Combining mowing and rolling to achieve a desired green speed and improve smoothness is possible, but caution is necessary to not overstress turf, especially during the heat of summer.

Mowing and Rolling Greens to Manage Green Speed and Turf Performance

High-quality putting greens are the result of balancing mowing and rolling with available equipment, labor, and weather.

BY ELLIOTT DOWLING AND PATRICK GROSS

Since the day Edwin Budding invented the first mechanized reel mower in 1830, there has been steady improvement in the conditioning and playability of putting greens. Today, mowing and lightweight rolling are the primary practices used by superintendents to achieve smooth, fast greens.

In the early days of golf, the height of the grass on putting greens was controlled naturally by the intense grazing of rabbits and sheep. This changed with the invention of mechanized mowers and the ability to mow the turf lower and more consistently. Rolling was also an important practice in the early days of golf, and it gained popularity in the early 1900s. The equipment used at that time was what many today would consider a heavyweight roller, and frequent use resulted in soil compaction and a decline in turf health.

Over time, advances in equipment technology resulted in mowers that can cut grass to less than 0.1 inch and a variety of lightweight rollers to provide fast, true putting surfaces on a consistent basis. In the quest for faster and faster green speeds, many superintendents have experimented with different mowing and rolling programs to see what combinations are best for creating smooth, fast greens while preserving the health of the turf. Unfortunately, there have been situations where unreasonable golfer demands for faster and faster greens have resulted in turf loss as superintendents implemented excessively low mowing and frequent rolling over a prolonged period. Where is the balance and what is realistic? The goal of this article is to examine the various factors associated with mowing and rolling greens and to put forth a practical guideline for developing an agronomically sound strategy that achieves an appropriate green speed without risking turf injury.

WHY MOW AND ROLL PUTTING GREENS?

Frequent mowing benefits putting green turf in several ways:

- Controls vertical growth.
- Helps grass spread laterally.
- Promotes high shoot density.
- Produces smooth surface conditions.
- Creates less friction with the golf ball and increases green speed.

Lightweight rolling has also become a common practice on putting greens. Primary benefits include:

- Increases green speed.
- Promotes smooth surface conditions.
- Allows for raising the cutting height while maintaining green speed.
- Aids with the incorporation of sand topdressing.
- Corrects soil heaving and mower scalping in regions with freeze-and-thaw cycles.
- Reduces algae and dollar spot disease.

The quality and frequency of mowing and rolling operations have a direct impact on both turf quality and surface conditions. Sharp, precisely adjusted mowers do a better job cutting grass blades cleanly and evenly. This benefits turfgrass health and putting quality.

BASICS OF MOWING AND ROLLING

Mowing injures the grass; therefore, healthy and actively growing grass is a prerequisite so that it can withstand and recover from the injury caused by mowing and rolling. If putting green turf is experiencing any type of stress (e.g., high temperatures and humidity, frozen conditions, or a pest infestation), mowing and rolling practices need to be adjusted and scaled back until the turf recovers, otherwise the risk of additional decline is possible.

TYPES OF MOWERS

There are two basic styles of putting green mowers: walk-behind or triplex. Walk-behind mowers have an 18- to 22-inch-wide cutting reel and are propelled by a gear-driven rear drum. The operator guides the mower back and forth across the green in straight lines, creating an attractive stripe pattern. Walk mowers are lighter than triplexes, leading to less stress on the turf, especially on the cleanup passes.

Triplex mowers feature three mowing heads mounted on a three-wheeled motorized frame. In most cases, the actual cutting head is identical between the triplex and a walking mower. The major advantage to triplex mowers is that one employee rides the machine over the green rather than walking, which, when combined with the larger cutting swath at 60 inches, leads to a quicker mowing operation.

