Shorter Mowing Heights are Hazardous to Summer Health

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Last year was a difficult year for golf course superintendents across the upper Midwest. Severe winterkill occurred on many golf courses followed by hot, dry summer conditions which reduced overseeding success and regrowth from surviving plants. In Madison, Wisconsin, additional pressure came from advocacy groups to reduce if not eliminate fungicide use on golf courses. For the most part, golfers just wanted to golf, expecting the near-perfect conditions to which they've become accustomed.

In the past 25 years we've seen amazing advancements in turf management. Automatic irrigation systems are now commonplace, mowers offer a better quality of cut, new fertilizer options offer a range of nutrient release timings, growth regulators now are used to enhance turf quality, and highly-specific, more environmentally benign pesticides are being used. The Golf Course Superintendents Association of America (GCSAA) now requires new superintendents to have a college degree to meet certification requirements; indeed, many superintendents had formal education in turf management even before the GCSAA's Professional Development Initiative went into effect.

In spite of the improvements in turf management the industry continues to struggle with maintaining putting green quality. As technology and education have improved, golfer expectations have evolved to demand consistently lower mowing heights and higher quality turf. Putting greens that were being mowed at nearly 0.25 inch heights 25 years ago are now being mowed at 0.1 inch, a 60% reduction! As turf maintenance costs climb it becomes more important than ever to understand how the grass grows, the stresses it must tolerate, and how management can be altered to continue to provide acceptable-quality turf without increased budgets. Specifically, what effects do the lower mowing heights have on the turf?

Adaptation of turfgrasses to mowing

Mowing simulates the animal grazing which is capable of stimulating photosynthesis, leaf growth, and protein production in grasses adapted for turf (Casler and Duncan, 2003). Among turfgrasses, proper mowing height can actually increase plant density compared to unmowed swards. Creeping bentgrass (*Agrostis palustris* Huds.) is the species most commonly used for putting greens with Penncross, Pennlinks, Penneagle, Seaside, and Emerald being the most widely used. Some recent cultivars which are gaining use include SR1020, L-93, and the Penn A and G series (McCarty et al., 2001). Ten years ago the optimal mowing height recommended for creeping bentgrass was 0.2-0.5 inches (Turgeon, 1996). Some newer cultivars are sold with a recommended mowing height of only 0.125-0.156 inches (McCarty et al., 2001). Although the newer cultivars may be capable of maintaining high turf density at 0.125 inch mowing height, research is starting to show the lower mowing heights are still detrimental and require increased inputs compared to taller mowing heights (Bruneau et al., 2001). In Wisconsin the predominant type of creeping bent-

grass is likely Penncross due to its long history of being the most commonly sold variety.

Turf growth and natural response to summer stresses

All green plants including turfgrasses depend on having green leaf tissues collect and transform the sun's energy into chemical energy via photosynthesis. The chemical energy is stored in the bonds which hold sugar molecules, produced by photosynthesis, together. Photosynthesis can occur at any temperature above freezing, with an optimal temperature range of 68-86° F for most cool-season plants (Jones, 1992). Of course many other variables affect photosynthetic rate including amount of sunlight, carbon dioxide (CO_2) supplied by air exchange between the atmosphere and the plant, water, and other factors. Plants "burn" the sugars over time in the process known as respiration in order to generate energy for growth. While photosynthesis occurs only during daytime, respiration occurs twenty-four hours a day, seven days a week and 365 days each year. Thus, sufficient photosynthesis is needed during the days of the growing season to supply energy to the plants when they are not actively photosynthesizing. Mowing temporarily increases respiration as the plants use a burst of energy to repair the leaf damage, though the benefits of mowing far outweigh the respiratory cost.

