Rocky Mountain Regional Turfgrass Association 2024 Conference

Golf Green Organic Matter Measurement & Management

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Department of Agronomy & Horticulture

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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
  - Sand and Tines

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THE FIFTH GREEN AT THE ESSEX COUNTY COUNTRY CLUB

1930 Advertisement

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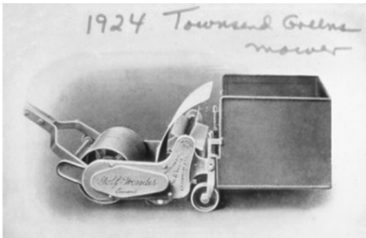
Closer cut mowers



As low as 0.25”

8

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

9

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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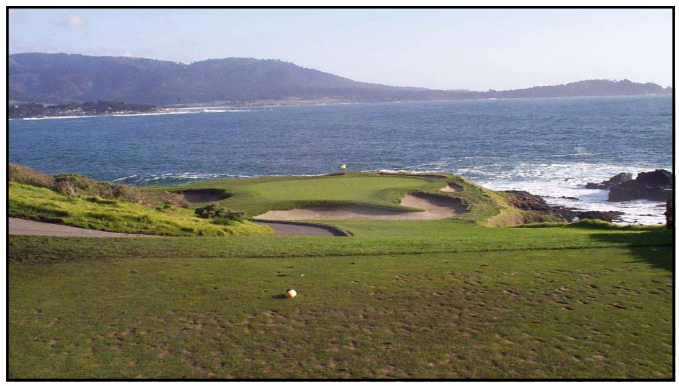

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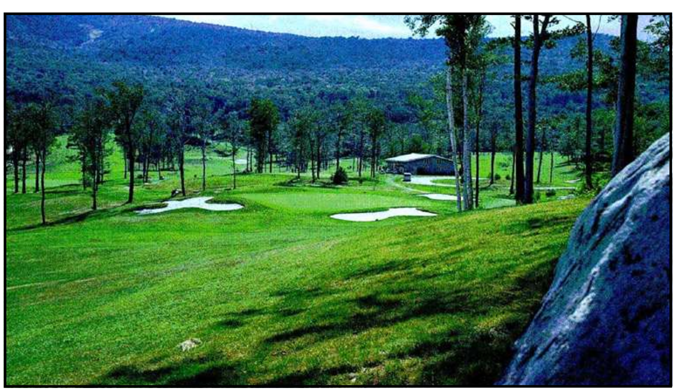

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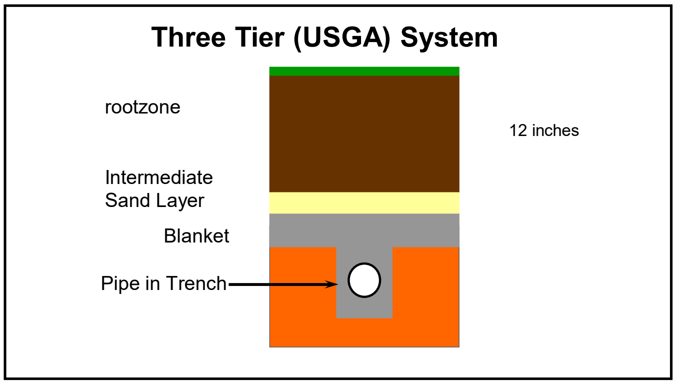

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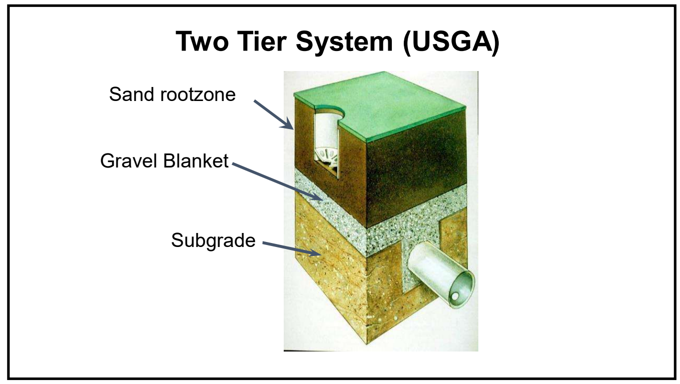

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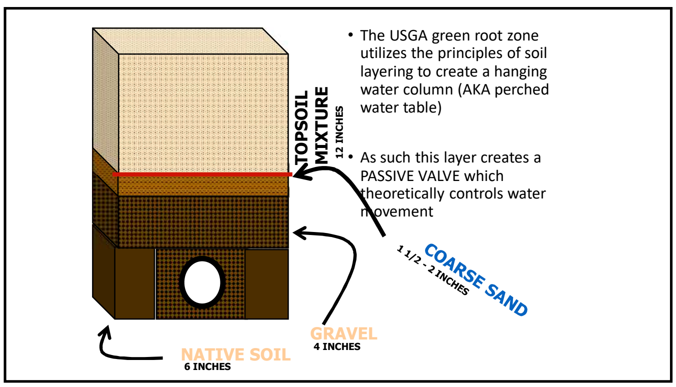