Both walking units and triplexes provide excellent mowing quality when properly sharpened and adjusted. Improvements in mower technology have resulted in newer triplexes that cut grass with the same quality as walking units, which is why many courses are returning to triplex mowers. Additionally, the labor shortage that the entire country is currently facing is forcing many facilities to utilize triplex mowers to save time with a reduced labor force. For example, a typical 18-hole golf course uses four to six employees to walk mow putting greens, while half the staff — or less — can perform the exact same job in the same amount of time with triplex mowers.

Proper mower setup is critical to achieve a quality cut and limit bruising and mechanical stress that can lead to suboptimal turf health.

Surface management plays a significant role in optimizing green speed, firmness, and plant health. A layer of sand at the surface protects plant crowns, improves resilience to compaction, and smooths imperfections.

HEIGHT AND FREQUENCY OF CUT

Another basic concept of mowing putting greens is determining the height of cut. This adjustment is entirely course specific and is determined by the superintendent based on the type of grass, surface contours of the greens, seasonal growth rate, and the desired green speed. What may be appropriate at one course may not be appropriate at another. One very important point that is often misunderstood is that not all grasses are equal. A mowing height that is considered appropriate for creeping bentgrass might not be appropriate for *Poa annua*, ultradwarf bermudagrass, or seashore paspalum. Determining the mowing height is not only dependent on grass type but also equipment, expectations, and labor availability. All grasses have a height-of-cut tolerance. It is typical for the height of cut to be adjusted up and down throughout the year based on seasonal growth rates and in response to stressful environmental conditions. Proper mower setup is necessary to achieve the desired height of cut and playability. Proper adjustment is critical to producing the cleanest cut, highest quality putting greens, and desired green speed.

Surface contours and architecture also are factors in determining the height of cut. Putting greens with sharp contours or undulations are subject to scalping from mowing too low. Once an area is scalped, recovery is often slow and seeding or even plugging is necessary to accelerate recovery.

How often putting greens are mowed is dependent on staff size and budget, but grass type and weather also play a role. On average, greens are mowed at least five days per week, and in most cases six or seven days per week. Courses that choose to mow five or six days per week will take advantage of a closed Monday or Tuesday to skip mowing and focus more on agronomic programs like top-dressing or aeration. Another reason to take a day or more off from regular mowing is as a precautionary measure during periods of hot temperatures or moisture stress when the added mechanical pressure could damage the grass.

ROLLING BASICS

Rolling is a practice that improves surface smoothness and uniformity and increases green speed. There are a variety of lightweight rollers used on greens, including sidewinder units and

roller attachments that can be mounted on a triplex mower. Some superintendents choose to roll in conjunction with regular mowing, often rolling two to four times, or more, per week. Conversely, some superintendents choose to alternate between mowing and rolling to reduce plant stress during hot temperatures or periods of slow growth. Research from the University of Tennessee showed that there is no statistical difference in green speed between plots mowed six days per week and rolled three days per week and plots that alternated mowing and rolling. That same research showed that turf quality improved during stressful weather when mowing and rolling were alternated (Samples et al., 2008).

Another rolling strategy sometimes used by superintendents is rolling a 20- to 30-foot-diameter area around the hole location, a practice known as target rolling. Rolling a limited amount of area around the hole location takes less time while still achieving the speed and smoothness desired by golfers in the area where they are most likely to notice it. Furthermore, this strategy can be implemented daily while giving the remaining area of the green a rest as the hole location and rolling treatment are rotated.

Rolling greens for tournament preparation is normally done as a supplement to mowing to increase green speed and promote smooth surface conditions.

HIGH-LEVEL MAINTENANCE AND SPECIAL EVENTS

Nearly all golf courses host tournaments or special events where faster green speeds and a higher level of conditioning is desired. There are four critical areas that must be addressed to successfully bring putting greens into peak performance for such events:

- Putting greens must be healthy prior to the event, and a sound agronomic program must be in place for routine maintenance — i.e., aeration, topdressing, nutrient management, water management, and pest control.
- There must be adequate staffing to perform the additional practices that will be implemented on greens. This must include an adequate budget for labor and overtime pay.
- There must be adequate equipment in the inventory that is in good condition for implementing the necessary practices.
- Sufficient time must be allowed to perform the necessary tasks ahead of play.

