



A closer look at aeration and sand incorporation:
It's about time(s)


The image is split into two parts. The left part shows a close-up of various aeration tools, including different sizes of hollow-tine cores and aeration spikes, some in their original packaging. The right part shows a tractor pulling a large aeration implement across a green golf course, with a cloud of dust or sand being kicked up behind it.

Roch Gaussoin, Emeritus Professor, University of Nebraska



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Acknowledgements

The logos are arranged in a grid-like fashion. At the top are USGA, Davis, and EFG. Below them are three GCSAA chapter logos: Nebraska Chapter, South Dakota Chapter, and Peaks & Prairies Chapter. The next row features Toro, PlanetAir, and DryJect. Below that are CTI and JRM. At the bottom is the Nebraska Turfgrass Association logo.

- USGA Davis Program
- Environmental Institute for Golf
- Nebraska GCSA
- GCSA of South Dakota
- Peaks & Prairies GCSA
- Jacobsen, Toro, DryJect, Ceres Turf Inc, JRM
- Nebraska Turfgrass Association

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Outline

- Historical perspective
 - Greens Construction
 - New Management Paradigm
 - Firm and Fast
 - Organic Matter Accumulation
- Fine tuning
 - Topdressing
 - Cultivation

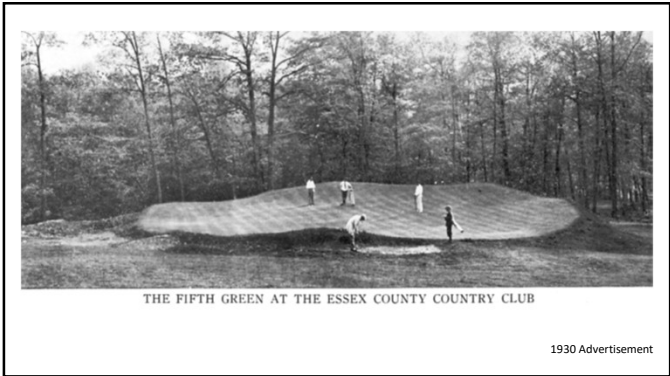
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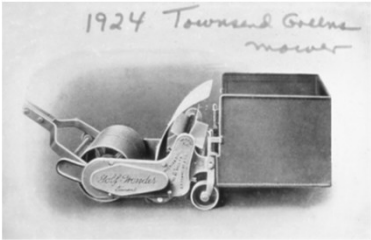


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Closer cut mowers



As low as 0.25"

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In 1932, a fruit farmer, Orton Englehardt, invented the impact sprinkler.



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USGA Method of Putting Green Construction

- Original Specifications in 1960
 - Since then, this method has been regularly researched, improved and amended
- Other methods
 - California Style (1990)
 - Purr-wick (1966)
 - Dutch Green (1960-70; primarily the Netherlands)
 - Native soil or push-up greens