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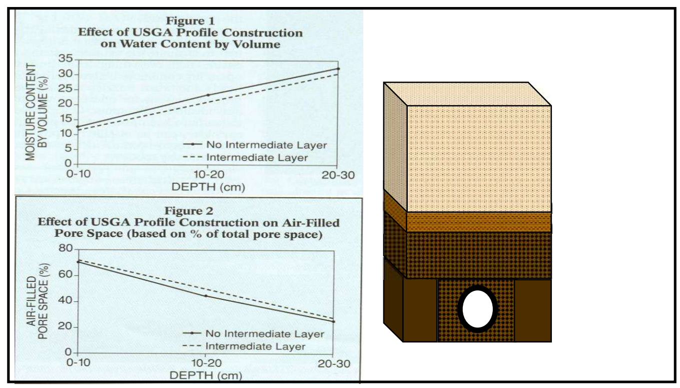

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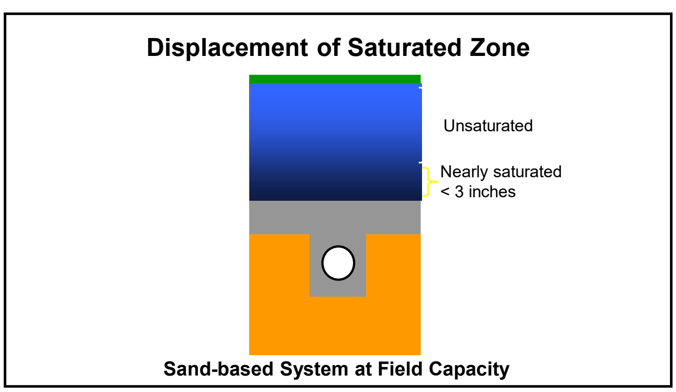

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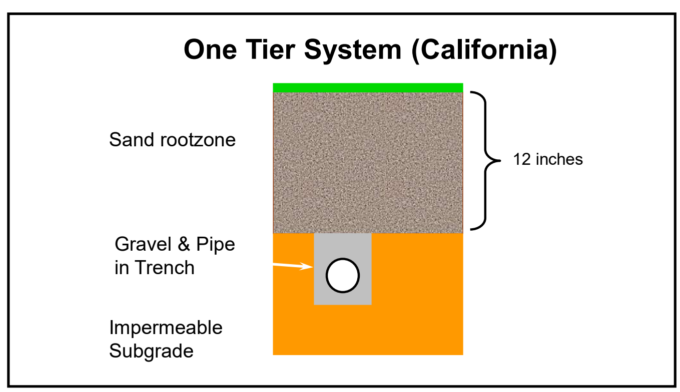

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Physical properties of sand-based root zones over time
1996-2005
University of Nebraska-Lincoln

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Objectives

- **Develop a better understanding of the impact of grow-in procedures on putting green establishment and performance.**
- **Investigate temporal changes in the soil physical properties of USGA putting greens.**

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Materials and Methods

- Field experiment initiated in 1997
- Greens constructed every year for four years
- Two rootzone mixtures
  - 80:20 Sand:Peat (v:v)
  - 80:15:5 Sand:Peat:Soil (v:v:v)
- Two establishment treatments
  - Accelerated
  - Controlled

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Project Schedule (Phase I)

1996 | 1997 | 1998 | 1999 | 2000

Greens construction (one set per year)

Seeding

Data collection on soil physical, chemical, and microbial characteristics influenced by root zone materials and grow-in procedures.

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Project Schedule (Phase II)

2002 | 2003 | 2004 | 2005

Data collection on soil physical and chemical characteristics as influenced by age, root zone materials and grow-in procedures.

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Materials and Methods

5 yr old green	**6 yr old green**	**7 yr old green**	**8 yr old green**

As of 2004

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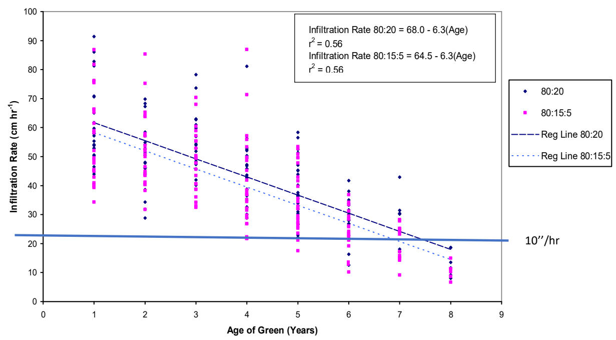

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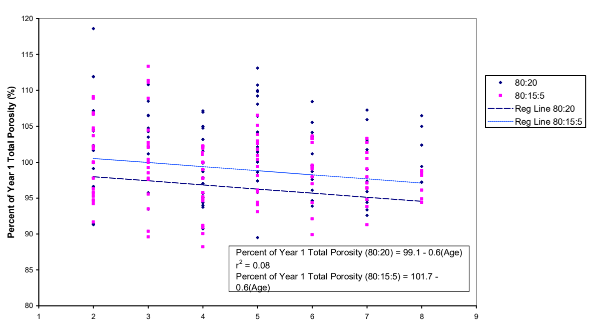

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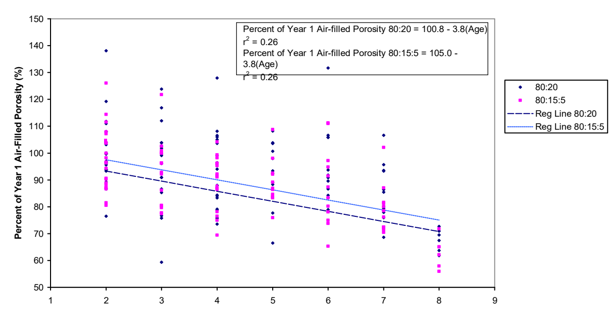

