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The article describes methods of purifying salt water, including the possible use of atomic energy, and ends with this thought: "There is no greater gift this country could give the earth than the perfection of techniques for transforming the sea into fresh water. And for our own good, we'd better do it soon!" The growing scarcity of fresh water is not an idle threat; it is real. Two recent references have been abstracted here to indicate the trend of thinking. To cite other references would serve no useful purpose.

During the educational turf conferences of the winters 1948-49 and 1949-50, USGA Green Section personnel stressed repeatedly the need for saving water on turf areas. Since 1945, Green Section research has been directed toward a program of growing the best turf possible with the minimum of artificial irrigation, using every known device such as: (1) Aeration of the soil to improve porosity and absorption and to reduce runoff; (2) More adequate fertilization to produce denser turf, which is the best-known method of saving water; (3) Emphasis on the turf grasses which have low-water requirements and high drought-tolerance. The Green Section expresses its considered opinion that funds for agricultural research may be used justifiably for turf research which is directed toward saving water. It is well known that, even in areas where water shortages are becoming critical, many turf areas regularly are overwatered. Agricultural and industrial interests should welcome the opportunity to support this phase of turf research because the savings in water largely will accrue to the benefit of agriculture and industry. We do not limit our thinking and our planning to golf course turf; we include all turf areas. We subscribe to the policy that the best turf for all purposes is that which is maintained with only sufficient water to keep it alive.

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KNOW HOW TO WATER

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To do a good job of turf irrigation, we must consider the rooting habits of grasses. If given an opportunity, grasses will develop surprisingly extensive root systems. It is commonly thought that the roots under turf are confined largely to the top six inches or certainly to the top foot. What are the rooting capabilities of turf grasses? The rooting depths of 15-months old plantings on a deep clay soil at Davis, Cal., were studied by measuring the extraction of soil moisture. The plots were irrigated deeply and then allowed to go without irrigation until the grasses wilted. When wilting occurred, all of the available soil moisture in the following soil depths had been extracted:

Effective Rooting Depth Grass	(inches)
Chewings fescue	8
Wahee fescue	10
F-74 fescue	10
Highland bent	12
Kentucky bluegrass	30
Merion bluegrass	30-36
K-31 (tall) fescue	36
Bermuda (U-3 and Common)	36+

In all cases considerable moisture extraction took place below the depths indicated.

Some roots were found at the five foot depth under Merion bluegrass and at the six-foot depth under the bermudas. The ability of grasses to root so deeply has not been considered in the preparation of sites for planting or in the irrigation management of turf areas. Of course, rooting depths will be less in shallow soils or where management practices have restricted root development. These data simply indicate the rooting capability of grasses under these conditions at this location. What practical application does this information have in turf irrigation? Such data help to answer the two basic irrigation questions: (1) how much water to apply and (2) how often to irrigate.

How Much Water to Apply

How do we decide how much water to apply? After a rain or an irrigation, a given depth of a well-drained soil will hold a certain amount of water, depending on its texture or particle sizes. This amount is called the field capacity. Any water applied in excess of the soil's field capacity will drain out. The drier the soil is at time of irrigation, the more water is required to wet a given depth. If the soil has been dried until the grass wilts (approximate wilting point). For example, to wet a two-foot depth requires one and one-half inches of water for sands, three inches for loams and five inches for clays.

Some turf is overwatered that is, more water is applied and soaks in than the soil will retain within the root zone of the grass. The surplus water drains down through the soil, carrying away nutrients and often creates soggy subsoil and consequently shallow roots.

Turf is often underwatered. For example, traveling sprinklers, as they are commonly used, usually apply only one third to one-half inch of water. If the soil has been dried out, one-third inch of water will wet only about five inches of a sandy soil, two inches of loam, and one inch of clay.

The superintendent should determine how much water his sprinklers are putting on. This may be done by using coffee cans as rain gauges. Uniformity of application can be checked by placing the cans in a line running out from the sprinkler. Many will be surprised to find how little water they are applying, especially near the fringe of the area hit by the sprinklers.

Where there is no appreciable surface runoff, the correct running time for sprinklers can be estimated if the rate of water application is known.

In many cases it is easier to let the sprinklers run until coffee-can rain gauges contain the depth of water required to wet the soil to the desired depth. If the sprinkling time is recorded, it can be used as a guide for future irrigations.

Remember that shallow rooting may be caused by repeated shallow irrigations or, in some soils, by application of excessive amounts of water. In either case, the shallow-rooted turf thus produced will then demand frequent irrigation to prevent wilting.

How Offen to Irrigate

Our turf irrigation habits are often bad habits from the standpoint of soil characteristics and the needs of the grasses. Irrigation practices are usually set by habit, the calendar or what we are told are the special moisture requirements imposed by the use to which the turf is put. Let us forget, for the moment, these special demands and look at irrigation solely from the viewpoint of soil characteristics and needs of the grass. Consider the soil as a storage reservoir. The storage capacity within the root zone is determined by the rooting depth of the grass and by the difference between the amount of water retained by the soil after irrigation (approximates field capacity) and that remaining when the grass wilts

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(wilting point). The water held by soil between field capacity and the wilting point is called readily available water. Grass will not suffer a water deficit as long as roots are in contact with available water. Sandy soils will hold one-half to three-fourths inch of available water per foot depth of soil, loam about one and one-half inches, and clays about two and one-half inches.

