Immediate Effects on Ball Roll Distance of Mowing and Rolling Treatments on a Golf Green

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Abstract

The effects on golf green ball roll distance (BRD) of mowing, rolling, and a combination of both cultural practices were studied at Gay Hill GC. BRD on three greens was measured using a stimpmeter following each treatment. Control measurements were taken on an un-cut green (5mm) to determine the effects of each treatment. Mean BRD values ±SE for each green were analysed for variance using ANOVA. It was found that mowing at 4.5mm saw a significant ($P<0.01$) increase in BRD. Similar results ($P<0.01$) were seen following the rolling treatment and also following a combination of both treatments. There was no significant difference ($P>0.05$) in BRD between each green used during the study. Although BRD increased after each treatment, compared to control, there was only a slight difference (< 6 inches) between each cultural practice. It was considered that repeat tests should be conducted to determine variance and to investigate what effects soil moisture and thatch content has on BRD.

Introduction

The practice of mowing is a necessary cultural operation for the management of golf greens. Turgeon (2005) suggests that it is the most basic form of cultural practices influencing most other cultural practices. Research carried out by Duich (1983) indicates that cutting height had the single largest impact on green speed. This certainly appears to be the perception of the golfer who is unaware of the many other options available to the greenkeeper which may also affect ball speed. Beard (2002) suggests that the turfgrass quality on a putting green should include the following attributes; consistency, smoothness, speed firmness, resilience, and absence of nap. Nikolia (2005) cites research carried out by USA Today (2002) showing that golfers consider green speed the number one factor to know about a golf course.

Ever since the introduction of the Stimpmeter, developed by Edward S. Stimpson (1935) and modified by USGA's technical department during the 1970's, there has been many experiments and trials carried out to determine the effects of a whole range of treatments, cultural and biological, on ball roll characteristics. Duich (1983) suggests that stimpmeter readings with a limited amount of experience can be repeated with a high degree of precision. The stimpmeter is therefore the best tool for replicating the experiment for this study.

Mowing and/or rolling are two of the most widely used strategies for increasing ball speed, whilst rolling is the least understood by most superintendents (Perez, 2007). The aim of this investigation was to determine the immediate effect of mowing and/or rolling, and a combination of both practices on ball roll distance (BRD). The design method for this trial replicates similar experiments carried out by Engel, *et al.* (1980) and also Throssell (1981) when green speed was measured on an assortment of courses across USA to determine variations in speed and the influence of several mowing factors on BRD. Kopec, *et al.* (2005) investigated the effects on BRD of mowing heights and rolling on Sea Isle 2000 Paspalum. Although this is a warm season grass comparison in the studies can be observed.

The research is designed to assist greenkeepers in assessing options for course presentation. Hartwinger, *et al.* (2001) suggests that one option for course presentation is the substitution of rolling for mowing on one or more days per week. The combined practice of mowing and rolling, although desirable for increasing BRD, is becoming hard to justify for day to day play based upon economic pressures and the increase in carbon footprint of running two items of machinery. The option of rolling in place of mowing also presents the greenkeeper with an option for maintaining or even increasing BRD without the need for lowering mowing heights. The main benefit of this is seen as reducing environmental turfgrass stress. (Nikolia, 2005) cites research carried out by Knoop (2002) suggesting that greenkeepers should aim to see how high turf can be cut without serious complaints instead of entering a contest to see how low greens can be cut. Another aspect of the study was to determine if there was any significant difference between each green following any or all of the treatments. Tiziani (1990) found during experiments, where greens used were of similar age and construction, uncontrollable naturally occurring variations in the environment of golf greens and changing

weather can induce substantial variations in BRD even under uniform cultural practices. For this study data collected from 3 greens following mowing, rolling, and a combination of both practices has been analysed and statistically tested to determine differences in results.

Hypotheses

- Green speed will increase when the green is cut
- Green speed of a cut green will be more than that of a rolled green
- Green speed of a cut and rolled green will be more than that of all other treatments

Methods

Experiments were carried out on 3 greens at Gay Hill Golf Club, Worcestershire, UK during November 2009. All 3 greens were of a similar age and construction, 85 years old clay based push-up with a sward composition of 70% Annual Meadow Grass (*Poa annua*) / 30% Bentgrass (*Agrostis tenuis)*. Treatments and measurements were taken on November 5th 2009 in dry conditions.