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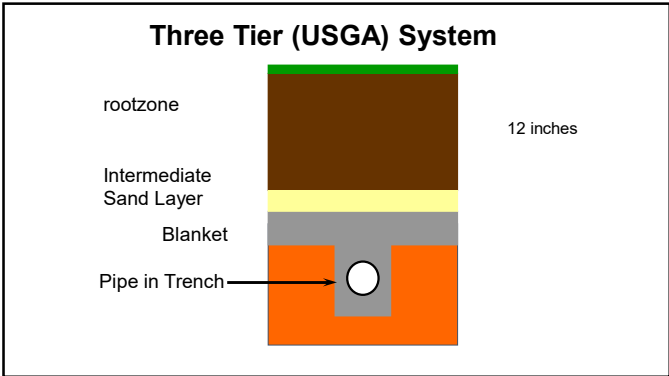
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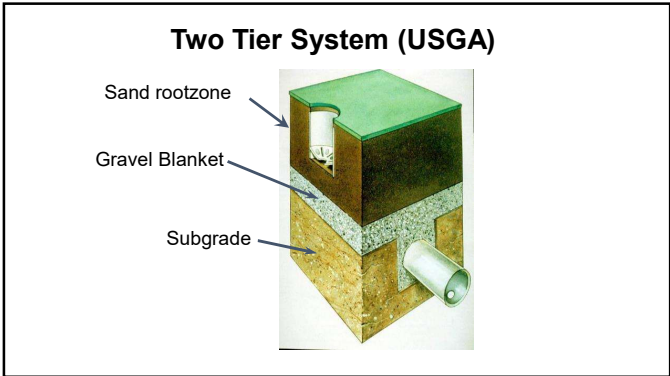
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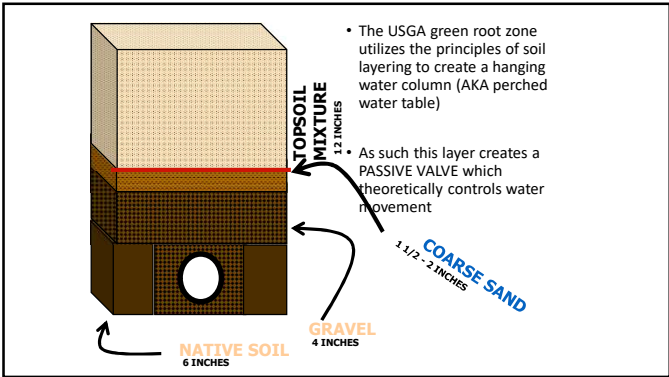
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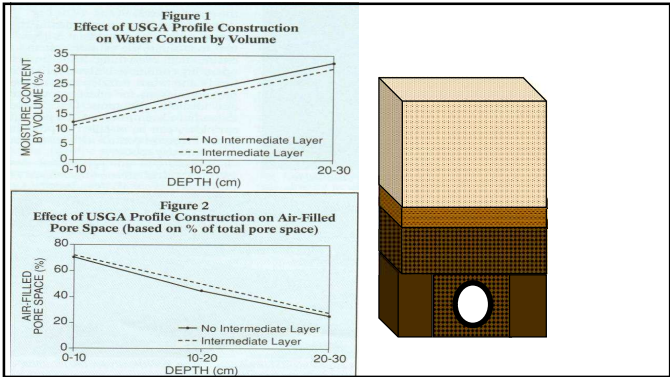
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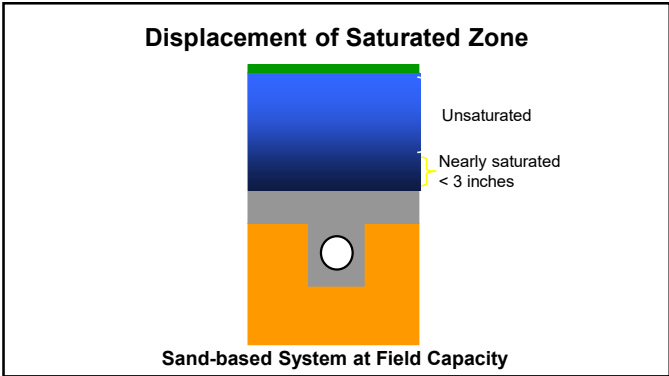
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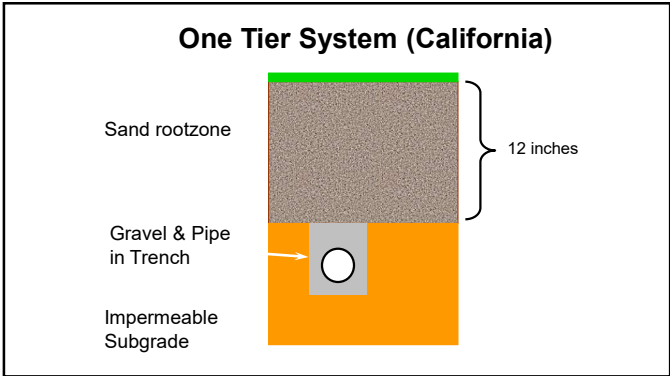
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Historical Perspective: USGA Green Section
Record and Precursors 1921-2024

Top 10 Key Word search

First mention; First "modern" mention

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Reasons golf boomed post-WW2:

• Prosperous economic times allowed recreational spending.

• Returning veterans looked for leisure activities.

• Golf on TV showcased the sport to wider audiences.

• Golf became part of corporate culture for networking and deals.

• New technologies and equipment made golf easier for the average player.

• Retirees had time to take up the game.

• Golf became part of suburban lifestyles and country club status.

.....increase in traffic, participants and play led to the 1960 release of the USGA recommendations for green construction

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OM accumulates as sand greens age

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Green Age (years)

22

8.5 year-old turf

Mat Layer

Root Zone

Sand

Sand + 20% Sphagnum

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Practices to change thatch into mat include topdressing and ...

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... cultivation.

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Organic Matter Management Study

Objectives

1. Determine if conventional hollow tine is more effective than solid tine aerification at managing organic matter accumulation

2. Determine if venting methods are effective at managing OM accumulation

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Treatments

Tine Treatment	Venting Treatment
None	None
2X Hollow tine	PlanetAir
2x Solid tine	Hydroject
	Bayonet tine
	Needle tine

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Treatments

Tine Treatment	Venting Treatment
None	None
2X Hollow tine	PlanetAir
2x Solid tine	Hydroject
	Bayonet tine
	Needle tine

15 Trts per Rep

6 Reps per year

2 different years

= A whole lot of fun for one graduate student or 180 trts

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All treatments received the same topdressing quantity (22 ft³/M*) but different frequency

Equilibrated to identify differences of the practices in question

*1 ft³ = 100 lbs of dry sand; yd³ = 2700 lbs

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Materials and Methods

• Green Age:

– 12 years

– 9 years

• Data collected:

– OM% (pre-cultivation/monthly)

– Single wall infiltration (monthly)

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OM Data Analysis Year 2

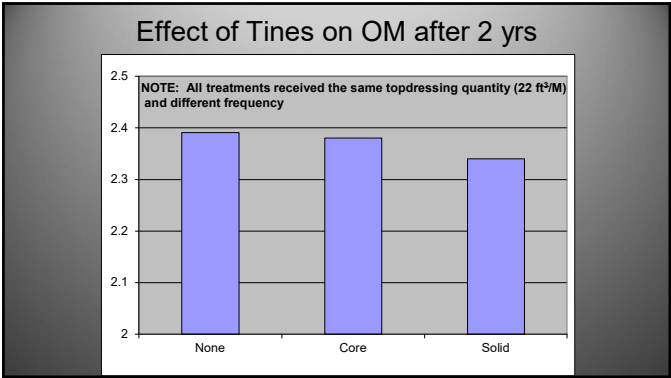
• No differences between green age except for higher % in older green

• No differences among venting methods

• No interactions with solid/hollow/none

• No differences among solid/hollow/none

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What these data do/don't suggest

