

2004 GREEN MAINTENANCE STUDIES

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“Putting greens must have turf of fine texture and of uniform surface. To accomplish this, close cutting is necessary and, with the modern putting green mower, it is possible literally to shave the grass down to the very surface of the ground. Because of the urge of the players for fast greens, the greenkeeper is inclined almost unknowingly to cut the grass exceedingly close” Oakley, 1926.

Introduction

Lowering putting green mowing height has been synonymous with increasing green speed since the rubber cored golf ball replaced the gutta-ball around the dawn of the 20th century. However, lowering mowing heights was not easy in the early portion of that century, but by 1930, due to advancements in mower technology, putting greens could be mowed as tightly as 3/16 (0.187) inch.

In 1947 the USGA mailed out a mowing height survey to its member clubs. Results reported from 27 states indicated that approximately 25% of the courses mowed their greens at 3/16”, 50% maintained them at 1/4”, and the remaining 25% mowed their greens at 5/16” or higher. In 1973 Dr. James Beard released his book *Turfgrass Science and Culture*. In the text Beard noted that bentgrass tolerated “continuous, close mowing at heights as low as 0.2 in”. From all the literature it seems apparent that the tightest a putting green mower could be set between 1930-1970 was 3/16”.

During the mid-1970’s advancements in manufacturing technology led to the production of thinner bedknives which coincidentally occurred about the same time the USGA released the Stimp meter and their Speed charts. These two events coupled together led to ever decreasing mowing heights being utilized to increase green speed.

However, what many superintendents and most golfers have not considered is the law of diminishing returns and how it relates to mowing height reduction and green speed increases. Diminishing returns is defined as “the proportionately smaller increase in productivity observed after a certain point in the increase of capital, labor, etc.”. Thus, the point of diminishing return is the point where increasing inputs is no longer validated by the outcome. In

regards to mowing height and green speed diminishing return should be considered any decrease in mowing height that does not result in an increase of at least 6" of ball roll distance. Why 6"? Because golfer surveys have indicated that golfers cannot detect differences in green speed of 6" or less. Therefore, decreasing the mowing height without producing a noticeable change in green speed is a fruitless effort that also results in more stressed turf.

Besides diminishing returns another fact that needs more careful consideration is that mowing height should not be used for course comparison in relation to green speed. For example, a 0.125-inch mowing height at one course should not be expected to result in similar green speeds as another course with greens mowed at 0.125-inch. This is due to the fact that different mower types, bedknives, rollers, mower maintenance, and other cultural practices can result in significantly different green speeds when two mowers are set at identical mowing heights. Unfortunately, this fact is lost on many and exacerbates many of the problems associated with lower mowing heights.

In an effort to point out some of these facts, and hopefully demonstrate that there are better methods than lowering mowing height to increase green speed and maintain healthy turf, The PGA TOUR and the MTF funded three research project to investigate differences among mower types, bedknives, mower maintenance, and the cultural practice of rolling to initiate a series of studies to help define best management practices to increase green speed and maintain a healthy turfgrass putting surface.

Study I

The PGA TOUR walk behind mower type study (Study I) was initiated on 22 June 2004 at the Hancock Turfgrass Research Center at Michigan State University on a Penncross creeping bentgrass research green constructed to USGA specifications. Mower type treatments included:

- 1) Toro 1000
- 2) Toro Flex 21
- 3) John Deere 220 B
- 4) John Deere 180 B
- 5) Jacobsen Greens King 552 (with a rusted stiff front roller)
- 6) Jacobsen Tournament 22

There were three replications of each treatment (plots mowed with the different mower types) and each plot measured 3' x 15' all mowed six days per week. The original mowing height was 0.156" for all six treatments and every two/three weeks the mowing height was dropped to 0.146, 0.136, 0.125, and 0.105-inches respectively. Data collection included green speed measurements taken at least twice at each mowing height (four for most), color and quality ratings, the actual height of cut being observed with a prism, and disease counts when relevant.

All mowers included in the study came equipped with a grooved front roller and were apparently brand new with the exception of the Treatment 5 (Jacobsen Greens King 552) which was apparently a demo as it arrived in less than perfect condition. With enough force its' front grooved roller could be turned by hand, but was certainly too tight to rotate during mowing. While we most likely could have corrected this problem (the roller was non-greaseable) it was determined that the roller should remain frozen to make some general observations about mower maintenance. Additionally, with the exception of Treatment 6 (Jacobsen Tournament 22) all the mowers had 11 reel blades. The Jacobsen Tournament 22 had 9 reels. At no time during the study were the bedknives changed, grinded, or back-lapped but all were checked on a near daily basis to ensure they had good reel to bedknife contact (i.e. they cut paper).