A control and 3 treatments were studied;

1. Control - Un-cut green (5 days since last cut), 5mm measured sward length (Plate 1)
2. Mown - Hand mown at 4.5mm using John Deere 220C pedestrian mower removing 0.5mm leaf blade (Plate 2)
3. Un-cut & Rolled - Rolled using Toro GM3000 triplex unit with Toro Turf Weight Rollers
4. Mown & Rolled - Combination mowing followed by rolling

Plate 1. Turf Prism used to assess sward length of the sites used as control

Plate 2. John Deere 220C Pedestrian Mower used and set at 4.5mm

Each green studied was split into 3 sections (front, middle, back) with measurements taken in each section in order to achieve a mean measurement of each green. A level area of green was sought by placing the stimpmeter flat onto the surface and placing a ball in the centre. When the ball remained stationary it was deemed to be sufficiently flat to carry out the test

with a degree of accuracy. Ball speed measurements were taken with a Stimpmeter. 3 new Titleist Pro V1 balls were rolled from the Stimpmeter, at a marked point of each section of the green. Although Titleist balls were used for this experiment, research carried out by Danneberger (2009, *personal communication*) suggests that ball make does not effect speed measurements. Each roll was measured and a mean of the 3 rolls calculated. The process was then replicated in the opposite direction. The two mean calculations were then added and averaged to provide a Stimpmeter reading for the area.

Measurements were carried out on 3 greens. The first measurement was for Treatment 1 (control) and subsequent measurements were taken following each mowing or rolling treatment. Raw data from a total of 216 ball rolls (Appendix II) was recorded throughout the 3 trail sites producing 16 final readings to be processed. Results were analysed using ANOVA: Two-Factor without replication processed in Microsoft Excel 2007 (Appendix I).

Results

Raw data taken from each green (12 x stimpmeter readings, 3 following each treatment) were studied and compared. Mean readings were used to analyse differences between treatments and greens (Table 1). Calculations for stimpmeter measurements used USGA guidance (Figure 1). All measurements were taken in imperial (feet and inches) for ease of understanding within UK golf industry.

Figure 1. Stimpmeter reading, as per USGA Instruction (Knowles, 2009)

$$\frac{(S\downarrow + S\downarrow + S\downarrow + S\uparrow + S\uparrow + S\uparrow)}{6} = \text{Stimpmeter measurement}$$

Where;
S↓ = measurement of roll
S↑ = measurement of reverse direction roll

ANOVA: Two-Factor Without Replication statistical tests were carried out to investigate comparisons and differences between treatments and greens. P-values (P) demonstrate how significant the differences are; $P>0.05$ is not significant, $P<0.05$ is significant and $P<0.01$ is highly significant (Walls, 2008).

Table 1. Mean stimpmeter readings (BRD) for each trail site (Measurement in inches)

	Green 14
Un-cut	mean of 92.39 ± 1.51 inch, n = 18 (min 90, max 96)
Roll	mean of 107.33 ± 4.09 inch, n = 18 (min 103, max 110)
Cut	mean of 102.89 ± 2.90 inch, n = 18 (min 98, max 107)
Cut & Roll	mean of 114.22 ± 4.09 inch, n = 18 (min 110, max 120)

	Green 16
Un-cut	mean of 91.94 ± 2.94 inch, n = 18 (min 90, max 96)
Roll	mean of 112.39 ± 4.71 inch, n = 18 (min101, max 123)
Cut	mean of 102.67 ± 4.78 inch, n = 18 (min 103, max 103)
Cut & Roll	mean of 107.56 ± 4.20 inch, n = 18 (min 100, max 114)

	Green 17
Un-cut	mean of 85.89 ± 2.51 inch, n = 18 (min 83, max 86)
Roll	mean of 105.28 ± 6.78 inch, n = 18 (min 100, max 109)
Cut	mean of 109.11 ± 5.78 inch, n = 18 (min 104, max 115)
Cut & Roll	mean of 116.17 ± 6.48 inch, n = 18 (min 110, max 124)

ANOVA test results (Table 2) indicated highly significant ($P<0.01$) increases in BRD following each treatment when compared to the un-cut (control) reading.

