MARCH 1966

USGA GREEN SECTION RECORD

A Publication on Turf Management
by the United States Golf Association

A CURTAIN OF WATER!

The ultimate goal of the irrigation engineer is to place sprinklers in such an arrangement that each square foot of turf receives the amount of irrigation it needs. No more — no less!

USGA GREEN SECTION RECORD

Published by the United States Golf Association

VOL. 3, No. 6 ***March 1966***

Published six times a year in January, March, May, July, September and November by the UNITED STATES GOLF ASSOCIATION, 40 East 38th ST., NEW YORK, N. Y. 10016. Subscription: $2 a year. Single copies: 30¢. Subscriptions and address changes should be sent to the above address. Articles, photographs, and correspondence relevant to published material should be addressed to: United States Golf Association Green Section, Texas A&M University, College Station, Texas. Second class postage paid at Rutherford, N. J. Office of Publication: 315 Railroad Avenue, East Rutherford, N. J.

Editor: Dr. Marvin H. Ferguson **Managing Editor: Robert Sommers**

IRRIGATION OF GOLF COURSES

Golf course irrigation is a subject of extremely widespread interest emphasized by the recent extended drought in the Northeast. The USGA Green Section Conference on Golf Course Management for 1966 was devoted entirely to this subject.

Because of the interest in the subject and because of the fact that a tremendous amount of information was presented to those in attendance, this issue of the Green Section Record as well as the May issue will be devoted almost entirely to the matter of irrigation.

In many cases, the panel discussions and answers to questions have been condensed in order to conserve space.

Editor

Is this to become commonplace?

Designing Irrigation Systems for Golf Courses

By **DONALD A. HOGAN**, Irrigation Engineer

In this first paper of the day, an attempt will be made to discuss some general aspects of golf course irrigation systems. Many points will be elaborated on in papers to follow.

While no attempt will be made to offer a short course in irrigation design, we shall dwell briefly on some of the fundamentals of sprinkler performance and principles of design. It is assumed that presently all adequate and proper golf course irrigation is accomplished with sprinkler irrigation.

SPRINKLER SPACING AND PATTERNS

Some principles to be discussed are familiar to many of you, but it may be advantageous to review them briefly. All the practical and efficient sprinkler systems available today are rotating nozzle type, applying water in a circular pattern. That is not a very profound observation, but nevertheless, a very important factor to remember when analyzing and selecting sprinkler patterns and their placement in a design.

A triangular pattern of sprinkler placement has proved to be the most efficient arrangement to produce uniform rates of application. Uniform rates of application plus adequate coverage are two of the prime requisites of all good irrigation systems. Considering the geometry of a circle, one will perceive that as the distance away from a sprinkler increases, the area increases very rapidly (by a factor of the square of the distance), so that the amount of water being applied per unit of area is decreasing rapidly. This fact necessitates using an arrangement of overlapping patterns so that adequate and equal amounts of water are applied to all areas during the sprinkling period. Acceptable maximum spacing for turf application demands that when sprinklers are located in a triangular arrangement, the distance between locations should be equal to approximately 67% of the diameter of the discharge pattern.

It is obvious that the area close to each sprinkler receives water from that sprinkler only, and that along a line running directly from one sprinkler to the next, as one coverage is decreasing the other is aiding until at a point one half the distance between the two sprinklers each is applying half the necessary amount. Furthermore, at a point the greatest distance from all sprinklers within the triangular pattern it requires the combined application of three sprinklers to result in an evenrate of application.

Thus we see the desirability of sprinklers being spaced in such a way that each one assists the adjacent ones in providing uniform application.

At the edge of an irrigated area such as a fairway there is not an adjacent row of sprinklers to assist, we find a scalloped area between adequate and inadequate moisture where the necessary additional application of water is missing. This should emphasize the fact that in the case of sprinklers located in fairways only, and not in the adjacent roughs, that the line of sprinklers must be located very close to the edge of the fairway to provide adequate coverage of the full fairway width, with very little effective watering in the roughs.

