Many plants survive water stress by developing more extensive root systems. Most turfgrass plants, however, are limited in this respect by their fibrous root systems, which are primarily distributed in the upper layers of soil. Most turfgrass plants are only moderately resistant to water stress, especially if we want them to remain green and playable.

On the other hand, and in some cases, moderate water stress may actually enhance plant quality by increasing the plant's resistance to further water stress. Actual effects in any specific case depend on the severity of the stress and upon the species and growing conditions before, during, and after this period of stress. In all cases, however, growth is reduced.

Turfgrass plants can also suffer from too much water, which results in a lush growth that is too soft, too succulent. Excessive soil moisture results in poor aeration. This can cause poor root growth, poor water and mineral absorption, increased disease susceptibility, and it may even kill the plant. Successful plant growth depends upon a plant's tolerance of both deficient and excess water and the ability of the turf manager to maintain the water supply within a particular plant's tolerance.

How much water is required for turfgrass growth and survival? *The Plant's Water Requirement Is The Minimum Amount of Water Required to Provide Optimal or Adequate Growth.* You can see right away that this is a somewhat nebulous concept which depends upon the species or variety, the purpose for which it is being grown, and the meteorological and other environmental conditions prevalent during growth. In general, the more water supplied to turfgrass, the more water it uses, often with no corresponding increase in growth. It is luxury consumption. Very little of this applied water is actually used for growth. Often less than one one-hundredth of the amount absorbed is actually retained by the plant for growth. The great bulk of absorbed water is evaporated or

transpired into the atmosphere. Turfgrass water requirement, therefore, depends primarily upon local climatological conditions and only secondarily on variety or species.

In conclusion, water is quantitatively and qualitatively the most important nutrient required for turfgrass plant growth. Water affects every aspect of plant growth and is truly the life substance of plants. Not enough is known about turfgrass minimum water requirements to give blanket recommendations, but research is now being conducted to develop more reliable methods of determining turfgrass water requirements in order to ensure maximum irrigation efficiency.

National Golf Day

The Green Section of the United States Golf Association salutes the Professional Golfers Association for its annual contributions to turfgrass research. Through its National Golf Day Fund, the PGA has contributed over \$275,000 to the USGA Green Section Research and Education Fund since 1952. The funds realized from National Golf Day have made it possible for the USGA to support a number of worthwhile golf turfgrass research projects which not only made possible work on important projects, but also helped train many of the present-day leaders in the field of turfgrass management.

Projects that have resulted from funds channeled through the USGA Green Section Research and Education Fund include studies on *Poa annua*, thatch control, the control of regular crabgrass and silver crabgrass (goosegrass), effects of 2,4-D on weeds and grasses, physical properties of putting green construction, bermudagrass selection and breeding, bentgrass selection and breeding, Kentucky bluegrass selection and improvement, selection and breeding of the fine and tall fescues, the effects of management practices on the speed of putting greens, disease, insect and weed studies, to name a few.

The Round of the Champions will be played on May 28 at the Oak Tree Country Club, in Edmond, Oklahoma. On that day Hollis Stacy, the Women's Open Champion, and Nancy Lopez-Melton, the LPGA Champion, will set the target score for women to shoot at, while Andy North, the U.S. Open Champion, and John Mahaffey, the PGA Champion, set the target score for men. Amateurs compete against the low score using full handicap.



Reservoirs of adequate water-holding capacity are best developed during construction stage of course development.

Maximum Use of Land Sites- EMPHASIS WATER MANAGEMENT

by REES L. JONES

IN DISCUSSING water in the context of golf course design, it seems that we either have too little or too much. When we have too little water to support good turf properly, we must look for supplemental sources or methods of supply. When we have too much water, the drainage systems must be designed to dispose of it rapidly from the entire playing area. Whenever possible, drainage systems should be designed so that runoff will be channelled into a reservoir or series of reservoirs to serve the dual purpose of water conservation and drainage.

When a site is being considered for a golf course, the major physical properties to take into account are topography, drainage, vegetation, soil and water. Perhaps the most critical element, however, is water. It would not be wise to build a

golf course if sufficient water is not available for irrigation to insure playable turf.

Golfers in the United States have been spoiled. They expect lush conditions even during droughts. In order to maintain a golf course in such a manner during dry periods, it is necessary to water the greens three quarters of an inch to two inches a week and the fairways from one inch to an inch and a half a week. The type of irrigation system chosen, as well as the total area of irrigation coverage contemplated, is also used to determine the quantity of water required. Golf course architects calculate these needs and design irrigation systems based on these factors.

While irrigation systems are installed for supplemental water, except in deserts or tropical areas, they are designed to yield the total water supply during periods of drought. The water source must be capable of yielding the maximum amount needed for all seasons.

A golf course architect is most concerned about an adequate water supply during the post-

REES L. JONES is President of the American Society of Golf Course Architects.

construction maintenance period, when the turf is becoming established. At this time it is imperative to have an adequate supply. If, because of the lack of sufficient water, a good stand of turf cannot be established during the optimum growing period, the ground probably will erode, and it will have to be replanted at substantial additional cost. Also, the revenue lost by not being able to open on schedule will have a detrimental effect on the golf course, especially if the course is part of a resort or real estate development. To minimize this possibility, golf course construction should begin early enough so that it will be completed at the beginning of the optimum growing period. Golf course architects often face the problem of beginning construction late because of economic reasons, and, consequently, not completing it at the proper time. Obviously, it is ideal to build the course during the dry season and grow the grass during the wet season. In many parts of the world, especially tropical areas where the growing season is 12 months, the acquisition of rainfall data is essential to schedule the construction of a golf course. If the supplemental water supply is not abundant, proper scheduling of the construction is imperative.

Golf course irrigation water comes from wells, streams or rivers, lakes and drainage canals; or by using effluent or by outright purchase from a local source.

Well drilling is a common way of finding an adequate water source. In most cases the well water is discharged into a pond or irrigation reservoir and then pumped into the irrigation system. Using this method, the yield of the well can be substantially lower than the amount required by the irrigation system. If the well is discharged into a reservoir, the daily gallonage requirement can be recharged over a 24-hour period, whereas if the well pumps directly into the system, the gallons per minute must be substantially higher to supply the daily requirement of the golf course.

Whenever possible, it is most efficient to locate the well and reservoir centrally. If the yield from one well is not sufficient, it is still best and in many cases more reasonable to pipe the water from all wells to a central reservoir. A central water source keeps the irrigation pipe sizes down, and thus the cost is cheaper for the irrigation system. This method of supplying water is better than pumping directly into the system from two or more wells, because pumping from several wells increases the possibility of dirty water. If sediment is passed into the system instead of settling to the bottom of the reservoir, irrigation problems and equipment malfunctions will occur more frequently.

A stream is another very common source for golf course irrigation water. Since many newer golf courses are being located in low areas or floodplains, these tributaries are often incorporated into the strategic design of the golf course. Before choosing a stream as a water source, the watershed area should be analyzed and tests should be made to determine the rate of flow during the driest times. If the test results indicate an adequate

supply of water, a pond should be excavated adjacent to the stream. Ideally, this pond should not be directly connected to the stream, but it should be filled by installing a feeder pipeline from the pond to the upstream point with the same elevation as the desired water level. A small dam must be built at this point to create enough "head" at the intake to fill the pond regardless of the rate of flow. This type of "bypass" pond can also be kept recharged by pumping into it from the stream. In some cases, because of existing topography, it is necessary to connect the stream into the excavated reservoir. However, this should be avoided if possible since silt, sediment and debris will soon fill the pond and cause constant cleaning. It should be noted that environmental groups in some areas now require us to feed our streams directly into the ponds for erosion control. Before one determines which method to use, all local or state regulations should be studied.

Water from rivers, because of their depth and constant rate of flow, can be pumped directly into the irrigation system. However, due to the probability of frequent dirty water, it is recommended that water from rivers be pumped into irrigation reservoirs.