Table 2. ANOVA for difference between greens following treatments

AVOVA Test	*Df*	*F-Value*	*P-Value*	Significant
Treatment	3	14.6557	0.0036	Yes

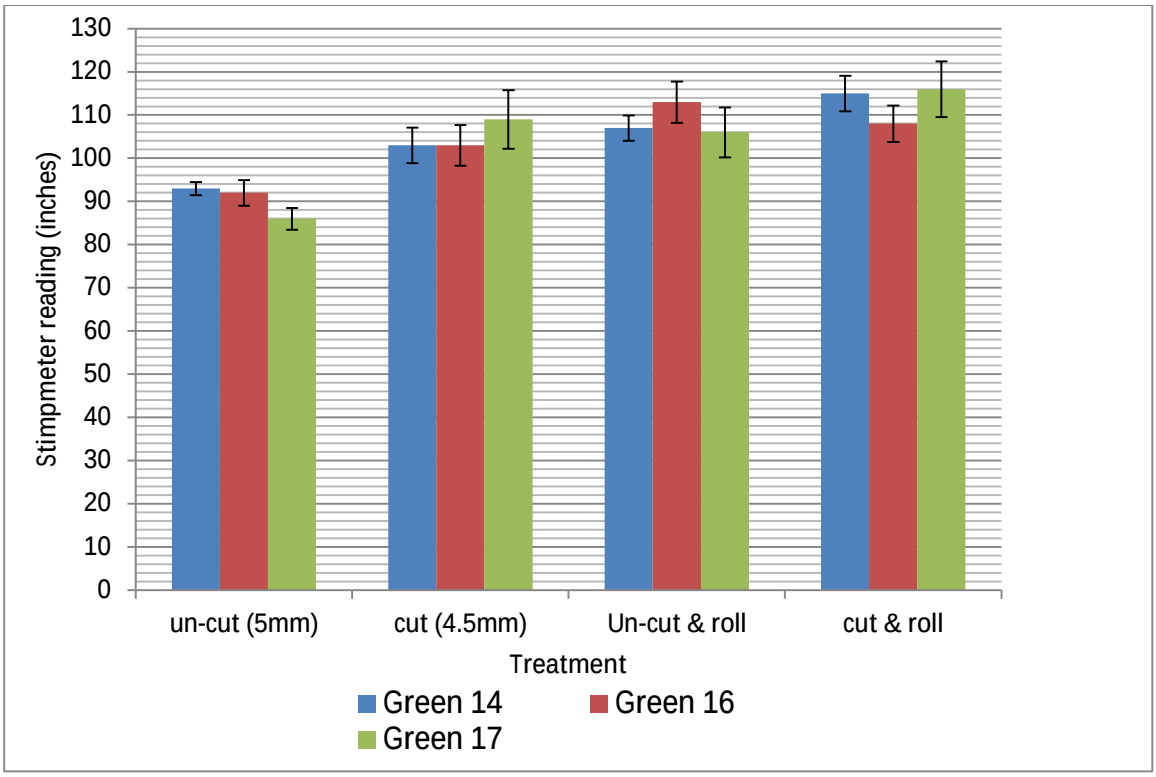
ANOVA statistical test also indicated that there was no significant difference ($P>0.05$) between the 3 greens studied following each treatment (Table 3).

Table 3. ANOVA for difference between greens following treatments

AVOVA Test	*Df*	*F-Value*	*P-Value*	Significant
Green	2	0.0126	0.9875	No

Results were set into a bar chart (Figure 2). Results indicate that there is an increase in BRD from the un-cut (control) and both the cut and un-cut & rolled treatments. The largest increase in BRD was in the cut & rolled treatment.

Figure 2. Mean (±SE) values examining difference in BRD between treatment groups



Discussion

Treatment – Cut at 4.5mm

The results indicate a highly significant ($P<0.01$) increase in BRD once each green was cut. The hypothesis that green speed will increase when the green is cut is supported by these results. Kopec *et al.* (2005) also reported that mowing height reduction increased BRD during their two-year study. The mean BRD following cutting was 104.89 inches (± 0.50) stDev 3.46, (8 feet, 9 inches) which is classed as fast for regular membership play and medium for tournament play according to USGA Speed Charts (Figure 3). Radko (2005) considers that only a BRD increase greater than 6 inches (> 6 inches) is deemed to be a significant increase and one which can be detected by the golfer.

