Mowing and Rolling For
Faster Speeds and Better Turf

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The worst invention we’ve ever seen is the Stimpmeter. I may bring one to the convention and break it because one of the things that all golf courses want to do is they all want to be like Augusta National. Augusta National has green speeds that are so quick, but you can’t bring the quick green speeds to golf courses that were designed in the early 1900s by architects that intended greens to run at 6, 7 or 8 on the Stimpmeter. I think a golf green should be cut to the level where you could still maintain the original hole locations that the architect intended. When I’ve had the chance to speak in front of memberships, I tell them to take a look at your course and remember that the architect in 1912 didn’t have big, heavy equipment to build the golf course, and he didn’t have in mind the fact you were going to have green speeds of 12, 13 or 14. I really appreciate it when I see a membership let the superintendents maintain the dignity of the golf course and the original intent of the architect and let the golf course play as intended.
GCSAA Survey - 2002

<table>
<thead>
<tr>
<th></th>
<th>1st Choice</th>
<th>2nd Choice</th>
<th>3rd Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>The greens are too fast</td>
<td>6.6%</td>
<td>7.4%</td>
<td>7.5%</td>
</tr>
<tr>
<td>The greens are too slow</td>
<td>37.2%</td>
<td>17.0%</td>
<td>14.5%</td>
</tr>
<tr>
<td>The rough is too thick/too tall</td>
<td>17.6%</td>
<td>24.7%</td>
<td>21.8%</td>
</tr>
<tr>
<td>Bunker sand is too soft or not raked</td>
<td>11.2%</td>
<td>22.5%</td>
<td>23.2%</td>
</tr>
<tr>
<td>Traps are in poor condition</td>
<td>5%</td>
<td>2%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Un-repaired ball marks</td>
<td>24.6%</td>
<td>22.6%</td>
<td>22.6%</td>
</tr>
<tr>
<td>Don’t Know/ No Answer</td>
<td>2.4%</td>
<td>1%</td>
<td>4.4%</td>
</tr>
</tbody>
</table>

The GCSAA 2002 Golf Leadership Survey, a real-time, computerized, opinion poll conducted at GCSAA's conference and show in Orlando, examined the opinions of 800 superintendents on trends in golf and golf course management. The survey is designed to position the golf course superintendent as an expert in trends affecting the golf industry.

Putting green management

- Stimpmeter
- Mowing heights are trending downward
- Rolling putting greens
  - Common practice in early 1900’s
  - Compaction concerns
  - New developments revitalize rolling in 1990’s
    - USGA sand-based putting greens
    - Lighter, faster rolling equipment
Can you increase mowing height or decrease mowing frequency with regular rolling?

Experimental Area

- University of Arkansas Agriculture Research and Extension Center (Fayetteville, AR)
- 6-yr old USGA green
- ‘L-93’ creeping bentgrass
  \((Agrostis\ stolonifera)\)
- Typical golf course maintenance
- 24 plots, each 5.0 by 18.0 ft
### Materials and Methods

#### Treatments

<table>
<thead>
<tr>
<th>Treatment no.</th>
<th>Mowing height (in)</th>
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<td>2</td>
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<td>6</td>
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<tr>
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<td>1/8</td>
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<tr>
<td>5</td>
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</tr>
<tr>
<td>6</td>
<td>5/32</td>
<td>6</td>
<td>0</td>
<td>5/32</td>
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<tr>
<td>7</td>
<td>5/32</td>
<td>6</td>
<td>3</td>
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</tr>
<tr>
<td>8</td>
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</tbody>
</table>
Materials and Methods

Treatments

• Mowing: Toro Greensmaster 1000
• Rolling: Tru-Turf (RS48-11C) greens roller

Visual Quality
Visual Quality

Quality rating

ABC
CD
D
AB
BCD
A
AB
ABC

1/8
1/8 + R(3x)
1/8 + R(6x)
1/8(3x) + R(3x)
1/8(3x) + R(6x)
5/32
5/32 + R(3x)
5/32 + R(6x)

5
6
7
8

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Visual Quality
Rolling at higher mowing heights

- Maintain green speed compared to lower mowing heights
- Implications?
  - Better putting green quality
  - Increased root production
  - Greater leaf area
  - Improved photosynthetic rate
  - Higher carbohydrate reserves

Additional stresses

- Foot traffic
  - Golf shoes with spikes
    - Metal spikes
    - Alternative spikes
  - High traffic areas
    - Around hole location
      - 4-5 ft diameter
      - 70% of traffic on green
      - Common walk-on areas
  - Ball marks