SPRINKLER UNIFORMITY

Should one consider spacing of sprinklers based only upon a percentage of diameter, and should he design accordingly, he could get into trouble. The assumption is that the result will be a uniform distribution of water.

Sprinklers with similar diameters may not necessarily produce similar precipitation patterns. Therefore, one may use two sprinklers with the same performance rating but find that the degree of uniformity in a given spacing arrangement is quite different. One may be acceptable while the other is completely unsatisfactory.

PRECIPITATION RATE

Another very important aspect of design is the precipitation rate that results from the spacing used for the specific sprinkler installed. The agronomists and soils specialists can tell us a lot about what this maximum rate should be. There are too many factors affecting this determination to be examined in detail in the scope of this discussion.

However, it has been found that with well-maintained turf, on reasonably permeable soil, an average rate of 1/3 of an inch per hour is acceptable. Rates that exceed this amount can result in run-off and ponding. Please note that the unit of definition we use is based on the amount applied if the sprinklers run the entire 60 minutes of the hour. The total amount of water applied during a given period may be considerably less even at a higher precipitation rate if the sprinklers are operated only for a very short duration of time.

For example, one designer asserted that he was applying water at a rate of 6/100 of an inch an hour and that the sprinklers discharge 36 GPM spaced 90 feet apart. In this case the rate was actually ½ of an inch per hour, but the sprinklers were operated for only 7½ minutes each hour. Inasmuch as this period approximates .12 hours, the ½ inch per hour rate will yield 6/100 inches of actual precipitation per hour. Obviously we must define our terms to describe properly and evaluate any circumstance.

SPRINKLER SIZING

Rotary pop-up sprinklers of variable output and effective diameter are available. With a given spacing, increased size of sprinklers increases the precipitation rate. Individual sprinkler coverage exceeding 80 to 85 feet in diameter demands a sprinkler with too high a precipitation rate for the satisfactory irrigation of golf course turf. Recent studies indicate that the smaller the droplet size the better penetration through the turf and thatch to reach the soil and therefore more efficient turf irrigation.

The principles of physics indicate that large droplets can be thrown much farther from a sprinkler than can small droplets. Necessarily then, large diameter patterns depend upon the maintaining of large droplet size. It is strongly recommended that only short to medium range sprinklers be used and that spacings be limited to a *maximum* of approximately 80 feet for golf course turf irrigation.

If one studies a sketch of a single-

All seems confusion at The Creek Club, Locust Valley N. Y., as workmen prepare to lay sod. In the second photograph the soil is pounded into place with a vibrating tamper. All is neat and trim again in the final picture. The soil is level with the adjacent fairway and the sod is back in place. No depression!

row down-the-middle arrangement of fairway sprinklers, he may observe that even with speed control for the overlapped and non-overlapped areas, the pattern of distribution is not satisfactory. The precipitation rate close to the sprinkler is far too high and the droplet size required to reach halfway across a wide fairway is much too large for satisfactory results.

OTHER DESIGN CONSIDERATIONS

The utmost care should be used in the design of a golf course irrigation system, particularly a permanent system with automatic control. Some of the considerations taken into account when designing a system can be summed up as follows:

1. Determine the amount of coverage desired by working with the green committee and golf course superintendent.

2. Evaluate the water supply available.

3. Establish the number of hours and period, generally night hours, when watering is permitted on the golf course.

4. Determine with the aid of local agronomists and the golf course superintendent how much water is needed (generally expressed in inches per week) to meet the combined needs of the turf for evaporation and transpiration (evapotranspiration).

5. After proper analysis, select the sprinkler performance, spacing, and precipitation rate. This can vary for different areas of the same golf course.

6. Design the sprinkler layout as dictated by specific areas to be covered and by other factors, such as wind.

7. Determine the areas of individual control considering:

   a. Specific areas to be covered, such as greens, tees, fairways, etc. including size, shape and location.

b. Topography.
c. Shade and sunny areas.
d. Areas of air movement versus calm areas.

8. Establish sequence of control and segregation of areas controlled by various automatic controllers. It is definitely recommended that the control areas be kept as small as possible and that a minimum number of sprinklers operate on each control circuit. Also where economically feasible, we prefer to have a single control valve for each sprinkler. Even though we may operate a few of these simultaneously on the same station of the controller, this arrangement eliminates drainage of the piping through the low sprinkler heads and affords the most economical design of piping.