Study II

In coordination with Study I two other mower treatments were included to make comparisons regarding mower maintenance and mower frequency. The mower utilized in Study II was a Toro 1000 walk-behind mower that routinely had its bedknife changed and its face grinded. Additionally, besides the maintenance the bedknife differed from the Study I Toro 1000 mower as the bedknife of the Toro 1000 in Study 2 was an on ultra thin model number 93-42-62 compared to tournament 93-42-63 bedknife on the Toro 1000 in Study I. This same mower was used to mow plots at 0.156" from 22 June-22 August 2004. Treatments with this mower included:

- 1) Single pass per plot
- 2) Two passes per plot (double-cut)

There were three replications of each treatment.

Study III

Mowing height, mowing frequency, lightweight rolling study

An additional mowing height rolling study was initiated 8 June 2004 to make comparisons about mowing at different heights and frequencies and lightweight rolling at different frequencies too. Since lowering the mowing height is used to increase green speed, but the practice too often leads to negative consequences for the putting surface turfgrass, treatments were devised to investigate the possibility for improved turfgrass color and quality in conjunction with increased green speed. The four different treatments included in the study were:

- 1) Mowed at 0.125" six days per week and never rolled
- 2) Mowed at 0.125" three days per week and rolled three days per week in place of mowing (i.e. daily alternating mowing/rolling).
- 3) Mowed at 0.156" six days per week and rolled every other day following mowing.
- 4) Mowed at 0.156" six days per week and rolled every day following mowing.

With the exception of Treatment 2 all plots were mowed six times a week taking a break on every Saturday. Data collection included color and quality ratings, green speed measurements, disease counts, and collection of root samples at the conclusion of the study in August. Plot size was 3 by 16 feet and there were three replications of each treatment. The plots were top dressed once every two weeks.

RESULTS

In regards to color and quality of turfgrass no meaningful data was produced for the duration of the Studies. This was most likely due to ideal growing conditions that persisted during the summer of 2004 in most of the mid-west and in mid-Michigan in particular. Additionally, on one occasion dollar spot counts were made and no meaningful results were obtained. However, as the mowing heights continued to be reduced it became apparent that the surface of some plots had a smoother appearance than others. Therefore, on August 19 plots were rated for smoothness by assigning a letter grade of A+ (excellent) to E (failing) to each plot. For statistical purposes each letter grade was transposed to a number (A+ =1, A = 2, etc.). The data, presented in Table 1, clearly indicates that Treatment 5 (the Jacobsen Green King 552 with the rusted front grooved roller) resulted in the least smooth or most shaggy putting surface (Table 1). There are little meaningful statistical differences among any of the other treatments, but it is noteworthy that the John Deere 180 B received the overall best rating.

In Tables 2a-2c green speed measurement are reported that were obtained at the different mowing heights for Study I. Data in Table 2a reflects the average green speed at the various mowing heights that were used during the study. At the mowing height of 0.156-inch no statistical differences resulted from any of the four measurements obtained at that height of cut or for the average. For the remaining heights of cut (0.146, 0.136, 0.126, and 0.105) Treatments 4 and 6 (John Deere 180B and Jacobsen Tournament 22, respectively) resulted in the consistently fastest green speeds while Treatment 5 (Jacobsen Greens King 552 with the rusted roller) resulted in the slowest green speed at all mowing heights. Data in Table 2b is nearly identical to the data in Table 2a except it is presented in the units of feet and inches making it easier for most individuals to decipher.

Table 1.

Surface smoothness rating.		
	Smoothness of Cut Rating August 19, 2004	
	Statistical Numerical Mean	Average Letter Mean
Toro 1000	4.0 ab	B+
Toro Flex 21	5.7 b	B-
John Deere 220 B	3.3 ab	A-
John Deere 180 B	3.0 a	A-
Jacobsen Greens King 552	8.7 c	C-
Jacobsen Tournament Mower	3.3 ab	A-
Probability	0.003	

Means in columns followed by the same letter are NOT significantly different at the 5% level using LSD mean separations test.

Table 2a.