Picture courtesy Ty McClellan, USGA Agronomist, Mid-Continent Region
Objectives

- Determine performance characteristics of the putting green surface and rooting characteristics
- Investigate net photosynthesis rates to determine stress levels
- Evaluate ball mark severity and recovery using digital image analysis
Penn G-4

Treatments - Cultivars

Mowing heights
2.5, 3.2, or 4.0 mm
(0.100, 0.125, or 0.156 inch)

Treatments - Mowing Height
Treatments - Rolling Frequency

Mowing height
2.5, 3.2, or 4.0 mm
(0.100, 0.125, or 0.156 inch)

0 Roll week
3 Roll week
6 Roll week

Treatments - Foot Traffic

Mowing height
2.5, 3.2, or 4.0 mm
(0.100, 0.125, or 0.156 inch)
Objectives

- Determine performance characteristics of the putting green surface and rooting characteristics
- Investigate net photosynthesis rates to determine stress levels
- Evaluate ball mark severity and recovery using digital image analysis

Parameters evaluated

- Ball roll distance
- Wear tolerance
  - Visual rating (1-9 scale)
  - Directly following foot traffic
- Visual turf quality rating
- Digital image analysis
  - Turfgrass coverage
  - Turfgrass color
  - Rooting characteristics

Root analysis from WinRhizo
Wear results

Mowing height effect on wear

- 2.5 mm
- 3.2 mm
- 4.0 mm

Foot traffic application date
Rolling frequency on wear

```
<table>
<thead>
<tr>
<th>Year</th>
<th>Wear injury rating</th>
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</thead>
<tbody>
<tr>
<td>2010</td>
<td>5.5</td>
</tr>
<tr>
<td>2011</td>
<td>6.0</td>
</tr>
<tr>
<td>2012</td>
<td>6.5</td>
</tr>
</tbody>
</table>
```

Turf quality, coverage, and color results
Cultivar*Date*Mow in 2011

Date*Roll in 2011
Turfgrass coverage and color

- Followed the same trends as turfgrass quality data
- Significant decrease as temperatures increase
- Lower mowing heights and higher rolling frequencies significantly reduced both
- All recovered to similar levels following favorable weather conditions

Rooting characteristics results
Cultivar*Year*Mow for root length

![Graph showing cumulative root length (cm) for different years and cultivars.](image)

Year*Foot traffic for rooting characteristics

<table>
<thead>
<tr>
<th>Response Variable</th>
<th>Treatment</th>
<th>August 2010</th>
<th>August 2011</th>
<th>August 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative Root Length (cm)</td>
<td>No Foot Traffic</td>
<td>1520 A</td>
<td>1639 A</td>
<td>1918 A</td>
</tr>
<tr>
<td></td>
<td>Foot Traffic</td>
<td>1338 B</td>
<td>1725 A</td>
<td>1521 B</td>
</tr>
<tr>
<td>Dry Root Mass (g)</td>
<td>No Foot Traffic</td>
<td>0.074 A</td>
<td>0.087 A</td>
<td>0.082 A</td>
</tr>
<tr>
<td></td>
<td>Foot Traffic</td>
<td>0.057 B</td>
<td>0.088 A</td>
<td>0.059 B</td>
</tr>
</tbody>
</table>
Objectives

- Determine performance characteristics of the putting green surface and rooting characteristics
- **Investigate net photosynthesis rates to determine stress levels**
- Evaluate ball mark severity and recovery using digital image analysis

Photosynthesis chamber
Photosynthetic measurements

- Full light measurements (Pg)
  - Completely clear day
  - Between 1100 and 1400 hours
- Dark measurements [soil (Rs) + canopy (Rc) respiration]
  - Single measurement
  - Completion of replication
  - Chamber covered with cardboard box
- Net photosynthesis = Pg – (Rs + Rc)

Net photosynthesis results
Net photosynthetic rates

- Decreasing rate into summer for both cultivars and years
- No significant differences observed for main treatment factors alone
- Significance in higher order interactions
  - Mow*Roll*Foot for Penn G2 in 2011 and 2012 (all dates combined)
  - Few consistent differences

Mow*Roll*Foot for Penn G2 in 2012

![Graph showing net photosynthetic rates for different mowing heights and foot traffic conditions.](image)
Objectives

- Determine performance characteristics of the putting green surface and rooting characteristics
- Investigate net photosynthesis rates to determine stress levels
- Evaluate ball mark severity and recovery using digital image analysis

