Evaluating Ball Mark Severity and Recovery Using Digital Image Analysis

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Introduction

Ball mark scars can significantly impact aesthetics and playability of golf course putting greens. Previous research has indicated ball marks repaired appropriately require 3 to 6 weeks to completely heal (1,4). However, minimal research has been performed on ball mark severity and recovery. Most of the published research has differentiated ball mark recovery based on repair tools and repair methods. Murphy et al. (3) evaluated ball mark recovery among bentgrass cultivars (*Agrostis* spp.) in New Jersey. Previous studies determined ball mark severity by filling the impression with a measured mass of sand, while recovery data were collected by either visual ratings or diameter measurements.

Digital image analysis (DIA) has proven to be very useful for measuring performance characteristics such as turf color, turf cover, and ball lie. Digital image analysis creates an objective data set that is not affected by bias and inconsistencies of human raters. There are many potential areas where DIA could be utilized in collecting data, including its application to ball mark studies.

Objectives and Hypothesis

- **Obj. 1 -** Determine if DIA could be used to evaluate ball mark severity and recovery on creeping bentgrass putting greens
- **Obj. 2 -** Evaluate the methods on a bentgrass putting green cultivar trial
- **Hypothesis -** Higher density cultivars would have less severe ball marks and recover more quickly during environmentally stressful periods

Materials and Methods

Ball mark severity - calibration

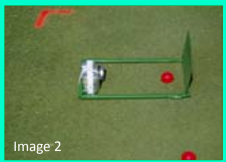
- A red golf ball was pressed into a block of molding clay in 20 mm increments
- At each depth, DIA was used to determine the percent of golf ball below the surface (ball mark severity)
- The volume of the impression was determined by adding sand to the impression

Ball mark severity - cultivar trial

- Twenty-eight creeping bentgrass (*Agrostis stolonifera*) and two velvet bentgrass (*A. canina*) cultivars were replicated two times on a sand-based putting green
- Time domain reflectometry (TDR) used to measure volumetric water content
- Two ball marks created per plot by pneumatic golf ball launcher at 40 psi (Image 1)
- Images from the front and rear view of a red golf ball placed in the impression were obtained using a special frame (Image 2) and digitally analyzed (Image 3) to estimate ball mark severity
- Ball marks were repaired 4-6 hours after treatment

Ball mark recovery – cultivar trial

- Light box and frame were used to collect images of ball mark injury (Images 4 and 5)
- Images collected 1 day after treatment (DAT) and 5-7 day increments thereafter
- Turfgrass coverage determined using DIA (5)



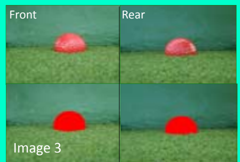


Image 1. Pneumatic golf ball launcher shooting ball at 40 psi
Image 2. Frame designed to hold camera and ensure images are equidistant from the golf ball in the ball mark
Image3. Analyzed images from the front and rear view of a single ball mark

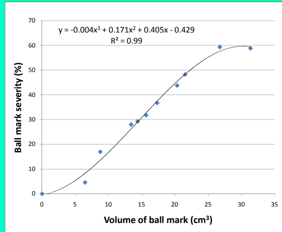


Figure 1. Calibration study to determine the accuracy of DIA in evaluating ball mark severity. A red golf ball was pressed into clay, obtaining images at each depth. Ball mark severity represents the percentage of ball below the surface.

Image 4. Light box mounted to frame with golf tees marking corners

Image 5. Ball mark injury centered in 4 inch cut-out of foam board frame

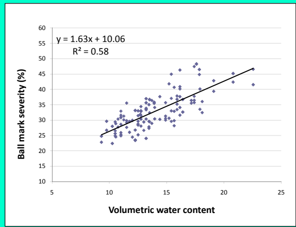


Figure 2. Relationship between volumetric water content and ball mark severity

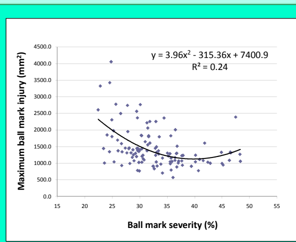


Figure 3. Relationship between ball mark severity and maximum injury

Table 1. Volumetric water content, ball mark severity, and maximum injury of creeping bentgrass cultivars available to market

