nitrogen fertilization (Lukens, 1970). Studies of the production and spread of *D. poae* spores has revealed that the primary source of inoculum for new incidents of disease is colonized leaf litter and that the production and dispersal of spores begins around the time of new leaf initiation in the spring and peaks in the month of May (Hagan and Larsen, 1985). Additionally, spore dispersal was dramatically increased on days in which the turf area was disturbed by the process of mowing (Nutter et al., 1982).

Drechslera Leaf Blight of Bentgrass

Drechslera leaf blight of bentgrass is caused by *Drechslera catenaria*. This pathogen causes reddish tan lesions or bands on creeping bentgrass and colonial bentgrass leaves during cool, wet weather. On closely mown bentgrass, individual lesions may be difficult to see without the use of a hand lens. The colonized leaves die back from tip and gradually become necrotic (Spilker and Larsen, 1985). As the weather becomes warmer in the late spring and early summer, the pathogen progresses to the base of the plant where it causes the crown to rot (Larsen et al., 1981). Affected areas have a red to brown colored blight and may resemble the symptoms of red leaf spot of bentgrass described below.

Helminthosporium Blight of Fescue, Ryegrass, and Bluegrass

Helminthosporium blight is most common on tall fescue and fine fescue species in Wisconsin. The causal agent of the disease is *Drechslera dictyoides*, which is a cool, wet weather leaf-spotting fungus. On tall fescue, individual lesions are first noticed as dark brown bars that form perpendicular to the midvein of the leaf. These lesions usually coalesce with longitudinal streaks of necrotic tissue giving the affected area a net-like appearance. Individual lesions on fine fescue species are irregular shaped, brown spots that often girdle the leaf. These girdled leaves turn yellow and die back from the tip. During warmer weather, areas of red fescue up to three feet in diameter may rapidly turn yellow, resembling patch diseases caused by other pathogens (Couch, 1995).

Helminthosporium Leaf Spot of Cool Season Turfgrasses

Helminthosporium leaf spot incited by *Bipolaris sorokiniana*

Figure 3. Helminthosporium leaf spot lesions on Kentucky bluegrass leaves.

is a major warm, wet weather disease of most cool season grasses. On taller cut grasses such as those found in golf course roughs, symptoms of the disease are seen as dark purple lesions with tan or white centers resembling those of melting-out. Contrary from melting out, the leaf spotting phase of Helminthosporium leaf spot occurs during the warm weather of late spring through early fall, and *B. sorokiniana* is less likely to infect and colonize the leaf sheath (Figure 3). On bentgrass greens, the disease looks like irregular areas of purpling grasses up to a few feet across. The centers of these patches quickly turn yellow to brown and the margins will retain the purple color resembling a "smoke ring". *B. sorokiniana* produces extracellular enzymes that break down cellulose and pectin, the main constituents of the cell walls of plants. Therefore, blighted plants are often matted down and slimy to the touch. Because of similarity in symptoms and time of occurrence, Helminthosporium leaf spot on bentgrass greens is often misdiagnosed as Pythium blight or Rhizoctonia blight (Couch, 1995).

Red Leaf Spot of Bentgrass

Red leaf spot incited by *Drechslera erythrospila* is a warm, wet season disease that is exclusive to bentgrass species. Symptoms of the disease are dark red to brown lesions that may have a straw colored center. The turf stand appears to have a red colored sheen which progresses to brown and then tan (Couch, 1995). The individual lesions may be hard to detect on bentgrasses mown at putting green height, so examination of plants in the apron of the green may be needed to detect leaf spot symptoms of the disease. Also, when healthy plants have a layer of dew in the morning, dew is absent from plants affected by this pathogen.