Man-made or natural large lakes filled by runoff from large watershed areas are also good sources of irrigation water. The elevation difference between the mean water level of the lake and the high point on the golf course is the prime determining factor in deciding whether to pump directly from the lake into the irrigation system or from the lake to an irrigation reservoir and then into the system.

Many courses built on low, relatively flat ground, often in coastal areas, obtain their water from the drainage canals which have been previously excavated. The water level of the canals generally represents the water table of the area. In most cases, ponds can be excavated and used for irrigation supply with similar results as using the canals. However, the flow and supply of water in the canals is generally more reliable since they are recharged by large areas of runoff as well as the ground water supply.

In Myrtle Beach, South Carolina, several courses use the water from the Intracoastal Waterway for their irrigation. Some of the courses pump directly from the canal into their irrigation systems while others pump into reservoirs and then into their systems. The latter method is best since the water from the Intracoastal contains a small degree of salt. The reservoir at Skyway Golf Club is also the receptacle for large quantities of runoff water harnessed through a complex ditch system. Thus the degree of salinity is substantially decreased by mixing the water from the two supplies. The parts per million of soluble salts found in the water is of critical importance. The U.S. Department of Agriculture feels that water containing 1,200 parts per million is acceptable for growing crops. For golf courses, water with more than 2,000 parts per million is not considered desirable for growing good turf.

With the general public's increasing concern for the environment and because of recently enacted laws concerning the treatment of our waste products, sewage effluent will be used increasingly for golf course irrigation. Each state has different regulations regarding the use of this water. The requirements of the state should be thoroughly checked before the water source is decided upon and irrigation systems are designed. The decision to use effluent as the water source poses two problems for the golf course architect. First of all, sewage effluent is generally not available at the time when the golf course is built. Because of this, an auxiliary water supply must be available when golf course construction is completed. Thus, money must be spent on a water source which won't be needed in years to come. The second major problem is that the effluent must be disposed of whether or not the golf course needs additional water. To partially alleviate this problem, large holding ponds should be constructed to retain the effluent water until it is needed.

Purchasing water is the least desirable way to irrigate a golf course; avoid it if at all possible. Even if obtaining water by one of the previously discussed methods seems to be prohibitively expensive, the long-run costs should be considerably lower and availability more certain if one of them is employed. However, purchasing water may be the best temporary solution if early use of effluent is a certainty.

In several cases a combination of two or more sources is needed to provide the necessary quantity of water. In any event, a thorough chemical analysis of the available water should be made before the source is decided. Results of the analysis should be studied by an agronomist to be sure that the water is suitable to grow the specified turf.

Immediately after determining the source, the required three-phase power should be ordered for the pump station and/or well pump. The pump station itself should be ordered early. Too often there are long delays in acquiring the necessary power and/or the pump station. Often installation and delivery cannot be made before construction is completed. This leads to the costly use of generators and/or diesel pumps. Use of a diesel pump without a pressure-regulating valve can be harmful to the irrigation system. As a result, the efficiency and life of the system is potentially decreased.

Golf course architects often joke that the three most important items of construction are drainage, drainage and drainage. Without good drainage a new golf course can become an economic disaster because of soil erosion, turf loss and the loss of revenue caused by many days of unplayable conditions.

Whenever possible, it is cheaper and easier to handle small drainage areas by surface grading swales or by regrading existing ones. Ditches are also an effective way to handle excessive runoff, but unlike swales, their use should be avoided on the turfed areas of the golf course. In cases of

moderate to large amounts of runoff, a great deal of erosion can occur. It is very difficult to maintain turf on ditch slopes, and they are unfair golf hazards because they are generally blind. It is advisable to use ditches only in non-play areas, to intercept large quantities of water where they will require little maintenance and will not affect play.

Concrete or asphalt-coated corrugated metal pipe with headwalls or drop inlets should be installed across a golf course to drain adjacent watershed areas. The initial installation of properly sized pipe will pay definite dividends immediately by erosion control before and during the grass-growing period and later by accommodating all future runoff.

Creeks and streams should generally be left in their natural state to be used as drainage courses and, whenever possible, as effective hazards. Swales and pipes should discharge into them since they are usually formed by natural positive drainage and are, therefore, the most effective means to pass excess water off a site and into an irrigation reservoir. It is best not to redirect them unless the playability of a hole will be vastly improved or if it is decided that they are too meandering to accommodate present or future runoff. Whenever possible, the drainage system should be designed so that much of the excess water can be captured in reservoirs to be used later as supplemental water for the turf. This is the cheapest method of obtaining irrigation water.

Drainage is the key consideration in building the golf course features — the greens, tees and bunkers. The greens are built with PVC drain pipe, a sub-surface gravel layer and a seedbed mixture consisting predominantly of sand. This method of construction, along with properly designed surface contouring, provides the drainage necessary to play a golf course soon after a severe rainfall. Tees are designed to be built with surface drainage without water-holding pockets. They are pitched slightly to shed excess water. Bunkers are no longer holes in the ground. They are generally built from imported fill, and their floors are shaped to be above the existing grade. Drainage pipe is installed to remove excess water caused by rainfall or from the use of the irrigation system.

In summation, if the golf course architect is allowed to and has done the proper job in his research and design, an abundance of water will be available to a golf course that drains well. The water supply will have been calculated, whenever possible, to furnish all the necessary water during a drought, and the drainage system will have been designed to eliminate excess water quickly from a course after periods of heavy rainfall. However, if the drainage system is effective, one should not be deluded into the belief that the course often needs the maximum amount of water per day. Each day the water should be re-evaluated so that the turf gets only the amount of water it requires. If the budget and the client allow, the golf course architect leaves the golf course well provided to manage water, the most important item in golf course management.



Ball resting on Poa annua, a water-loving grass plant, now the predominant species on many irrigated golf courses.

Firm vs. Soft Playing Conditions

by JOE BLACK

WHEN I WAS a very young man, I had aspirations of becoming a great tournament player. I worked hard at my game, and I was fortunate enough to earn my Tour card. At that time the "World Championship" was played every year at the Tam O'Shanter Country Club near Chicago. It had the most prize money of any tournament at the time, and it was the first tournament I selected to play in. Fortunately, I qualified to play.

You've heard of sleepers and rabbits; well, I was a dew sweeper.

I was one of 150 professionals playing. There was also an amateur competition, a women's professional competition and a women's amateur competition, so I think the number of players in the tournament numbered some 300.

My tee time the first day was at 6:06 A.M. Getting up at 4 o'clock was a new experience for me, and so was dew on grass. I was going to be very smart, and since it wasn't quite daylight, I was going to try to hit it down the fairway the first few holes, shoot for the middle of the greens,

two-putt. I just wanted to stay around par until it became light enough and I became awake enough to take a run at the golf course.

On the first hole I drove the ball right down the middle of the fairway, about 150 yards short of the green. I played an 8-iron and shot right at the middle of the green even though the pin was tucked in behind the left bunker.

I hit what I thought was a real good shot, but when I walked up, the ball wasn't on the green. One of the groundkeepers was raking the bunker behind the green, and so I thought, well, maybe it went in the bunker. When I asked him if he had seen the ball, he said, "Oh, you mean the one that flew over my head and out-of-bounds?"

That's when I learned what wet grass will do to a golf ball.

In Texas, we don't have conditions like that. When you're playing under wet conditions, you have a lot of what players on the Tour call "shooters" or "flyers." When grass comes between the club blade and the ball, it reduces the amount of spin on the ball, and the ball shoots or floats. It will travel a much longer distance than normal. As a matter of fact, the Rules of Golf prohibit putting anything on the clubface that might create this condition.

That was my first experience in learning to play under wet conditions. Obviously, my game

JOE BLACK once was Tournament Director of the PGA Tour and is responsible for setting up golf courses for the PGA Championship. He is the golf professional at the Brookhaven Country Club, in Dallas.

plan was destroyed on the first hole, and I didn't play too well in the tournament thereafter.

There are pros and cons of playing under wet and dry conditions on various parts of the golf course. I'm not proficient at talking about wet conditions because in Texas right now we are 25 inches under normal rainfall for the last four years. We are in a drought period.