Cultivar	Volumetric water content	Ball mark severity (%)	Maximum injury (mm^2)
CY-2	17.0 AB[z]	0.350 ABC	999.6 A
Authority	14.3 BCDE	0.317 ABCD	1116.0 AB
Alpha	14.9 BCD	0.380 A	1122.7 AB
T-1	15.2 BC	0.324 ABCD	1132.1 AB
Penncross	14.4 BCDE	0.377 AB	1201.7 ABC
Shark	14.2 BCDE	0.294 CD	1221.9 ABC
Penn G-1	14.0 BCDE	0.271 D	1232.5 ABC
Penn G-2	18.7 A	0.388 A	1324.1 ABC
Penn A-2	15.3 ABC	0.337 ABCD	1370.1 ABC
Penn G-6	15.3 ABC	0.349 ABC	1372.7 ABC
Tyee	12.3 CDE	0.286 CD	1372.8 ABC
SR 1020	13.0 CDE	0.340 ABCD	1385.0 ABC
Crenshaw	13.8 BCDE	0.329 ABCD	1398.4 ABC
Crystal Bluelinks	16.8 AB	0.381 A	1543.1 ABC
MacKenzie	11.1 E	0.303 BCD	1617.7 ABC
Penn A-1	11.9 CDE	0.285 CD	1678.0 ABC
Declaration	14.2 BCDE	0.352 ABC	1799.5 BC
L-93	11.6 DE	0.281 CD	1899.6 BC
Penn A-4	11.7 DE	0.294 CD	1922.2 C

[z]Data presented as means of four replicates. Means followed by different letters within a column are significantly different at ($P < 0.05$)

Results and Discussion

Ball mark severity - calibration

- Digital image analysis of the percentage of ball below the surface was an effective means to estimate ball mark severity (%) (Fig. 1)

Ball mark severity - cultivar trial

- Significant differences were observed among cultivars with respect to volumetric water content and ball mark severity (Table 1)
- Ball mark severity and soil moisture exhibited a significant linear relationship (P-value < 0.01) (Fig. 2)
- Ball mark injury increased from 1 to 6 DAT consistent with a previous report (2)
- 'Declaration', 'L-93', and 'Penn A-4' had significantly greater scar area than 'CY-2' at 6 DAT (Table 1)
- Ball mark severity was poorly correlated with maximum injury (Fig. 3)
  - ❖ Cultivars with greater soil moisture had greater ball mark severity
  - ❖ Increased organic matter may have improved resiliency of these cultivars and minimized injury
  - ❖ Murphy et al. (3) observed similar results and suggested further development of thatch/mat layer may increase tensile strength reducing variability among cultivars

Ball mark recovery - cultivar trial

- Most ball marks healed within 60 days
- 'Penn A-4' had the greatest reduction of injury (1442 mm^2) over 31 day period following maximum injury at 6 DAT
- The velvet bentgrass cultivar, SR 7200, was slowest to heal with scar area ranging from 330 to 603 mm^2 at 50 DAT, which contrasts previous research demonstrating minimal ball mark injury and competitive recovery rates for SR 7200 (3) (*data not shown*)
- The extended length of time to full recovery and poor performance by some cultivars may be a result of the timing of the study
  - ❖ The end of July and first of August were extremely hot, which likely slowed recovery rates
  - ❖ Temperatures became more optimal for bentgrass growth around the end of August, and recovery rates began increasing

Conclusions and Future Work

- Digital image analysis can be used successfully to determine ball mark severity and recovery
- The majority of ball marks in this study required 7-8 weeks to fully recover
- Surprisingly, higher density, heat tolerant cultivars were not able to recover quicker than coarser, standard cultivars such as L-93
- Ball mark recovery images will be obtained daily following treatment until injury area decreases to model the initial expansion of ball mark injury
- These methods will be incorporated in a mowing height, rolling, and foot traffic study to evaluate ball mark severity and recovery under various treatment regimes on a creeping bentgrass putting green

References

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