Control of Helminthosporium Diseases

There is a lot of information for turfgrass pathologists to digest when considering all of the subtle differences between the symptoms and timing of the Helminthosporium diseases. Luckily, because these fungi are taxonomically closely related, there are several important characteristics that all of the Helminthosporium diseases have in common that allows golf course superintendents to treat them as one single group of pathogens. New outbreaks of all of these diseases are initiated through seed transmission of the pathogen or from colonized turfgrass crowns and leaf debris in established turf stands. All of the Helminthosporium pathogens produce foliar leaf spots or blighting during either cool, wet or warm, wet weather. Additionally, a very important aspect that all of the pathogens have in common is their ability to cause crown and root rots (effectively killing the plant) during the summer months. Other things that enhance disease severity are high humidity, close mowing, and nitrogen applications.

Cultural control methods that will help minimize disease intensity include reducing humidity by improving drainage, air movement, irrigation practices, and light intensity. Also, raising mowing heights and maintaining sharp mower blades in problem areas is recommended when feasible. Applications of fertilizers that are high in readily available nitrogen should be avoided prior to and during conditions favorable for disease development. If fertilizer must be applied during weather conducive for disease, applications should either be split into two applications, contain a high proportion of slow release forms of nitrogen, or be followed by a preventative fungicide application.

Probably the best news for golf course superintendents is that all of the Helminthosporium diseases are controlled by the same fungicides. There are thirteen fungicides that are currently labeled for the control of *Drechslera* and *Bipolaris* species, of which iprodione, vinclozolin, and mancozeb have consistently been proven to be very efficacious. If you have any questions regarding Helminthosporium diseases or the efficacy of other fungicides in controlling them, please do not hesitate contacting the Turfgrass Diagnostic Lab.

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Greening Up the Golf Course

By Dr. John Stier, *Department of Horticulture, University of Wisconsin-Madison*

Being in San Diego last month made me long for the look and smell of green grass. Each spring as snow melts, golfers come and play, also longing for that look and smell of green grass. Some superintendents shudder, knowing the grass may not quite be ready, or perhaps wishing for a few more days to finish winter projects. But the desire remains: green grass.

Grass often turns brown during winter when its exposed to the open air or when its killed by disease or low temperature fungi. Exposure to open winter air kills foliage either by desiccation or by sunlight. (Foliar death may actually enhance the survival of the plants though as desiccation is ultimately reduced.) Chlorophyll, a complex molecule that gives foliage its bright green color, is both stimulated and degraded by sunlight. At freezing temperatures, however, the plant is unable to produce new chlorophyll, causing turf to turn brown. Of course, not all grass that's exposed to the environment throughout the winter will turn brown because some of the foliage may be protected. Furthermore, genes in a given plant or variety may protect chlorophyll against degradation.

The rate of spring greenup depends partly on the grass genetics, temperature, and sunlight. *Poa annua* and perennial ryegrass are often the first grasses to greenup as long as they survived winter. Creeping bentgrass is a bit slower, while Kentucky bluegrass is often the slowest of the most commonly-used cool-season turfgrasses. Rates of greenup vary among varieties within a species. For example, most common types of Kentucky bluegrasses (e.g., 'Kenblue') green up sooner than many improved types ('Fairfax', 'Award') (NTEP, 2003). If leaves are already brown then one must wait for new leaf production. Under ideal situations, cool-season grasses can produce one new leaf in about 5-6 days. The time interval between production of each leaf is called the phyllochron. The phyllochron is increased at sub-optimal temperatures or when nutrients or irrigation are in limited supply. In these cases spring greenup can often be enhanced through management.

Greening up the grass

Mowing is a tremendous stimulant for growth. On a brown turf, mowing removes the dead foliage, exposing surviving plant parts and the soil to warm sunlight. Soil temperatures increase and biochemical reactions start producing new cell walls, proteins, and other compounds needed for growth. While shoots of cool-season turfgrasses can grow at temperatures as low as 40 degrees Farenheit, optimal temperatures are between 60-75 degrees (Beard, 1973). Roots may grow at any temperature above 32 degrees, but optimal growth is achieved between 50 to 65 degrees.