On the teeing ground, the optimum would be a fairly dry condition, because the more the tee is watered, the more it tends to become dangerous because of slippery footing. Obviously, one of the good things that can be said about a little wet condition on the tee is that it might make it a little bit easier to push the peg into the ground, but I don't think too many of us have much trouble doing that anyhow.

In wet conditions the ball will not roll far and most players lose a lot of distance. There is also the problem of mud on the ball.

Since wet conditions dramatically reduce the spin on the ball, a player can't control distance or direction. This results in a loss of maneuverability. To a lot of players, maneuverability is not too important, but to good players maneuverability is very, very important. It enables them to cut or draw the ball into a pin position, or otherwise finesse it into position on the green.

Wet, soft conditions, in effect, have the same effect as widening the fairway, which, I believe, hurts the game. Much of the skill in accuracy is taken out of the game. Dry conditions shorten the golf course, and while not everyone will agree, I think it's great to have a golf course shortened a bit. It allows more control, and to me the advantage should go to the best player.

The best players truly control the spin of the golf ball. This makes it much easier for them to hold the green and to maneuver the ball to difficult pin positions.

Another thing about dry fairways which I think is very important is that it narrows the fairways and requires the player to be a much more accurate driver. I think one of the best examples I could give was the 1977 PGA Championship at Pebble Beach. As you know, Pebble Beach had had a tremendous drought and on many holes, particularly the 9th and 10th, it was almost impossible for the players to hold the ball on the fairways. Dry conditions tremendously narrow the width of the fairways.

When the rough is wet it is a tremendous problem, particularly if it is allowed to grow high. First of all, the ball cannot be hit very far out of tall, wet grass. For the good player who keeps the ball in the fairway, it's no problem; for the poor player who strays into the rough a lot, it's very, very bad. Again, it's difficult to control the spin of the ball out of the rough. Also, the heavy grass will grab the blade of the club, many times negating the loft, many times causing the blade to open. The result is erratic shots.

Of course, the intent of rough is to penalize a poor shot, but wet conditions make playing out of the rough ever so much more difficult.

Wet, heavy grass sometimes will keep the ball in play and prevent the ball from running into difficult situations, such as behind trees or other obstacles.

The ball can be hit a greater distance, where the ground is dry, and the ball can be controlled much better. The dry grass won't grab the blade so much. Dry turf tends not to create as many flyer lies. The only time that I know of when there has probably been a perfect rough, or at least when the players agreed that it was perfect rough, was under very wet conditions.

During the 1972 PGA Championship at Tanglewood Golf Club in North Carolina a few years ago, we experienced nine inches of rain before we could top out the rough — it was about seven-inch bermuda rough — and it was as wet as it could possibly be. I believe it was Chi Chi Rodriguez who said, "This is the fairest rough we've ever played — no one can play out of it!"

I will tell you this, they could not play out of the wet rough at Tanglewood, and so it wasn't surprising that the two players who came right down to the final hole, in position to win the championship, were Jack Nicklaus and Lee Trevino. This is what good rough does. With good rough the best players will be on top every time.

As for bunkers and wet conditions, you have the obvious first problem — the embedded ball. These are extremely difficult shots to play, and they are, in my opinion, very unfair. There is also the possibility of casual water in the bunkers, which creates a situation in which a player may take relief without penalty. Unfortunately, sometimes there is no place for the player to take relief; as a result, he might have to take a penalty



in order to move away from the casual water in the bunker. Water in the hazards, therefore — and particularly in bunkers — is a very, very bad situation.

On the putting green, the optimum playing condition for championships is to create very, very firm playing conditions. I know that when I'm conditioning a golf course for a PGA Championship, we begin on Tuesday to dry the greens. We do no more watering than necessary, which normally means we water very lightly to try to keep the greens as firm as possible. The reason for that is that we want only the players who play shots with a lot of spin on the ball to be able to hold the green; players who play poor shots should not.

We try to have the greens extremely firm in championship play, firmer than most clubs would normally want to keep their greens for member play. I feel that optimum playing conditions, even in club play, require very firm greens, again to give the advantage to the better player. Firm greens also keep ball marks to a minimum, and so you have a better putting surface. Turf on wet greens obviously is easily damaged. You'll see more larger ball marks and more spike marks.

Wet greens create poor putting conditions. The player with a better touch loses advantage because wet greens usually are slow. Also, the ball normally will not break nearly so much, as it will on a dry, firm green. Consequently, far less talent is needed to read them. Optimum playing conditions would be on dry greens, simply because the advantage should go to the player with the best touch, the one who can read the greens best. Also, dry greens don't present nearly the problem with spike marks or turf damage from ball marks.

In the final analysis, my preference for conditioning a golf course for regular member play as well as championship play is to try to keep the golf course as dry as possible, merely to keep the grass alive. In my opinion, for many years we have tremendously overwatered golf courses. We have been more concerned with creating a beauty spot than in setting up optimum playing condition for the game itself.

Whenever I consider this problem I think of my experiences playing golf in Scotland. To me the British provide optimum playing conditions — the turf is very tight and very dry, which allows the player every opportunity to spin the golf ball. The greens are very firm and very dry and only well-executed shots hold the greens. The rough is so severe that it takes skill simply to get the ball back in play once you've hit into it. That is the way the game was intended to be played.

I think that in this country we have moved away from this ideal. We overwater despite the fact that we have a tremendous problem with water conservation. Practicing water conservation, I think, will help us to create better playing conditions.

As a golf professional, I can tell you that my members complain most when the golf course is wet. I'm always a little bit sensitive to their feelings, and I am concerned about the women who come out to play in the morning when there is dew, or when they have to play early after the course has been watered the previous night. They complain about wet feet and shoes rotting. It's just a deplorable condition to play on very wet golf courses. Maybe water conservation will create better playing conditions for all of us.

Golf is enjoyed on unwatered fairways in parts of the world where through the years tough grasses are the result of nature's oldest law and only the fit survive. 18th hole, St. Andrews, Scotland.



Water Management

by **GEORGE W. CLEAVER**, President,
Golf Course Superintendents Association of America



GOOD WATER MANAGEMENT is the most important factor in golf turfgrass management. Irrigation and fertilization are the two most important management tools that the golf course superintendent utilizes to grow grass.

Water is not only necessary, but it also exerts influence on every aspect of grass growth. It is most important, therefore, that the golf course superintendent have a basic understanding of water and how it moves through the soil. This is necessary to the understanding of plant, water and soil relationships.

To the casual observer, and sometimes to the person actually doing the watering, the task appears to be a simple routine matter. Knowledgeable turfgrass managers recognize this and continually emphasize that proper irrigation is like a balancing high-wire act — there's no room for error! There is delicate balance between water and air space in soils that must be understood and preserved. Pore space includes large pores which provide space for root growth, air space and allows for rapid movement of water through the soil. The smaller soil pores affect water retention. Both are very important to healthful plant growth.

The physical character of the soil has a decided effect on the availability of soil moisture to plants. Physical aspects of the soil concern the size and arrangement of particles that make up the top mix. Involved is water percolation through the mixture, water retention, texture and bulk density. All have an effect on soil resiliency, which is so important to golf.

The superintendent's task in pursuit of an efficient irrigation program revolves around the preceding as well as factors of weather and location. Temperature, humidity, wind, sunlight and precipitation are factors that strongly enter into daily decisions necessary for judicious watering during the growing season. Once these factors are understood, the practical aspects of carrying out the watering program can be resolved by these questions: how much, how often and how best to apply the water? These are difficult questions to resolve because of the many variables involved.

The amount of water to apply at any time depends first upon how much moisture is present in the soil. Generally, one should apply only

In shade, grasses normally grow weak and spindly and lighter in color as compared to their growth in adequate sunlight.



A sprinkler at work. Most members erroneously feel that the more water applied, the healthier the turf.

enough water to replenish what was lost through evapotranspiration and how much the plant used since the last watering. My philosophy is to apply only enough water to insure wetting the entire root zone. Plant roots will not grow without some moisture. Through careful study and observation, one can adjust the program to daily requirements of the plant. There are wide differences in drought tolerance among grasses. The application of too much water at any one time is serious only if the soil is poorly drained and the excess cannot be removed within a reasonable period of time.

