CHAPTER 3

Growth Cycle Considerations

Consider a Kentucky bluegrass lawn or sports turf and how it reacts to annual changes in temperature, moisture, day length, and light intensity. At certain times of the year, vertical, leafy top growth may seem ample for cattle production, and mowing chores seem endless. Then there is another time of year when fresh, new shoots of grass begin to pop up in brown patches of turf that earlier seemed permanently lost to summer heat and drought stress. These are examples of how turfgrass reacts to the environment in a cyclic manner at different times of the year. At certain times seedhead production or leaf growth is favored, at other times belowground parts grow best in response to changing environmental conditions.

These shifts in growth are the result of eons of plant evolution. All organisms have evolved mechanisms that are necessary for the survival of species. The reproductive mechanisms of the perennial turfgrasses are closely linked with seasonal growth patterns that assure seed production in spring and summer, which, in turn, assures the dispersion of seed through the remainder of the growing season. Under natural conditions, seed of cool-season grasses germinates in late summer and seedlings develop during autumn, while seed of warm-season grasses lies dormant through the winter and germinates late spring to summer.

In understanding, predicting, and taking advantage of turfgrass response to environmental changes, it is important for the turfgrass manager to perceive the changes in growth from the perspective of the plant's annual production of seed, which requires tremendous amounts of energy from the plant. Mowing limits the actual development of seedheads, but the plant is still geared genetically for that result.

COOL-SEASON GRASSES

Consider what happens to Kentucky bluegrass during its annual growth cycle beginning about mid-September in the transition zone environment. Days become shorter in September as the sun gradually works its way to the winter equinox. Temperatures moderate and days and evenings are noticeably cooler. The bluegrass plant responds to these changes as underground rhizomes, growing slowly in summer, increase their lateral spread and begin to emerge from the soil to form new plants (Figure 3-1).

These emerging plants produce tillers and a new community of turfgrass plants (Figure 3-2) begins to colonize the patches of (often) brown summer turf which looked as if it were beyond recovery. Shoot and root production increase and must be maximized during the fall to provide energy for maximum seed production to occur in the spring.

The recuperative power of the turfgrass in late summer–fall is often dramatic. It should remind us to wait until next spring before a decision is

Figure 3-1 Kentucky bluegrass rhizomes exposed under sod.

Figure 3-2 Development of Kentucky bluegrass community from new tillers (top) emerging from rhizomes. (Courtesy of C. W. Lobenstein.)

made to make any drastic repair of the turf, such as resodding a lawn. Give the turfgrass time to make its own repairs. Even bunch grasses that lack the spreading, underground rhizomes of Kentucky bluegrass or aboveground stolons of bentgrass can make rapid recovery at this time of year if moisture is available. Watch perennial ryegrass and you will find that a turf comprised of sparse plants may become dense during fall as tiller production goes into high gear. While tiller and rhizome growth increase in the fall, vertical leaf growth begins to decrease, so leaf demand for food also decreases. This change ensures that carbohydrates and other food materials manufactured in leaves are available to tillers and other developing plant parts, including roots, which have a sustained need for food during fall and early winter.

The orientation of leaves and tillers also changes in response to shorter days and cooler fall temperatures. Growth is more decumbent as shoots grow at an angle away from vertical and toward the ground. This is another survival mechanism that has evolved in response to grazing by animals, thus allowing more shoots to survive through the winter for spring seedhead production. Cool-season turfgrass may be mowed closer during fall without removing much leaf tissue compared with the long, warmer days of late summer. Homeowners may choose to lower the cutting height of their mowers for a more picture perfect lawn in response to this altered growth pattern. Dunn recalls experimental Kentucky bluegrass plots at Rutgers University that were mowed during fall to ¼ inch, much like a putting green. This would not be practical in spring and summer, when shoots assume a more vertical, upright growth habit.