Removal of green tissue helps too. In turfgrasses, mowing stimulates the production of hormones in the remaining plant tissue that are responsible for new tiller production. Hormones like cytokinins stimulate new cell division. Auxins and gibberellins stimulate cell enlargement. An unmowed turf plant has relatively few tillers, while plants consistently mown at an optimal cutting height have numerous tillers and produce a thick turf. Mowing brown grass can actually hasten spring greenup by a few days to weeks when combined with needed nutrients and moisture. Once enough green tissue exists for photosynthesis to produce more carbohydrates than is used by respiration, growth jumps tremendously!

Low soil temperatures in the spring can keep nutrient availability to a minimum. Air temperatures warm first, of course, then the upper soil layer where turfgrass crowns reside. Since soil thaws from the surface on downwards, it is often new root production from the crowns themselves that is important for water and nutrient uptake during spring greenup. Small flushes of nutrients may occur as snow melts and as nutrients are released from dead foliage, but these may not be enough to meet turf needs until soil-bound nutrients are released.

Nitrogen particularly can be in inadequate supply because the microbes responsible for releasing nitrogen from organic material are relatively inactive in cold and frozen soil. Microbes, primarily bacteria, are relatively inactive in cold and frozen soil. Thus it is not uncommon to see chlorotic patches and/or slow-growing turf in the spring where soil temperatures have remained cold. Adding moderate rates of water-soluble nitrogen (e.g., 0.5 lb per thousand square feet per month) early in the spring can stimulate new growth without seriously depleting storage carbohydrates which will be needed for root growth as soil temperatures increase. Phosphorus may also be in limiting supply in cold temperatures when root activity is reduced (Carrow et al., 2001). Where phosphorus has not been banned by local ordinance, an application of phosphorus fertilizer may aid new growth.

Irrigation is also helpful for stimulating spring greenup. Once a new leaf develops from the crown, its water that drives the expansion of each cell, ultimately accounting for most of the growth that is seen. Of course, irrigation also ensures the nutrients in fertilizer are solubilized for plant uptake.

As discussed in the previous issue of The Grass Roots, covers can be used to warm soil temps and hasten spring greenup. Due to cost and labor issues these are mostly useful on greens and tees. Medium to light colored covers are preferable as black materials may increase temperature to undesirably high levels. All covers can potentially increase disease so constant monitoring is required in case they need to be removed. If the turf is not snow-covered it may be advisable to first apply protective fungicides. Lush growth under covers can also be detrimental if sudden drops to sub-zero temperatures occur because cold hardiness decreases quickly as turf greens up.

Growth regulators are often used in the spring for *Poa annua* control. While certain products like Primo may be effective for producing a darker green color during the growing season, none of these growth regulators have been shown to enhance spring greenup. In fact, if used too late in the preceding autumn some growth regulators may actually delay spring greenup up to several weeks. While applications of gibberellic acid (GA) can counteract the effects of GA-inhibiting growth regulators (trinexapac-ethyl, paclobutrazol, and flurprimidol), any compound such as GA that relies on transport through the leaf is unlikely to be effective when applied to brown, dead leaves. Use of plant growth regulators should be confined to label instructions which generally indicated application to green, actively growing turf.

In some cases grass may have been killed by winter conditions or even thinned out during the autumn. There's no question that seed germination is most rapid when soil temperatures are warm: that's part of the reason Kentucky bluegrass germination can range between seven and 21 days. Research at Purdue University, though, showed an early spring seeding was key to success if seed was planted in the spring. For a golf course where traffic continues to increase after snow melts until it peaks in the summer, early seeding can be especially important. Even if snow is still in the forecast, by early spring its unlikely to stick around and the limited freezing/thawing may even help germination by scarifying the seed coat. If possible, add a bit of mulch to keep the seed in place and provide favorable germination conditions. Straw works great, though some superintendents favor paper mulch pellets or other materials. On slopes, thin wood fiber-based "blankets" work well for preventing erosion and acting as a mulch for germination.