Most summer turf problems on a golf course are related to the use or misuse of water. It appears to be the one factor that is most difficult to control. Water has an effect on soil compaction, turfgrass wear, rooting depth, turfgrass growth and the encroachment of weeds.

Excessive watering and heavy foot traffic on wet soil will aggravate compaction, seal the soil pores, deplete the oxygen in the soil and restrict the root growth.

Many greens are overwatered because the irrigation program is controlled by people who are more interested in their ball holding the green than in moisture requirements necessary to good golf.

Water is critical to plant life. Supplemental irrigation is always necessary if turfgrass is expected to remain green throughout the growing season.

The frequency of irrigation is governed by the water-holding capacity of the soil and the rate that the available water is depleted. Frequent heavy watering on poorly drained soils will keep the upper layers of the root zone near the saturation point most of the time. This encourages shallow rooting and promotes other weakness in grasses,

which makes them more susceptible to weed, disease and insect problems.

The rule I follow in water management is to apply water only when needed, where needed and in the correct amount.

A knowledge of soils, terrain, turfgrass requirements, prevailing winds, natural precipitation, length of watering season, permissible hours of operation each day and sources and quantity of water supply are basic in the selection and design of a good irrigation system.

The big question no longer is whether or not to have irrigation, but rather should the system be manual, semi-automatic or fully automatic.

In my view, the automatic irrigation system has emerged as a sound and efficient new management tool for better golf turf. The automatic system eliminates such problems as the need for a night watering man, inexperienced and unreliable help, labor turnover and continuous instruction and communication with all. The efficient use of water will become more important as prices rise and as restrictions are placed on supply.

An automatic irrigation system eliminates total dependence on night watermen. This is always a difficult position to fill, yet it has always been one of the most critical jobs in golf course management.

There are other advantages of automatic irrigation, but the savings in labor and water alone are enough to insure its continued growth. One glaring disadvantage is that members tend to believe that it is a cure for all turf problems.

Water management is an art and science, skillfully performed by the turfgrass manager who has acquired his knowledge through study, observation and experience.

Color Variances in Turfgrasses

by ALEXANDER M. RADKO, National Director, USGA Green Section

"GOLF IS PLAYED on grass, not on color!" This comment is credited to Dr. Fred V. Grau, former Director of the USGA Green Section. In August, 1977, an article entitled "Green Is Not Great" appeared in *Golf Journal*, which expanded on this thesis. Walter Woods, the very capable greenkeeper of St. Andrews, in Scotland, puts it this way:

"We maintain for the golfer the fine fescues and bents in a style consistent with 400 years of history. Links maintenance becomes part history and part modern technology. We try to keep things reasonably yellow except for the green. Applying fertilizer to the greens changes the texture of the grass."

Without question, the first priority for golf dictates that grass be playable, that it be carefully tailored to the requirements of the game. All else is secondary.

Golf is unique in that courses, terrain, climate and location differ. However, the specifications best suited to the game remain constant. The turf must be maintained so that each player can use whatever skills he has to play the ball with consistency from tee to cup in the least number of strokes on every hole.

The golf course covers a large expanse. To keep it in uniform cover, season after season, is a difficult assignment. It takes tough grass to contend with diseases, insects, weeds, traffic and difficult weather while being constantly beaten with implements once described by an Oxford logic tutor as "ill-suited to the task!"

Grass is the same as other living things in this universe. Tough grass is the result of life's constant survival of the fittest battles. Coddle it and it weakens — nurture it patiently to encourage its strengths and the result will be rewarding. Carl Sandburg said it best in his poem "Grass":

"I am the grass. Let me work."

There is a happy medium somewhere between Scotland's natural yellow and what Walter Woods refers to as America's "manufactured" green, which combines aesthetics with playability to the economic and quality enhancement of golf.

Grass is a remarkable plant. It has many uses: it provides food, it insulates and protects the earth against erosion, it provides shelter for some peoples, it helps keep dust subdued, it takes carbon dioxide from the air and converts it to oxygen, it is invaluable for recreational purposes, it is aesthetically pleasing and greatly enhances any landscape. Grass is indeed one of earth's most precious commodities.

Green is a pleasant color. Color psychologists who deal in fashion design advise their clients to

wear green when they feel low. Green, they say, is a healing color. We in golf have known this for some time. For years we have enjoyed therapeutic value in viewing the beautiful and quietly awesome expanse of golf course greenery. Some people believe that every well-managed golf course is one of the wonders of the world. Nature is a color panorama. It offers colors in multiple tint.

The artist attempts to capture on canvas the many shades of green which nature so freely provides. Each has his preference, whether artist or golfer. As a general rule though, Europeans have a decided preference for light green turfgrass while Americans prefer dark green. Differences in grass color are caused by several things, principally heredity. Most grasses reproduce sexually, resulting in wide genetic diversity among progeny. The fine-leaf fescues, the bentgrasses and the bermudagrasses are among the prominent golf course grasses that exhibit much genetic variance, and it is not surprising that the first commercial turfgrass nursery in the United States, established by J. B. Olcott, in Connecticut, comprised primarily fine-leaf fescues.

Kentucky bluegrasses, on the other hand, reproduce by apomixis, which insures that a high percentage of the progeny will be identical to the mother plant. Merion bluegrass is an example of the dark green color that Americans prefer. When turf is established from Merion bluegrass seed, which numbers in excess of two million seeds per pound, almost every single seedling is identical to the parent plant. *Adelphi* Kentucky bluegrass is an example of a very dark green bluegrass, *Touch-down* is judged moderately dark green, *Delta* medium green, and *Ben Sun* is considered light green.

Several other factors have a bearing on color:

1. Light intensity — grasses grown in shade will be lighter in color than the same grasses grown in full sunlight.

2. Fertilizer — grasses will take on a darker hue as the fertilizer rate increases to upper safe limits of application.

3. Iron (ferrous sulfate) — applications at light rates will cause grass color to darken. Repeated applications, however, are necessary to sustain the dark color. Heavier applications to safe limits will cause the turf to turn black.

4. Water — excess water will cause grasses to take on a washed-out or bleached look, generally causing the turf to become lighter in color than normal. Judicious irrigation will retain the normal color of each grass in the turf stand while limited water could cause the turf to turn blue-green, grey-green or tan.

5. Temperature will cause several variations in color. These changes occur in spring, summer, fall and winter, annually. The most dramatic changes are evident in warm-season grasses, the zoysias and bermudagrasses. When killing frosts occur, they quickly turn yellow or tan, while Washington creeping bentgrass and similar types found widely on northern golf courses become purple.

Color is important, but the premier requirement of a first-rate golf course is to develop a turf that meets the playing standards for golf. Forcing color and growth through excessive use of water and fertilizer not only is harmful to the turf, but it also detracts from the game. The long-range goal is to develop tough turf and a firm playing surface so that skill and excellence in play prevail. Isn't this what golf is all about?



(Above) Somewhere between Scotland's pleasing yellow and America's penchant for a lush turf there has to be an acceptable natural green. From a fescue fairway of yesteryear.

(Left) After the first killing frosts, Washington creeping bentgrass turns purple. In spring and during the remainder of the growing season, it is green. Purple or green, it provides a superior putting surface when managed well.

(Below) Dormant warm-season grasses, adapted to southern and transition zone golf courses, afford an excellent lie though not always green in color during the winter months.





Kentucky bluegrass test plots at Rutgers University. Note natural genetic variance in color and resistance to disease.

Nutrients Affect Color and Vigor of Turfgrasses

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

GENETIC INHERITANCE, the use the turf is subjected to, the medium in which it is grown and the management imposed upon it, are the critical factors in its performance. When this combination is right, the use of nutrients can be the catalyst to whatever end result you wish — either aesthetics or playing excellence.

Turfgrasses differ greatly in their natural color. Many good turfgrass stands have been ruined by the heavy use of fertilizers designed to improve color and turf vigor. Color sometimes has become the guideline for determining the health of the grass stand. Hopefully, golfers will learn that this is not true and will concern themselves more with playing quality.