Where automatic control is utilized, the operating period for each circuit should be divided into two or three separate periods spaced a few hours apart so that a small amount of water may be applied initially to break the surface tension. Additional irrigation cycles are then utilized to apply the moisture at such a rate that it will penetrate into the soil. This we term "repeat cycling."

9. Selection of type of control — manual, semi-automatic or programmed complete automatic. Also specific type of equipment as type of sprinkler drive, hydraulic or electric control valves, etc. Both types of automatic control valves should be considered because many factors dictate which will perform the best on each specific golf course.

10. Design the distribution system.
a. Piping
b. Valving
c. Pressure control including booster pumping and pressure reducing plus flow control where necessary.
d. Water supply development, pumping, storage, etc.

11. Estimate the installed cost of the project.

12. Prepare specifications for the project including types of equipment and material to be used and construction methods the contractor is to follow. Wherever possible we use non-corrosive materials which includes plastic pipe.

It is my opinion that the person or firm who designs the golf course irrigation system should also supervise the installation, test the completed system, and supply to the owner as-built drawings and operating instructions. Who this person or firm should be is most ably expressed by Dr. John H. Madison, Jr., of the University of California at Davis. After an extensive study of irrigation systems including a substantial study of golf course irrigation he wrote:

"We cannot be tolerant of inadequate design. It is my belief that the trouble we find ourselves in is due to a misuse of the bid system. In asking for a bid we seldom present a sound set of specifications based on good engineering principles. Instead, most systems are designed by the same companies who are later going to bid on them. They know their designs will be competing in price with those of their rivals.

"To compound the problem, the supplier is often told to design to the sum which has been budgeted or which will be acceptable, when, in fact, the *bid should determine the cost and engineering the design—not cost, the design.*

"To me it seems the best answer to our present problems is to have the system designed by a private engineering firm which is paid directly (by the owner) and whose success depends on continually doing a good job of designing fully functional systems."

As a concluding thought, it appears advisable to point out that the permanent irrigation system with automatic control for golf courses is rapidly becoming a necessity for the economical and satisfactory maintenance of good golf turf.

COMING EVENTS

March 16-17........ Michigan Turfgrass Conference
Michigan State University
East Lansing, Michigan

March 21........ USGA Conference on Golf Course Management
Americana Riverside-West Motor Inn
Portland, Oregon

March 21-23........ Royal Canadian Golf Assoc. Conference
Inn on the Park
Toronto, Canada

March 22-23........ Wisconsin Turf Conference
Wisconsin Center
Madison, Wisconsin

March 23........ USGA Conference on Golf Course Management
The La Salle Hotel
Chicago, Illinois

March 25........ USGA Conference on Golf Course Management
Marriott Twin Bridges Motel
Washington, D. C.

May 24........ Central Plains Turfgrass Field Day
Lincoln, Nebraska

Factors Influencing Irrigation

By **JAMES L. HOLMES,** Moderator, **LEE RECORD, HOLMAN GRIFFIN,** USGA Green Section Agronomists

Among the factors which affect irrigation practices are type of grass, maintenance levels, climate, soil type, infiltration rate, evapotranspiration rate, wind velocity patterns, terrain, turf uses, disease factors, water supply, and labor availability.

In opening remarks, panel members discussed evapotranspiration and transpiration. Evapotranspiration is defined as being all the moisture lost from the soil into the atmosphere. This results from direct evaporation from the soil and water transpired by existing plant growth. Transpirational moisture is moisture which evaporates to the atmosphere from existing plants, primarily through leaf stomata.

Evapotranspiration rates are directly related to existing environment. Tests have shown that solar energy is the most important factor. As solar energy increases, the evapotranspiration rate increases.

Other climatic factors influencing evapotranspiration rates are air temperature, air movement, type and extent of plant cover, topography, soil type and condition, and of course the availability of moisture in the soil.