Conclusion

Plant genetics dictate only part of spring greenup. Early mowing, moderate fertility, and sufficient moisture can be used to hasten spring greenup. Covers may be useful on greens and tees to warm the soil but must be used cautiously to avoid disease and cold stress problems. Growth regulators may be useful for reducing *Poa annua* seedhead production but won't increase spring greenup. Finally, bare areas should be seeded as soon as possible in the spring rather than waiting for soil temperatures to warm to optimal levels.

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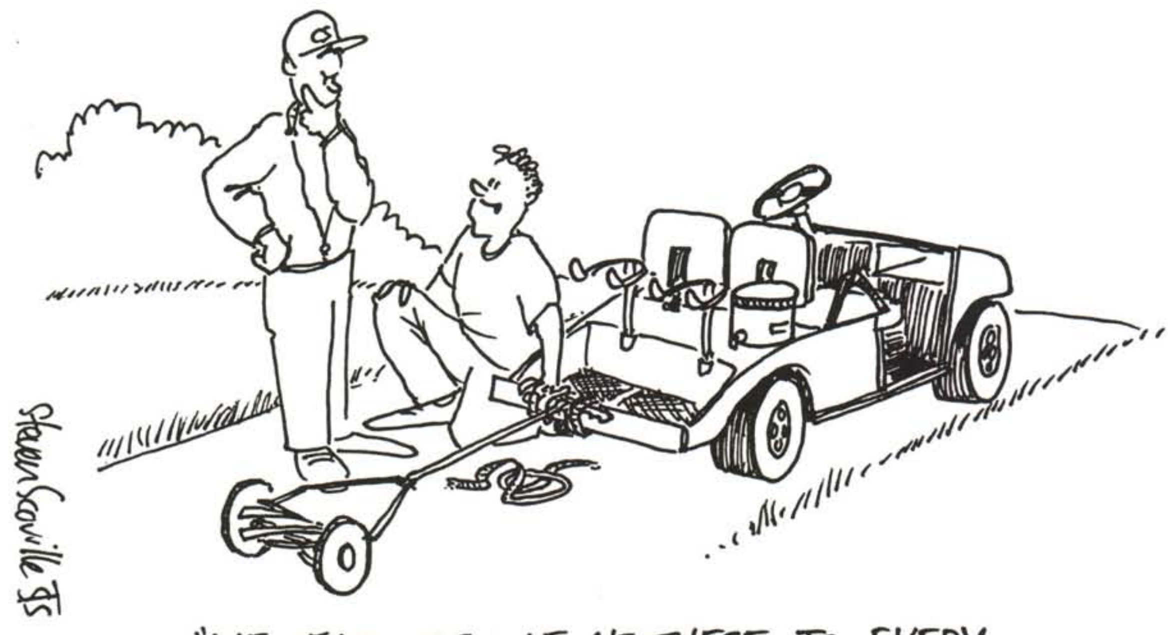

