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

OSC 2025 Webinar

Roch Gaussoin, Emeritus Professor, University of Nebraska

EXTENSION

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Acknowledgements

- 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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Donald Ross 1927

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THE FIFTH GREEN AT THE ESSEX COUNTY COUNTRY CLUB

1930 Advertisement

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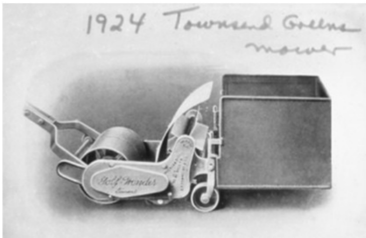
Closer cut mowers



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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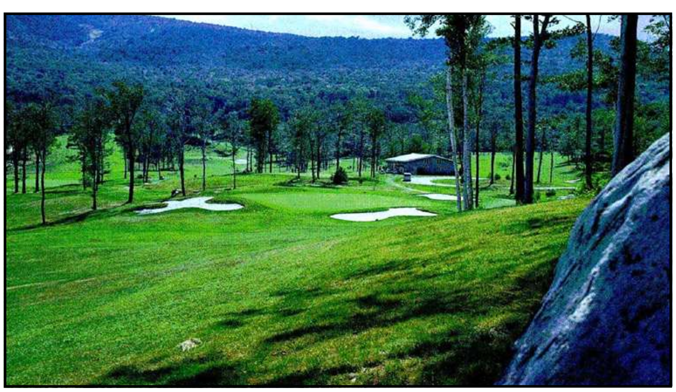

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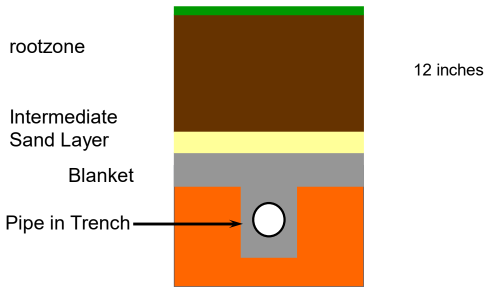
Three Tier (USGA) System



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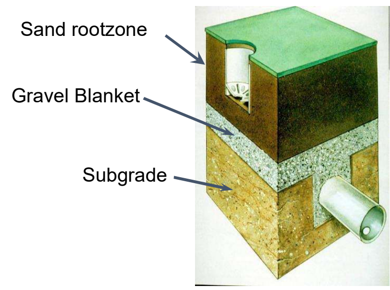
Two Tier System (USGA)



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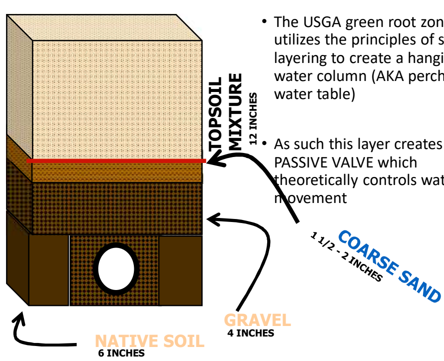

- The USGA green root zone utilizes the principles of soil layering to create a hanging water column (AKA perched water table)
- As such this layer creates a PASSIVE VALVE which theoretically controls water movement

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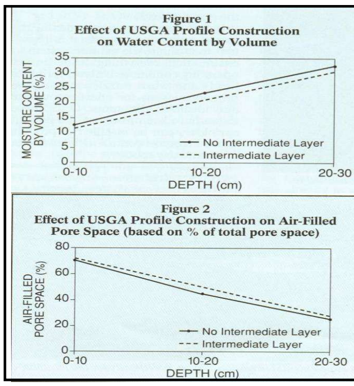

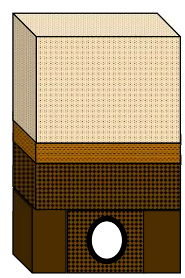

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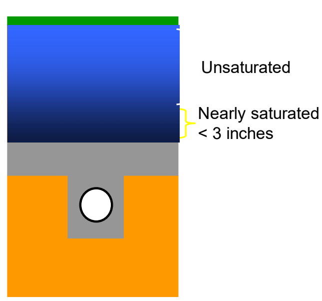
Displacement of Saturated Zone