Average green speed measurements at different heights of cut (HOC) reported in feet.					
	HOC 0.156	HOC 0.146	HOC 0.136	HOC 0.125	HOC 0.105
Toro 1000	9.40	8.89 b	9.06 ab	9.24 bc	9.32 bc
Toro Flex 21	9.13	8.73 b	9.02 ab	8.95 c	9.44 ab
John Deere 220 B	8.67	8.78 b	8.72 bc	9.05 c	8.58 cd
John Deere 180 B	9.20	9.40 a	9.47 a	9.62 ab	10.17 a
Jacobsen GK 552	8.84	8.66 b	8.23 c	8.16 d	8.39 d
Jacobsen Tour	9.16	9.30 a	9.49 a	9.88 a	10.20 a
Probability	NS	0.000	0.002	0.001	0.002

Means in columns followed by the same letter are NOT significantly different at the 5% level using LSD mean separations test.

NS means data in column is not statistically significant.

Table 2b.

Average green speed measurements at different heights of cut (HOC) reported in feet and approximate inches.					
	HOC 0.156	HOC 0.146	HOC 0.136	HOC 0.125	HOC 0.105
Toro 1000	9' 5"	8' 11"	9' 1"	9' 3"	9' 4"
Toro Flex 21	9' 1"	8' 9"	9' 0"	8' 11"	9' 5"
John Deere 220 B	8' 8"	8' 9"	8' 9"	9' 1"	8' 7"
John Deere 180 B	9' 2"	9' 5"	9' 6"	9' 8"	10' 2"
Jacobsen GK 552	8' 10"	8' 8"	8' 3"	8' 2"	8' 5"
Jacobsen Tour	9' 2"	9' 4"	9' 6"	9' 11"	10' 2"

Table 2c.

Approximate average increase in green speed with the slowest treatment utilized as the check.					
	HOC 0.156	HOC 0.146	HOC 0.136	HOC 0.125	HOC 0.105
Toro 1000		~+3"	~+10"	~+13"	~+10"
Toro Flex 21		~+1"	~+9"	~+9"	~+13"
John Deere 220 B		~+1.5"	~+5"	~+10"	~+2"
John Deere 180 B		~+9"	~+15"	~+18"	~+21"
Jacobsen GK 552		-----	-----	-----	-----
Jacobsen Tour		+8"	~+15"	~+21"	~+22"

In Table 2c the data is presented as the average increase in green speed of each treatment compared to the slowest green speed among treatments (which was always Treatment 5 the Jacobsen Greens King 552 with the rusted roller). This data demonstrates two very important points:

- 1) Different mowers set at identical heights of cut result in different green speeds and
- 2) Proper maintenance of mowing equipment (like something as simple as making sure the front roller is properly lubricated) can have a significant impact on the aesthetic appeal and playability of the golf green.

In the Table 3 the season average green speed comparison between plots single-cut and double-cut with the same mower are presented. The double mowed plots averaged 6" greater green speed than the single mowed plots based upon twelve green speed measurements obtained between 30 June and 22 August, 2004.

In Table 4 root weight data taken from two different depths from the single and double mowed plots is presented. Note that the double mowed plots resulted in more roots in the 0-3-inch depth, but single mowed plots resulted in greater rooting mass at the 3-6-inch depth.

Table 3.

2004 Single cut / double cut season average green speed measurements 2004*		
	Data in feet	Approximate Average feet & Inches
Toro 1000 single mow @ .156"	9.24	9' 3"
Toro 1000 double cut @ .156"	9.72	9" 9"
Probability	0.02	

* Based upon 12 green speed measurements during the season.

Table 4.

2004 Single cut / double cut root weights in grams.		
	0-3 inch depth	3-6 inch depth
Toro 1000 single mow @ .156"	0.196 g	0.033
Toro 1000 double cut @ .156"	0.295 g	0.017
Probability	0.03	0.05

In Table 5 are the green speed results from Study III. Interesting observations include plots mowed daily at 0.125-inch were no faster than plots mowed every other day at 0.125-inch and rolled on non-mowing days on the day plots were rolled and not mowed as well as on the days plots were mowed and not rolled. Additionally, plots mowed at 0.125-inch 6 days per week resulted in no significant difference in green speed compared to plots mowed at 0.156-inch daily that were rolled every other day on the day they were rolled as well as on the days they were not rolled. Finally, Treatment 4 (plots mowed at 0.156-inch per week and rolled every day after mowing) resulted in significantly faster green speeds than all other treatments in the study on the day Treatment 4 plots were the only plots rolled.