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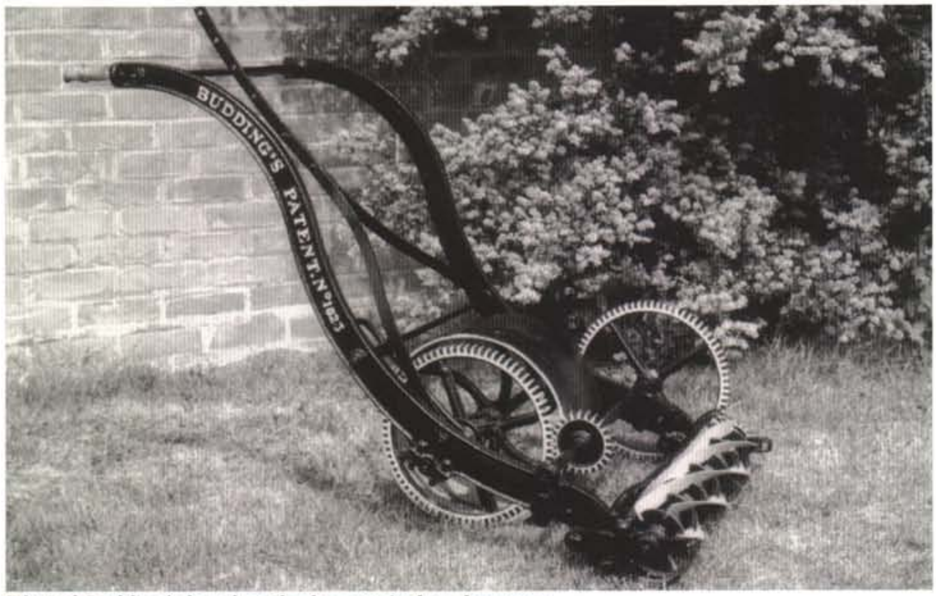
THE ART & INVENTION ERA
-in the Early Evolution of Turfs 1830-1952

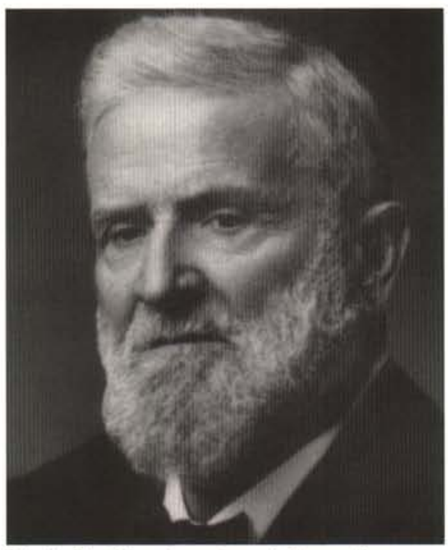
By Dr. James B. Beard, President & Chief Scientist of International Sports Turf Institute Inc., College Station, Texas

Editor's note: This paper was presented by Dr. Beard at the 2004 Wisconsin Turfgrass and Greenscape Expo. He generously allowed us to share it with The Grass Roots readers, and we are indebted to him for that.

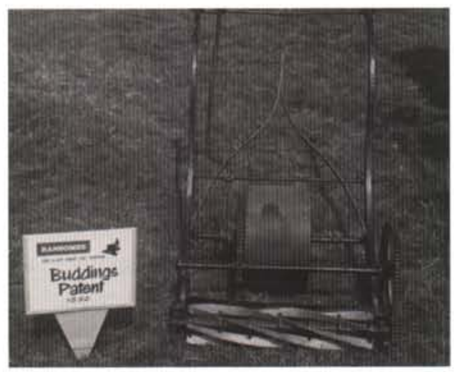
The evolution of turfs as we know them today occurred in association with animal agriculture in climates favorable for grass growth, especially rainfall and temperature. The earliest significant uses of turfs for lawns was in the United Kingdom, where rainfall distribution throughout the year is reasonably good and where the moderate temperatures favor the growth of cool-season turfgrasses, such as *Agrostis*, *Festuca*, *Lolium* and *Poa*. In addition, the grazing of sheep was a significant agricultural activity throughout the countryside even from 1800 to 1950. The key advances that furthered the use of turfgrasses involved inventions and developments achieved through trial-and-error activities which is termed the art of turfgrass culture. Twelve developments that highlighted the turfgrass discovery and invention era are summarized in Table 1 and are discussed in the following sections.



Edwind Budding's hand-pushed mecanical reel mower.



Edwin Budding, inventor of the reel mower.



Front view of Buddings 1832 reel mower.