Many nutrients affect turfgrass growth. Nitrogen, phosphorus, potassium, calcium, magnesium, manganese, iron, sulfur, boron, copper, and zinc determine the growth rate, and, therefore, the

health and vigor of the turf plant. Many articles and research papers are available concerning the effect of nutrients on plant growth.

Although information on turfgrass is not abundant, there is enough to provide turf managers with good working guidelines. The important thing to remember is that the objective is not to create a nursery or a scenic park but to provide a surface for playing golf.

Soil tests are the basis for fertilizer recommendations, and they help to establish general guidelines. Bear in mind, however, that golf course turf is a very special commodity and that not everyone agrees on quantities of nutrients required for its best growth performance. A pH test provides information about whether the soil is acid, neutral or basic. A pH reading of 6.0 to 6.5, which indicates the soil is moderately to slightly acid, appears to be best for a number of turfgrasses.

This fits the requirement and is a good starting point, since few golf courses are established to a monostand.

Zoysiagrasses, Kentucky bluegrasses, annual bluegrasses, creeping red fescues, bentgrasses, bermudagrasses, and ryegrasses all grow well at pH 6.0 through 6.5. Although pH 6.0 may be on the acid end of the scale for most of these grasses, all the nutrients are readily available in the soil at this level. A pH of 6.5 is the level at which most nutrients are readily available to the plant. Of the eleven nutrients mentioned earlier, only phosphorus, calcium, manganese, sulfur and iron are inhibited to any degree at these pH levels. All of these materials are commercially available and can easily be applied in forms that are readily available to the plant.

Below the moderately acid level, the availability of calcium and magnesium is reduced. Phosphorus may also become insoluble because it forms compounds with iron and aluminum in the soil. At extremely low pHs, magnesium and aluminum solubility increases, and these elements may become toxic to the plant. At high pHs, copper and zinc become less available and iron and magnesium may become deficient; boron also becomes less available above pH 7.0.

Nitrogen, iron and sulfur show the quickest effect on turfgrass color. Potassium strengthens the plant considerably, but visual effects are not readily visible. Nitrogen, iron, potassium and sulfur are four main nutrients that are needed most after the plant has become well established. Used judiciously they can help grow a very fine quality golf course turf. By experimenting to determine the best combination of these materials for

your specific area, a balanced nutritional program can be developed.

Nitrogen stimulates the plant's growth more than the other nutrients. As a result, nitrogen has become the most used and misused plant food.

Overstimulation weakens the plant to the point that it becomes more susceptible to heat stresses, traffic, insect and disease infections. In addition, the overstimulated grass also requires more attention in mowing, watering, aeration, vertical mowing and other maintenance practices.

By carefully controlling the amount of nitrogen, by exercising good judgment in the timing of all applications, and by carefully choosing the source of nitrogen, all contribute to the careful nurturing of this special purpose turfgrass.

Ideally, nitrogen should be made available as the grass needs it in a manner that allows a steady, consistent growth rate. The growth rate should be just enough to withstand traffic and recover quickly on greens, tees and fairways. Grasses growing at this pace will have plenty of natural color and will be vigorous enough to withstand a reasonable amount of environmental stress.

Talking about a constant nitrogen supply program is easy, but obtaining the desired result is more difficult. Nitrogen is available in different analyses and forms:

1. Soluble — forms which are readily soluble in water such as urea, ammonium sulphate, ammoniated phosphate, and other inorganic salts.

2. Slowly Soluble — microbial activity and/or soil chemical action is necessary for the nitrogen to be broken down into a form so that it is available to the plant. These include ureaform and natural organic fertilizers.

Merion bluegrass, heavily fertilized on the left side of a check strip. Professional and low-handicap golfers prefer the tighter lie of the check strip.



3. Slow Release — soluble nitrogen is coated with plastics, sulfur or other materials resistant to hydrolysis. The nitrogen becomes available slowly as the coating deteriorates.

It is very hard to continually achieve a predicted consistent release of the nitrogen with the slowly soluble and slow release types because they are all subject to effects of temperature, moisture and soil chemistry. However, as imperfect as they may be, judicious combination use of different nitrogen sources can bring desired results.

The main thing to remember is that nitrogen should be used principally to stimulate growth and not to add color. If color alone is needed, other nutrients can be used. Ferrous sulphate and chelated iron are examples, and they are easy to apply. The sulphate form is fast acting while the chelated form requires time to show color change.

Iron is likely to be deficient in heavily watered areas, poorly drained soils, or soils with a high organic matter content. Light rates applied on a regular basis while the plants are actively growing will help the turf retain color without noticeable effect on the growth rate.

Potassium is used by the plant in quantities second only to nitrogen. The amount of potassium required usually is about one-half to two-thirds of that of the nitrogen requirement. Potassium in adequate amounts promotes greater winter hardiness, better resistance to disease, and improves wear tolerance. Good levels of potash help combat brown patch, *Fusarium* patch, red thread, *Helminthosporium*, and dollar spot. Some of these are the same diseases which are encouraged by high nitrogen levels.

The need for greater potassium usage is especially more obvious in areas where warm-season grasses are being exposed to severe winters. Observations and research have indicated that adequate potassium levels in the soil at about the time of the last mowing of the warm-season grasses improve their winter hardiness.

Sources of potassium generally used are potassium sulphate and muriate of potash, otherwise known as potassium chloride. Potassium-sulphate is usually preferred because of its lower salt index, and because it contains sulfur, another required element.

Sulfur seldom was a problem in the past. It was supplied in adequate amounts when industry was allowed to discharge this element into the atmosphere. Then it returned to earth in precipitation. Now that there are EPA restrictions on smoke discharge, it is important to apply sulfur in quantities that will insure a proper supply for healthful grass growth.

Turfgrasses will show a distinct yellowing if they lack sulfur. In many cases it resembles nitrogen or iron deficiency. Research has shown there is a direct relationship between the sulfur requirement and the amount of nitrogen that is used. Some reports have shown that approximately 20 percent to 25 percent sulfur is required to balance the amount of nitrogen that has been applied.

Studies conducted in the Northwest have shown that sulfur has some properties that help to reduce disease. *Fusarium* patch has been minimized where adequate sulfur levels have been maintained, and observations have shown that sulfur may help to control *Ophiobolus* patch. Sulfur also helps to reduce the occurrence of dollar spot on warm-season grasses.

Dr. Roy Goss has shown that adequate sulfur levels have suppressed *Poa annua* infestations in bentgrass turf by helping to produce a more vigorous turf.

Some of the most dramatic results have been on soils that are deficient in phosphorus. This should have added emphasis, since a number of turfgrass managers have effectively reduced phosphorus in their fertility programs in an attempt to reduce *Poa annua*.

The remaining nutrients required for turfgrass growth can be obtained through use of micro-nutrient preparations that are readily available commercially. A good balance of nutrients in the soil is essential for the healthful growth of intensely managed turf.

Always remember that so long as the grass is actively growing, it will be green. The job of the turfgrass manager is to balance nutrients so that an even growth rate and a healthy turf can be maintained to provide the best possible playing conditions for the game.

CHERRY Hills SUPERINTENDENT HONORED AT CONFERENCE

James Young, Superintendent, Cherry Hills Country Club, Englewood, Colorado, was presented a plaque by the Golf Course Superintendents Association of America for his superb work in conditioning the course for the 1978 U.S. Open Championship. GCSAA President George Cleaver made the presentation upon completion of his address.

STIMPMETERS AVAILABLE

Stimp meters are now available to university turfgrass workers engaged in research, teaching or extension. Price \$15.00 each (includes mailing costs). Send requests to: United States Golf Association, Golf House, Far Hills, N.J. 07931.



Generally, the fine fescues predominate on dry mounds, high dry areas and in unwatered roughs.

