the center of the fairway with outlet valves spaced according to the width of the fairway and the range of coverage and capacity of the sprinkler head. The sprinkler is attached to a coupler which is inserted into the valve, and with a single twist of the coupler, water is released from the valve to the sprinkler. The action of the water and the setting of the mechanism on the sprinkler determines the speed at which the sprinkler revolves. Special type sprinklers such as pop-up, part-circle, and low altitude sprinklers are available for tees, greens, and other specific areas. Various management practices are used in applying the water required, such as (1) alternate use of the valves and (2) grouping of certain areas as units of operation, taking advantage of the overlap as an adjunct to controlled application and labor modification, or to fit into specific operating hours determined by play or restricted use of water by local ordinances. The time required and the amount of water applied at any one time is regulated by the circumstances peculiar to each situation.

The comparative costs of installing the quick-coupling system is in between the completely automatic system and various hose systems. Installation costs depend on the conditions encountered and the obstacles to be overcome at each individual golf course. While installation costs may be higher than hose systems, they are considerably less than estimated costs of completely automatic systems.

From the standpoint of efficiency, under reasonably good labor management the quick-coupling system may be handled by one man under normal conditions, plus some extra labor for abnormal periods of drought or need for increased application.

The quick-coupling system is capable of efficient water distribution. It is flexible as to sources of water supply, and to the mechanics of operation such as required by players and local restrictions. Distribution to remote areas by means of hose or portable pipe is simple and various size sprinklers may be used to adjust coverage on any outlet.

In conclusion it would seem important to emphasize the following points with regard to any system of irrigation:

1. Management of water is more important than the simple mechanics of operation.
2. Installation costs should be considered with a view to maintenance and labor costs.
3. Sound judgment based on all available knowledge and technique should be used in determining where, how, and when to water.
4. Conservation of water is becoming more and more a matter of national concern and lack of support of conservation possibly could further restrict the use of water on the golf course.
5. The critical stage of fairway irrigation is the transition period from unwatered to watered turf— give the grass a chance to get adjusted to more intensive irrigation practices, or be prepared for **Poa annua** and weeds.

Turfgrass Culture and Soil Water Relationships

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Golf turf is as good as the agronomic watering practices it receives. A good source of water, a good distribution system, or a good sprinkler system does not insure good turf; it merely makes the watering program easier or feasible. Also, the green that is wet enough to hold a golf shot pleases the golfer, but does not make for the best turf or the least turfgrass troubles. The needs of the grass cannot be compromised without harm.

A golf course that has consistently good turf, is always the highest tribute to the superintendent's watering program. Some accomplish this result with an inadequate watering system, poor drainage, and compacted or clayey soils. I have told students that we have many golf course superintendents who can grow grass on top of a table in summer. Unfortunately too many are doing this. Even though a superintendent can succeed in spite of such handicaps, it is a waste of his time and the club's money to work under such unfavorable conditions. Also, there are some courses that will always experience poor turf until bad conditions are corrected.

Good soil and water relationships start with understanding the fundamentals. How does water occur in the soil? How much water do soils hold? How fast will a turf accept water? What part of the soil moisture can turfgrass obtain? Why is good drainage and percolation important? What constitutes good watering? These are the questions.

How does water occur in the soil? Moisture in the soil can be divided into three parts, according to its value to the grass. First, unavailable water—this water is held so closely by the soil that it cannot be taken by the plant. Second, available water—this water is retained in close association with the soil particles by capillary attraction, but it is largely available to the plant. Third, gravitational water—this water drains off shortly if drainage is proper. It is superfluous and is harmful as it occupies air space and ruins soil structure. Some of you have questioned the technical basis for a golf course superintendent closing the course for several hours following a heavy rain. This permits the gravitational water to move out and reduces the chance for soil compaction.

How much water does a soil hold? A sandy loam soil may contain 17 pounds of water for 100 pounds of soil. About 4½ pounds of this water will be unavailable and 12½ pounds remains for the grass. A loamy soil contains an average of 25 to 30 pounds of available water for each 100 pounds of soil, or more than twice as much as a light sandy soil. The amount of water a soil will hold can be expressed in terms of the water required to wet the soil to a given depth. One-fourth inch of water will wet a sandy soil to a depth of 4 inches and a clay soil to slightly more than one inch. One inch of water fails to wet 5 inches of clay soil. Most of the year, roots should be deeper than this. To make the problem of small water applications more acute, the total amount of water applied does not penetrate the soil. Interception and evaporation prevent a large percentage of the small applications from entering the soil. The light application is largely a cooling treatment.

How fast will a turf accept moisture? A water infiltration rate of one to two inches per hour is usually good for traffic areas. Many areas do well to accept ¼ inch per hour. When penetration becomes this slow or slower, watering is very difficult.