Summer imposes an additional stress on turf physiology apart from golf traffic. The high temperatures decrease the efficiency with which plants can "fix" CO_2 into sugars. Under optimal conditions, the plants use less energy in photosynthesis than they produce, resulting in a net gain of energy-rich sugars. As temperatures increase, even within the "optimal" range for photosynthesis, a conflicting process known as photorespiration causes oxygen to compete with CO_2 for sugar production, resulting in a net loss of energy in the plant. High humidity becomes more common in summer and reduces the amount of CO_2 uptake which also reduces photosynthesis. As temperatures increase plants produce less shoot and root growth because their enzymatic processes don't function as well as at cooler temperatures. For example, seven instead of five days may be required to produce a new leaf which reduces the recovery rate for ball marks, skids, etc. Finally, respiration increases as temperatures increase, which causes plants to "burn" additional sugars even though they are less likely to produce new growth.

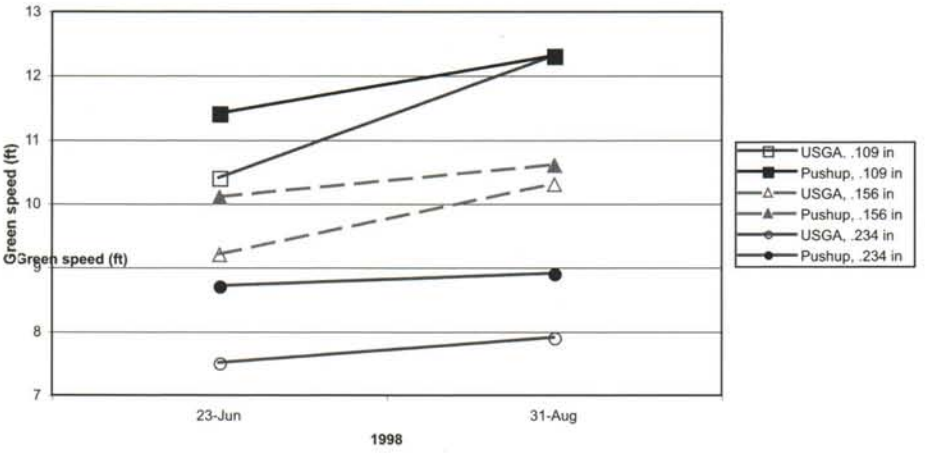

Fig. 1. Effect of mowing height (in = inches) on green speed over the summer (after Kussow, 1998).

The various summer stresses ultimately lead to less shoot and root growth and shorter shoot and root lives. Turf density is reduced which allows weeds such as annual bluegrass (*Poa annua*) and algae to flourish. The stresses also produce a turf which is even less capable of withstanding continuing or additional stresses such as traffic, shade, drought, and disease. Too much stress kills turf.

Evidence for harmful effects of increasingly lower mowing heights

The push for increasingly lower green heights is the demand for faster green speed. The most thorough study I've ever seen was the putting green management study conducted by Dr. Kussow at the University of Wisconsin-Madison between 1993-2000. Fig. 1 shows the greatest speed was obtained at 0.109 inch mowing height compared to 0.156 and 0.234 inch mowing heights. The most striking results, though, were the increases in green speed during the course of the summer even though mowing height stayed the same. The changes were greatest at the 0.109 inch mowing height and least at the 0.234 inch mowing height. Differences between soil type are evident in Fig. 1, with USGA greens often providing less speed, except when summer conditions and low mowing height stressed the turf in which case both soil types provided similar speeds (0.109 and 0.156 inch heights in August). By 31 August 1998, 'Penncross' putting green turf had 35.6 tillers/in^2 of ground when mowed at 0.109 inch compared to 39.1 and 41.8 tillers/in^2 when mowed at 0.156 and 0.234 inch heights, respectively. 'Providence' performed similarly to 'Penncross' while 'Crenshaw', developed specifically for summer stress conditions, only had reduced density when mowed at 0.109 inches (Kussow, 1998).