Development 1 - Reel Mower

For years turfed areas were cut to a relatively uniform height either by the hand scythe or by a hand cycle in the case of closely maintained turf areas that were cut more frequently. The leaves of grasses were best cut by the scythe or cycle when the grass was wet, such as during early morning dews or after rains. This was a very laborious, time-consuming activity. Thus lawns of even a reasonable quality were limited primarily to wealthy estate owners. This started to change in 1830 with the invention of the reel mower by Edward Beard Budding in Gloucester, England. This first manually pushed reel mower was more cost effective, which allowed the opportunity for middle-class residents to maintain residential and village green turfs which enhanced their quality of life. The original 1830 leaf cutting design of the Budding reel mowers continues to be used to this day - more than 170 years later.

Development 2 - Clay Drain Tile

Cylindrical clay tile sub-surface drains were developed in the United Kingdom in the c.1840s. This was the standard worldwide technique for sub-surface drainage of soils for over 100 years. During most of that period the clay tiles were installed by manual digging of the trenches. Thus, these sub-surface drains did not come into widespread use until the development of the powered mechanical trenching machine in the early 1900s.

Development 3 - Weed-Free Grass Seed

The next major advance occurred in the 1880s involving the marketing of weed-free grass seed based on proper seed cleaning, processing and testing techniques as pioneered by Orlando M. Scott of Ohio, USA. Initially he utilized a manually-cranked, wooden seed cleaning machine that he had modified. Prior to that time grass seed was harvested from pastures that were typically contaminated with weeds and the resultant seed sold directly to turf users. There were no effective, selective controls for the weeds in seed harvest fields or in the home lawns and turf areas planted with the weed seed contaminate grass seed. Thus, the solution was the development of procedures to clean the weed seeds out of the grass seed. In addition, O.M. Scott pioneered seed testing procedures long before governmental agencies enacted laws requiring seed testing and labeling.

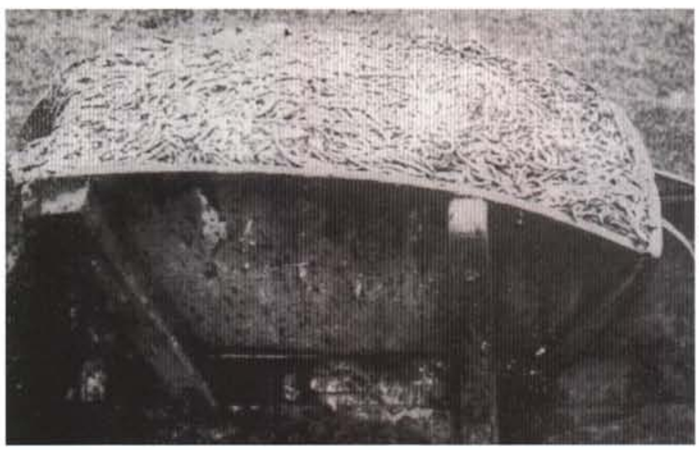
Development 4 - Earthworm Management

The next major advance in the 1890s was the development of an earthworm management control by Peter W. Lees of England, United Kingdom. Prior to this event the two main practices discussed in gardening books were rolling and mowing of the turf, with rolling listed first. This can be attributed to the disruption of the surface by extensive earthworm populations, particularly in England where early turf culture evolved. Thus, with the development of the earthworm management, rolling became substantially less important as a turfgrass cultural practice. In fact, rolling was eventually recognized in the 1920s as having negative effects in terms of soil compaction, especially on clayey soils. The procedure involved applying the irritant to the soil surface and watering it in with excess quantities of water. As a result the earthworms came to the surface, were raked into piles, shoveled onto wheel barrows, and physically hauled off the turf area. It also should be noted that prior to this event the game of golf and golf courses had been limited principally to the coastal areas of Scotland and northern England, called linksland or seaside courses. Attempts to develop upland golf courses were relatively unsuccessful, principally because of the unplayable putting green surfaces caused by earthworms. The emergence and major expansion of golf courses on upland soils occurred at the same time, and could be

This photo shows earthworm irritant being watered in.

Earthworms emerge from putting green turf,

and are piled up.



Three wheel barrow loads are removed from the green.