After this discussion, questions were entertained from the floor. Questions asked and comments given are as follows:

Q. What effect does free moisture have on disease activity? Can disease-causing organisms be introduced through the water supply and, if so, are they a significant factor in occurrence and severity of disease?

A. It has been demonstrated that most fungi which attack grass plants require free moisture in order to penetrate the plant. Also, fungi reduce much better in a moist environment. Therefore, free water with special emphasis on frequency of watering definitely favors parasitism.

Futher, it has been demonstrated that the majority of disease causing organisms exist in both parasitic and saprophytic stages and are known as facultative organisms. The fungi known to be most damaging to grass plants subsist in dead organic matter such as mat and thatch as well as on the live grass plant. They are constantly present and may become actively parasitic on a grass plant if the plant loses vigor.

Other environmental conditions are such as previously discussed moisture relationships directly related to the severity of parasitism. It follows then that spores or fungus parts introduced through the watering system probably would be a minor consideration in respect to the overall disease syndrome. On the other hand, if irrigation water contains ingredients such as chemical waste or salts which are toxic even to a minor degree to a grass plant, the plant may be damaged to the point that it loses disease resistance and is thus subject to attack by the constantly present fungi. Once the balance between plant resistance and susceptibility is tilted in favor of the fungus, disease conditions can reach epiphytotic proportions.

If at any time there is evidence that the supply of water is damaging to existing turf, such water should be tested immediately. Obviously, if the water is proved to be damaging, another supply must be found if you expect to maintain healthy turf at all times.

Q. Is there a relationship between the amount of nutrients in the soil or soil fertility levels and water use by the plant?

A. Yes, it has been repeatedly demonstrated by plant scientists that if a soil is low in fertility, larger quantities of water are used in relation to the amount of growth.

Q. What is the water requirement of turfgrasses and does this vary according to species?

A. Panel members commented that it has been their experience that practically all types of grasses used on golf courses in the United States require approximately the same total amount of water in order to subsist and reproduce. However, larger amounts of water are needed in areas where evapotranspiration rates are high. This is true because excess water is evaporated from soil and transpiration rates are high in areas of high solar energy. As a general rule of thumb, somewhere between 1 and 1½ inches of water per week is considered adequate in the Midwest and the Northeast. In the desert Southwest, 3 inches per week is more nearly the requirement. It might be noted that experience indicates that bentgrass and *Poa annua* require more frequency of water than other types of grasses used. However, the total demand does not seem to be any greater.

Q. Is a fairway watering system necessary and desirable for the production of fine turf in the Northeast?

A. From floor and panel discussion, it was determined that in any given year there is a period when fairway turf regresses to a dormant or semi-dormant state. At this time the soil is dry and compacted. Playing conditions are not considered desirable by the majority of golfers. There is a definite tendency by present-day golfers to insist upon lush, well-turfed and "soft" fairway conditions. Also, the golfing season in the Northeast is relatively short. As a result of all this, demand for fairway watering systems by the membership is becoming ever more insistent. It would follow that a fairway watering system is necessary and desirable for the production of fine golf course turf in the Northeast. However, golfers should be made aware that not all turf problems are magically eliminated as a result of the installation of a fairway watering system. Rather, a number of problems will arise which have not been a consideration in the past. Examples are: increased weedy growth which is more difficult and expensive to control; the encroachment of *Poa annua* which is considered by most to be a "fair-weather" friend or a grass plant which tends to die-out during periods of stress; disease activity will be greatly increased (a number of golf courses with watered fairways are already following a fairway fungicide spray program); water holding areas will develop and efforts must be made to improve drainage. Often such efforts are quite expensive.

Q. What is meant by water holding capacity of a soil?

A. The water holding capacity of a soil is that amount of water held by the soil when moisture relationships are between field capacity and permanent wilting point. This amount of water will vary considerably depending upon the type of soil. The range is between 30 and 300 tons per acre foot. The amount of available water is lesser in a sandy soil and higher in a heavier or clay type soil.