Preparing greens for tournaments and special events is mainly a function of increasing the frequency of mowing and rolling. Multiple mowing and rolling treatments each day impart extra stress on the turf and therefore should only be done for a short duration of seven to 14 days to avoid potential turf loss.

One of the main strategies for increasing green speed for special events is lowering the height of cut. Care must be taken to avoid lowering the height of cut too quickly and beyond the tolerance of the turf species. Aggressive reduction of the height of cut leads to thinning of the turf canopy, scalping, moss invasion, and an overall reduction in color and turf quality. Reducing the height of cut can be safely done in 0.005-inch increments at two- to three-day intervals until the desired green speed is achieved. This process can take one to two weeks and must be planned well ahead of a tournament.

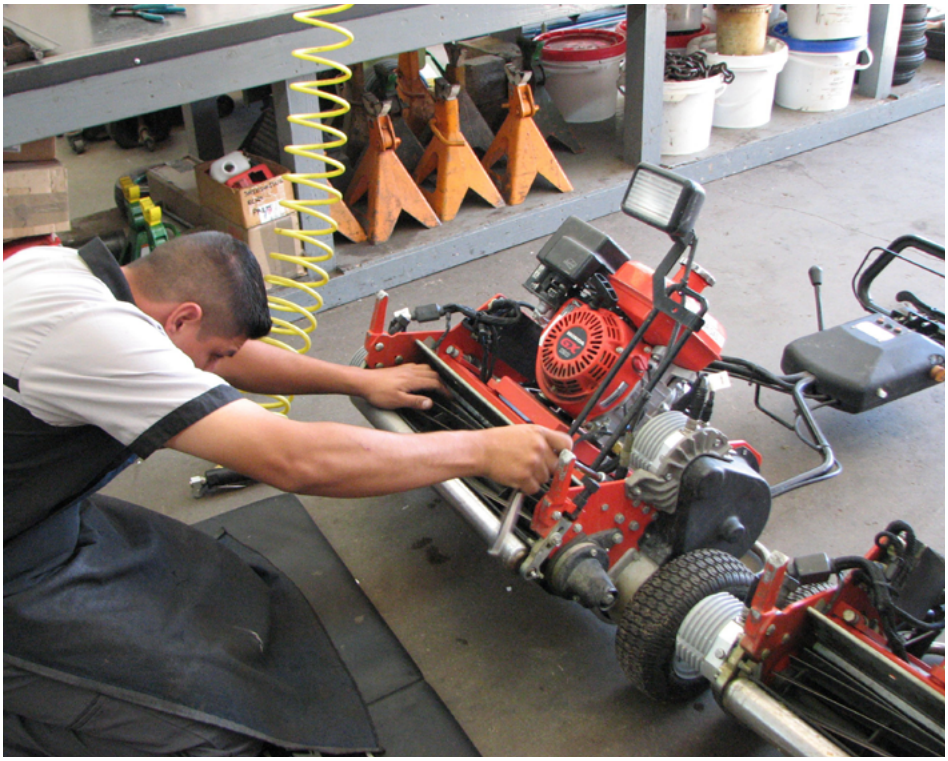
It is important to point out that there is no specific cutting height that correlates to a specific green speed. There are too many site-specific variables that influence cutting height and

green speed, including turf species, climate, season, slopes and surface contours of greens, and other such variables. Multiple studies have been done on the impact of lowering the height of cut on green speed.

Michigan State University looked at the impact of 1/32-inch (0.031 inch) height-of-cut reductions on *Poa annua* and creeping bentgrass putting greens. When the cutting height was lowered by 1/32 inch from 3/16 inch (0.187 inch) to 5/32-inch (0.156 inch), there was an increase in green speed of 8 to 12 inches. Lowering the cutting height an additional 1/32 inch to 1/8 inch (0.125 inch) resulted in an increase in green speed of only 6 to 8 inches. The smaller increases in green speed with each reduction in cutting height is what Dr. Thomas Nikolai refers to as the law of diminishing returns (Nikolai et al., 2005). Reducing the height of cut will only take you so far and is just one aspect of producing fast greens. To balance green speed and turf health, it is recommended to mow as high as possible to achieve the desired green speed, which preserves extra leaf material for photosynthesis and growth.