Irrigation Affects Species Predominance

by **JAMES T. SNOW**, Agronomist, Northeastern Region, USGA Green Section

A TURFGRASS STAND is most often a community of different grass species and cultivars which react dynamically to cultural and environmental changes. In other words, as conditions change, so does the relative population of each species or cultivar in the community. A number of factors influence the ultimate composition of the turfgrass stand at any time, including the climatic and soil environment, the cultural system under which it is maintained, the influence of turfgrass pests, the type and intensity of use it receives, and the genetic makeup of each individual cultivar.

Although it is just one of many cultural factors which can influence competition between grasses in a turfgrass stand, irrigation is perhaps one of the most important. It is also one which can vary greatly from superintendent to superintendent, and a knowledgeable outsider may have little difficulty determining the irrigation philosophy of the superintendent simply by observing the percentages of the various grasses on the golf course.

It would be a mistake, however, to rely solely on this type of observation and analysis. Climate, soils, and local topography will affect how natural

rainfall and bodies of water influence nearby turf. The competitive ability of any particular grass species or cultivar will be weakened or enhanced by annual rainfall and distribution, water-holding capacity of the soil, and location near rivers and streams with regard to flooding or high water tables. Specifically, and with respect to the influence of water on turfgrass stands in northern regions, the fine fescues compete best in droughty soils, Kentucky bluegrass in moist but well-drained soils, and bentgrass in moist, poorly drained soils or where flooding occurs occasionally. Annual bluegrass (*Poa annua*) is similar to bentgrass in its ability to compete well in moist or overly moist conditions. There is a difference, however, between *Poa annua* and bentgrass which can be used by the turfgrass manager to encourage one over the other. This will be discussed later in more detail.

THE FESCUES

The group of fine fescues, generally regarded as low-maintenance grasses, is perhaps the best example of a turfgrass which is very dependent upon specific cultural and environmental condi-

tions to thrive. On golf courses the fescues are most frequently found in droughty, infertile areas of the rough, on high mounds and around sand bunkers and elevated tees. The mechanism by which these grasses conserve water during dry periods makes them very drought tolerant and highly competitive with other cool-season grasses. They are well suited to the areas they inhabit, offering color and textural contrasts to the other grasses and providing a substantial penalty to the golfer who strays into their domain.

In past years it was not uncommon to find golf courses with fairways composed largely of fescues, and a few such courses exist today. However, the advent of the modern irrigation system all but eliminated the fine fescues from frequently irrigated fairway turf. Fescues are not found in moist soils, and by maintaining high soil moisture through regular irrigation, these grasses have been relegated to the droughty and unirrigated areas of the golf course. As moisture increases, the bentgrasses, Kentucky bluegrasses and *Poa annua* all gain a significant competitive advantage over the fescues.

POA VS. BENT: AN IRRIGATION STRATEGY

The cultural demands of low-cut *Poa annua* and bentgrass are very similar in nature, and this makes the development of a program to promote bent over annual bluegrass a most difficult task. Under relatively high moisture and fertilization regimes, both types of grasses compete very well against other grasses. The Kentucky bluegrass-annual bluegrass relationship can also be a hard one to control, but usually other factors, primarily cutting height, are more important than irrigation in determining the relative population of each grass in a Kentucky bluegrass-*Poa annua* stand. It is true, though, that judicious irrigation can promote Kentucky bluegrass over *Poa annua* on low-cut bluegrass tees or fairways.

While it is difficult to give bentgrass the upper hand in the bent-*Poa* relationship, it is very easy to develop predominantly *Poa annua* greens, tees or fairways. Soil cultivation during the prime annual bluegrass germination periods (early spring and mid-fall) and frequent irrigation throughout the season will dictate a largely *Poa annua* turf. The key to the spread of annual bluegrass is irrigation, which artificially provides moisture to promote seed germination and seedling development during these critical early spring and fall-winter germination periods.

Although it would be unrealistic to expect to eliminate annual bluegrass from the golf course, one of the keys to successfully suppressing *Poa annua* is certainly careful irrigation. If there is one basic rule to follow in irrigating turf to promote bentgrass over annual bluegrass, it would have to be: "Irrigate only as necessary to keep the desirable grasses alive."

If we were to follow this irrigation strategy throughout the season, it might go as follows:

Withhold for as long as possible any urge to irrigate in the spring and then irrigate only after

long intervals, allowing the soil to dry between each session. Doing this will discourage *Poa annua* seeds from germinating and developing and will encourage the permanent grasses to develop deep, strong root systems in their search for water down through the soil profile. The root systems will not tend to grow deeply if, through frequent irrigation, moisture is readily available at the surface. One added benefit is the suppression of some of the summer annual weeds, such as crabgrass and knotweed. Though this irrigation philosophy may be easy enough to rationalize, the golf course superintendent may have a difficult time implementing it over the demands of the club membership. After a long winter's layoff, many golfers are anxious to see lush, green grass and soft greens so that every shot will hold, whether it be a high pitch shot or distance requiring a 2-iron. They may have just spent tens of thousands of dollars on a new irrigation system and want to see it used to suit their needs and desires. The only way to overcome this problem is through education, and it may take some time to convince the membership that withholding water in the spring will pay dividends later in the season.

As the season progresses through spring and early summer, irrigate only when necessary. Some turf managers prefer to wait until signs of wilt are evident before they apply water. The state of the turfgrass roots as summer approaches will help determine the mid-season irrigation strategy. If roots are deep and dense, irrigation every few days may prove adequate, whereas if roots are near the surface, daily watering and syringing may be necessary to keep the turf alive.

As high temperatures begin to dominate the summer weather, turfgrass roots naturally tend to cease growth and become shorter. It is therefore important to investigate root survival frequently and adjust the irrigation schedule accordingly. Mid-summer is not the time to withhold water in an effort to suppress *Poa annua*. Just do whatever needs to be done to promote turf survival, regardless of the species present. At the same time, don't overcompensate by overwatering; this can be just as devastating as providing too little moisture.

Autumn is again a time for judicious irrigation in the effort to prevent *Poa annua* germination and development. Temperatures decline and turfgrass roots respond with increased growth, especially when the soil is allowed to dry between each session. Irrigation should continue in the fall only to the point of ensuring that soil moisture is adequate to provide good winter survival. During most years, natural rainfall will satisfy this requirement, and late fall irrigation will not be necessary.

By providing the proper cultural conditions and by adhering to this annual irrigation strategy, *Poa annua* can be suppressed and an increase in the relative population of permanent grasses can be achieved in a bent-*Poa* turfgrass stand. Where bentgrass already predominates, *Poa annua* invasion can be minimized or avoided altogether.



After flooding recedes, the turf turns brown or dies, the soil remains a problem for play, traffic and turf growth long thereafter.

Water Effects on Turfgrass Wear

by **CARL H. SCHWARTZKOPF**, North-Central Director, USGA Green Section

WATER IS JUST one factor that has an effect on turfgrass wear. Other factors include cutting height, fertility level, species and cultivars. Water, therefore, is only one of the many critical concerns over which the turf manager exercises control in his attempt to provide a more wear-tolerant turfgrass plant for golf.

Since irrigation can be controlled, it has been found helpful to water perennial bluegrass areas deeply and infrequently. On well-drained soils, deep and infrequent irrigation of perennial grasses

helps minimize mechanical and physical damage to the soil. Furthermore, maintaining an irrigation regime that encourages perennial grasses will discourage annual grasses.

Research has shown that perennial grasses are substantially more wear-tolerant than *Poa annua*, the most abundant annual species found on golf courses. When cloudbursts, unexpected rainstorms or malfunctions in the irrigation system occur, it is important to route the traffic and minimize it so that damage to the golf course will

be minimal. In areas where water accumulation is a continuing problem, drainage improvements must be made. If necessary, a pump should be installed to remove excess water within a reasonable period.

Excess amounts of water in plant and soil affect both plant and playing conditions. When saturated soil conditions exist, reduced amounts of oxygen in the root zone inhibit the metabolic functions of the plant, thereby causing the turf to become thin and weak. Occasionally, during the hot summer when excessive water accumulates within the soil profile, turfgrass loss occurs because of a phenomenon known as wet wilt. Furthermore, traffic over a saturated soil causes soil compaction, and it could cause permanent damage to the soil system. Damage to the green and tee end of fairways is evidenced by large equipment turning in those areas. Also, since many people enter and exit on the putting surface from the front, additional mechanical and physical damage may occur on the approach area of the green.