Q. What are the three classes of water in the soil?

A. The three classes of water in the soil are hygroscopic — capillary — gravitational. Hygroscopic water is tightly or chemically bound to soil particles and not usable by the grass plant. Capillary moisture is that moisture which is available to the grass plant and most used in growth. Gravitational water is excess water which drains through the soil.

Q. What are the most desirable infiltration and percolation rates in a soil to support grass?

A. A considerable amount of research is being done in this area at the present time. Data indicate that a soil which when compacted contains approximately 40% by volume of the total as air space, or voids, is the most suitable for supporting turf plants. Ideally, of the the total pore spaces in the soil, 50% should be of a capillary nature, 50% should be of a non-capillary nature. Or, when water is added, 50% will drain from the soil and 50% will remain. Thus, ½ the total void space of the soil contains air and the other half contains water, most of which is available to the grass plant. In order for this phenomenon to work properly, infiltration and percolation rates are quite high. The surface of the soil should be such that water will penetrate readily. If the percolation rate or movement of water through the soil is between ½ and 2 inches per hour, it should be possible to maintain adequate air - water relationships in the soil at all times.

Q. Does the proximity of other plants such as trees affect water—turf relationships?

A. Certainly, plants such as trees and bushes transpire large quantities of water, thus tend to dry an area. The presence and location of such plants definitely compounds and confuses watering programs. In order to develop fine turf in these locations, the golf course superintendent must plan his watering program accordingly.

In summation, it is apparent that for production of fine golf course turf, availability of adequate water is primary. However, this is an extremely complex subject and one which cannot be taken lightly. After a fairway watering system has been installed, maintenance practices become more demanding and difficult.

Fungi as Agents of Disease

NOEL JACKSON and **FRANK L. HOWARD,** Rhode Island Agricultural Experiment Station.

An introductory paper outlining the relation of fungi to disease in turfgrasses. The number of fungal species involved, their economic importance and distribution is discussed. The cellular and physiologic characteristics fitting these fungi to act as pathogens is considerd. Interactions between host, parasite and environment are described.

The unique cultural practices employed and their affect on the growth habit of grasses as factors favoring attack by specific fungus are pointed out. The role and nature of propagules as inoculum is surveyed.

A discussion of sympton expression resulting from fungal invasion both to individual plant parts and turf is given and the possibility of wrong diagnosis using symptoms only is noted. The subject of organic residues and additives as substrates for potential fungal parasites is discussed.

Green Section Award to Musser

H. Burton Musser, 72, who retired in 1959 as Professor of Agronomy in the School of Agriculture of the Pennsylvania State University, was named the recipient of the Green Section Award of the United States Golf Association for "distinguished service to golf through work with turfgrasses."

Professor Musser was presented with the Award by Clarence W. Benedict, of Greenwich, Conn., before he retired as USGA President, and Henry H. Russell, of Miami, Fla., Chairman of the USGA Green Section Committee, during the Association's conference on Golf Course Management at the Biltmore Hotel in New York.

Professor Musser was responsible for the development of Penncross bentgrass, Pennlawn fescue and Penngift crown vetch, a plant used mainly for erosion control along the nation's highways.

He began his research which led to the development of Penncross creeping bentgrass in 1937 and released the variety for general use in 1953. The development of Pennlawn fescue was carried on concurrently and took about the same length of time.

Clarence W. Benedict (right), former USGA President, presents the Green Section Award to Professor H. Burton Musser at the Green Section conference in New York.

He has written numerous technical works for trade journals and articles for popular magazines, and is the author of "Turf Management," a publication of the USGA.

Perhaps the greatest contribution Professor Musser has made to the field of turfgrass management lies in his role as an educator of men who have entered this field. More than half a dozen men now active in turfgrass management can claim Professor Musser as their major advisor during the times when they pursued their doctoral training.

Professor Musser was graduated from Bucknell in 1914, decided he wanted something other than a liberal arts degree and then attended Penn State, graduating in 1917.

After college he joined the United States Department of Agriculture in 1917, left to serve in the Navy during World War I, returned following the Armistice and then joined the faculty of Penn State in 1922.

From 1930 until his retirement he was in charge of turfgrass research. He served as a Lt. Colonel in the Army Air Corps during World War II, responsible for dust and erosion control at air fields within continental United States.

