The Roots of the Matter

by Mary Owen

Roots are the foundation of a turf. They perform functions vital for plant growth. This article will discuss the structure and function of roots, the effects of the environment and cultural practices on root growth and strategies for increasing rooting. It will focus on roots and root systems of both cool season grasses and warm season grasses used for sports field and other natural turf playing surfaces.

Root Systems

Turfgrasses have two different root systems during their lives. The first—the primary or seminal root system—develops from the embryo and emerges directly from the germinating seed. It functions actively for six to eight weeks providing water and nutrient uptake for the tiny seedling.

During this seedling growth phase and shortly after the first leaf emerges, an adventitious root system begins to form. This root system originates from buds at nodes on the crown. It replaces the seminal root system, becoming the main functioning root system for the plant. Adventitious roots also will form at nodes on the lateral stems: stolons, rhizomes and tillers. These root systems allow the lateral stems to eventually develop into plants functioning to a large degree independently of the main turfgrass plant.

Turfgrass roots are fibrous and multi-branched. Each root tip is covered by a cap that protects the tender meristem (growing point) as the root bores through soil. The meristem replenishes the root tip and provides for growth of new cells in the root. The new cells behind the meristem eventually stretch and lengthen; this action pushes against the root cap and is what actually makes the root grow longer.

As a root matures, the cells become specialized. The cells of the endodermis (the outer layer of the root) behind the area of cell elongation are able to develop the long, slender, almost microscopic extensions called root hairs. These hairs greatly increase the surface area that can actively absorb water and nutrients. The roots of cool season grasses can form root hairs only from specialized cells in the epidermis called trichoblasts; warm season grasses can develop root hairs from all cells in the epidermis.

A new root is white and slender. As it matures, it turns brown and becomes thinner. Its ability to absorb water and nutrients declines. Eventually the whole root dies, sloughing off just below the crown. This cycle of root growth, maturity, aging, death and replacement is a natural, ongoing process. It may be accelerated by environmental or climatic conditions or by cultural practices.

Just as different grasses vary in leaf texture, color or growth habit, they also vary in the size, depth and distribution potential of their root systems. Warm season grass root systems are deeper and more extensive with roots that tend to be larger in diameter than the finer, more shallow systems of cool season grasses.

Healthy turfgrass roots are well branched. The ability of a turfgrass plant to effectively compete for water and nutrients is directly related to the extent of branching.

How Do Turfgrass Roots Grow?

Cool season grasses

To understand the cycle of cool season grass root growth, consider the cycle of carbohydrate production and use. In photosynthesis, plants, using the energy of sunlight, produce carbohydrates from CO2 and H2O. These carbohydrates, when broken down through the process of respiration, provide energy to the plant. Roots contain no chlorophyll so they cannot photosynthesize. They depend on the leaves for carbohydrates for their energy needs. The absorption of nutrients and the movement of water and nutrients from cell to cell within the root require energy.

Carbohydrates produced at the time shoots are actively growing will be used in the areas of most rapid growth (leaves) before they are sent to the roots for respiration and energy production.

When temperatures are too cool for rapid shoot growth, carbohydrates will be available to the roots. When temperatures are warmer, and when shoot growth is stimulated during very warm weather, carbohydrates will be used by the leaves before any are translocated to the roots.

The roots of cool season grasses grow and function most vigorously when soil temperatures are cool. Spring is the most intense period of root initiation and growth, with fall slightly less active. Since temperatures for maximum root growth, (ranging from 50 to 64 degrees Fahrenheit) are slightly lower than those for maximum shoot growth (ranging from 59 to 75 degrees Fahrenheit), roots grow rapidly before shoot growth begins in the spring and after shoot growth stops in the fall. Even when cool fall temperature stops shoot growth, roots are still actively growing. Carbohydrates are moved into stems and to a lesser extent into roots at this point, providing for slow but continued growth in cold (not frozen) soils until active growth resumes in spring.

Turf grown in reduced light situations will lose even more roots. Turf which has been stimulated by high levels of nitrogen for rapid shoot growth during warm weather may lose large amounts of roots even while shoots remain active.

When air temperatures rise in summer, the efficiency of photosynthesis in cool season grasses is reduced. The leaves produce fewer carbohydrates for translocation to the roots. As energy available for root growth and work is reduced, root growth slows, limiting the root system's ability to absorb water and nutrients from the soil and transmit them to the other parts of the plant.

As air temperatures rise, soil temperatures will follow. As soils warm, root respiration increases. As respiration increases more and more carbohydrates are used up. So, when temperatures warm, the use of carbohydrates increases while the supply decreases. Eventually this can lead to root starvation and death resulting in a net loss of roots to sustain the rest of the turfgrass plant. Roots will not be replaced until cool weather resumes.