The reduced tiller density at the lower mowing heights allowed

algae to develop (Fig. 2). By August, algae was present on approximately 80-90% of the putting green surfaces when the turf was mowed at 0.109 inch. Turf mowed at 0.156 inch height had less than 10% algae cover while no algae grew when turf was maintained at 0.234 inch height. Putting green quality was best at 0.156 inch height based on a combination of bentgrass cover and uniformity, amount of grain, and degree of upright growth.

The combination of low mowing height and summer stress also greatly decreased turf root mass in Kussow's study. As most turf managers know a well-developed, actively growing root system is vital to continued survival and development of the green turf appreciated by all golfers. Root mass declined by 50% between spring and summer when turf was mowed at 0.109 inches, 35% at 0.156 inches, and hardly at all at 0.234 inch height (Fig. 3). Especially disturbing was the lack of root recovery as the growing season drew to a close in October. These plants would have entered winter with diminished carbohydrate reserves and less chance of survival and reduced spring growth. Clearly summer stress has long term impacts when combined with excessively low mowing heights.

Even the new bentgrasses marketed for low mowing height conditions such as the Penn A and G series perform better at 0.156 inch height compared to 0.125 inch (Bruneau et al., 2001). Cultivars such as 'G-6' are still susceptible to summer stress as shown in Fig. 4 which compares summer turf quality to turf quality averaged over the entire year. Just as disturbing is the obvious importance of fungicide applications for maintaining putting greens: turf quality was markedly reduced in the absence of preventive fungicide applications regardless of mowing

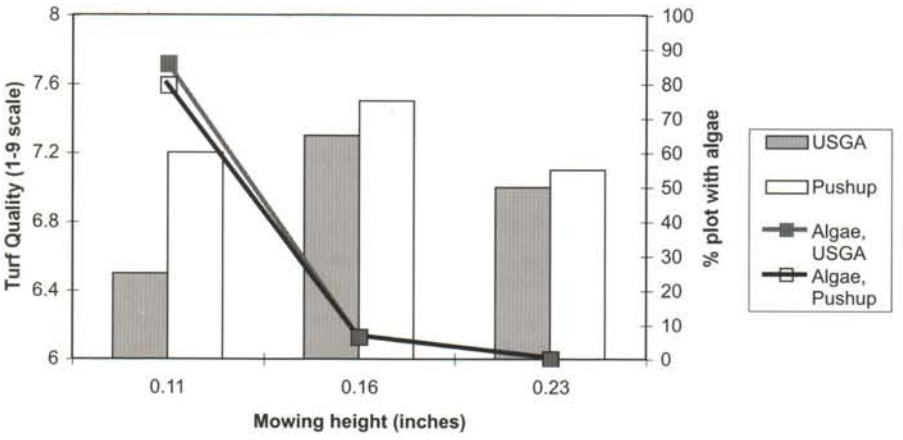

Fig. 2. Effect of mowing height on turf quality and algae development on a Penncross putting green, Madison, WI (after Kussow, 1998). Bars show turf quality; the two lines show the amount of algae present at each mowing height.

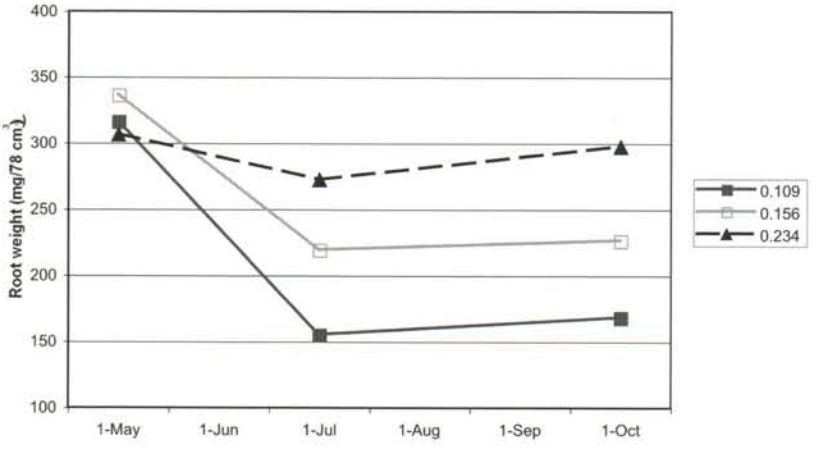

Fig. 3. Summer stress decreases 'Penncross' creeping bentgrass root weight depending on mowing height, Madison, WI (after Kussow, 1998).