Professor Musser was a Fellow of the American Society of Agronomy, is a holder of the service plaque of the Golf Course Superintendents Association of America and since his retirement has been the Executive Director of the Pennsylvania Turfgrass Council. During the last five years this organization has raised $100,000 which it has contributed to Penn State for research.

Professor Musser is the sixth recipient of the Green Section Award. Previous winners were Dr. John Monteith, Jr., of Colorado Springs, Colo.; Prof. Lawrence S. Dickinson, Amherst, Mass.; O. J. Noer, Milwaukee, Wis.; Joseph Valentine, Ardmore, Pa., and Dr. Glenn W. Burton, Tifton, Ga.

The winner receives a replica of the Green Section Award, the original of which hangs in "Golf House," USGA headquarters in New York.

Effects of Soil Amendments and Irrigation

WAYNE C. MORGAN, J. LETEY, S. J. RICHARDS, and N. VALORAS. University of California, Riverside.

The effects of three physical soil amendments, two irrigation programs, and two surface compaction treatments were determined on the growth of Bermuda grass in a greenhouse experiment. Peat moss, calcined clay, and lignified redwood were used as the amendments and were mixed with a Ramona clay soil on a 30% volume basis.

The top growth was better where irrigation was guided by tensiometer records as compared to a set program of adding one-half inch of water three times a week except for the lignified redwood in which irrigation technique had very little effect. Top growth was better when the soil surface received no compaction.

In general, the treatments affected root growth similar to the top growth. Calcined clay and lignified redwood reduced the compactability of soil as compared to peat amended and unamended soil. Differences in compactability of the various soil mixes were most pronounced under a set irrigation program.

Water infiltration rates were highest under lignified redwood and calcined clay. Soil compaction had greatest effect upon the infiltration rate of peat amended and unamended soil.

On The Research Front

A symposium dealing with the subject of turfgrass diseases was presented to scientists attending the meetings of the American Society of Agronomy in Columbus, Ohio in November 1965. Abstracts of papers are presented here. The full text of the five papers will be published by Virginia Polytechnic Institute. The USGA Green Section Record will announce the availability of these papers when they are published.

Fungicides in Disease Control

CHARLES J. GOULD, Western Washington Experiment Station

The increasing use of turfgrass fungicides is a natural result of increased acreage of turf, a growing appreciation of turf quality, and probably an actual increase in disease incidence. Mercurials dominated the market for many years and one of the oldest of these, a mixture of calomel and corrosive sublimate, is still widely used. Since the introduction of the dithiocarbamates in the 1940's, a flood of new materials has appeared and several have proven useful against certain pathogens.

Single pathogens are most economically controlled by specific fungicides. However, there is an increasing trend toward broad spectrum mixtures containing two or more fungicides. These are particularly useful to homeowners, as well as golf course superintendents and other turf managers in areas where more than one pathogen may be active at the same time. Additional trends are new methods of application, for instance substituting one heavy drench for several sprays; improved formulations, for example by smaller particle size; and new types of equipment. Results indicate that in controlling turfgrass diseases the formulation and method of application may be almost as important as the type of fungicide used.

Salinity Tolerance of Creeping Bentgrass

VICTOR B. YOUNGER, FRANK NUDGE and **O. R. LUNT,** University of California

Seven varieties of creeping bentgrass were grown in solution cultures containing five salt concentrations (20, 60, 100, 140 and 180 meq/1) to determine their salinity tolerance. The experimental design was a complete randomized block with four replications. All grass cultures were clipped at weekly intervals. Total dry weight of the last five clippings served as the measure of salinity tolerance. Growth of all varieties decreased with increased salinity.

Arlington and Seaside varieties showed the greatest salt tolerance followed closely by Old Orchard and Pennlu. Penncross was the least salt tolerant of the varieties tested. Individual seedlings of Seaside showed great variation in amount of injury from the highest salt concentration. Results indicate that more highly salt tolerant strains may be obtained by screening seedlings of Seaside and other varieties in this way.