Sand-based System at Field Capacity

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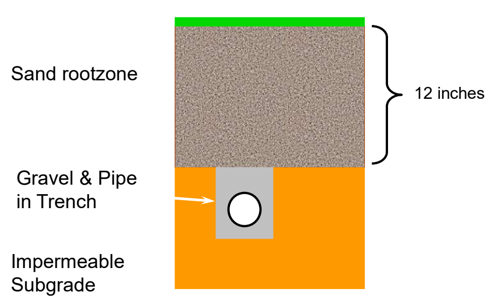
One Tier System (California)



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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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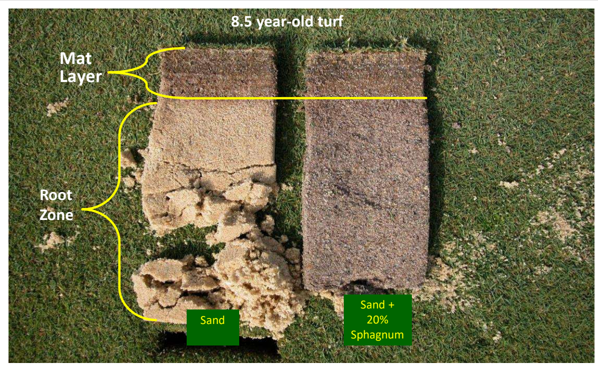

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Organic Matter Management Study

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 ft^3/M*) but different frequency

Equilibrated to identify differences of the practices in question

**1 ft^3 = 100 lbs of dry sand; yd^3 = 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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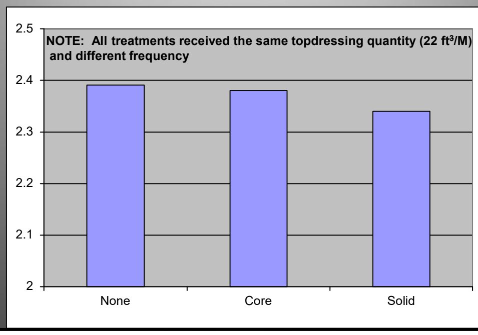
Effect of Tines on OM after 2 yrs



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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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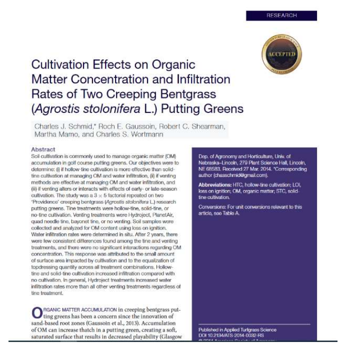
RESEARCH

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

Charles J. Schmid,* Roch E. Gaussoin, Robert C. Shearman, Martha Mamo, and Charles S. Wortmann

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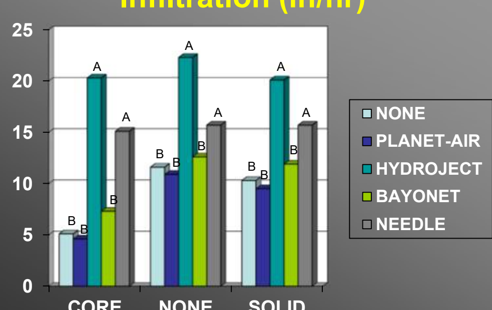
Infiltration (in/hr)



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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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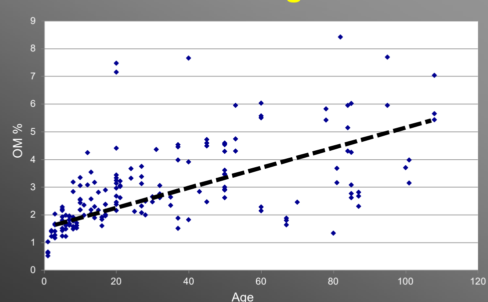
Green Age



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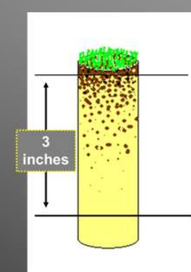
Is the age effect misleading?