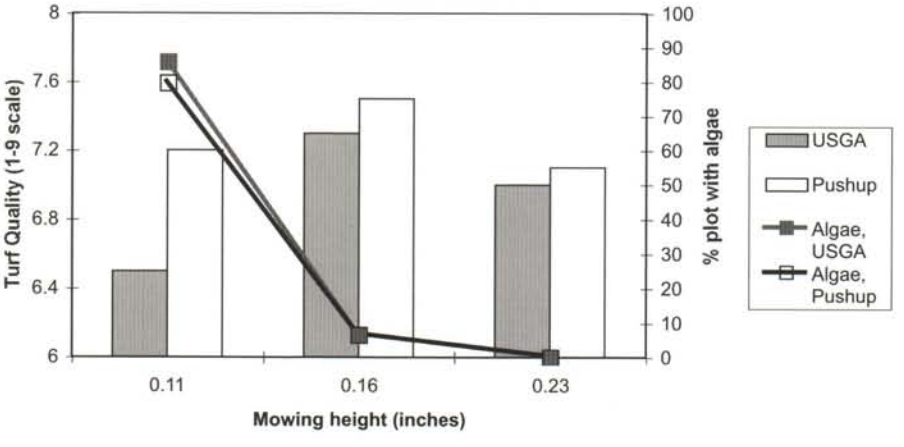

Fig . 4. Quality of 'G-6' creeping bentgrass dependent on mowing height, time of season, and preventive fungicide applications, Pinehurst, NC (after Bruneau et al., 2001).

height. Of 19 cultivars tested, including four of the Penn A and G series, all had turf quality similar to Penncross in the absence of fungicide applications (Bruneau et al., 2001). Unless golfer expectations change it is unlikely the industry will ever be able to provide acceptable quality putting green turf at mowing heights below 0.156-0.25 inch without fungicides. The only hope might be if multigenic (i.e., multiple genes) resistance for all common diseases can be bred into turf cultivars. Such efforts will be costly and require many years, though gene maps being developed by researchers like Dr. Jung at the University of Wisconsin-Madison and Drs. Scott Warnke and Reed Barker at the United States Department of Agriculture will facilitate breeding efforts.

Balancing mowing height and golfer demand (conclusion)

The driving force behind the push for increasingly lower mowing heights is apparently golfer demand, at least from key individuals. Lower mowing heights undoubtedly decrease turf quality by increasing the potential for algal or moss invasion and turf death from various environmental stresses. Summer heat stress may precondition turf to fail in the winter even if it survives the summer.

Maintaining a consistent putting green speed can be challenging. As seen in Fig. 1, speeds change over the summer even when mowing height is kept constant because of decreasing turf density and development. Green speed change is least noticed at the now unacceptably high mowing height of .234 inches, probably because this is close to the optimal cutting height range for creeping bentgrass and the turf is not severely stressed.

A mowing height of 0.156 inches seems to provide a balance between turf quality and inputs. Even the new A and G series perform better at .156 inches than at lower mowing heights. Data from Bruneau et al. (2001) clearly show the need for fungicide especially at lower mowing heights. The data discussed here are food for thought as we continue to balance current and likely regulations on fungicides, water use, and possibly turf management changes due to rising fuel costs. In short, the low mowing heights of today are simply not suitable to a low input, environmentally sustainable golf course. Few superintendents I know would challenge the concept of increasing mowing heights if golfers would accept less green speed but such a concept will need to gain ground through bodies like the PGA and Wisconsin State Golf Association before reality can be achieved.

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