- Cultivation, when topdressing quantity was equal, was insignificant as a means to control OM
- However, a superintendent must use whatever tools they have at their disposal to ensure sand is making it into the profile and not the mower buckets

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Topdressing interval relative to Tine/Venting combinations (22 cu ft/M)*

- **NONE/NONE**
– 5-10 days
- **Solid & Hollow/NONE**
– 7-14 days
- **Solid & Hollow/Venting**
– 14-18 days

*Observed and calculated based on displacement and surface area opened

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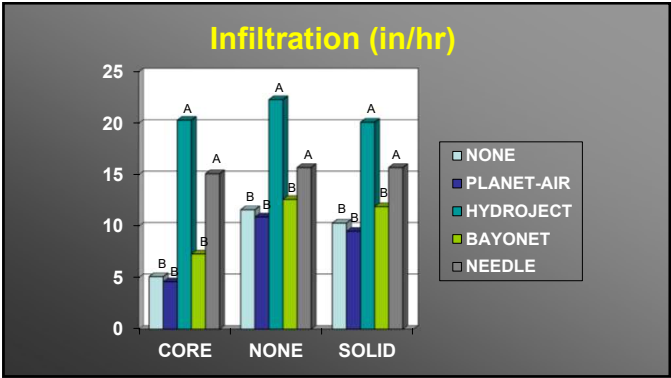
Cultivation Effects on Organic Matter Concentration and Infiltration Rates of Two Creeping Bentgrass (*Agrostis stolonifera* L.) Putting Greens

Charles J. Schmidt, Rich E. Casanova, Robert C. Shearman, Martha Mayo, and Charles S. Wommersley

Abstract: Soil cultivation is commonly used to manage organic matter (OM) accumulation on golf course putting greens. Our objectives were to determine if tines and venting were effective in reducing OM and infiltration rates on two creeping bentgrass putting greens. The study was a 2 x 2 factorial experiment with tines (solid or hollow) and venting (none or 1/4 inch) as treatments. OM was measured at 0, 1, 2, and 3 inches depth. Infiltration was measured using a double ring infiltrometer. Results showed that tines and venting significantly reduced OM and increased infiltration rates. The response was attributed to the removal of OM and the creation of pores in the soil.

Full paper available at: <https://doi.org/10.1080/0013717X.2019.1644444>

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Project Objective

- National Survey
- Determine cause and effect relationship among maintenance practices and their interactions relative to surface OM accumulation

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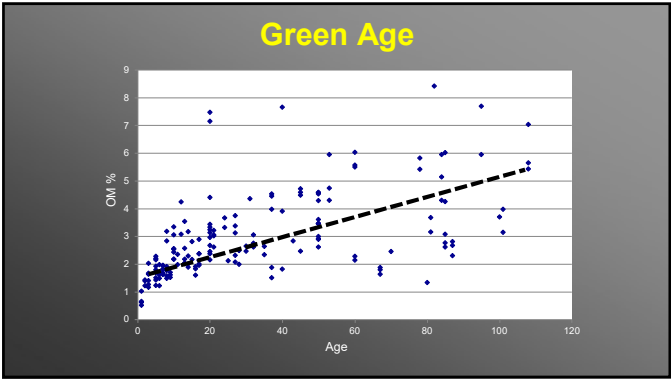
2006/07/08 Samples

- Sixteen states
 - Nebraska, South Dakota, Iowa, Wyoming, Colorado, Washington, Wisconsin, Illinois, New Jersey, Minnesota, New Mexico, Montana, Hawaii, California, Connecticut, Arkansas.
- 117 golf courses sampled
 - More than 1600 samples

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Is the age effect misleading?

- Sampling issue:
 - Mat depth increases as green ages resulting in more OM in the same volume soil.

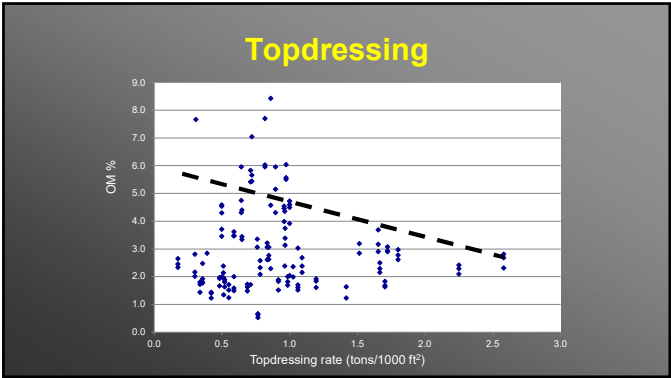
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A Standard Method for Measuring Putting Green Surface Organic Matter

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Survey Summary

- None of the variables collected, by themselves, or in combination with others, predicted OM
- Courses using >18 cubic ft*/M of topdressing with or without “venting” had lower OM
- Of the known cultivars, no differences in OM were evident

**1 ft³ = 100 lbs of dry sand; yd³ = 2700 lbs*

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Organic Matter Concentration of Creeping Bentgrass Putting Greens in the Continental U.S. and Resident Management Impact

Charles J. Schmidt,* Houch E. Gaussoin, and Sarah A. Gaussoin

*Charles J. Schmidt and Sarah A. Gaussoin, Dept. of Golf Management, University of Mississippi, University, 39268; Houch E. Gaussoin, 2019 West University Blvd., Leavenworth, KS 66043; Sarah A. Gaussoin, Dept. of Horticulture, University of Mississippi, University, 39268. Received 17 May 2014. *Corresponding author: schmidt@olemiss.edu

