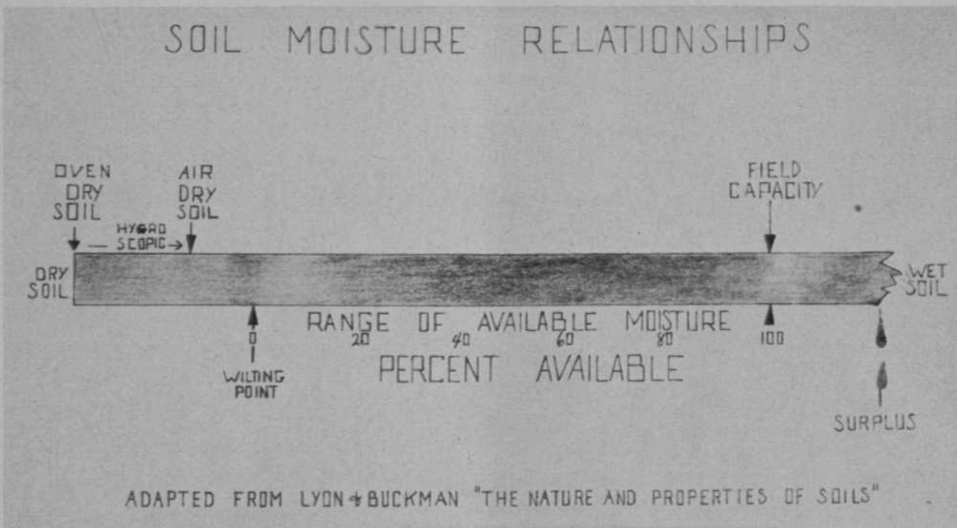

How to Measure Soil Moisture and Conserve Water, Labor*

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Perhaps over the years Greenkeepers have heard more about soil and water relationships than any other phase of turf maintenance. Slowly our information on soil moisture conditions has increased, and now more scientific methods of measuring and controlling soil moisture are available. A method is suggested which can be applied to fairway and tee areas. It will provide a sound practical basis for supplemental irrigation as well as conserve labor and water.

Let us briefly review the various moisture fractions in the soil. If we let a sponge represent the soil, which holds water in a similar way, and apply water, the following forms appear: We get runoff, a form of gravitational water, and if we sprinkle it long enough, percolation occurs, that is still gravitational or surplus water. When the sponge stops dripping it has its "field capacity" or water holding capacity. That represents the amount of water held by the soil against the pull of gravity. When the sponge is squeezed, the available water is removed. In a similar way roots would take up available moisture from the soil. The sponge is still damp, just as soil is still slightly damp when the roots can no longer attract moisture from between the soil particles. That then represents the wilting point of soil.

Another way to represent available water is by a line graph as shown above. From left to right are points indicating oven dry soil, field capacity and free water. Unavailable water is indicated on the left. It is of limited amount and includes hygroscopic as well as some capillary water. The range of available water between the wilting point and field capacity is of the most interest. To the right of that is superfluous water, which is usually within the root zone only a limited time.

If we consider the available water, which we are interested in measuring, then the chart in Figure 2 at the right applies. On the left hand side the percent of available water is indicated. The number of days following water applications is indicated at base of graph. Within one day after water application, the soil moisture tends to reach an equilibrium. After field capacity is reached the upper slope of the line indicated that water is rather uniformly available to grass roots. When the available moisture is below 20%, it is difficult for the plant to obtain enough

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moisture to prevent wilting. Therefore, in hot afternoons the turf begins to wilt. That is followed by progressively more severe wilting until, when the available water is zero, the turf goes dormant or dies. Notice that the slope of the line flattens out after 20% is reached. Therefore at that soil moisture content, irrigation should be applied.

Greenhouse Tests

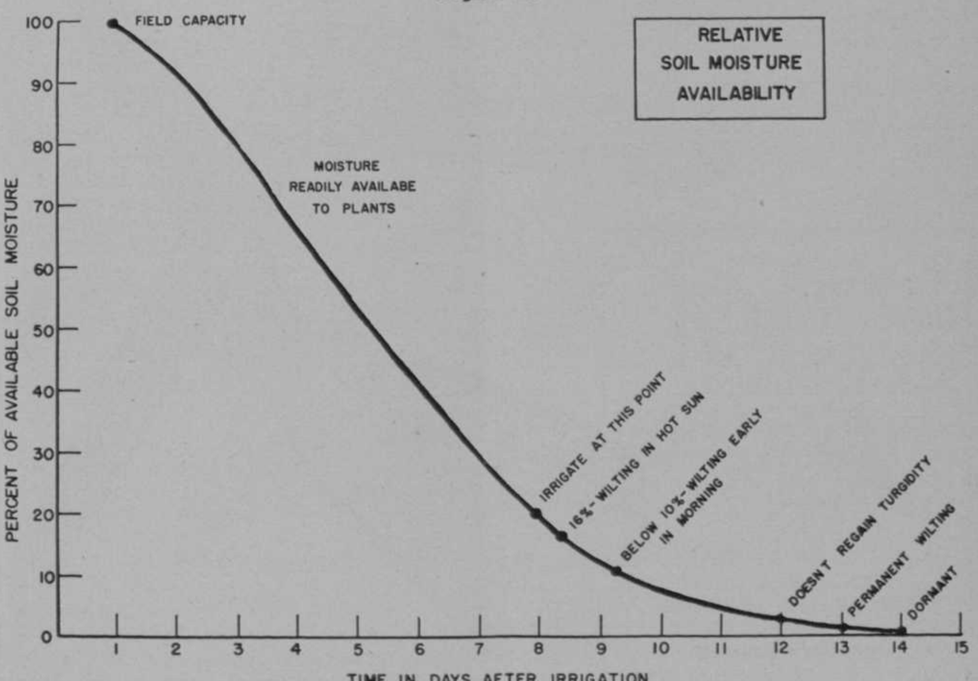
In the greenhouse four soil moisture ranges were maintained for three months. Fifteen cultures each of bent, fescue and bluegrass were planted on one soil type. Twelve cultures of each grass were fertilized with 10-6-4. Moisture blocks were placed four inches from the surface. These indicated the soil moisture available to plants in the cultures and water was applied only when the available soil moisture was at the lower limit of the range in which the turf was growing. Cultures which were in the lowest soil moisture range were allowed to wilt for as much as five days before water was again applied.