Just as excessive amounts of water are externally damaging, excessive amounts of water forced internally are equally detrimental to turfgrass growth, wear and playability. The turfgrass plant is composed mainly of water. This water is essential for transporting nutrients, amino acids and other compounds vital for growth and for sustaining daily metabolic functions. Also, water is

essential in the cooling process of the turfgrass plant, known as transpiration.

When excessive amounts of water occur within the turfgrass plant, it is not as tolerant of environmental stress. These environmental stress conditions include foot/vehicular traffic, high winds, and high or low temperatures. Succulent or delicate plant shoots have a reduced wear tolerance and tend to promote "flyers." Research has shown that turfgrass areas maintained under excessive nitrogen fertility levels, deficient potassium levels, intense irrigation or areas of low light intensity are more likely to exhibit wear injury.

As the use of golf courses and other large turfgrass areas increases, it is important that measures be taken in an attempt to cope with increased traffic. Therefore, it is essential to provide drainage in areas where it is needed, maintain adequate but not excessive nutrient levels and above all to irrigate judiciously. Also important are the cultural and management programs of coring, slicing, spiking to help provide a healthy environment for turfgrass growth.

A well-balanced turfgrass maintenance program will greatly enhance turfgrass density and wear quality. Wear tolerance and plant density also contribute to playing enjoyment. A full, firm turf stand for the ball to sit up on and a firm soil to play from, add immeasurably to the enjoyment of the game. Water management is extremely important to all of the above.

Wear strips quickly develop when traffic is forced to confined area between fairways on a heavily played public course.



Irrigation Affects Budget

by DONALD D. HOOS, Western Director, USGA Green Section

"WATER IS THE cause of 90% of the problems on the golf course." This is a statement I heard one of the Green Section agronomists make shortly after I joined the staff last year. Since traveling and visiting golf courses this year and observing many of the problems myself, I believe my fellow agronomist made a conservative comment.

If we consider that the grass plant is 80- to 90-percent water, then maybe it makes more sense that water can be the cause of so many of our problems. Even though water can be a problem, it is also essential for proper turfgrass management. The cost of water is a major portion of golf course maintenance budgets.

With ever increasing budgets, many clubs are now looking at methods of either reducing maintenance costs, or else assuring that they don't increase further. Labor is the largest single item in most golf course maintenance budgets. The cost of irrigation is usually right behind labor. If present economic trends continue, we can anticipate that they will remain the most expensive items on the maintenance budget. If we want to reduce or limit the amount of money devoted to irrigation, perhaps we should examine the areas where irrigation affects the budget.

We might classify the effects as direct or indirect. The direct costs are obvious: they include the actual purchase price of the irrigation water, the energy costs for pumping and delivery of the water, and the direct costs for maintenance and repairs of the irrigation system. The indirect costs are not as obvious, and sometimes they are quite intangible. They include part of the maintenance costs of all equipment, chemical costs and labor costs.

The figures we normally associate with irrigation costs and those that are reflected as the irrigation costs in the budgets are the direct costs of irrigation. These costs will be based directly on the amount of water the golf course uses. The more water used, the greater the cost. The more water used, the greater the energy costs for pumping and delivery. The obvious way to lower these direct costs, or to keep increases within reason, is to achieve maximum efficiency from the irrigation system and watering practices. The irrigation program or schedule should be designed to meet turfgrass and playability requirements, to maintain optimum turfgrass quality, and to avoid excessive use and waste.

It is important that we understand the water requirements of the turfgrass plant as well as soil and water relationships in developing our irrigation program. This will help insure that we are not needlessly applying water and that we are achiev-

ing maximum efficiency from our irrigation operation.

What should our watering program be to achieve maximum efficiency? We know that the plant seems to absorb moisture best at or near the field capacity of the soil. This is the level which we should strive to maintain. In most soils, throughout even a four-inch root zone, we are unable to maintain this level by simply watering frequently to replace lost moisture. We should allow the soil moisture content to drop almost to the wilting point before more water is added. Then, the entire root zone should be recharged with fresh water. By watering in this manner, plants will always have adequate moisture and oxygen for proper growth. Frequent watering would tend to exclude oxygen near the surface.

Water should never be applied faster than the soil can absorb it. The application rate should be adjusted in relation to the infiltration velocity of the soil for a minimum amount of runoff. More frequent, light watering during the irrigation cycle may be required to wet the root zone fully on heavier clay-type soils. Careful consideration should be given to insuring that proper spacing of heads, proper type of sprinkler head and total operating time of the sprinkler are used to achieve the proper water application rate for the particular soil type.

In some areas, the energy costs for pumping the water are actually greater than the cost of the water itself. If your golf course fits into this category, the need for application of proper watering techniques becomes even more important, since energy costs can be expected to accelerate at even faster rates than water costs. The use of a properly designed irrigation system also becomes more important in considering energy costs. Use of modern pumping systems may provide possible energy savings. Use of combinations of motors rather than operation of excessively large motors for smaller irrigation requirements may be a consideration, along with proper spacing of sprinkler heads to provide uniform coverage and insuring that all sprinklers connected to a valve are located in areas with similar irrigation requirements. For instance, the top and bottom of a hill have different irrigation requirements; valves and controllers should allow different irrigation programs for each area.

These all become budget considerations if we want to conserve energy, maximize the efficiency of our irrigation system and still maintain the quality of our turfgrass operation.

Other factors, such as climate and temperature, play a major role in the water use rate of the plant. We can see, therefore, that the water use



(Above) When grass growth is heavy due to excessive natural or irrigation water, clippings present a messy problem and turf and soil present a soft surface to play from.

rates of the plant are constantly changing throughout the seasons, and our irrigation program should be adjusted accordingly. The cost-conscious superintendent will constantly monitor and adjust the irrigation program almost daily to meet the specific plant needs. When we have achieved this, we know we are doing as much as possible to realize maximum benefit from our irrigation dollar.

The indirect effects of irrigation on the budget encompass the total golf course operation. Items such as mowing frequency, fertilization, pesticide application, repair and maintenance of equipment, etc., are all indirectly affected by our irrigation practices. These items all play a role in the computation of our budgets. The proper application of water will help insure the best response of the turfgrass to other maintenance practices. The misapplication of water will result in turfgrass and maintenance problems that will ultimately be reflected in our budgets.

Irrigation practices can have a great effect in a simple operation such as mowing. Overirrigation can stimulate too much top growth at the expense of root development during active growth periods. To compensate, either more frequent mowing or more frequent sweeping must be done to remove the clippings. Either of these procedures will require a greater expenditure of labor, and they will be reflected in the budget. Even if the growth rate of the grass increases without an increase in mowing frequency, the effects of the overirrigation will be reflected in the budget by the cost of increased maintenance work on mowing equipment. For example, reels and bedknives will have to be sharpened more frequently because they are used so often in unfavorable conditions. These costs are real and are generated to some degree by your irri-

(Below) Irrigated turf requires more mowing, therefore more back-lapping, new bedknives more often and more of the mechanic's time.



gation practices; however, they are probably not recorded in your budget as irrigation costs.

Fertilizer and chemical costs also are influenced by irrigation practices. Fertilization is done to supply the grass plant with the needed nutrients to provide a uniform and steady growth rate throughout the growing season. We may use different methods to achieve this goal. They include applications of soluble fertilizers on a light, frequent basis, or applications of insoluble or organic fertilizers at higher rates on a less frequent basis, or a combination of materials both soluble and insoluble through the growing season. Our goal is to produce a dense, uniform turfgrass that provides the desired playing qualities.