Soil organic matter (SOM) accumulation in creeping bentgrass (Agrostis subulata) L., C3B putting greens has been a concern for decades. Gaussoin et al. (2010) investigated the negative effects associated with excessive SOM (disease, insect problems, and reduced water infiltration, localized dry spots, reduced high year to year SOM concentrations in C3B greens throughout the continental U.S. to determine management practices, and their interactions, that significantly affect green OM content. Regression techniques were used to determine the significance of various management practices and site-specific characteristics on green OM content. Three hundred and eight putting greens in 104 golf courses in 15 states (AR, CA, CO, IL, IN, IA, KS, LA, MI, MN, MO, NE, NY, ND, OH, OK, SD, TN, VA, WI, WY) were surveyed for management practices and SOM concentration from June 2006 through June 2008. All golf courses surveyed were C3B with varied levels of annual irrigation (the amount 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5, 16.0, 16.5, 17.0, 17.5, 18.0, 18.5, 19.0, 19.5, 20.0, 20.5, 21.0, 21.5, 22.0, 22.5, 23.0, 23.5, 24.0, 24.5, 25.0, 25.5, 26.0, 26.5, 27.0, 27.5, 28.0, 28.5, 29.0, 29.5, 30.0, 30.5, 31.0, 31.5, 32.0, 32.5, 33.0, 33.5, 34.0, 34.5, 35.0, 35.5, 36.0, 36.5, 37.0, 37.5, 38.0, 38.5, 39.0, 39.5, 40.0, 40.5, 41.0, 41.5, 42.0, 42.5, 43.0, 43.5, 44.0, 44.5, 45.0, 45.5, 46.0, 46.5, 47.0, 47.5, 48.0, 48.5, 49.0, 49.5, 50.0, 50.5, 51.0, 51.5, 52.0, 52.5, 53.0, 53.5, 54.0, 54.5, 55.0, 55.5, 56.0, 56.5, 57.0, 57.5, 58.0, 58.5, 59.0, 59.5, 60.0, 60.5, 61.0, 61.5, 62.0, 62.5, 63.0, 63.5, 64.0, 64.5, 65.0, 65.5, 66.0, 66.5, 67.0, 67.5, 68.0, 68.5, 69.0, 69.5, 70.0, 70.5, 71.0, 71.5, 72.0, 72.5, 73.0, 73.5, 74.0, 74.5, 75.0, 75.5, 76.0, 76.5, 77.0, 77.5, 78.0, 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Tine Trial Fall 2021

• Check

• Hollow ½" ID

• Solid ½"OD

• DryJect (3x3)

• ¼" Solid (Needle)

• DryJect (3x2)

• Needle + Solid

• Needle + Hollow

Procore 648 - 3" target depth on all tines

Dryject = 5"

Sampled for OM the day after

Treatment in 1' depth increments to 4 "

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Treatment	% OM 0-4"	
Check	4.5	a
Hollow	3.7	b
Needle	3.1	c
DryJect (3x3)	2.7	d
Needle + Hollow	2.3	d
DryJect (3x2)	2.3	d
Needle + Solid	2.3	d
Solid	2.2	d

• No differences among depths

• Dilution only

• Dryject and needle tine were least surface disruptive

• Data is preliminary

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Spring 2023 Tine Trial

• ²⁸ tine types/configurations including Viper tines

• 2 devices (ProCore 648 and DryJect)

• Timing (spring/fall)

• Topdressing before or after

• Data

- OM
- Surface parameters using the USGA GS3
- Infiltration

Equipment and Tine Support Provided by

TORO

CTI

DryJect

Ceres Turf, Inc.

Heartland Golf & Turf Services LLC

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<https://www.usga.org/content/usga/home-page/course-care/regional-updates/central-region/2018/solid-tine-aeration-order-of-operations.html>

Solid-Tine Aeration Order Of Operations



Apply dry seed to putting greens

Before solid tine aeration to improve operational efficiency



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Treatments (Spring, FB Oct 3 except DryJect on Oct 16)

• Main Plots (42' X 60' with a 6' border between)

- 1. Topdress before tines with 0.25"(0.125" on October 2023) on surface (equates to 1 (1/2 fall) ton/1000 ft² or 20 ft³/1000ft²)
- 2. Topdress after tines

• Sub-plots (tine treatments) set at 3" depth

- 1. 5/8" Viper Nose™
- 2. 1/2" Viper Nose™
- 3. 3/8" solid
- 4. ½" solid cross
- 5. Untined control
- 6. ¼" solid
- 7. .50" solid
- 8. 3/8" hollow, side eject
- 9. 1/2" solid cross
- 10. .75" solid slicing
- 11. 1/2" hollow, tapered
- 12. 1/2" hollow side eject
- 13. DryJect 3X3
- 14. Untined Control
- 15. DryJect 2X3

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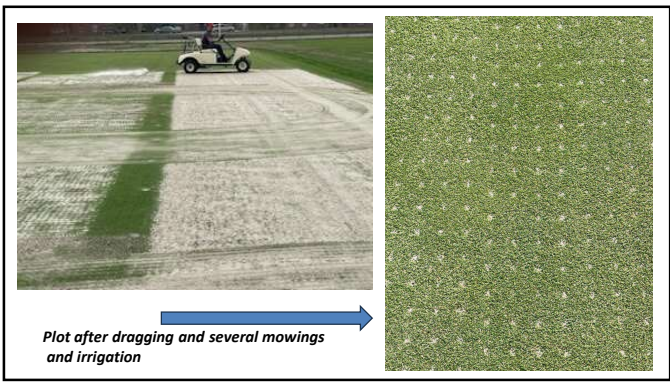
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Data Collection