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



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Mat Development with Age

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A Standard Method for Measuring Putting Green Surface Organic Matter

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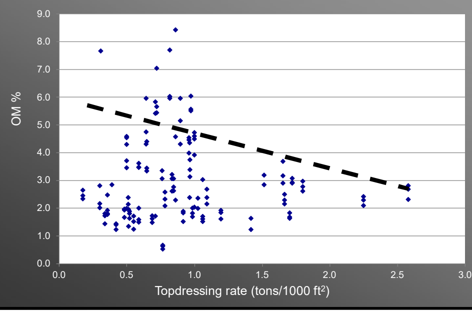
Topdressing



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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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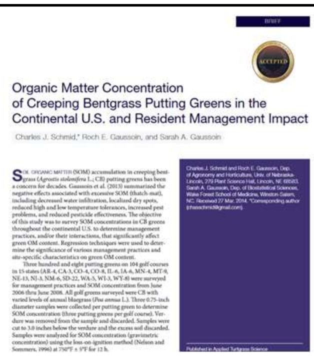

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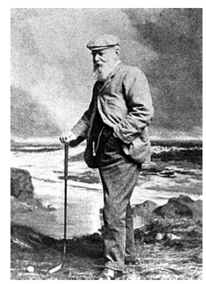
Topdressing

Old Tom Morris (1821–1908) is thought to have discovered the benefits of topdressing accidentally when he spilled a wheelbarrow of sand on a putting green and noted how the turf thrived shortly afterward (Hurdzan, 2004).



J.B. Beard is his classic textbook "Turfgrass Science & Culture, 1973 writes:
"The most important management practice for OM management is topdressing"

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Research Need (2004)

- Comprehensive evaluation of sand quantity, particle size, sampling protocol and cultivation methods

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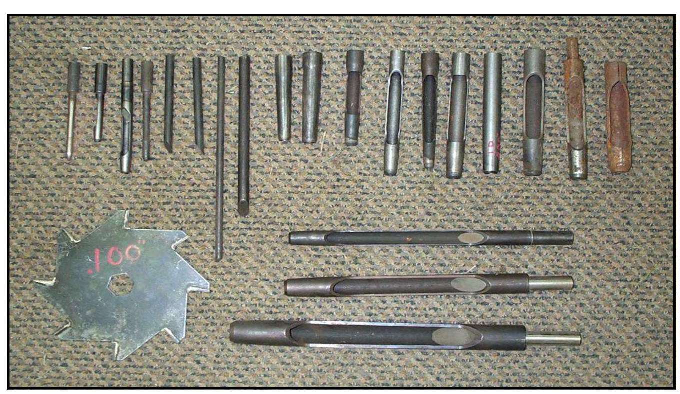

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Tine Trial Fall 2021

- 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

- ~~9~~ *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 Ceres Turf, Inc. DryJect Heartland Golf & Turf Services LLC

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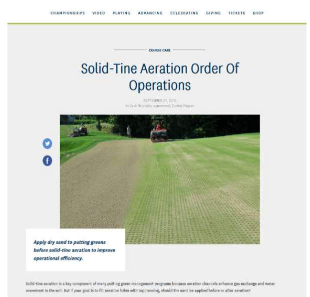
https://www.usga.org/content/usga/home-page/course-care/regional-updates/central-region/2018/solid-tine-aeration-order-of-operations.html



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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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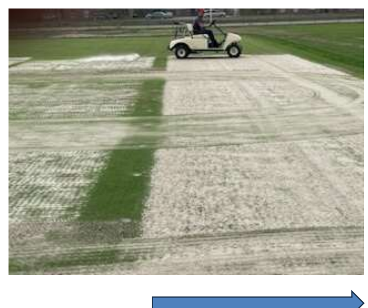
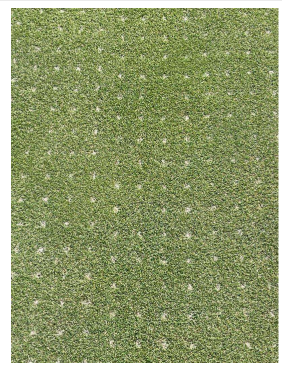