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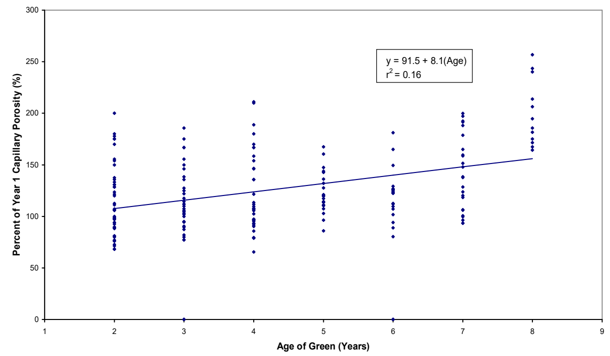

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Microbial Properties

(data from O.J. Noer/USGA project on aging golf greens) and microbial survey of regional golf courses

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Microbial Biomass & Stability

As a green matures the bacterial population shifts from aerobic to anaerobic

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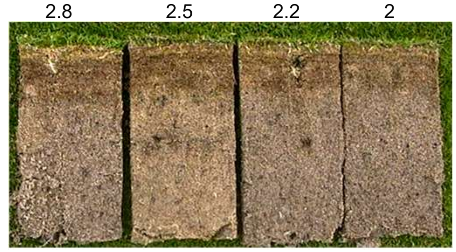
Mat development (cm)

2.8	2.5	2.2	2



8	7	6	5

Green age (years)

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Formation of Mat

- Formation of mat layer increased approximately 0.25" (0.65 cm) annually (following establishment year).
- No visible layering, only a transition is evident between mat and original rootzone.
- Topdressing program
  - Light, Frequent
    - every 10-14 days (depending on growth) and combined with verticutting
  - Heavy, Infrequent
    - 2x annually (spring/fall) and combined with core aerification

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Annual organic matter accumulation in a sand/peat green

Year 1	2	3
0.65%	3.0%	6.0%

USGA spec. green constructed with 20% (by volume) organic matter

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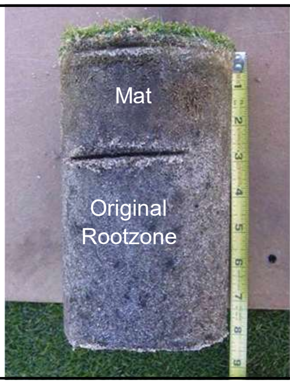

- 2004 USGA research committee site visit
- original rootzone
- mat development

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Materials and Methods

- 2004 rootzone samples taken below mat layer from each soil treatment and sent to Hummel labs for Quality Control Test (24 total samples)
- Tested against original quality control test (z-score).

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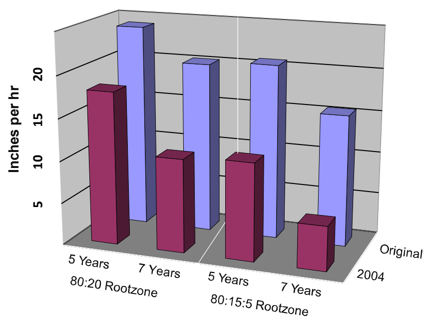

Comparison of preconstruction K_{sat} values to K_{sat} values taken 10/04.

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Change in Rootzone Particle Size Distribution

- All rootzones tested in 2004 showed increased proportion of fine sand (0.15 – 0.25 mm) with decreased proportion of gravel (> 2.0 mm) and very coarse sand (2.0 – 1.0 mm).

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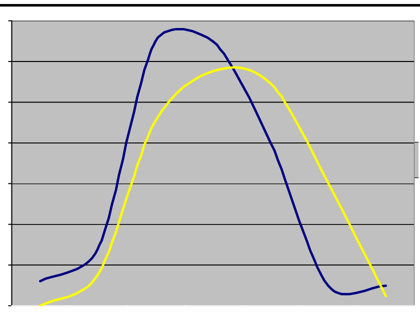

USGA sand size compared to sand used in topdressing program for USGA plots at Mead, NE.

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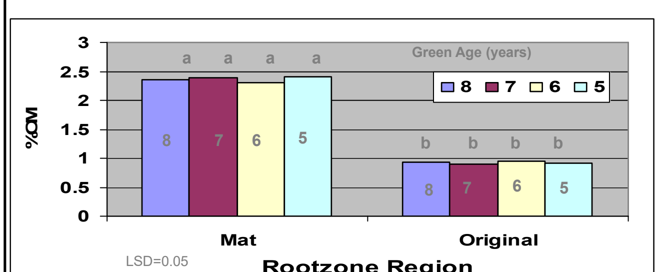
Rootzone vs Mat: Organic Matter



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Root Zone: Mat vs. Original

(samples taken July 15, 2004)

- pH: Mat < Original
- Mat > Original: CEC, OM, microbes and all nutrients

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Conclusions

- Based on *in situ* green testing K_{SAT} decreased, and surface moisture increased, over time due to organic matter accumulation above the original rootzone and increased fine sand content originating from topdressing sand
- Organic matter did result in positive agronomic change: pH, CEC, nutrient holding capacity, microbial stability and amount

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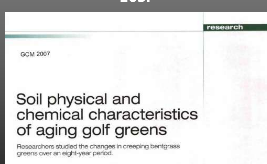
Want to know more?