As the growth cycle continues in late fall, leaf growth slows to the point where mowing can be stopped but leaves may retain green color for several more weeks. Then cold temperatures and drying winds may finally cause leaves to become brown and turf to become dormant. We use the word *may* because cool-season grasses sometimes retain green color throughout the winter in parts of the transition zone if mild temperatures prevail and soil moisture is adequate. Well-timed snows often insulate and protect the cool-season grasses during the coldest and driest parts of winter. Green leaves continue to manufacture food materials through the process of photosynthesis. This will occur as long as leaves retain chlorophyll, the pigment that provides the green color of leaves and makes photosynthesis possible. The manufactured food is translocated through phloem cells to slowly growing roots or is consumed by the plant through respiration to provide energy for "maintenance" growth in winter.

In the transition zone, root growth gradually accelerates during February and early March as soil temperatures begin to warm. During March through early April, new tillers develop and by middle to late April, tillering is reaching peak production. Transition zone turf managers should anticipate this growth pattern and complete any necessary spring fertilization before the onset of peak tillering. The goal is to ensure that nitrogen and other nutrients will be present in the soil during the interval in spring when tillering is maximum. If fall fertilization was minimal, late winter to early spring fertilization may be necessary to encourage thickening of the turf and deep rooting.

Another physiological change takes place as soils continue to warm and days become longer. This is a shift from root development to leafy top growth and it usually occurs in middle to late April through mid-May in the transition zone, depending on prevailing spring temperatures. Now the food materials manufactured in leaves are used primarily for new leafy top growth at the expense of the root system, a reverse of the late fall–early winter scenario. The massive production of leaves, in turn, provides the energy of photosynthesis needed to drive the production of seedheads. Shoot orientation has changed back to vertical for two reasons. The vertical orientation allows for better light penetration to stimulate photosynthesis. Reproductive culms shed and catch pollen and disseminate seed more effectively if the inflorescence is higher in the air to catch the wind.

Moderate to heavy applications of nitrogen fertilizer coinciding with this growth change may exacerbate top growth at the expense of the root system (Figure 3-3). In extreme cases, unwanted top growth remains unmowed until the turf manager or homeowner is able to chop it back with a rotary mower. The turfgrass plant responds to this treatment by regenerating new leafy growth to be chopped back again. The plant's reserve

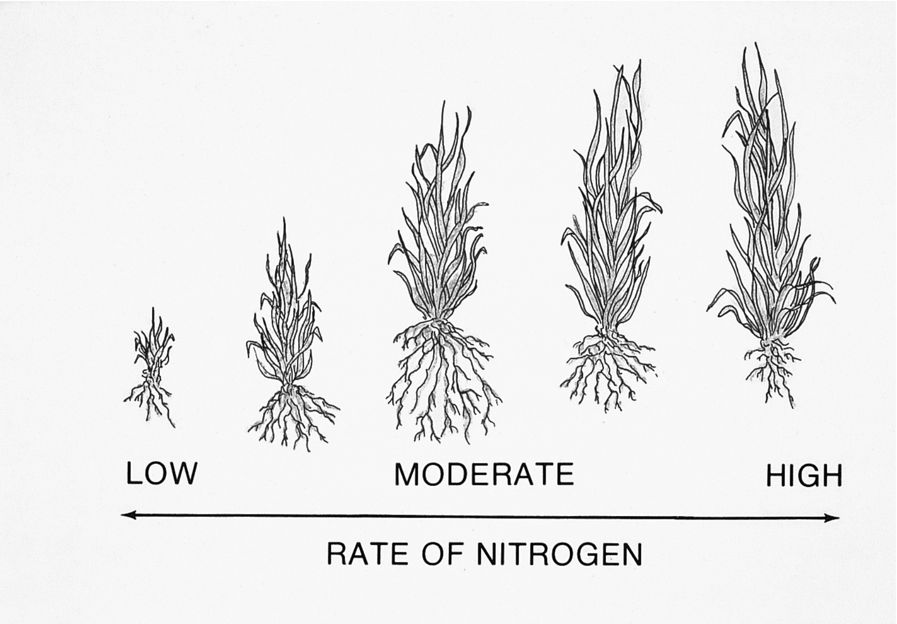

Figure 3-3 Influence of nitrogen on top versus root growth.