Plot after dragging and several mowings and irrigation



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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 Effect	10-Oct NDVI-1	18-Oct NDVI-2	21-Oct NDVI-3	26-Oct NDVI-4	%OM	9-Oct Infil-1	16-Oct Infil-2	25-Oct 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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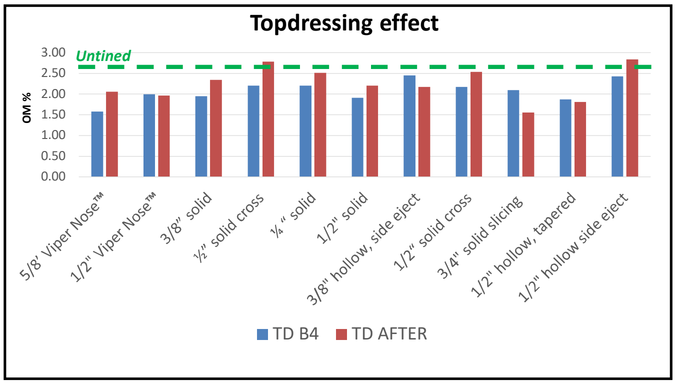

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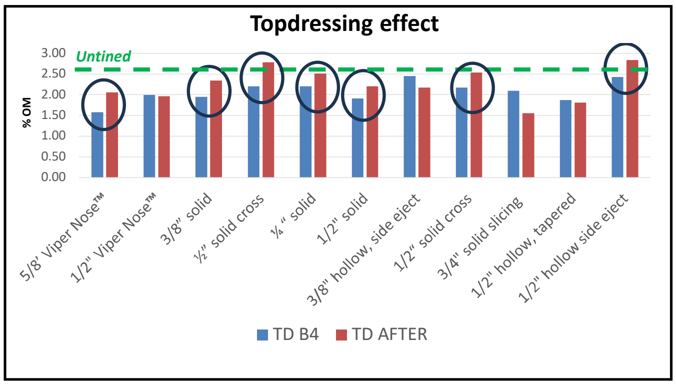

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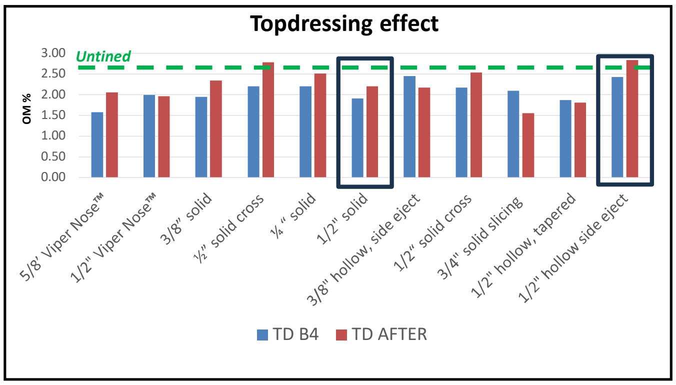

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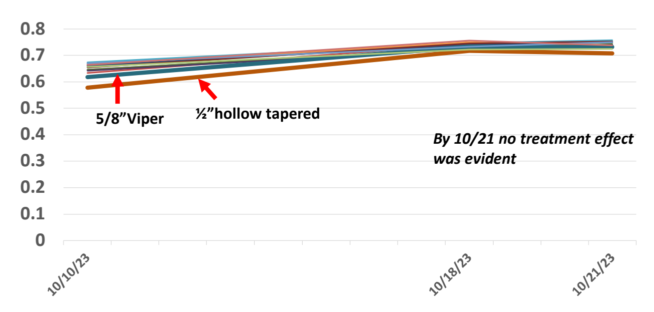
Tine treatment effects on NDVI (cover)



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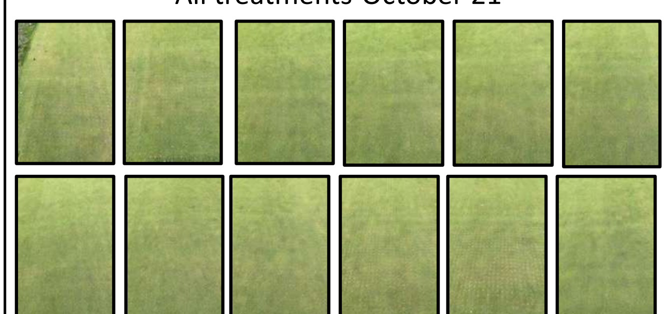
All treatments-October 21



