Soil Conditions and Root Development

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ROOTS ARE vital to plants—they provide anchorage, store food and absorb water, nitrogen and minerals. For this reason, Dr. Sprague explained, it is extremely important that cultural practices be governed just as closely by root demands as by the requirements of top-growth.

While anchorage and food-storage functions of roots are important, it is in the absorption of water and nutrients that plant roots are most vital to the plant. In this connection, the speaker pointed out:

Absorption of Water and Nutrients

Without the essential elements for growth, the permanent fixation of the plant would be of little value, and there would be no food to store. Quantities of water absorbed by plant roots are far greater than ordinarily thought. It has been estimated that on bent greens of average quality, the grass roots must take up during the growing season at least 3,750 gals. of water for each 1,000 sq. ft. of green. On Kentucky blue — redtop fairways, the amount absorbed by roots during the season is approximately 186,000 gals. per acre. In other words, the plant must take up 300 to 500 lbs. of water for every pound of dry substance formed in leaves, stems and roots.

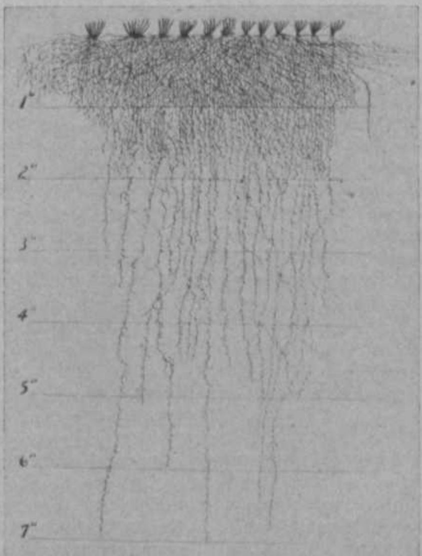

Fig. 1. Typical distribution of roots at various depths, for grass on putting greens

With regard to nutrients, the roots of fertilized bent putting greens must absorb, for each 1,000 sq. ft. of surface, nitrogen equivalent to that found in 15 lbs. of sulfate of ammonia, phosphorous equivalent to 12 lbs. of superphosphate, and potash equivalent to 6 lbs. of muriate of potash. On healthy Kentucky blue—redtop fairways the nitrogen absorbed per acre equals that found in 400 lbs. of sulfate of ammonia, phosphorus equal to 200 lbs. of superphosphate, and potassium equal to 200 lbs. of muriate of potash.

Both water and mineral substances are held by the soil with some tenacity; consequently the roots must make intimate contact with every group of soil particles before the water and minerals in contact with these particles may be utilized.

Root Structure

Grass roots are admirably adapted for making contact with the soil particles (Figure 1). Fine roots develop in whorls at each joint of stems that are located at or below the surface of the soil. As a result here is built up a fine network of roots and their branches to form what is called a fibrous root system. This is very different from the tap root system of such plants as dandelions, dock, trees, etc. These fibrous roots of grasses do not live indefinitely, but usually die within a year or two and are replaced by other roots. New roots are formed most abundantly during the spring months after growth of tops begins, and death normally comes in fall or early winter.

If the individual roots or branches are carefully examined (Figure 2), it will be found that at the tip there is a root cap composed of loosely arranged cells which slough-off as the root grows and pushes between the soil particles; these cells acting as a lubricant much as would oil on a bearing. Immediately back of the tip, is the growing point where new cells are constantly being formed as the root elongates. After formation, the new cells soon begin to enlarge, and the effect is to increase the length of the root and push the growing point further into the soil mass. As the cells enlarge, some of them are modified to perform different functions. Near the center of the root, certain groups of cells become elongated and the walls are thickened for conducting water; others become adapted for the movement of foods, and both types together form the vascular strands or veins as they are called. Between these strands and the outer layers are the storage cells which comprise the

cortex, and the outermost layer of cells form the epidermis or protective coating. Certain of the epidermal cells are greatly elongated and become root hairs.

Root hairs are of great importance since practically all water and nutrients absorbed by the plant enter through them, very little passing through the epidermis. Moreover, root hairs are found on roots in a very limited zone just back of the growing tip, and the individual hairs have a relatively short life. New root hairs must be formed continually to maintain normal absorption. When the root hairs have died, the epidermis of the root at that region becomes impermeable and unable to function for absorption. Since root hairs are very easily affected by soil conditions, attention must be given to this relation. It has been estimated that the root hairs increase the area of contact with a soil by 10 to 15 times as compared with the same root without hairs.

The extent of the root system and the thoroughness with which it occupies the soil mass is determined to a great extent by the system of management followed and by the nature of the soil itself.

Soil Moisture and Aeration

Experiments have shown that within certain limits, a relatively low water content of the soil stimulates roots to greater development, and likewise increases the abundance of root hairs. For example, plants grown in a soil with a moisture content of 19% available water have a total root area 1.2 times as great as the leaves and stems, whereas similar plants grown in a soil with only 9% available water possess a root area more than twice as great as the tops.

Soils which are compact and poorly aerated will permit only scanty growth and this will be confined to the upper layers. On the other hand, when the soil is very dry, root development is retarded or may even cease, the above-ground parts being dwarfed accordingly.

With the artificial watering generally practiced, one may do much to modify root development. Keeping the surface soil too moist during the early part of the season when new roots are being formed will favor development of a relatively shallow root system. Under such conditions the turf will be easily injured by drought later in the season because of the small volume of soil from which moisture is obtained. On the other hand, reducing the quantity of water used, or withholding water as long as possible will promote a deeper root system if other soil conditions are favorable for growth. Waterlogging the soil even temporarily may cause the death of roots in the flooded soil layers. Certain grasses are more tolerant of over-watering than others, but all of the better species are injured by such conditions.