- **Gaussoin, R., R. Shearman, L. Wit, T. McClellan, and J. Lewis. 2007. Soil physical and chemical characteristics of aging golf greens. *Golf Course Manage.* 75(1):p. 161-165.**



Soil physical and chemical characteristics of aging golf greens

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Research Need (2004)

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

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OM accumulates as sand greens age

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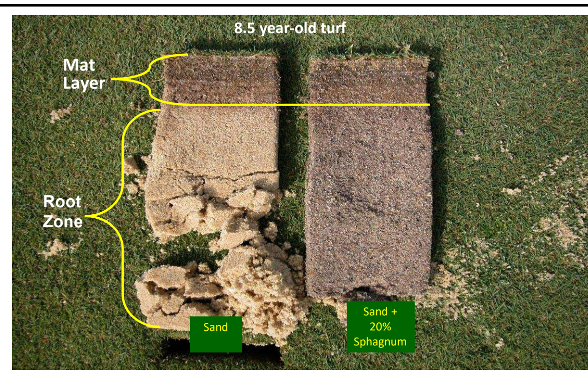

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Organic Matter Management Study

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

55

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 1

- No differences between green age except for higher % in older green
- No differences among venting methods
- No interactions with solid/hollow/none

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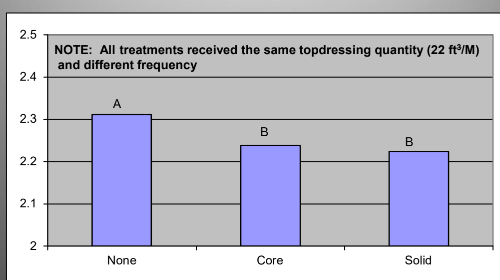
Effect of Tines on OM after 1 yr



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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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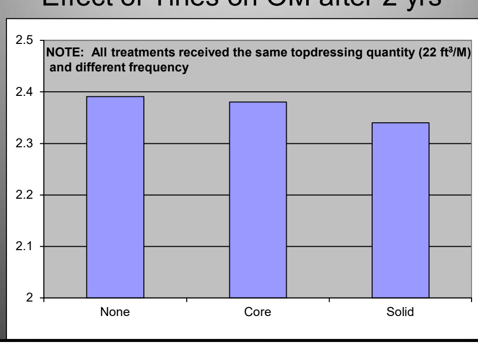
Effect of Tines on OM after 2 yrs



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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

ACCEPTED

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

Abstract

Soil cultivation is commonly used to manage organic matter (OM) accumulation in golf course putting greens. Our objectives were to determine: (i) if hollow-tine cultivation is more effective than solid-tine cultivation at managing OM and water infiltration, (ii) if venting methods are effective at managing OM and water infiltration, and (iii) if venting alters or interacts with effects of early- or late-season cultivation. The study was a 3 × 5 factorial repeated on two 'Providence' creeping bentgrass (*Agrostis stolonifera* L.) research putting greens. Tine treatments were hollow-tine, solid-tine, or no-tine cultivation. Venting treatments were Hydroject, PlanetAir, quad needle tine, bayonet tine, or no venting. Soil samples were collected and analyzed for OM content using loss on ignition. Water infiltration rates were determined in situ. After 2 years, there were few consistent differences found among the tine and venting treatments, and there were no significant interactions regarding OM concentration. This response was attributed to the small amount of surface area impacted by cultivation and to the equalization of topdressing quantity across all treatment combinations. Hollow-tine and solid-tine cultivation increased infiltration compared with no cultivation. In general, Hydroject treatments increased water infiltration rates more than all other venting treatments regardless of tine treatment.

Dep. of Agronomy and Horticulture, Univ. of Nebraska–Lincoln, 279 Plant Science Hall, Lincoln, NE 68583. Received 27 Mar. 2014. *Corresponding author (chasschmid@gmail.com).

Abbreviations: HTC, hollow-tine cultivation; LOI, loss on ignition; OM, organic matter; STC, solid-tine cultivation.

Conversions: For unit conversions relevant to this article, see Table A.

ORGANIC MATTER ACCUMULATION in creeping bentgrass putting greens has been a concern since the innovation of sand-based root zones (Gaussoin et al., 2013). Accumulation of OM can increase thatch in a putting green, creating a soft, saturated surface that results in decreased playability (Glasgow

Published in Applied Turfgrass Science
DOI 10.2134/ATS-2014-0032-RS

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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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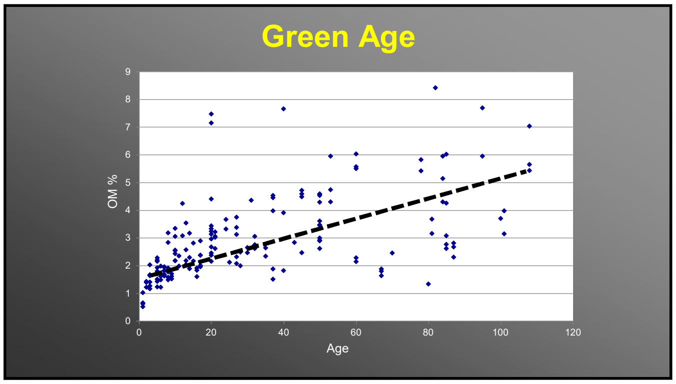