Methods for ball mark studies

FieldScout 300 TDR Soil Moisture Meter (Spectrum Technologies) with 3.8 cm (1.5 inch) probes

Simple average of two values results in ball mark severity

\[ \frac{36\% + 44\%}{2} = 40\% \]

This means 40% of the golf ball is below the putting surface
Ball mark recovery methods

Light box with frame marked by two golf tees at corner to assist in finding ball marks

Ball mark severity results
Volumetric water content vs. ball mark severity

Cultivar*Roll*Foot in 2011
## Ball mark recovery results

### Rolling frequency in 2010

<table>
<thead>
<tr>
<th>Rolling frequency</th>
<th>Maximum ball mark injury</th>
<th>95% Confidence intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 times/wk</td>
<td>1099</td>
<td>1008 – 1190</td>
</tr>
<tr>
<td>3 times/wk</td>
<td>1253</td>
<td>1162 – 1345</td>
</tr>
<tr>
<td>6 times/wk</td>
<td>1476</td>
<td>1367 – 1585</td>
</tr>
</tbody>
</table>
SR 1020 in 2010

Penn G2 in 2010
SR 1020 in 2011

Injury area was significantly different at $\alpha = 0.05$
No significant differences were observed for any date at $\alpha = 0.05$

### Mow*Foot of days to 50% recovery in 2010

<table>
<thead>
<tr>
<th>Mowing height (mm)</th>
<th>Foot traffic</th>
<th>Days to 50% recovery</th>
<th>95% Confidence intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>No foot traffic</td>
<td>11.36</td>
<td>9.709 – 13.68</td>
</tr>
<tr>
<td></td>
<td>Foot traffic</td>
<td>13.96</td>
<td>11.87 – 16.96</td>
</tr>
<tr>
<td>3.2</td>
<td>No foot traffic</td>
<td>10.12</td>
<td>7.915 – 14.03</td>
</tr>
<tr>
<td></td>
<td>Foot traffic</td>
<td>11.35</td>
<td>9.253 – 14.67</td>
</tr>
<tr>
<td>4.0</td>
<td>No foot traffic</td>
<td>11.03</td>
<td>9.686 – 12.82</td>
</tr>
<tr>
<td></td>
<td>Foot traffic</td>
<td>10.01</td>
<td>8.816 – 11.57</td>
</tr>
</tbody>
</table>
# Roll*Foot of days to 50% recovery in 2011

<table>
<thead>
<tr>
<th>Rolling frequency</th>
<th>Foot traffic</th>
<th>Days to 50% recovery</th>
<th>95% Confidence intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 times/wk</td>
<td>No foot traffic</td>
<td>5.757</td>
<td>5.016 – 6.756</td>
</tr>
<tr>
<td></td>
<td>Foot traffic</td>
<td>4.883</td>
<td>4.326 – 5.605</td>
</tr>
<tr>
<td>3 times/wk</td>
<td>No foot traffic</td>
<td>5.146</td>
<td>4.483 – 6.041</td>
</tr>
<tr>
<td></td>
<td>Foot traffic</td>
<td>5.599</td>
<td>4.968 – 6.413</td>
</tr>
<tr>
<td>6 times/wk</td>
<td>No foot traffic</td>
<td>5.024</td>
<td>4.523 – 5.650</td>
</tr>
<tr>
<td></td>
<td>Foot traffic</td>
<td>6.741</td>
<td>5.891 – 7.876</td>
</tr>
</tbody>
</table>

## Conclusions and implications
Conclusions

- Environmental stresses affected all parameters
  - Poorest levels in July or August each year
  - Recovery following more favorable conditions
- Effects of the main factors were not as significant as expected
- Lower mowing heights and increased rolling frequencies reduced performance characteristics
- Slight increases in physiological parameters as mowing heights were increased

Implications for golf course managers

- Low mowing heights appear beneficial during favorable environmental conditions
- Raising mowing heights and reducing traffic imperative during high environmental stress
  - Change hole locations regularly
  - Alter common walk-on areas
  - Implement target rolling
- Raising mowing heights may create slight advantages physiologically
Acknowledgements

- KSU Turf Program
  - Dr. Dale Bremer
  - Kenton Peterson
  - Kira Shonkwiler Arnold
- Funding Sources
  - OJ Noer Foundation
  - U of A Horticulture
- Equipment Donations
  - The Toro Company
  - DMI Speed Roller
  - FootJoy