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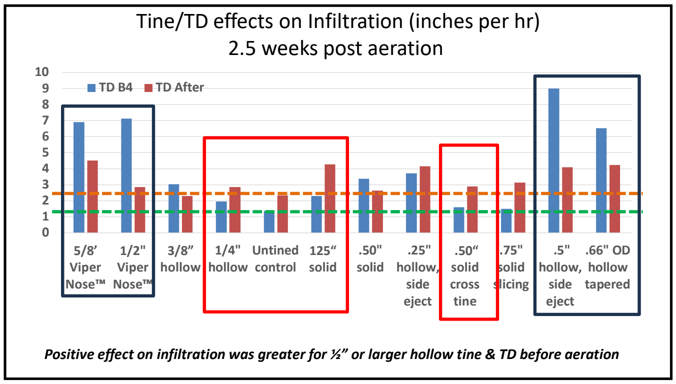

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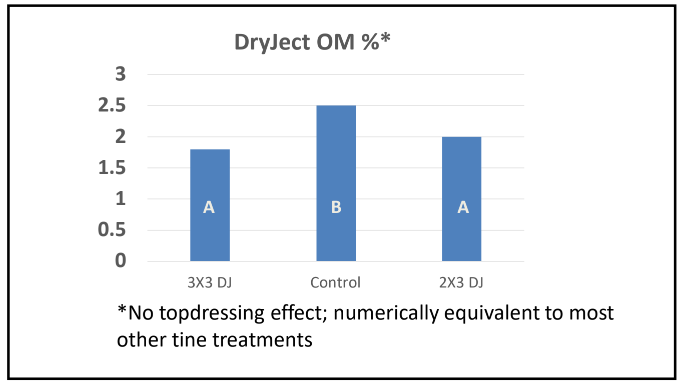

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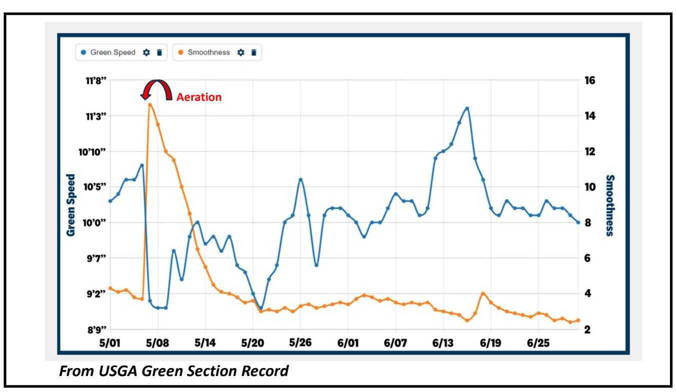

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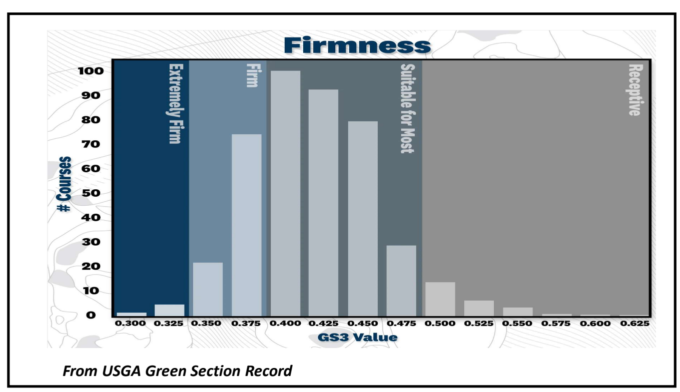