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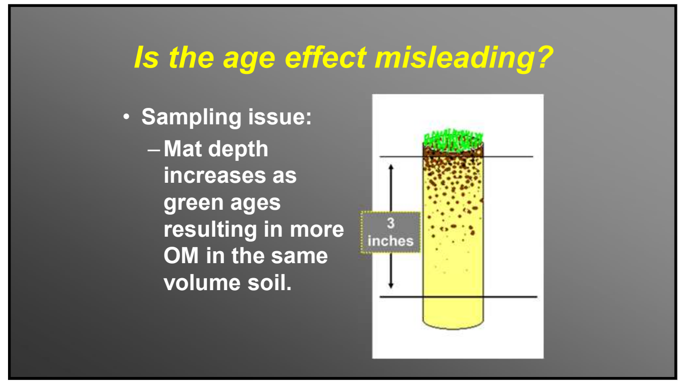

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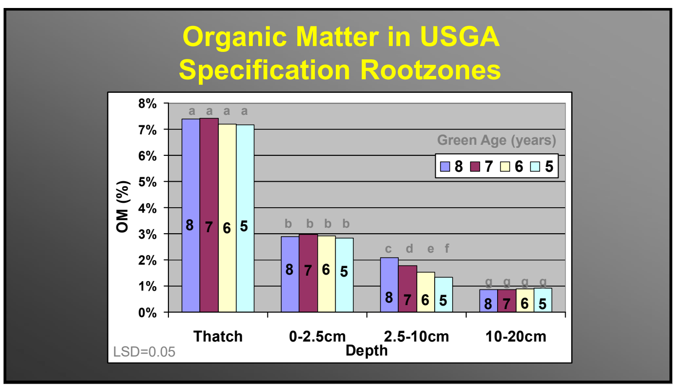

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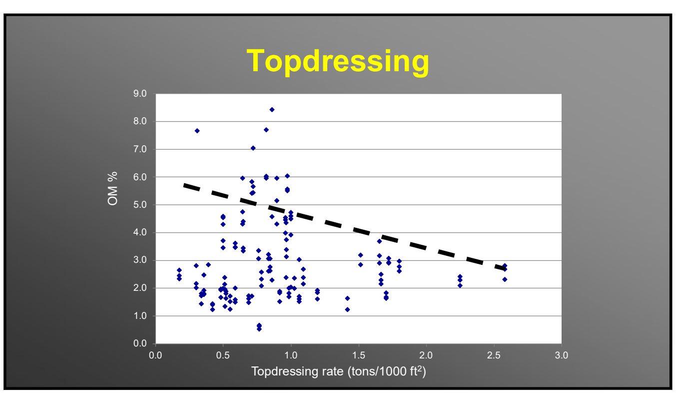

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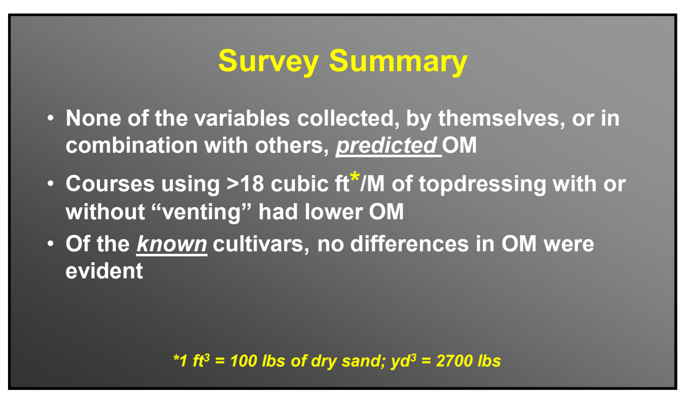

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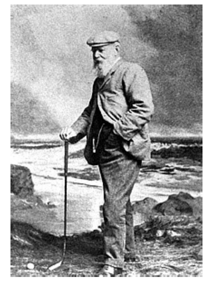
Topdressing

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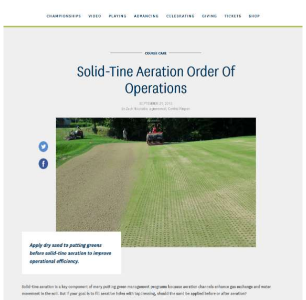
https://www.usga.org/content/usga/home-page/course-care/regional-updates/central-region/2018/solid-tine-aeration-order-of-operations.html



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"Advocates of solid-tine aeration report that they get the same benefits of thatch and organic matter reduction with less labor for the collection and removal of aeration cores. Whether you pull a core or use solid tines, it's all about sand volume and the ability to dilute organic matter in the rootzone. Regardless of the method, the most important factor is filling the hole with sand. It's all about dilution, and if you can do that with less of a mess and less labor, then solid-tine aeration is a viable alternative."

From: 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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Please mark all that apply. In the last 5-10 years, on our greens, our facility has:

- Increased topdressing quantity
- Increased topdressing frequency
- Increased hollow tine (equal or greater than 0.5") aeration
- Increased solid tine (equal or greater than 0.5") aeration
- Decreased hollow (equal or greater than 0.5") tine aeration
- Decreased solid tine (equal or greater than 0.5") aeration
- Made minimal changes in topdressing application quantity/frequency.
- Made minimal changes in cultivation practices.
- Increased "venting" practices.