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Warm season grasses

Photosynthesis is more efficient in warm season grasses than in cool season grasses. As temperature and light increase, so do shoot and root growth. Optimum temperatures for warm season root growth range from 75 to 84 degrees Fahrenheit; while those for optimum shoot growth range from 81 to 95 degrees Fahrenheit. Root initiation and activity peaks in late spring and summer. When temperatures cool, root and shoot growth slow. When the plant enters dormancy, root growth ceases. The peak loss of roots for warm season grasses is in late winter.

Photo courtesy: Mary Owen

Dense, fibrous, healthy roots growing in the modified sand rootzone of a multi-use field.

What Do Turfgrass Roots Do?

Roots absorb water

Roots are the principal entryway for the water needed to maintain turgor and for photosynthesis and many other processes in the plant. Water is needed to replace that lost through transpiration and through mown leaf ends.

Roots absorb nutrients

While carbon, hydrogen and oxygen—the main building blocks of organic compounds—are derived from the atmosphere and from water, the remaining 13 essential mineral nutrients are principally absorbed from the soil by the roots. Nutrients do not just "seep into" or passively move into roots; nutrient absorption requires energy. This energy comes from respiration: the breakdown of carbohydrates in the presence of oxygen with a subsequent release of the energy captured by the plant in the process of photosynthesis. When carbohydrate reserves are low or unavailable, roots will not have the energy needed to absorb nutrients. Deep, extensive root systems are able to access more nutrients as well as water from a larger volume of soil.

Roots anchor plants

Plants with deep and extensive root systems contribute to a stable playing surface and are less likely to rip out from divoting.

How Can You Enhance Root Growth?

Monitor development

Inspect the root system frequently. Note its depth and distribution and how that relates to time of year, climate and management practices.

Maintain a well-aerated root zone

Depth and extent of roots and root branching increase in a well-aerated rootzone. Roots expend less energy as they bore through a non-compacted soil. Roots in poorly aerated soil tend to be thicker in diameter and less branched and are inefficient at water and nutrient uptake.

Irrigate intelligently

Space irrigation events as far apart as possible without sacrificing turf quality. Turf watered deeply and infrequently has been shown to have a deeper, more extensive root system with a higher level of carbohydrate reserves than turf watered frequently and shallowly.

Fertilize judiciously

Provide adequate nutrients at the proper time. Apply potassium before expected stresses of heat, cold and drought.

Time nitrogen applications to maximize root growth while maintaining a healthy balance in root growth and shoot growth. In cool season grasses, nitrogen applications in late summer and late fall will result in an increase in rooting while spring and especially summer applications will result in an increase in shoot growth with a corresponding reduction in rooting. Cool season grass roots have the ability to store some nitrogen applied in the late fall for use when growth resumes vigorously in the spring. Avoid overly stimulating shoot growth during periods environmentally unsuitable for root growth (i.e. in the summer for cool season grasses).

The balance between shoot growth and root growth in warm season grasses is less affected by timing of nitrogen applications.

Maintain soil pH from 6.0—7.0

Turfgrass roots grow very poorly at reduced pH, especially at pH of 5.0 and below.

Photo courtesy: Mary Owen

Sports play and traffic on wet fields can compact the soil, making root growth very difficult.

Mow appropriately

Mow cool season grasses as high and as infrequently as possible given the use of the turf. This is especially important during times of environmental stress. Constant defoliation by frequent mowing reduces the photosynthetic potential of the turf depleting carbohydrate supplies available for root growth. Cool season grasses are especially sensitive to this. Low mowing can dramatically reduce the depth and extent of roots of cool season grasses, though bentgrass is not as severely affected as the others.

Warm season grasses are less affected by low mowing. Bermudagrass especially will tolerate low mowing without significant reduction in rooting.

Take care with herbicide use

Avoid using herbicides when turf is under stress or when root growth is restricted as such turf may be more seriously damaged and take longer to recover than healthy turf. Bensulide, benefin, oxadiazon, oryzalin, pendimethalin, prodiamine, siduron, DCPA and other herbicides may inhibit root growth.

Conclusion

Roots are the foundation of a turf. Attention to the growth, development and health of the root system by the turf manager can ensure a deep and extensive root system able to sustain a vigorous, properly performing playing surface.

Mary Owen is extension educator and turf specialist for the University of Massachusetts, Amherst, Mass. She is a past STMA Board Member and an active member of the STMA Certification and Conference Committees.

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