Figure 3. Speed Charts Developed by the USGA (based upon data from tests performed by USGA Green Section agronomists over two years) (Radko, 2005)

Speeds for Regular Membership Play	
8'6 "	Fast
7'6 "	Medium-fast
6'6"	Medium
5'6"	Medium-slow
4'6"	Slow

Speeds for Tournament Play	
10'6"	Fast
9'6"	Medium-Fast
8'6"	Medium
7'6"	Medium-slow
6'6"	Slow

Source: USGA 1977

The mowing treatment reduced the height of cut from 5mm to 4.5mm which effectively increased BRD from 90 inches (7'6") to 104 (8'9"). There is evidence to suggest that further 0.5mm reductions will continue to increase BRD by the same margins. Radko (2005) believes that the law of diminishing returns implicates that there is no known BRD increase following incremental drop in mowing heights. The results of stimpmeter readings following mowing on each green were consistent ± 0.5 inch, n = 3. The evidence collected statistically indicates uniformity between greens and with good green speed. Duich (1983) believes that the ultimate goal for all superintendents should be to provide uniformity among all greens.

Treatment – Un-cut and Rolled

The average BRD following rolling treatment was 108 inches (± 0.46) stDev 3.79. The BRD was again significantly greater ($P<0.01$) than the control. The BRD was surprising in that the hypothesis was that a green cut at 4.5mm would have greater green speed than that of the un-cut and rolled green. The null hypothesis was accepted and questions rose as to why the null hypothesis was not rejected as the effect of mowing would produce significantly greater

BRD. Hartwinger *et al.* (2001) suggests that that both mowing and rolling affect BRD by roughly the same magnitude. Investigation into the weight distribution of the turf roller compared to the pedestrian mower should be studied and also how the weight impacts upon a putting green surface. A hypothesis which would explain the results from this experiment would be that there is a greater impact on the sward and soil bulk density from a turf roller. There was a 7 inch difference between min (106) and max (113) readings which were used to calculate the average BRD for the un-cut treatment. The 16th green reading (113) showed the greatest increase. This could possibly be due to higher soil moisture content or higher thatch content. If greater weight impacted the surface during treatment the possibility would be that thatch would temporarily compact to a higher degree thus producing greater BRD. This effect may only be temporary as thatch would quickly expand back to previous levels thus slowing BRD. Repeat experiments should be carried out to determine greater accuracy within results.

Treatment – Cut and Rolled

The hypothesis of green speed of a cut and rolled green will be more than that of all other treatments is supported by the results (Figure 2). The average BRD following rolling and cutting was 113' (± 0.39) stDev 4.36 which equates to 9'5". The BRD increase from that of the 'cut' green is significant (> 6 inches) according to Radko (2005) where as the increase compared to the 'rolled' green is not deemed to be significant (< 6 inches). The 9'5" measurement also remains within the same USGA green speed classification as that of both other treatments.

Summary

Although the 'cut and rolling' treatment produced the greatest BRD questions still exist as to whether the combination of both treatments would be deemed to be economically and environmentally sustainable. The results show that BRD was not significantly greater (> 6 inches) than that produced by the single cultural treatments of either cutting or rolling. These findings contradict research carried out by Duich (1983) who stated that double mowing increased BRD by 8 inches, which would be a significant (> 6 inches) increase. Hartwinger *et al.* (2001) concluded that regular multiple rolling treatments (four to seven times per week) decreased turf quality even though BRD increased.

The experiments carried out collected sets of data from numerous points within each green. Standard stimpmeter assessments normally utilise just one set of measurements from a single point within a green. The need for collecting data from various points is questionable for future studies. More importantly studies should be carried out in more favourable conditions than those commonly associated with a winter climate. Firm and dry conditions are likely to provide results with greater accuracy.