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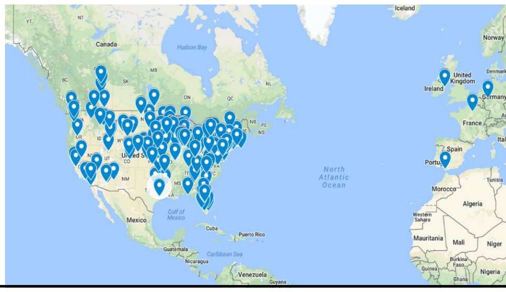
2016 Survey Respondents via Greenkeeper



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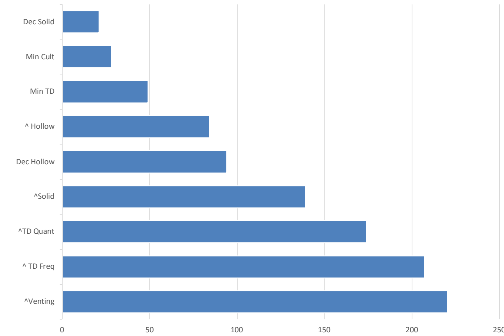
303 Responses



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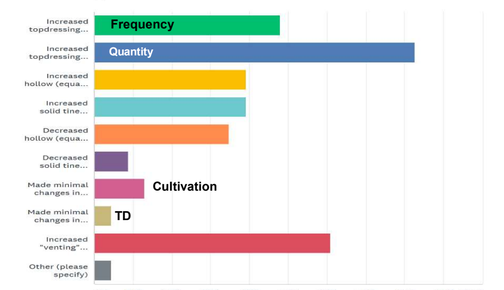
(Please mark all that apply.) In the last 5-10 years, on our greens, our facility has:

Answered: 23 Skipped: 0 2019 GIS seminar attendees



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USGA

Golf Course Superintendents Association New Jersey 1926

New Jersey Turfgrass Association

Rutgers New Jersey Agricultural Experiment Station
Center for Turfgrass Science

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Sand Particle Size (1-mm and 0.5-mm sands)

Particle Name	Diameter (mm)
Fine Gravel	2 – 3.4
Very Coarse Sand	1 – 2
Coarse Sand	0.5 – 1
Medium Sand	0.25 – 0.5
Fine Sand	0.15 – 0.25
Very Fine Sand	0.05 – 0.15
Silt	0.002 – 0.05
Clay	< 0.002

Photo: TJ Lawson

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Research on…

- Topdressing
  - ✓ Sand Size
  - ✓ Rate
- Cultivation

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Research Objectives:

1. Effects of topdressing with sand lacking coarse particles
2. Does core cultivation and backfilling holes with medium-coarse sand offset any negative effects of topdressing with sands lacking coarse particles?

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Conclusions

Strong impact of <u>core cultivation</u> plus backfilling with medium-coarse sand:
- reduced organic matter and capillary porosity (water retention)
- increased air-filled porosity
- consistently drier playing surface

Sand size effects depended on the level of core cultivation (interaction)

Medium-coarse and medium-fine sands
- similar at diluting organic matter and reducing surface water retention
- topdressing with medium-fine sand caused a finer sand size in mat layer, which was corrected by core cultivation (holes backfilled with medium-coarse sand)

Fine-medium sand
- Greater surface water retention and reduced infiltration due to finer sand size and capillary porosity in mat layer
- Core cultivation (holes backfilled with medium-coarse sand) reduced these effects; however, not completely due to the quantity of fine and very fine sand remaining above 30% (by weight) in the mat layer

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What these data do/don't suggest

- Cultivation, when topdressing quantity was equal, was insignificant in affecting OM
- Superintendents, however, 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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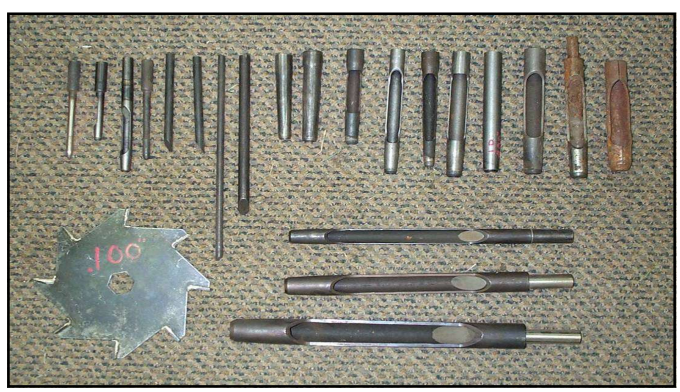

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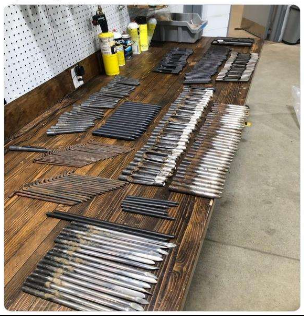
eric tuchols
@hhgcgrounds

I pride myself in having a nice selection of aerifing tines depending on how I'm feeling



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Research Need (2004)

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

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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
  - Other data