The critical factor in cases of waterlogging and over-watering is usually not the excess of water, but the absence of sufficient oxygen for plant growth in the pore spaces of the soil.

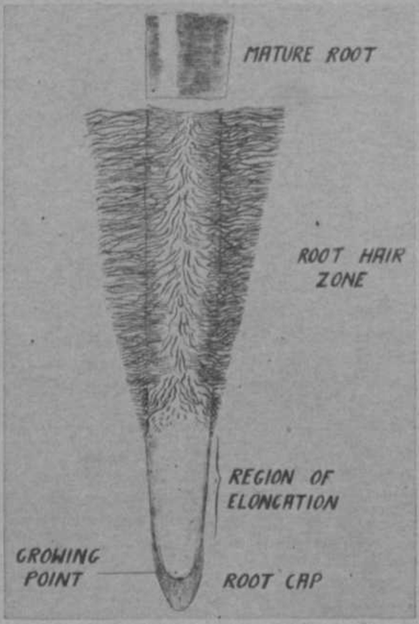

Fig. 2. Enlarged view of young grass root tip. Root cap protects growing point and acts as lubricant as root pushes through soil. Root hairs absorb practically all water and nutrients required by plant

Little if any growth of roots occurs when soils are frozen. Growth of our northern grasses begins soon after the soil temperatures reach 40° F. However, the soil does not warm-up in spring as soon as the air, and the deeper layers are slower in warming than the upper layers. Therefore, little root growth is made until the mean daily air temperatures are at least as high as 45° F. Soils that contain a large amount of water are much colder in spring than well aerated soils which contain smaller amounts of water.

Nutrient Supply

Supply of nutrients in an available form in the various horizons or layers of soil is an important factor in modifying the character of root systems. Roots branch more profusely in the soil layers that are liberally supplied with nutrients. Upon coming in contact with a soil layer rich in nitrogen, roots not only develop much more abundantly and branch more profusely, but they also fail to penetrate as far into the deeper soil.

On the other hand, the presence of an abundance of phosphates has been shown to increase root development strikingly. If phosphorous is deficient in soil, its application in an available form may be expected to greatly stimulate root length and branching.

Soil Acidity

Soil acidity and a lack of lime may also limit root penetration. The tolerance of turf grasses to soil acidity varies with the species, but all are injured to some extent by strong acidity. In some cases it may be found that the roots will penetrate only as deeply as the soil is freed of active acids. Soil acidity may affect absorption of nutrients and water even before it modifies root extent. This is due to the fact that root hairs are injured or destroyed by excessive acidity, just as they are killed by the presence of poisons in the soil water.

The extent of the root system can be considerably influenced during the period of its development by the height and frequency of cutting. Plants cut very short are able to manufacture only a limited quantity of food in the leaves. If the supply of nitrogen is abundant or excessive at this period, the tendency will be to produce luxuriant top growth without a corresponding root development. On the other hand, plants that are cut less closely may utilize considerably greater amounts of nitrogen without hampering the development of the root system. The critical point seems to be the ratio of carbohydrate food present in the plant to the supply of available nitrogen. An overabundance of nitrogen favors top growth and retards root growth. This relation is probably most important in early spring when roots are actively growing.

Dr. Sprague concluded by giving details and results of the studies made at New Brunswick, N. J., on which the preceding remarks were based. The study data will be found in March GOLFDOM.

Bacteria in the Growing of Turf

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PLANTS commonly used in greens are the specialized and selected representatives of their class, expected to thrive and to survive under conditions that would be fatal to most plants. Frequent, close cutting, stimulation and over-stimulation of root development, compacting the soil, and frequently abnormal moisture, temperature and aeration conditions represent an environment that is not normal. It is evident that this abnormal environment would weaken and ultimately destroy the most hardy of the turf grasses except as special devices and treatments be used toward offsetting the weakening effects of the treatment. Such devices and treatments must reckon with the presence and activities of bacteria.

Factors which affect the growth and vigor of turf grasses may be grouped under the heads of environment and in connection with the food supply of plants. Amount, character and distribution of organic matter is of major importance. Amount of organic matter directly affects the circulation of air and water in the soil, and, to some extent, its temperature. Everything being equal, the more organic matter in the soil, the greater the amount of water absorbed and held. It is possible, therefore, to create a supply of organic matter so large as to interfere with optimum root development. The quality of the organic matter is also of direct significance in that its composition and physical nature may favorably or unfavorably influence root growth and the activities of soil bacteria. Distribution of the organic matter is also a factor of importance, since the amount of it at different depths of the soil and subsoil control the circulation of water and air and, through these, the feeding of the plants.

Everything being equal, the deeper the root zone the more vigorous the plants and the greater their resistance to unfavorable changes in their soil and climatic environment.

Carbon's Part Important

Approximately 50% of the dry weight of grasses, and of other plants, is carbon, the element which makes up all but a small proportion of the entire weight of coal or charcoal. There is only about .03% of carbon dioxide in moisture-free air. Areas on which vegetation is flourishing draw heavily and repeatedly on this relatively small supply. Had it not been for the constant movement of air above the land surface the gases overlying any area on which forests, cultivated crops or grasses grow vigorously would become depleted of their carbon dioxide supply to a point where plant growth would be checked. It is fortunate that there is not only the circulation of air, but also the replenishment of carbon dioxide from the soil itself.

Actively developing plant tissues con-