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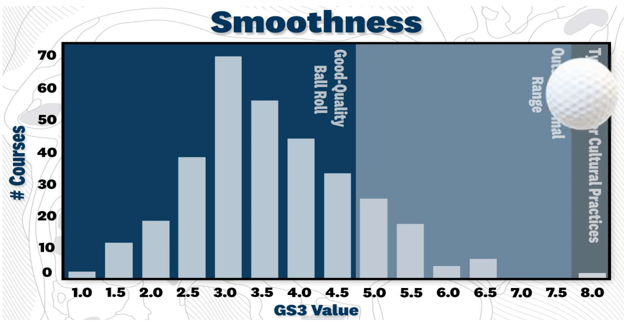

From USGA Green Section Record

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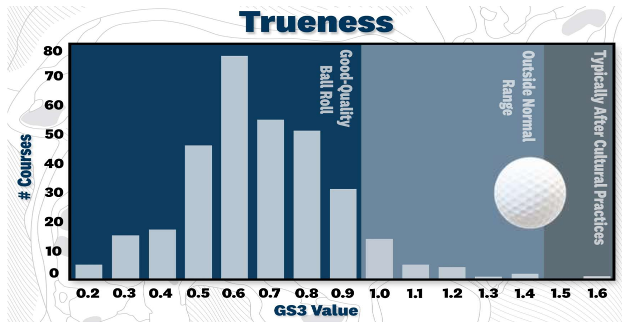

From USGA Green Section Record

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Fall 2023 GS3 Data Results (≤.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 (≤.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

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

Results were similar and NS 2 & 3 WAT

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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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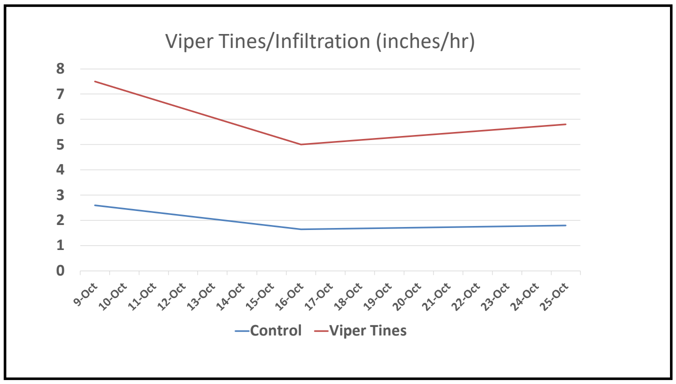

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1/2 Solid	1/2 Hollow
% OM	
1.8	2.4

**

Oct-25 Infiltration	
1/2 Solid	1/2 Hollow
Inch/hr	
2.8	6.6

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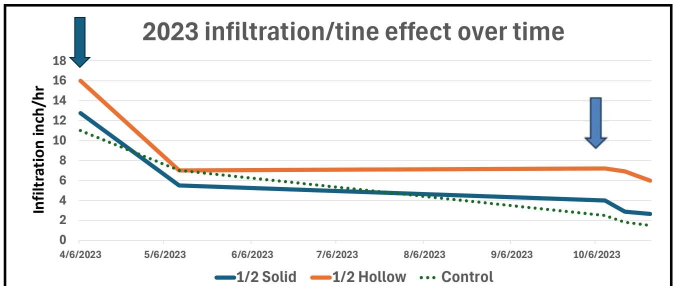

Prior to study, area was aerated with ½" solid tines 2X/yr and topdressed with medium-fine sand for 5 years. Initial infiltration in 2018 was 12"/hr.

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Early Results

- Lots of stuff going on
- Topdressing before aeration, even with <u>*some*</u> hollow tines will incorporate more sand
- Higher and prolonged infiltration greater for hollow tines ½" or larger than any solid tines
- Viper tines had greatest increase in infiltration over time than any other tine
- ***Uninterrupted use of solid tines needs to be rethought***

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Spring 2024 Results

- Cumulative effect of 3 cultivation events
- Similar outcomes to Fall 2023
- "Better" GS3 data

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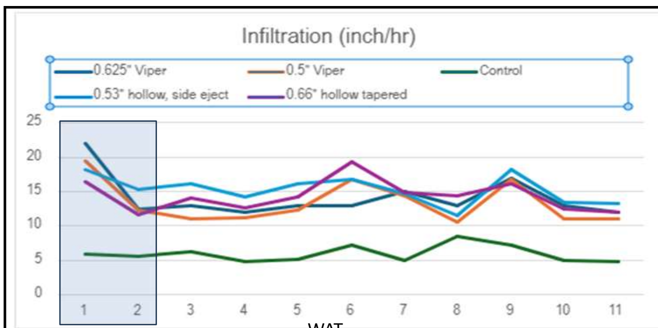