Equipment and Tine Support Provided by

TORO CTI Ceres Turf, Inc. DryJect Heartland Golf & Turf Services LLC

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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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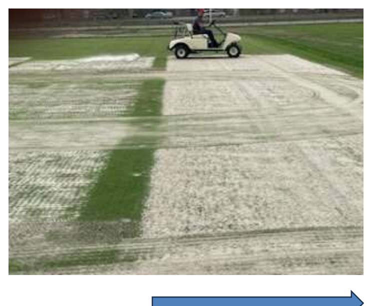
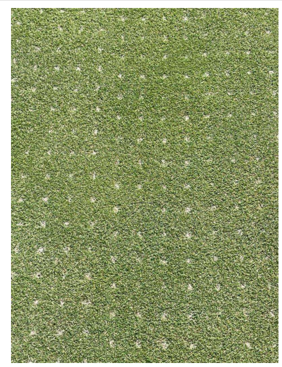


Plot after dragging and several mowings and irrigation



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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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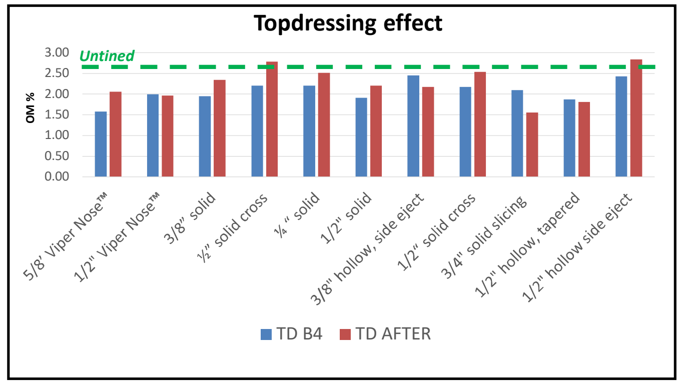

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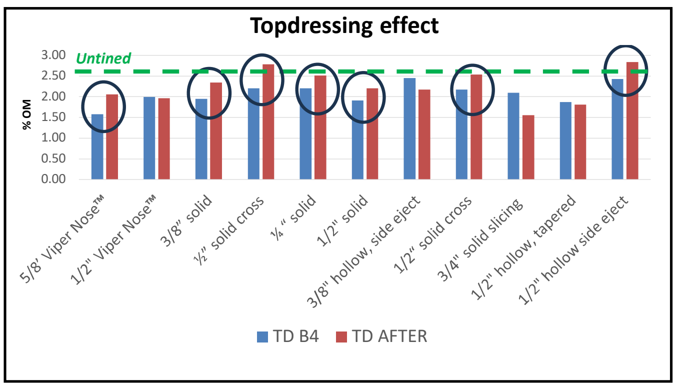

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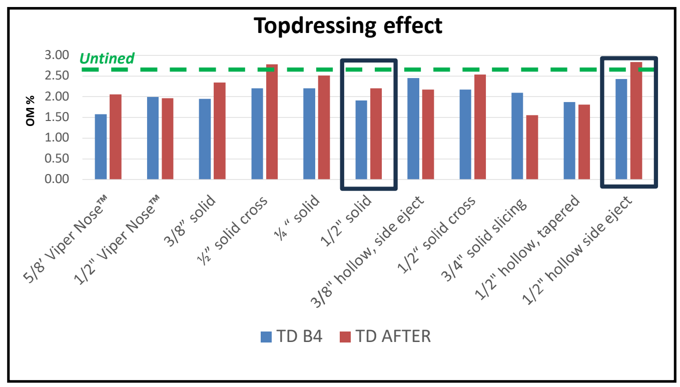

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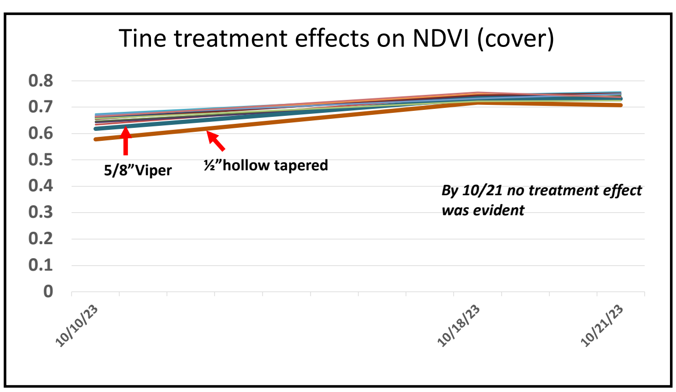

109

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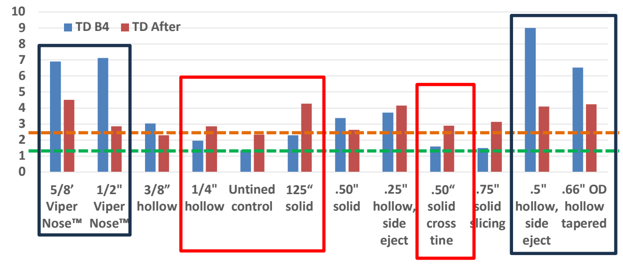
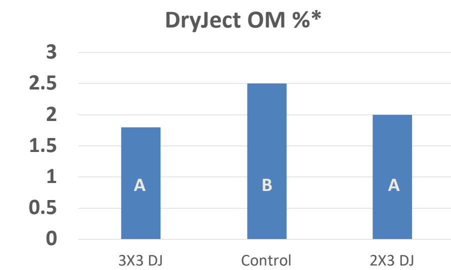
Tine/TD effects on Infiltration (inches per hr)
2.5 weeks post aeration



Positive effect on infiltration was greater for ½" or larger hollow tine & TD before aeration

111



*No topdressing effect; numerically equivalent to most other tine treatments

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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.