pool of carbohydrate is gradually depleted as leaf tissue, the photosynthetic center for new food materials, is removed continuously by mowing. Careless mowing might be tolerated in the fall when tiller growth is more decumbent and much of the leaf tissue escapes the mower. But in middle to late spring, shoots are more erect and leaves are elongating rapidly. Significant quantities of green leaf tissue are likely to be removed with each mowing. The turfgrass plant is weakened as food materials are rapidly depleted. Turfgrass in this condition is more susceptible to disease.

However, the most insidious result of this mismanagement may not be seen until late spring and early summer. Root systems that were decreased at the expense of new top growth are unable to give maximum support to the whole plant during late spring–summer stress. Size and numbers of roots are also reduced in response to excessive spring fertilization and mowing. If the root system cannot support the turfgrass community during several weeks of summer heat and drought, the turf can be injured or killed. This is an extreme case, and careful mowing together with light fertilization in spring allows competent turfgrass managers to avoid this result. But it should serve to remind us that for best results in the transition zone, most fertilization should be done in the fall. This is a point that will be emphasized again in Chapter 6.

In summer, little top growth takes place without irrigation. Even in irrigated locations, growth of leaves and shoots will slow noticeably as temperatures rise. This is partly because food manufactured by cool-season turf is used quickly when respiration begins to outstrip photosynthesis. In other words, the capacity of the grass to manufacture new food (carbohydrate, etc.) cannot keep pace with the burning of that food for energy (Figure 3-4).

Careful management is required to nurse cool-season turf through the stress periods of a transition zone summer. Balanced soil nutrition is crucial along with intelligent watering practices. Turfgrass managers have the additional concern of assaults by insects and disease pathogens. Many of these pests reach a peak in their annual cycle of virulence during summer. At the same time, cool-season turfgrass is weakened and nearing a low point in its ability to ward off pest attacks. If the turf can weather the summer months, relief will come in early fall when temperatures moderate and rainfall becomes more abundant with passing cold fronts. The cycle will soon shift again to a favorable period for tillering and growth of belowground parts. So the cycle is completed, albeit at different times according to the regions of the transition zone. This process is called the *growth cycle.*

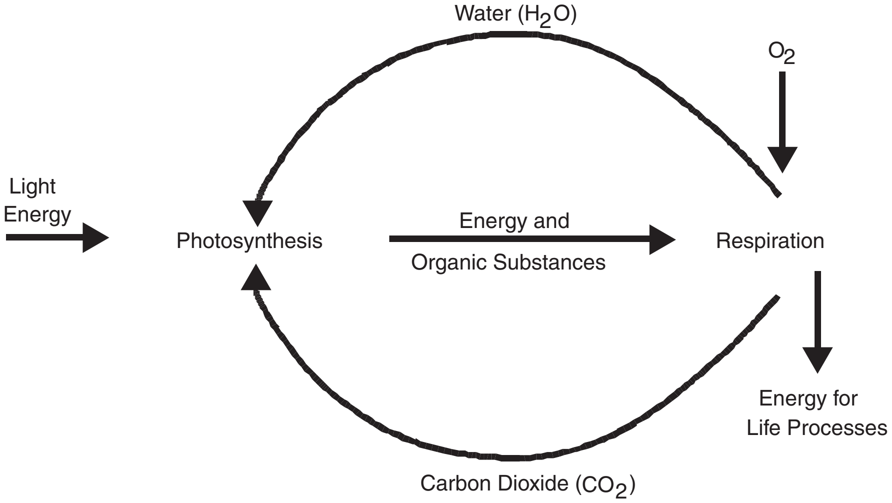

Figure 3-4 Photosynthesis and respiration.