• Organic matter, 3-5 days after treatment directly over aeration hole

• Infiltration approx. weekly

• NDVI (cover measured digitally) every few days

• Firmness

• Surface Moisture TDR 0-3'; 3-6"

• GS3

–Ball roll

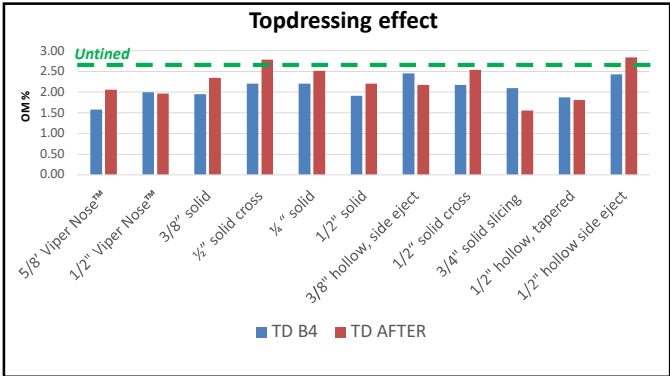
–Smoothness

–Trueness

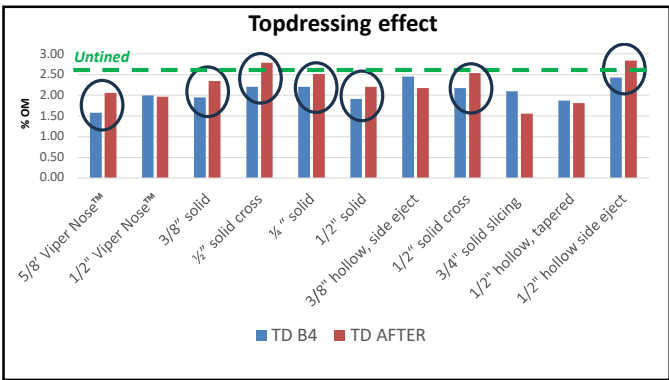
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Fall 2023 Data Results (<.05 = statistical difference)								
ANOVA	10-Oct	18-Oct	21-Oct	26-Oct		9-Oct	16-Oct	25-Oct
Effect	NDVI-1	NDVI-2	NDVI-3	NDVI-4	%OM	Infil-1	Infil-2	Infil-3
Topdressing (TD)	0.1161	0.5583	0.6987	0.2785	0.0466	0.3444	0.188	0.1061
Tine TRT	<.0001	0.0049	0.0353	0.114	<.0001	<.0001	<.0001	<.0001
TD*TRT	0.0761	0.925	0.2796	0.1175	0.0107	0.1	0.0076	0.4673