Influence of Nitrogen on Bermudagrass

C. Y. WARD and W. R. THOMPSON, JR., Mississippi Agricultural Experiment Station.

Six nitrogen sources were evaluated at four frequencies of application on Tifgreen bermudagrass (Cynodon spp.) sod managed as a golf putting green. Each source was applied so as to supply a total of 16 pounds of nitrogen per 1000 square feet per season. The frequencies of application were: three, four, eight, and 16 times per growing season (March 15 to November 1). Plots were scored for turf quality at frequent intervals by visual observation during 1964 and 1965. Clippings were taken for dry matter production and total nitrogen analysis during 1965.

Nitrogen sources and intervals of application produced significant differences in turf quality. Ammonium nitrate and urea treated plots produced high quality turf throughout the entire season. Milorganite plots produced higher quality turf than those fertilized with other organic sources. Soluble nitrogen sources produced highest turf quality when applied eight and 16 times per season; whereas, insoluble nitrogen sources produced more uniform growth with less frequent applications.

Poa Annua Control

FELIX V. JUSKA and A. A. HANSON, USDA, Agricultural Research Service, Beltsville, Maryland

The interrelationship of herbicides and levels of phosphorus in controlling *Poa annua* was investigated in the greenhouse. Five herbicides were evaluated at seven phosphorus levels and at two planting dates — immediately following herbicide application and 48 days later. Surviving seedlings were counted and seedlings harvested at 21 and 35 days, respectively.

Trifluralin gave complete control at both planting dates while Zytron was second among the herbicides tested. At both planting dates high levels of phosphorus reduced the effectiveness of calcium arsenate. At the second planting date the addition of phosphorus gave a slight increase in number of surviving seedlings in the Betasan, Zytron, and Dachthal treatments. Surviving plants in the Zytron and Dacthal treatments were more vigorous at higher levels of phosphorus.

Effect of Different Nitrogen Sources

A. J. POWELL and W. H. McKEE, JR., Virginia Agricultural Experiment Station.

Experiments were conducted on a golf green and highway slopes to study the effect of fall and winter nitrogen fertilization. Slow release and soluble sources of N were applied periodically in fall and winter to bentgrass. Best color was maintained during the winter with biweekly applications of soluble N and ureaformaldehyde and with a urea-hydrocarbon wax product applied only in October.

The green color was related to availability of N. The high rates of N (10 pounds/1,000 square feet) gave better green color than the low rate (5 pounds/1,000 square feet). Analysis of the plant material indicates reduced hot water soluble carbohydrates with N.

Results with Kentucky 31 fescue on highway slopes showed better stand density and color with slow release forms of N; however, high rates of ureaformaldehyde were required because of slow N release.

USGA GREEN SECTION RECORD
40 East 38th Street, New York, N. Y. 10016

TURF TWISTERS

ZOYSIA FAIRWAYS

Question: We are interested in the use of zoysia for fairways. Can you give us an opinion as to its suitability? (MISSOURI)

Answer: Zoysia produces the densest, firmest turf imaginable when it is well established. It is difficult to establish because of the fact that it must be planted from sprigs or plugs. Once established, maintenance requirements are relatively low, and there are very few pests that are likely to cause trouble.

One possible objection to zoysia is that the turf is so dense and springy that it may tire the golfer to walk on it. This build-up can be controlled, however, by close mowing and vigilance to forestall the formation of too great a mat.

MOWING MERION

Question: We understand that Merion bluegrass can be mowed closer than common Kentucky bluegrass. Why? (*Illinois*)

Answer: It is true that Merion can be cut a little closer than can common bluegrass. Merion is a shorter growing plant with relatively short internodes and leaves. It also tends to tiller more than does common bluegrass.

NIGHT MOWING

Question: Is night mowing healthier for the grass plant? (Penn)

Answer: In hot summer months, it appears likely that mowing during the day may cause some damage. Damage to tissues normally results in increased respiration rates. It is believed that night mowing may help to alleviate these effects. However, where disease is a problem and dew is heavy, bruising the grass and then allowing it to stay wet all night may contribute to fungus activity.

With our present knowledge, an unqualified answer is not possible.