WARM-SEASON GRASSES

Zoysiagrass, bermudagrass, and buffalograss are three warm-season species that have enough cold tolerance to be functional as turfgrass in the transition zone. They dominate summer turf while the cool-season grasses are languishing. The growth cycle for these warm-season grasses is less complex than that of the cool-season grasses. Seed production occurs from June to September, depending on the species. The development of seedheads of the warm-season turfgrasses, with the exception of zoysiagrass, does not appear to be affected by day length. A shoot is stimulated to produce a seedhead when it becomes large enough to support the growth of the seedhead. The internal stimulus for this event is unknown. Warming temperatures in spring cause the warm season grasses to begin greenup. Growing points that survived winter resume cell division, differentiation, and expansion in the formation of leaves. This breaking of dormancy takes place between early March and late April in the transition zone depending on the species and the region and prevailing temperatures from one year to the next. Buffalograss and zoysiagrass generally precede bermudagrass in breaking dormancy; however, this sequence may be modified according to cultivar within a species and the varied microenvironments where these grasses are located. Due to its marginal winter hardiness in the transition zone, bermudagrass must start growth from scratch at the growing points protected by soil, thatch, and sward. There are no surviving leaves. Buffalograss and zoysiagrass are winter hardy enough to have many surviving shoots, with leaves that simply resume growth where it ceased last fall, minus the most elevated portions of leaf tissues that were killed by cold and desiccation during winter. But warm-season grasses, especially bermudagrass, are in a fragile condition at this time, because stored carbohydrates have been depleted by respiration through the winter necessary to keep the stems alive.

Research by J. DiPaola and their associates (1982) at Texas A&M University suggests that new root systems are generated in spring to replace old bermudagrass roots that expired during winter. When further depletion of carbohydrates occurs from the demand of newly growing leaves, entire sections of sod might die from a combination of starvation and infestation by pathogens. In this situation it becomes a race between the pathogens and other stresses and growth of new roots and shoots that determines the extent of turf injury. The intensity of warming spring temperatures plays a large role in determining which side wins. Pesticides and other chemicals must be used with great care during the rootless, greenup interval. Specialized management procedures that tear and disrupt turf should be delayed until the grass is completely green and growing actively. Benefits of nitrogen fertilization during spring greenup are questionable since additional nitrogen could presumably force leafy top growth and divert food (carbohydrates) from the developing root system.

Growth is usually in high gear by May to early June, depending on location in the transition zone. Maximum growth will occur during the summer months. Seedhead production of zoysiagrass occurs in a flush at this time. Buffalograss heading also begins at this time, but not in one flush, and seedhead production can continue through the summer, depending on the cultivar. Bermudagrass heading begins in July and continues into early fall. This lack of a flush in seedhead production indicates that seedhead production depends on continuous growth and maturation of vegetative shoots and not on day length as with the cool-season grasses and zoysiagrass. Therefore, the fertilizing recommendation is simple; fertilizer should be applied during the warm months while the grass is making maximum growth according to location and use of the grass.

Maximum growth of all plant parts of bermudagrass and zoysiagrass takes place during summer in the transition zone if moisture is available. These species can also make growth in warm weather during periods of moderate drought stress. But dormancy will occur if there is no rainfall or supplementary irrigation. There are subtle differences in temperature optimums for different plant parts. For example, the optimum temperature for bermudagrass shoots is higher than for roots. However, these differences are small when compared with optimum seasonal temperatures for plant parts of a cool-season species such as Kentucky bluegrass.

Growth of all plant parts begins to slow when evenings become cooler in late summer and early fall. But photosynthesis proceeds in green leaves if fall temperatures are favorable and the materials needed to harden the plant in preparation for winter are manufactured during this late summer–early fall interval in the transition zone. Leaves retain their green color until a series of light frosts or a hard freeze turns them brown. Bermudagrass is most sensitive to cooling temperatures. Its leaves become pale green to yellow after night temperatures drop below 10°C. Zoysiagrass leaves will show a similar response as night temperatures approach 0°C.