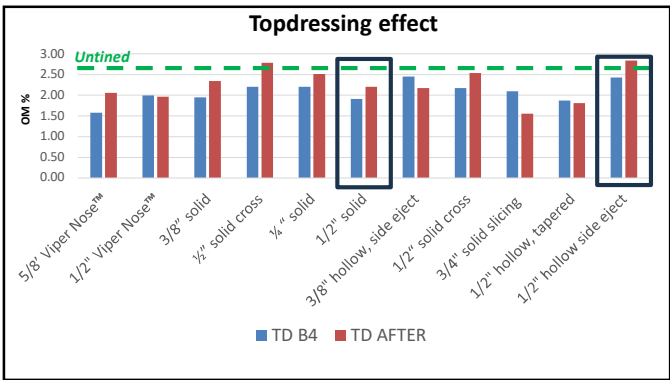
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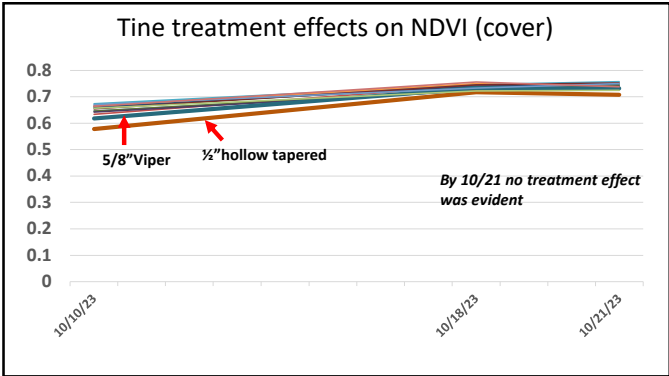
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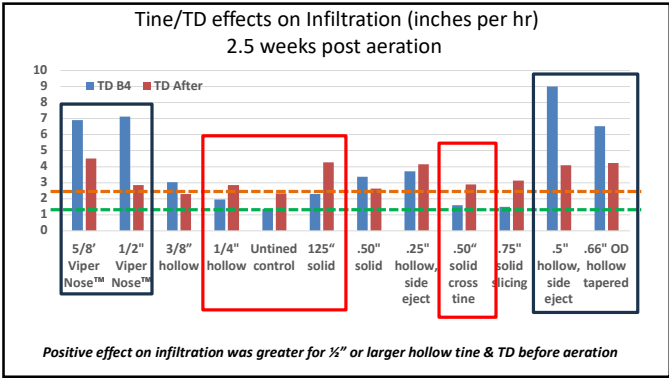
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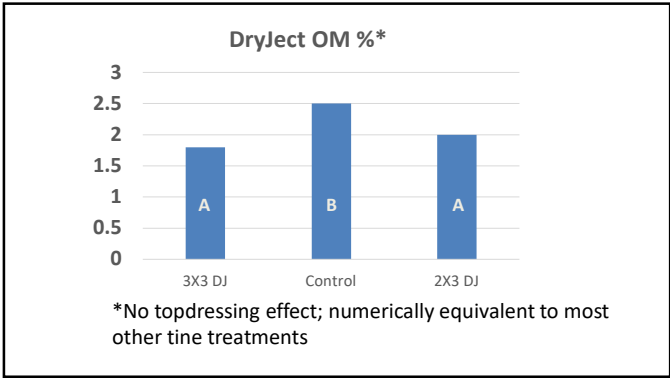
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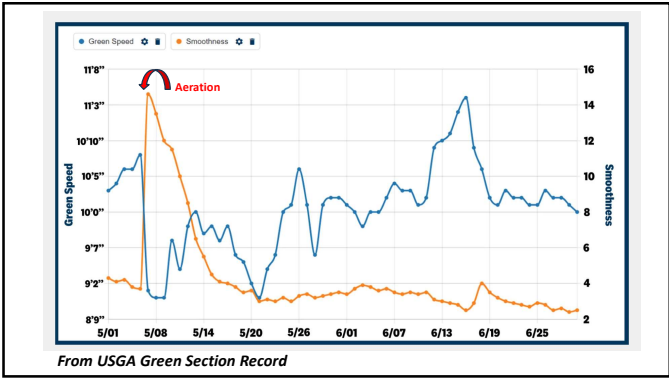
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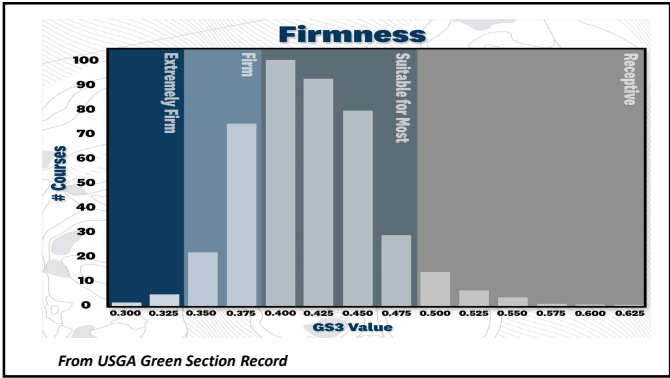
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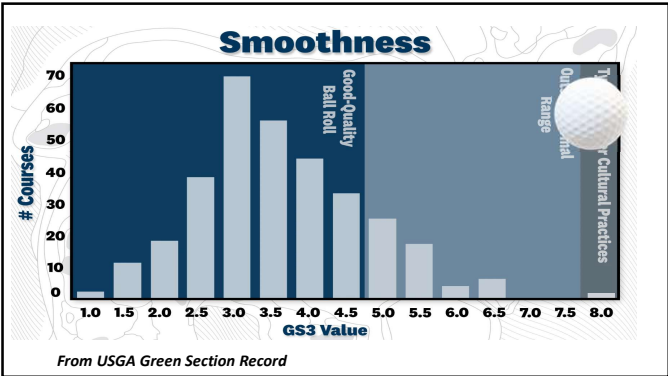
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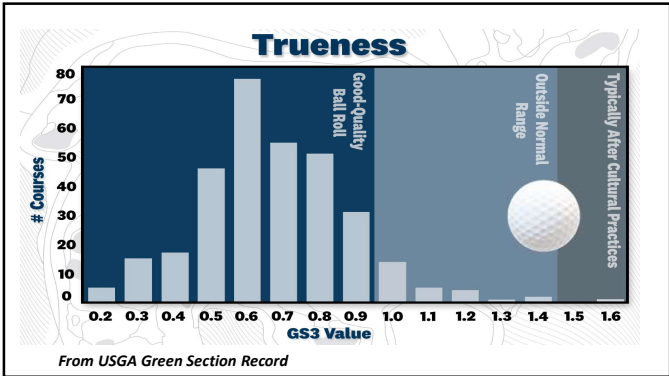
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Fall 2023 GS3 Data Results ($\leq .05$ = statistical difference)

Ball Roll 1 WAT		
Effect	F Value	Pr > F
TD	5.5	0.1437
TRT	4.44	<.0001
TRT*TD	2.85	0.0027

TD before aerification increased ball roll more for ½" or greater hollow tines than same diameter solid tines. Solid tines had higher ball roll than equivalent hollow tines. Effects were less evident 2 WAT.

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Fall 2023 GS3 Data Results ($\leq .05$ = statistical difference)

Trueness 1 WAT		
Effect	F Value	Pr > F
TD	0.16	0.7316
TRT	1	0.4689
TRT*TD	0.66	0.8037

Results were similar and NS 2 & 3 WAT

Smoothness 1 WAT		
Effect	F Value	Pr > F
TD	0.33	0.6245
TRT	0.64	0.8234
TRT*TD	0.83	0.636

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Treatments would appear to be visually different and when data were captured ball deviations appeared evident. Visual STRI Smoothness data were not collected.