Increasing mowing frequency is another common method to improve surface quality and increase green speed. Double mowing in perpendicular directions removes additional leaf material from the turf canopy, resulting in smoother surface conditions. Interestingly, double cutting does not result in a rapid increase in green speed. It is typically necessary to double cut greens over several days to see an increase in green speed, often in the range of 6 to 11 inches (Nikolai et al., 2005).

After multiple days of double cutting, green speed will tend to plateau. Although double cutting requires more time and labor, the main advantage is that an increase in green speed can be achieved without resorting to a drastically low cutting height. If double cutting in preparation for a tournament, the process must be initiated three to seven days in advance to achieve an increase in green speed for the event. During a tournament, some facilities with adequate resources mow greens in the morning and in the evening. Although leaf growth from the previous 10 to 12 hours is removed, the resulting change in green speed is variable but can have a positive cumulative effect when practiced over several days.



Sharp, properly adjusted mowers are critical for producing the cleanest cut, highest quality putting greens, and desired green speed.

Rolling greens is normally done as a supplement to mowing for tournament preparation. It is common to see an initial 6- to 12-inch increase in green speed immediately after rolling. In some cases, the increase in speed can last for hours or have a residual effect for one to two days. How long the rolling effect lasts is dependent on several factors, including season, day length, and turf growth. One of the hazards of rolling greens daily during tournaments is the wear pattern and turf thinning that can occur on the edges of greens where the roller changes direction. Turning boards made of carpet, wood, plastic, or other materials are often placed on the edges of greens and moved during equipment operation to minimize turf damage in the areas where rollers and mowers are turned. If possible, rotating the direction of rolling each day helps to reduce the amount of damage on the edges of greens.

DETERMINING THE PROPER COMBINATION OF MOWING AND ROLLING FOR YOUR FACILITY

The effects of various cutting heights, mowing frequencies, and rolling programs will be different for every course. Obtaining benchmark measurements for several days in a row is the only way to determine the effects of different mowing and rolling treatments for a facility. The following protocol is typical for USGA championship preparation and can be used as a guideline for developing a mowing and rolling program for putting greens at any facility.

- Identify relatively flat areas on greens for taking Stimpmeter® readings. The surface slope should be less than 1 percent in the measurement areas and preferably 0.1 to 0.2 percent. The areas used for taking Stimpmeter readings should be marked with a felt-tip marker so that readings can be taken in the same exact location each time. One or two greens will provide an acceptable amount of data, but taking measurements on more greens makes the information more dependable.

- Take Stimpmeter readings before and after mowing to determine the amount of green speed increase as a result of a single cut at the determined height.
- Take Stimpmeter readings before and after rolling to gauge the increase in speed from the rolling treatment.
- On a separate green, take Stimpmeter readings after a single cut. Place the grass clippings in a 5-gallon bucket that has markings on the inside at 1-inch increments. Mow the same green a second time, take Stimpmeter readings again, and place the grass clippings in another marked 5-gallon bucket. Compare how much grass was removed with a single cut versus a double cut as well as the change in green speed. Note that this is a volume measurement of clippings and not a weight measurement.
- Take Stimpmeter readings at various cutting heights and record the results.
- Use a prism gauge to evaluate mowing quality and the effective cutting height in the field. Ideally, this should be done with the mechanic so that there is a better understanding of any adjustments that are needed to the sharpness and cutting height of mowing equipment.
- Stimpmeter readings should also be taken in the morning, at midday, and in the afternoon to check the variability in speed and the amount of growth or "bounce-back" from rolling that occurs.
- Record the amount of time necessary for each activity so that a realistic calculation can be done for labor requirements.
- Constantly evaluate turf quality throughout the process to monitor potential negative impacts to turf density and overall quality.