How long will the supply of available water in the soil reservoir last? This depends upon weather conditions, particularly light intensity, temperature, humidity and wind. Trees and shrubs may compete with the grass for water and increase the drain on the soil moisture supply. The rate of water use differs from day to day and place to place. Even on a single piece of turf, water consumption may vary considerably according to exposure. Thus one cannot give accurate figures for water use.

As stated previously, the approximate number of days between irrigation depends on (1) the depth of soil containing roots which has been wet by the last irrigation, (2) the soil texture which determines the available water capacity and (3) the rate of water use.

Where the water use rate is one-inch per week, as is assumed in Chart No.2, a grass which has effective roots to a depth of 12 inches should not need irrigation on a sandy soil for three or four days, on a loam for eight days, and on a clay for thirteen days. If the effective rooting depth is 36 inches, then the grass should not require irrigation on a sandy soil for 11 days, on a loam for 23 days and on a clay for 39 days. Are these right? Have grasses been shown to go without water for such long periods of time without drying or loss of color?

The possibilities of infrequent irrigation are being studied at Davis. This past summer was one of the hottest on record, with temperatures above 90° and close to 100° F most days, and low humidity. On a deep clay soil, the 15-month-old grass slots did not show distinct wilting until the following periods had elapsed:

Elapsed Days Before Distinct Wilting		
Grass		14
Creeping fescues and bent		24
Merion bluegrass		30
K-31 fescue	approx.	36

After these periods, the grasses were distinctly wilted but had not turned brown. The U-3 and common bermuda plots were irrigated by mistake after 36 days. Since beginning the experiment in June, the bermuda plots received only one irrigation up to the date of this meeting October 7). These data indicate that, where grasses are deep rooted, they can go for long periods between irrigations even in the hot, dry interior valleys.

Some of you will say, "1 can't do this with my turf."

I'll agree you can't if your roots are shallow because of shallow soil or management practices which have restricted root development. Shallow irrigation, very often the cause of shallow roots, results from application of too little water or from failure of the water applied to soak into oil. Slow water penetration is a major problem with many soils. On these soils which take water slowly, deep irrigations without excessive runoff are difficult with much of the sprinkler equipment now in use. With such soils, more frequent irrigation may be necessary until measures can be taken to improve water penetration and minimize runoff. The more often a soil is irrigated, the greater the opportunity for compaction of the surface soil which further retards water penetration. Thus a vicious cycle is established.

"The curse of irrigated agriculture is often too much water. In turf, the curse is somtimes too much water, but more often it is too little water, applied too often."

Consider, for example, a grass which has an effective rooting depth of 24 inches on a loam soil. Within this depth of soil the previous irrigation should have stored about three inches of available water. If the water-use rate is one inch per week and, to be conservative, one plans to use only two inches of this water, then this turf should go at least two weeks between irrigations. We could supply the water needed by one two-inch irrigation every two weeks. But if we apply only one-third inch of water or because of slow water penetration only one-third inch penetrates, then we would have to irrigate three times per week or a total of six irrigations instead of one. The more frequent irrigations add to labor costs, waste water, magnify disease and weed problems and increase the opportunity for soil compaction. No good pasture operator would allow stock on his pasture for at least three days after irrigation to avoid trampling damage. We can't keep human livestock off the grass, but we can decrease the opportunity for compaction in this example by adding two inches of water to the soil in one irrigation instead of in six light sprinklings.

This illustration should present us with a challenge to see what we can do to reduce irrigation frequency. To do this we must (1) use sprinkler equipment which will not apply water at an excessive rate, (2) cultivate turf areas where needed to improve rate of water penetration and (3) develop schedules and practices which permit sprinklers to remain in one place long enough to apply an adequate depth of water.

There has been a lot of talk ahout using too much water. You will note I have not said that we are necessarily using too much water, but in many cases we are watering far more often than would be required if full advantage were taken of the deep-rooting capabilities of the grasses. Generally, one cannot make a sudden change in irrigation frequency. If your grass is shallow rooted as a result of either dry or water-logged subsoils, gradually encourage deeper rooting by improving subsoil moisture conditions.

A good turf irrigator should know (1) the rooting depth of his grasses, what depth is being dried out between irrigations, and (2) how long sprinklers should be run to replace the soil moisture. Only if you have answers to these questions, can turf irrigation be put on a sound basis. Turf should be irrigated on the basis of soil characteristics and the need of the grass for water. Special turf uses may at times force us away from sound irrigation principles, but we should return to good irrigation practices whenever possible. Some type of soil sampling tool is a must for the good irrigator.

I haven't given you all the answers on how to water turf. We don't know all the answers. We hope our research program will help supply them. I believe we can now say with assurance that there are two simple rules to follow for good turf irrigation:

(1) Water deeply

(2) Water infrequently

The curse of irrigated agriculture is often too much water. In turf, the curse is sometimes too much water, but more often it is too little water, applied too often.

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