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Deeper Dive Into Data

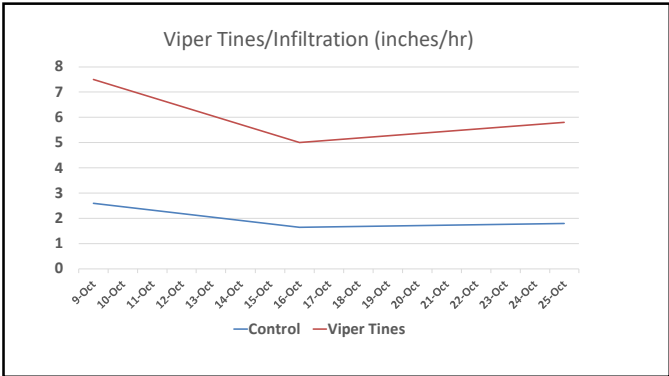
Confounding data due to excessive enthusiasm of researcher

Different statistical approach to isolate specific factors of interest

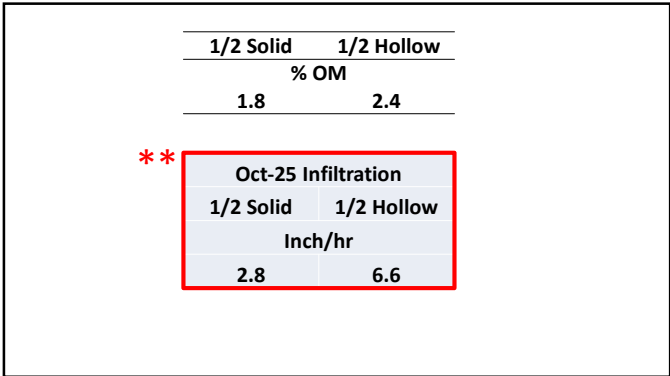
Orthogonal comparisons

This approach successfully separated out differences not evident from traditional ANOVA analysis for other data. GS3 data still needs to be investigated.

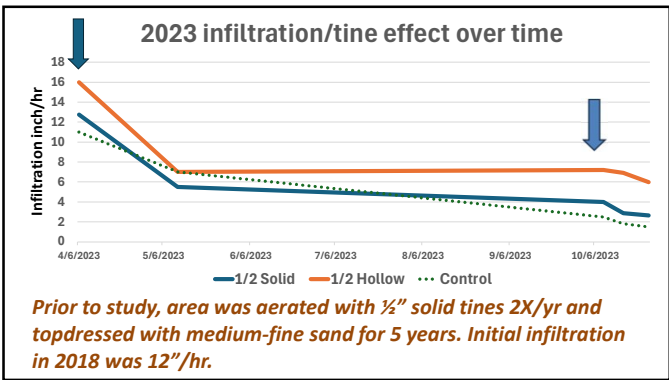
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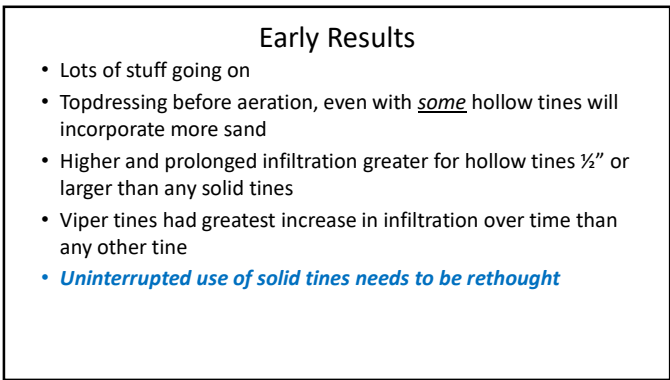
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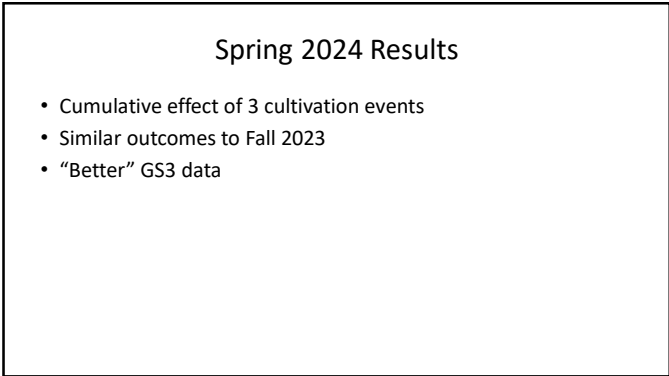
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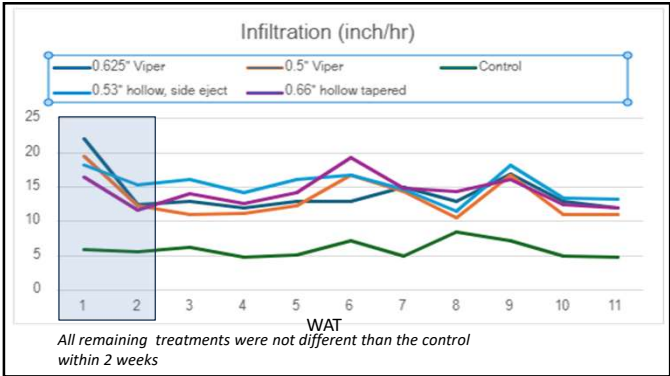
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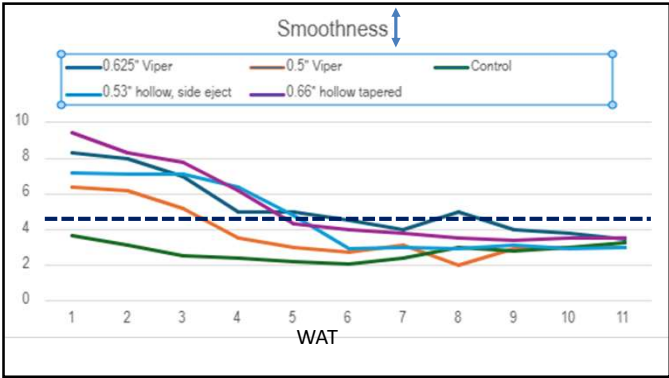
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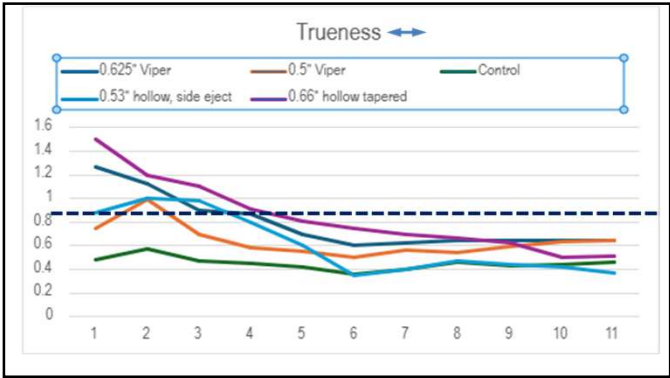
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Consider the Potential of Less-Aggressive Aeration, 2023
Elliott L. Dowling, regional director, East Region, USGA