The measurements taken throughout this process will provide valuable data to determine the impact of different mowing and rolling treatments. It is typical to see a gradual increase in green speed over several days when multiple mowing and rolling treatments are implemented. Then it's up to the superintendent and other decision-makers to determine what is realistic given the available resources.

SURFACE MANAGEMENT

Mowing and rolling play an integral role in managing green speed and putting green performance, but other cultural programs to promote surface smoothness, relieve compaction, and remove/dilute organic matter also play a role. Light and frequent sand topdressing is one of the most important practices for maintaining quality putting greens because it smooths the surface and dilutes organic matter. Topdressing throughout the growing season is a very effective practice for maintaining a firm and fast playing surface and is also effective at reducing anthracnose severity (Murphy et al., 2018).

Cultivation is equally important because it removes organic matter (OM) to maintain consistent and appropriate levels so that excessive moisture retention does not lead to soft

The effects of different cutting heights, mowing frequencies, and rolling will be different for every course. Testing different combinations and taking Stimpmeter readings after each procedure is the best way to determine what works best.

Triplex mowers can provide excellent mowing quality and require fewer employees to mow greens compared to the use of walk-behind greens mowers.

surfaces. Some of the more common cultivation practices include:

- Core aeration with hollow tines set at a specific spacing and depth to remove a target percentage of OM.
- Vertical mowing is often used to remove OM from the very top portion of the soil profile and reduce leaf density. Vertical mowing is not a substitute for core aeration, but it is an effective way to remove OM and clean up dead leaf tissue without disrupting the surface as much as core aeration.
- Grooming is a less aggressive form of vertical mowing, but it is no less effective in maintaining healthy, smooth putting surfaces. Grooming works much the same as vertical mowing without cutting as deep into the thatch layer.

CONCLUSION

Mowing and rolling greens seems so simple, yet there are many nuances involved that must be executed properly if the desired green speed and surface conditions are to be achieved. Key aspects that must be considered include:

- Maintain the highest possible cutting height to achieve the desired green speed so that turfgrass health can be preserved.
- Mow with sharp and properly adjusted mowers.
- Experiment with different mowing and rolling programs — e.g., height of cut, frequency, and other variables — to see what produces the best results for the putting greens at your facility.
- Attend to basic agronomic programs to keep the grass as healthy as possible so that the added stress of mowing and rolling can be tolerated.

There is no one-size-fits-all approach to managing green speed and turf performance. Before you even begin to develop or refine your putting green management program, you must first detail what it is that you want out of your putting greens. This is the opportunity to take a hard look at your course, clientele, budget, and labor force, and set realistic goals that are achievable and repeatable. Balancing mowing and rolling with available equipment, labor, and current weather will help you achieve the smoothest and highest quality putting greens on the most consistent basis. Coupling these maintenance practices with proper agronomics to provide your putting green turf with the best opportunity for optimal turf health and will help you achieve your goals effectively and efficiently.

CITATIONS

Barden, A. 2018. Benefits of light and frequent topdressing. *USGA Green Section Record*. April 6. 56(7): 1-3.

Hartwiger, C. 1996. The ups and downs of putting green rolling. *USGA Green Section Record*. July/August. 34(4): 1-4.

Murphy, J. A., B. Clark, and J. A. Inguagiato. 2018. Update on BMPs for anthracnose on annual bluegrass turf. *Golf Course Management*. February. 86(2): 76-85.

Nikolai, T., C. D. McKinnon, and C. Johnson. 2005. 2004 green maintenance studies. Proceedings of the 75th Annual Michigan Turfgrass Conference. Michigan State University. 1-10.

Samples, T., and J. Sorochan. 2008. Turfgrass maintenance: Rolling. University of Tennessee Extension.

ELLIOTT DOWLING *is an agronomist in the USGA Green Section Northeast Region, and* PATRICK GROSS *is the director of the USGA Green Section West Region.*