Table 5.

2004 Mowing height Rolling Frequency Study			
Treatments		Average green speed when T2, T3, and T4 Rolled	Average green speed when T4 only treatment rolled
T1	Mowed daily @ .125"	9.71	9.25 b
T2	Mowed every other day @ .125" Rolled on days when not mowed	9.91	9.23 b
T3	Mowed daily @ .156" Rolled every other day	10.11	9.46 b
T4	Mowed daily @ .156" Rolled daily	10.15	10.04 a
Probability		NS	0.01

Means in columns followed by the same letter are NOT significantly different at the 5% level using LSD mean separations test. NS means data in column is not statistically significant.

Other data collected that resulted in no significant differences include color and quality ratings, dollar spot counts, root weights, and in situ water infiltration tests.

Conclusions

Several studies performed at MSU over several years clearly indicate that golfers cannot detect differences in green speed on adjacent research plots and/or on successive putting greens on the golf course. Additionally, studies performed at numerous research facilities across the United States over a twenty year period indicate a non-linear relationship between decreasing mowing heights and increasing green speeds. What this demonstrates is the law of diminishing returns and careful examination of that data seems to indicate that any decrease in mowing height below 0.125-inch is NOT likely to result in a noticeable increase in green speed. It is my hypothesis that on many if not most of the golf courses in the USA that decreasing mowing height to increase green speed has likely hit the point of diminishing returns.

From the series of studies performed at MSU during the summer of 2004 it is obvious that different mowers set at identical heights of can result in noticeably different green speeds. Additionally, it is also apparent that proper maintenance of the mowing equipment can have just as significant (if not more) of an impact on green speed as lowering the mowing height. Clearly, if the superintendent, university turfgrass researchers, USGA agronomist, or

any putting green consultant could articulate these facts to green committee members it may lead to healthier turf. Thus two solid points that should be shouted about are 1) "Mowing heights cannot be used for course comparison in regard to green speed" and 2) "If green speed is an issue at your golf course creating the time to maintain the mowing equipment adequately cannot be overemphasized".

Then how should one increase green speed? Well, double cutting is an option. Results from this study indicate that plots double cut at 0.156 did not show a significant drop in color or quality (albeit during ideal grass growing conditions during the summer of 2004) and an increase in root mass 0-3-inches under the thatch/mat layer. However, there was a decrease in root mass 3-6-inches under the thatch/mat layer compared to single pass mowed greens and the average increase in green speed was only 6". I must admit, I've never been a big fan of double-cutting because of the extra work the mower is put under and the amount of increase in green speed is inconsistent (the only other season long continuous double cutting study resulted in an increase in green speed of 10" after three months double cutting). What is most important about the data produced from the double-cutting portion of the research from a management standpoint is it clearly indicates the necessity of more frequent irrigation applications (NOT to be confused with more water) since there were more roots near the surface but less roots deeper in the profile. So much for deep infrequent irrigation methods when double cutting.

Data from these, and other studies performed at Michigan State University and other Universities over the past 15 years, indicate that lightweight rolling may be the best practice to increase green speed and retain healthy turfgrass on the putting surface. This lightweight rolling research was the first study ever that looked at the feasibility of alternating mowing with lightweight rolling to produce acceptable green speeds and healthy turf.

Interesting results include plots mowed daily at 0.125-inch were no faster than plots mowed every other day at 0.125-inch and rolled on non-mowing days on the day plots were rolled and not mowed as well as on the days plots were mowed and not rolled.

Additionally, plots mowed six days per week at 0.156-inch and rolled every other day (3x/week) resulted in no significant difference in green speed compared to plots mowed at 0.125-inch daily regardless if the 0.156-inch plots were rolled or not. This clearly demonstrates the residual effect of rolling lasting for two day (i.e. the day of rolling and the day after rolling) that has been reported in most lightweight rolling green speed studies. Additionally, rolling six days per week did not result in decreases in turfgrass color or quality, rooting, or in situ water infiltration tests. However, it should always be pointed out that the plots were on a frequent sand-topdressing program (every

two weeks) and rolling more than 3 times per week without being on a frequent topdressing program is not advisable.

Considering all the data at hand next year I hope to address question I get regarding alternating single mowing with rolling on one day followed by double cutting and not rolling the next t produce consistent green speeds from day to day.

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