ISTRC International Sports Turf Research Center Aerification Displacement Chart					
Tine Size	1.35" x 1.35" Centers	1.5" x 1.5" Centers	2.0" x 2.0" Centers	2.5" x 2.5" Centers	3.0" x 3.0" Centers
1/4" Hollow Tines	3.14%	5.18%	1.32%	0.79%	
3/8" Hollow Tines	7.07%	4.91%	3.78%	1.77%	
1/2" Hollow Tines	12.57%	8.73%	4.91%	3.14%	
5/8" Hollow Tines		13.64%	7.65%	4.91%	
5/8" Hollow Vertidrains					1.32%
3/4" Hollow Tines				7.07%	1.77%
3/4" Hollow Vertidrains					1.77%
1" Hollow Tines					3.14%
1" Hollow Vertidrains					3.14%
7/8" Drill and Fill (7" Centers)					1.32%
Graden Verticutter 15 Blades at 1" Spacings	1mm Blade 3.93%	2mm Blade 7.87%	3mm Blade 11.81%		

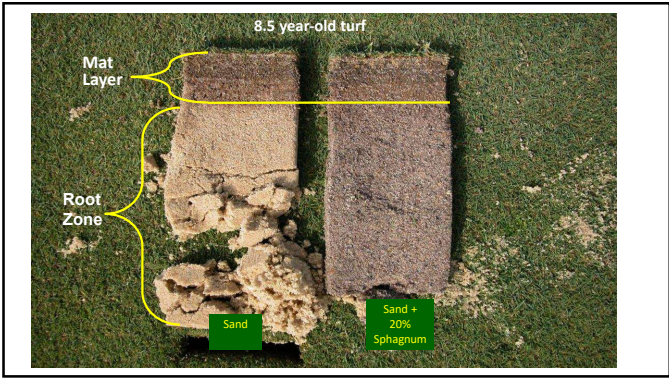
Notes:
1/4" quad tines remove as much material as regular 1/2" hollow tines
3/8" minimum for ease of topdressing fill if replacement of material is required
For double aerification make two passes at approx. 37° (slightly less than 45°) to minimize overlap

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What have we learned?

- A high-quality sand and a well-built root zone are relatively stable and will perform properly for many years.
- What changes over time is the surface...

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It matters how you manage the accumulating thatch/mat layer

- Cultivation has a significant impact. At minimum, use practices that help incorporate sand.
- Topdressing is critical. Can use a fine sand (0.25-5 mm) to ensure enough sand will be applied during summer, in combo with a medium (< 1 mm) with more aggressive aerification (core, solid or injection). Avoid sands of < 0.15.

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It matters how you manage the accumulating thatch/mat layer

- Topdressing before cultivation increases sand incorporation and decreases OM
- Larger diameter hollow (>0.5”) tines increase sand incorporation, infiltration and surface uniformity disruption; surface disruption duration is much shorter than infiltration benefit
- Solid tines decrease OM and infiltration more so than hollow tines over time, care must be taken to include venting or occasional hollow tine cultivation

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Chapter 12 ASA Monograph (3RD Edition)
Characterization, Development, and Management of Organic Matter in Turfgrass Systems

R.E. Gaussoin, Dep. of Agronomy and Horticulture, Univ. of Nebraska
W.L. Berndt, Dep. of Resort and Hospitality Management, Florida Gulf Coast University
C.A. Dockrill, Teagasc College of Amenity Horticulture, Dublin, Ireland
R.A. Drijber, Dep. of Agronomy and Horticulture, Univ. of Nebraska



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Contact Information

- Roch Gaussoin
- rgaussoin1@unl.edu

Thank you!



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