All remaining treatments were not different than the control within 2 weeks

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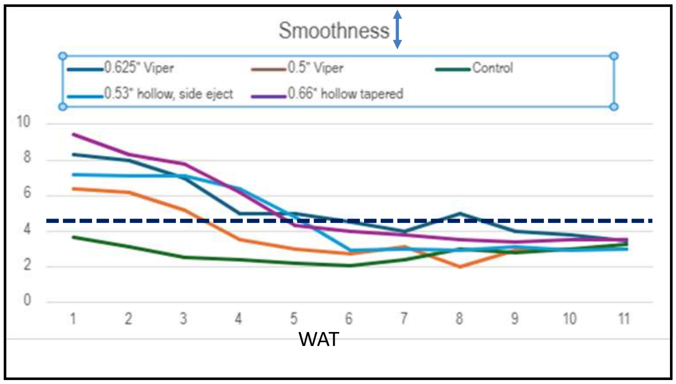

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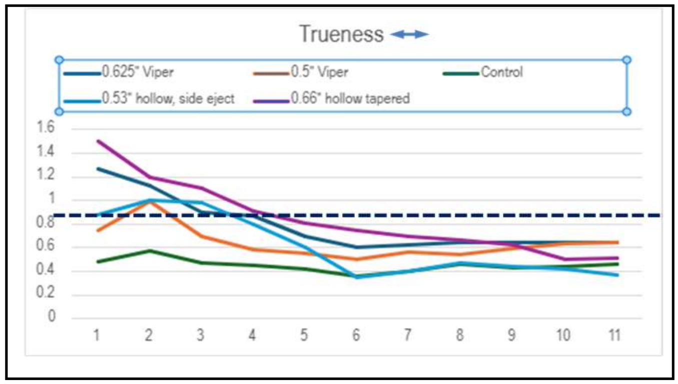

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Consider the Potential of Less-Aggressive Aeration, 2023
Elliott L. Dowling, regional director, East Region, USGA

ISTRC
International Sports Turf Research Center
Aerification Displacement Chart

Tine Size	1.25" x 1.25" Centers	1.5" x 1.5" Centers	2.0" x 2.0" Centers	2.5" x 2.5" Centers	5.0" x 5.0" Centers
1/4" Hollow Tines	3.14%	2.18%	1.23%	0.79%	
3/8" Hollow Tines	7.07%	4.91%	2.76%	1.77%	
1/2" Hollow Tines	12.57%	8.73%	4.91%	3.14%	
5/8" Hollow Tines		13.64%	7.67%	4.91%	
5/8" Hollow Vertidrain					1.23%
3/4" Hollow Tines				7.07%	1.77%
3/4" Hollow Vertidrain					1.77%
1" Hollow Tines					3.14%
1" Hollow Vertidrain					3.14%
7/8" Drill and Fill (7" Centers)					1.23%
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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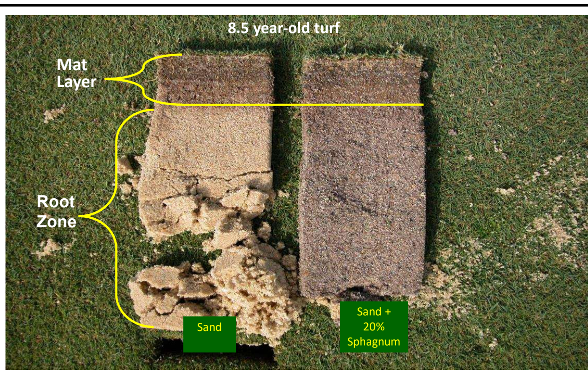

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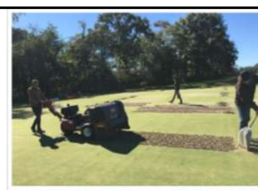

It matters how you manage the accumulating thatch/mat layer

- 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

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Thank you!

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