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Appendix I

ANOVA: Two-Factor Without Replication

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
14	4	418	104.5	83.66666667
16	4	416	104	80.66666667
17	4	417	104.25	165.5833333
un-cut (5mm)	3	271	90.33333333	14.33333333
cut (4.5mm)	3	315	105	12
Un-cut & roll	3	326	108.6666667	14.33333333
cut & roll	3	339	113	19

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.5	2	0.25	0.012623	0.987483	5.143253
Columns	870.9167	3	290.3056	14.65778	0.003611	4.757063
Error	118.8333	6	19.80556			
Total	990.25	11				

Appendix II

		Green	14	(inches)								
Treatment			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
Un-cut (5mm)			101	89		87	93		85	82		
			95	93		89	89		86	87		
			104	95		89	102		98	99		
		ave	*100*	*92*		*88*	*95*		*90*	*89*	*outcome*	Feet
		stimp		*96*			*92*			*90*	*93*	7'9"
Roll			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
			127	74		108	120		112	109		
			138	78		96	117		111	109		
			125	77		100	118		106	107		
		ave	*130*	*76*		*101*	*118*		*110*	*108*	*outcome*	Feet
		stimp		*103*			*110*			*109*	*107*	8'11"
Cut (4.5mm)			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
			111	84		112	101		93	120		
			108	85		115	100		92	118		
			109	89		114	99		86	116		
		ave	*109*	*86*		*114*	*100*		*90*	*118*	*outcome*	Feet
		stimp		*98*			*107*			*104*	*103*	8'7"
Cut & Roll			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
			141	94		105	122		113	112		
			141	94		108	115		114	91		
			155	93		113	119		115	111		
		ave	*146*	*94*		*109*	*119*		*114*	*105*	*outcome*	Feet
		stimp		*120*			*114*			*110*	*115*	9'7"

		Green	16	(inches)								
Treatment			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
Un-cut (5mm)			73	106		91	98		78	100		
			73	110		90	101		82	101		
			74	108		94	99		79	98		
		ave	*73*	*108*		*92*	*99*		*80*	*100*	*outcome*	Feet
		stimp		*91*			*96*			*90*	*92*	7'8"
Roll			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
			98	150		89	112		100	126		
			98	146		90	112		101	127		
			97	146		93	110		101	127		
		ave	*98*	*147*		*91*	*111*		*101*	*127*	*outcome*	Feet
		stimp		*123*			*101*			*114*	*113*	9'5"
Cut (4.5mm)			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
			84	125		93	97		74	128		
			86	124		100	108		77	132		
			78	117		99	120		79	127		
		ave	*83*	*122*		*97*	*108*		*77*	*129*	*outcome*	Feet
		stimp		*103*			*103*			*103*	*103*	8'7"
Cut & Roll			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
			86	136		94	121		103	116		
			92	131		92	129		94	94		
			97	140		98	123		95	95		
		ave	*92*	*136*		*95*	*124*		*97*	*102*	*outcome*	Feet
		stimp		*114*			*110*			*100*	*108*	9'0"

		Green	17	(inches)								
Treatment			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
Un-cut (5mm)			98	72		97	80		97	77		
			99	68		95	85		90	79		
			91	69		91	84		98	76		
		ave	*96*	*70*		*94*	*83*		*95*	*77*	*outcome*	Feet
		stimp		*83*			*89*			*86*	*86*	7'2"
Roll			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
			145	76		136	85		102	94		
			149	69		133	74		98	97		
			144	66		141	80		109	97		
		ave	*146*	*70*		*137*	*80*		*103*	*96*	*outcome*	Feet
		stimp		*108*			*109*			*100*	*106*	8'10"
Cut (4.5mm)			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
			145	85		136	86		121	88		
			147	86		128	87		116	85		
			142	83		128	88		122	91		
		ave	*145*	*85*		*131*	*87*		*120*	*88*	*outcome*	Feet
		stimp		*115*			*109*			*104*	*109*	9'1"
Cut & Roll			Front			Middle			Back			
			↑	↓		↑	↓		↑	↓		
			159	83		139	94		121	98		
			159	88		132	95		117	100		
			170	83		134	93		120	106		
		ave	*163*	*85*		*135*	*94*		*119*	*101*	*outcome*	Feet
		stimp		*124*			*115*			*110*	*116*	9'8"