Nitrogen fertilization, appropriate for cool-season grasses at this time, should be withheld for warm-season species. Applications of nitrogen in late summer or early fall, September and October, may interfere with the hardening process in the transition zone and contribute to soft, succulent tissues with increased susceptibility to winter injury. Whereas nitrogen is withheld in fall, potassium is routinely applied to assist with the hardening process. One of the important roles of potassium (see Chapter 4) is its involvement in the manufacture of carbohydrate, protein, and other materials needed for hardening. The form of carbohydrate also begins to change in the warm-season grass at this time of year. Starch, the principal carbohydrate in bermudagrass and zoysiagrass, is partly converted to sugars. This conversion is associated with the tolerance of warm-season grasses to cold temperatures. A partial conversion of sugars back to starch will take place in late winter–early spring before warm-season grasses emerge from dormancy.

SELECTED REFERENCES

Aldous, D. E., and J. E. Kaufmann. 1979. Role of root temperature on shoot growth of two Kentucky bluegrass cultivars, *Agron. J.,* 71: 545–547.

Beard, J. B., and W. H. Daniel. 1965. Effect of temperature and cutting on the growth of creeping bentgrass (*Agrostis palustris* Huds.) roots, *Agron. J.,* 57: 249–250.

Beard J. B., and W. H. Daniel. 1966. Relationship of creeping bentgrass (*Agrostis palustris* Huds.) root growth to environmental factors in the field, *Agron. J.,* 58: 337–339.

Burns, R. E. 1972. Experimental factors affecting root development and reserve carbohydrates of bermudagrass cuttings, *Agron J.,* 64: 44–45.

DiPaola, J. M., J. B. Beard, and H. Brawand. 1982. Key events in the seasonal root growth of bermudagrass and St. Augustinegrass, *HortScience,* 17: 829–831.

Etter, A. G. 1951. How Kentucky bluegrass grows, *Ann. Mo. Bot. Gard.,* 38(3).

Evans, L. T., I. F. Wardlaw, and C. N. Williams. 1964. Environmental control of growth, pp. 102–125 in C. Barnard (ed.), *Grasses and Grasslands,* St. Martin's Press, New York.

Hull, R. J. 1992. Energy relations and carbohydrate partitioning: I. Photosynthesis, pp. 176–179 in D. V. Waddington, R. N. Carrow, and R. C. Shearman (eds.), *Turfgrass Agronomy Monograph 32,* ASA, CSSA, and SSSA, Madison, WI.

Koski, A. J., J. R. Street, and K. J. Karnok. 1984. Seasonal rooting characteristics of five cool-season turfgrasses, p. 152 in *1984 Agronomy Abstracts,* ASA, Madison, WI.

Langer, R. H. M. 1972. *How Grasses Grow,* Edward Arnold, London.

Schmidt, R. E., and R. E. Blaser. 1969. Effect of temperature, light, and nitrogen on growth and metabolism of 'Tifgreen' bermudagrass (*Cynodon* sp.), *Crop Sci.,* 9: 5–9.

Smith, F. E. 1973. Growth of roots, rhizomes, and tillers of Kentucky bluegrass (*Poa pratensis* L.) cultivars and genotypes as affected by fertility level, cutting height, and season, M. S. thesis, Virginia Polytechnic Institute, Blacksburg, VA.

Sprague, H. B. 1933. Root development of perennial grasses and its relation to soil conditions, *Soil Sci.,* 36: 189–209.

Stuckey, I. H. 1941. Seasonal growth of grass roots. *Am. J. Bot.,* 28: 486–491.

Troughton, A. 1957. *The Underground Organs of Herbage Grasses,* Commonwealth Agricultural Bureau, Farnham Royal, Buckinghamshire, England.

Watschke, T. L., R. E. Schmidt, E. W. Carson, and R. E. Blaser. 1972. Some metabolic phenomena of Kentucky bluegrass under high temperature, *Crop Sci.,* 12: 87–90.