What can be done about poor water penetration? (1) Change and improve soils that have high clay, low sand, and low organic matter content. (2) Utilize all methods of minimizing compaction, especially on the clayey soils. (3) Grow good turf. Apparently a good and growing turf keeps more channels open for water penetration. (4) Control thatch or excessive surface accumulation as this seriously interferes with the rate of water acceptance. Cultivation and spiking are aids to water penetration on thatch areas.

What is the effective rooting depth of turfgrasses? It is the soil depth to which a grass root system removes water before more water is necessary to avoid drought effects. Effective rooting depth may range from a fraction of an inch for bentgrass under stress to 36 inches for Kentucky bluegrass or bermudagrass growing in a well-drained favorable soil. The greater effective rooting depths make watering easier. Unfortunately, this depth varies seasonally for a grass area. Severe heat, heavy compaction, drought, disease, and excessive moisture can lead to sudden and serious loss of the root system.

Good drainage is critical to deep effective rooting. Why is drainage so very important for good root performance? Poor drainage frequently means a poor oxygen supply. This condition prevents the soil organisms from producing the available nutrients needed by the roots. Also, deficient oxygen hinders root absorbtion of water and nutrients, i.e. starvation, drought, and suffocation are the result of bad drainage.

The oxygen supply is rarely limiting if the soil will permit ready passage of water. Fresh water can carry enough oxygen to keep grass roots healthy. Thus, good internal drainage is fundamentally necessary.

How is good oxygen supply insured? This is done by (1) maintaining a porous turf surface, (2) using a soil texture that is 65 to 80 percent sand and 5 to 10 percent clay, (3) using a soil that has a moderate amount of organic matter, (4) managing a soil to prevent layers, and (5) establishing good drainage at the base of the soil. These are basic requirements for good soil oxygen relations. Note they parallel the requirements for soil water management. Without these the task of maintaining good turf in severe weather becomes far more difficult than necessary.

What constitutes good watering? Good watering has three requirements: (1) Watering when the grass has the need. This is decided largely by the appearance of the grass, plus observation of the soil. Some grass types or species require water sooner than others. When grass roots are short or fail to function, the watering frequency must be greatly increased. High temperature increases the urgency for watering. "Blue" wilt on a turf area is a serious warning of urgent water need. The importance of avoiding unnecessary water and the criticalness of applying water prior to serious wilting cannot be over-stressed.

Some prefer to water well in advance of critical dryness. This may be necessary if the watering system is inadequate, but it should be remembered that any unnecessary use of water:

(1) Increases disease
(2) Ruins soil structure and brings compaction
(3) Encourages weeds
(4) Costs money

Watering should be timed carefully with rainfall. A predicted rainstorm or a forecast for continued drought should alter watering procedures.

(2) A second requirement for good watering is applying the moisture at a rate the soil will accept. The rate may be tediously slow, but nothing but harm and waste results from rapid application. Devise the system and techniques that give the proper rate.

(3) A third requirement of good watering is applying the amount needed to recharge the effective root zone. This may be two inches or more with deep rooted grasses or a fraction of an inch with a grass that has lost its roots.

Individual judgment is of greatest importance in watering. The critical moment requires immediate action. On behalf of the superintendents, I have the greatest admiration for the faithfulness and delicate attention they give to watering through a long hot dry summer.

Sprinkler Types for Golf Courses

By WILLIAM BERESFORD
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I consider it a great honor and privilege to present to you my experience with sprinkler systems on the West Coast. During my 32 years at the Los Angeles Country Club, the past nineteen as Superintendent of Grounds, we have operated eighteen holes (South course) on a hose system. This system was installed in 1911, a 6" main coming in at around 160 lbs. pressure which has since been reduced to 90 lbs. in the past 5 years causing some turmoil during the summer season. Most of the mains were oil well casing at that time, and are still in use. These mains were installed down the middle of the fairways; all laterals were galvanized; ¾" garden valves in boxes were spaced about 150 ft. apart; a few laterals were spaced in the rough for the convenience of watering trees and rough.

Tees and greens have adequate valves to insure proper watering. These are off to the side and around the greens and tees. Soils on this golf course are clay. They do drain fairly well yet hold moisture.

Good turf plays a very important part in the use of water. We, at The Los Angeles Country Club, are considered to have the finest fairways of Bermuda in the United States during 12 months of play. This grass is more drought resistant than any grass for this purpose.

Our irrigation season during normal winter rainfall starts April 1st until December 1st. All sprinklers used on fairways are rainbird No. 70's. It requires three men 8 hours, six nights per week to cover 18 holes which includes tees and greens. Each man has six fairways, six tees and six greens. He keeps 100 ft. of hose at each green, 50 ft. at each tee and