The three major nutrients normally applied in our fertilizer program are, of course, nitrogen, phosphorus, and potassium. When we say soluble, we are normally talking about highly water-soluble nitrogen, such as urea or ammonium sulfate, while ureaform and IBDU are examples of water-insoluble sources of nitrogen. Regardless of the water solubility of the nitrogen fertilizers, they all depend upon water to make the nitrogen available to the turfgrass plant. Nitrogen is not strongly bound to the soil particles and can be readily leached. Excessive irrigation levels on a too frequent basis will speed the movement of nitrogen through the soil profile and cause an increase in the nitrogen fertilization schedule. Thus, it is important to practice watering techniques that maximize the efficiency of nitrogen fertilization.

Normally we do not have problems with leaching losses of phosphorus and potassium, because

these materials are more highly bound to the soil particles. Once we have supplied these materials at a sufficient level to meet the demands of the grass plant, we can normally expect them to be available throughout the growing season. However, leaching losses of potassium can be a problem on greens of sand construction that have a low cation exchange capacity. In a few cases, there have even been reports of phosphorus losses on high sand content greens. Therefore, irrigation practices can have an effect on the efficient use of all fertilizers. Research has proven that plants which are properly supplied with nutrients actually require less water for growth and development.

The benefit of other chemicals can also be affected very dramatically by the proper use of water. The development of a healthy plant with a good root system that resists or outgrows insect and disease damage can often eliminate the need for many pesticides. The importance of proper irrigation in developing the desired healthy turfgrass plant has received a great deal of attention. It would be difficult to put a price tag on the part irrigation plays in the effectiveness of our chemical pesticide program, but we can be assured that proper irrigation is important to its overall performance and efficiency.

The proper use and management of water on the golf course is the key to successful turfgrass management operations. Water, either directly or indirectly, affects almost every operation on the golf course. If we can use water efficiently and in a judicious manner, it will ultimately reflect favorably in the golf course budget.



How Water Behaves in the Soil

by DR. DOUGLAS T. HAWES, Director, Mid-Continent Region,
USGA Green Section

IN ORDER TO understand properly how water behaves in the soil, we must understand what water is and what soil is. Water is certainly easy to describe: as every high school student learns, it is a liquid composed of molecules made of two atoms of hydrogen and one of oxygen. What is not usually learned is the special properties of these molecules.

Water molecules are polar, with a strongly positive hydrogen end and an equally negative oxygen end. Water exhibits strong hydrogen bonding to other molecules, primarily other water molecules. This gives water a very high boiling point for such a small molecule, and at the same time it gives it a relatively high freezing point. Water molecules are also strongly attracted to other polar molecules, so much so that plants are unable to extract all the water from the soil.

Water retention in the soil is directly related to the amount of surface area on the soil particles. Therefore, the more soil particles in a given volume of soil, the more water the soil can hold. Particles having the most surface area per volume are clay and organic matter. Soils heavy in these two materials, therefore, have very high water-holding capacities, but they are not necessarily good mediums for the roots of turf under golf course traffic.

Soil is not as easy to describe as water. A simplistic all-inclusive definition is a loose naturally occurring material on the earth's surface in which plants grow. This definition allows for inclusion of a wide range of material, from relatively infertile sands to black gumbo prairie soils.

Soil is always considered to have some organic matter in it. A microflora of fungi, bacteria and algae plus enough nutrients to support some type of plant life.

Because soil is so variable in nature, the understanding of how water behaves in soil is very difficult. Water molecules tend to form a film of moisture around particles. The more plentiful the water, the thicker the film held there by the collective forces of adhesion and cohesion. If all the pores of soil are small, then this water film excludes air from the soil. If the soil's pores are large, then once the film reaches a certain thickness, the force of gravity is stronger than the weak forces of adhesion and cohesion on the outer layers of the film and the water is removed, leaving air pockets.

Plant roots do not simply absorb this water like a sponge. They must expend energy to absorb

water and must expend energy to grow out into moist areas after they absorb the water immediately next to themselves. Oxygen from soil air is needed for both processes. Water will move back into areas where the roots have absorbed the moisture by capillary movement but not rapidly enough to satisfy plant need under conditions of high water use. Capillary action is almost nonexistent in coarse sands and very slow in fine-textured soil of poor structure. To add to this problem, cool season grass roots tend to have slow growth rates under warm summer soil conditions. In fact, root systems of *Poa* species and creeping bentgrass may be more dead than alive when soil temperatures exceed 70 degrees Fahrenheit for long periods in July and August.

Nature appears to have designed grass plants which survive the hot, dry stresses of summer best by going into a dormant stage when their root systems are needed least. By not allowing the grass plant to become dormant, we spend the summer fighting nature.

Plant roots need an ideal medium to absorb water if an ideal plant is to be grown above ground. An ideal medium becomes even more important if the plant above ground is to be put under a tremendous amount of stress by being mowed abnormally close to the ground.

Close mowing results in a minimum of leaf surface to produce stored energy, and, therefore, there is little energy to keep the root system functioning.

The ideal medium for plant roots will vary some with the type of plant one is trying to grow. Grass is most difficult to grow where traffic is reasonably intense. Intense traffic compacts the soil and reduces pore space. Most importantly, the larger pores in which air movement in the soil takes place are lost. The ideal medium for grass roots is one that will have, after compaction, at least 50 percent pore space. Ideally, about half of this will be water-holding pore space and half larger pores which will hold air.

The USGA Green Section specifications for putting green construction arrive at a satisfactory method of handling water in putting greens under intense traffic. The desired porosity is built into the specifications so that the compacted mixtures have a total pore space volume between 40 and 55 percent. The volume of non-capillary pores (those in which air moves) are insured to be not less than 15 percent.



(Above) A fairway turf grown on ledge — green color evident mainly over cracks in ledge providing more air (oxygen) to grass roots.

(Below) Traffic on wet soil destroys structure and causes serious problems of soil compaction.



Water retention capacity is also handled by the USGA specifications in that the mixture should have a laboratory capacity between 12 and 25 percent by weight on an oven-dried soil basis.

USGA specifications call for a minimum laboratory infiltration and transmission rate for water of two inches per hour for greens planted to bermudagrass and three inches per hour for greens planted to bentgrass. A maximum infiltration and transmission rate in the laboratory should not exceed 10 inches per hour with normal materials. Rates of four to six inches per hour are ideal. These rates are determined on a topsoil mix which has been compacted at a moisture content equal to field capacity and maintained under a constant head flow of water for 24 hours at a temperature of 20 degrees centigrade.

The USGA specifications for putting green construction have evolved because water management is so critical to growing desirable grass on putting greens. It is much easier to maintain putting greens if we have an artificial soil mix, because soils differ so widely from place to place. The definite characteristic thus obtained from an artificial mix comes as close as possible to providing optimum conditions for plant roots without demanding the tender loving care and cooperating weather necessary with most native soils.

TURF TWISTERS

BUD BREAK

Question: I've received permission to begin a more systematic program of maintenance for my club's key ornamental and shade trees. Can you think of something which I may have overlooked in my program enclosed? (Connecticut)

Answer: Your projected program is fine, but so many ornamentals (and shade trees) are bothered by insects that overwinter on the plants that a sound maintenance program should begin with a dormant oil spray just prior to bud break in the spring. Caution — the label will list species which may be severely damaged by such sprays. Dormant oil spray is not for all plants. If in doubt, contact your University Extension Service.

STEM ELONGATION

Question: What is gibberellic acid, how is it produced, and how does it affect grasses? (Georgia)

Answer: Gibberellic acid is a plant-regulating chemical. It is produced by a fungus grown in liquid culture medium from which the acid is extracted. The process is similar to that used in the production of antibiotics. Grasses respond by rapid blade growth and stem elongation, and color changes to a slightly lighter green.

AND ROOT OF THE PROBLEM

Question: Two of our greens usually come through the winter in very poor condition. What can we do to put these greens back into good playing condition as early as possible? (Maine)

Answer: If the greens are injured over a large area, they should be closed, using temporary greens until recovery is complete. Slice and seed the injured areas in two directions and make a light application of topdressing. An alternative would be to aerate, spike, topdress and overseed. Maintain adequate moisture near the surface for seed germination and development by careful, frequent syringing each day. Also, get to the root of the cause and take corrective measures so that this problem does not reoccur annually.