After the grasses were well established, the variations in soil moisture were started. However, under excess moisture conditions it took considerable time to kill back the roots. When that occurred, there was a sharp reduction in growth. This was primarily caused by a lack of nitrogen availability as indicated by yellowing of the grasses. The yield of clippings was highest from culture under high soil moisture range conditions and least on those under excess soil moisture conditions.

Even more important than the yields of clipping was the amount of roots found in the soil after 100 days of growth under a given moisture condition. Cultures that were "too wet", under excess soil moisture, had roots less than two inches deep and little feeding area in the soil. Such turf responded very quickly to applications of soluble nitrogen. Cultures maintained in the high soil moisture range, from 50-150% available, had a vigorous growth as they were not limited in available soil moisture. The roots were extensive and the rhizomes of the bluegrass cultures indicated a very healthy condition. When cultures were maintained between 120-20% available water, a well distributed root system was found. Such cultures had a root distribution that contacted as much soil as possible in order to secure adequate water and nutrients. Turf that was forced to wilt between water applications has fewer roots, but they were well distributed. Under these conditions the rhizomes of bluegrass were dark brown, very small and inactive when compared to those cultures maintained under more moist soil conditions.

When fertilized and unfertilized soil was tested under the same soil moisture conditions, as determined by the soil

(Figure 2)



moisture blocks, what was the comparison? Compared to the fertilized cultures, the unfertilized produced only one-half as much clippings, three-fourths as much roots and yet, required the application of 85% as much water. Thus a low fertility level gave only a slight saving in the amount of water applied.

Field Plot Tests

We had found in the greenhouse that the soil moisture blocks were satisfactory for indicating available soil moisture. Therefore, a series of five rates of supplemental irrigation was conducted on bluegrass and fescue in field plots. The amount and number of irrigations depended on the soil moisture content maintained in the individual plot. In 1949 one plot received 20 irrigations, another four, another two heavy, another two light, and finally no supplemental irrigation. In Michigan during that year there were two drought periods when irrigation was badly needed. At one time the unirrigated turf turned dormant only two or three days before a rain came, but it took several weeks for it to produce a satisfactory turf after going dormant. In contrast the plots that received only two light applications of water but at times when the grass would have gone dormant otherwise, were able to remain green until a rain came.

In turf research one of the most difficult problems is to find a satisfactory measure of the response to a treatment. The percent of bare ground, yield of clippings, ball support, turf composition and turf rating were all used. This paper summarizes them as affected by the available soil moisture and number of irrigations applied.

The percent of bare ground was estimated with the aid of a grid. Particularly where the available soil moisture approached zero percent, no irrigation, there was a large amount of bare ground. This was most obvious where the fescue made a clumpy-type of growth. High-cut fescue that was unirrigated had 22% bare ground in September. At this same time similar plots maintained with above 20% available soil moisture averaged only 2% bare ground.

The yield of clipping increased as the available soil moisture increased. Plots maintained above 50% available soil moisture had a very vigorous growth. However, the very high yields produced under high available soil moisture did not reflect improvement in the turf rating.

Another measure of the effect of controlling soil moisture was the distance between the ball and the ground level. With both bluegrass and fescue, all plots which were maintained above 20% available moisture had little difference in ball support. However, where the soil moisture was not maintained above 20% available moisture, the turf became open and pitted during drouth and lies were very poor.

Rating Turf

Ratings of the turf produced under different soil moisture levels were made during August, September and October 1949. In August the drouth had just started; in September fall rains had begun; and by October the fall growth of the grass had been made. These ratings were based on ground cover, density, uniformity of ball lies, color and vigor. All plots which were maintained with above 20% available soil moisture had rather close rating. Thus, the more the water applied the more the yield. However, heavy water application did not improve the turf ratings above that of plots receiving only two good irrigations.

The questions of how to judge irrigation needs and how to save labor are old ones. And the problem of water conservation is becoming very important.

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