116

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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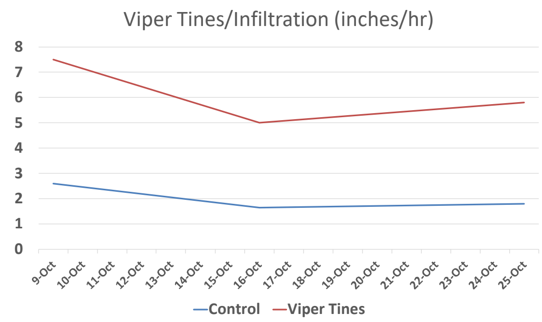

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1/2 Solid	1/2 Hollow
% OM	
1.8	2.4

**

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

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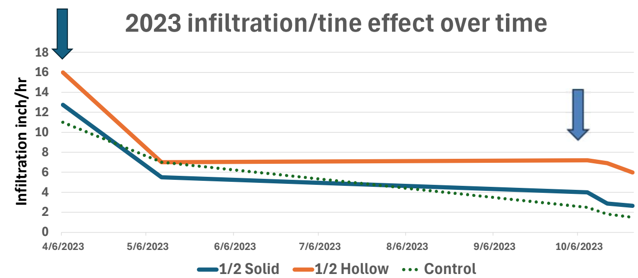

Prior to study, area was aerated with ½" solid tines 2X/yr and topdressed with medium-fine sand for 5 years. Initial infiltration in 2018 was 12"/hr.

120

Early Results

- Lots of stuff going on
- Topdressing before aeration, even with *some* 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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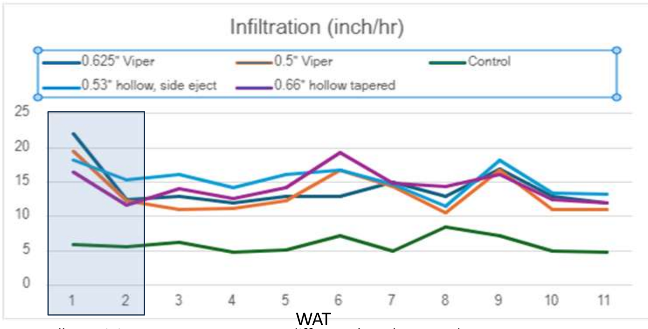
Spring 2024 Results

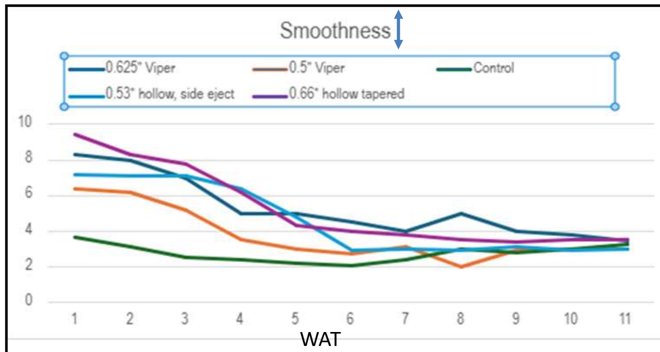
- Cumulative effect of 3 cultivation events
- Similar outcomes to Fall 2023
- "Better" GS3 data

122



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

123



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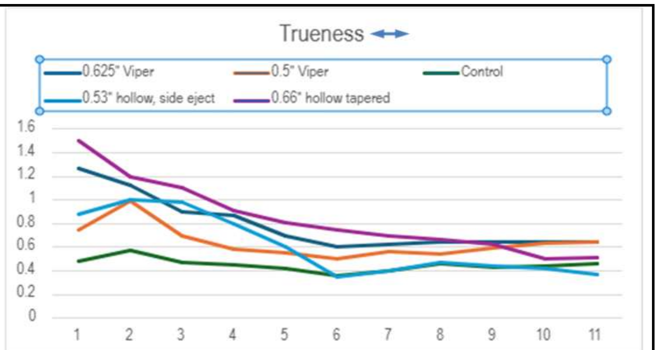

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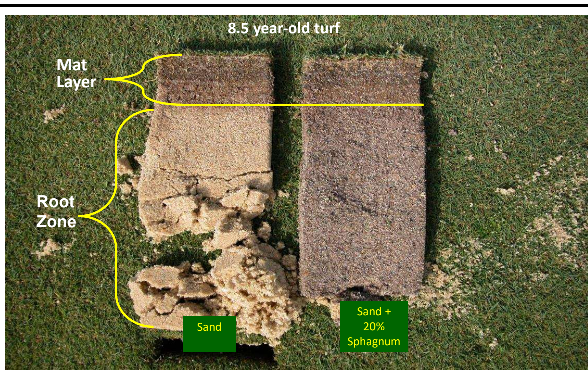
What have we learned?

- 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…

126



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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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Managing for Drier Mat Layer

Topdressing

- As much and as often as feasible — ~1 ton / 1,000 sq ft / yr; **18-22 ft³ / M / yr**
- Select as coarse a sand as feasible — 0.5-mm sand okay if dominated by medium sand (not fine or very fine sand)
- Cost and interference with play and mowing are the limiting factors

Core Cultivation

- Very effective at producing a drier surface
- Cost and time for healing are greatest limitations

Solid Tine Cultivation

- Too soon to have a lot of data, but some initial data not as positive of response as hollow tine – stay tuned

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Key is matching your growth rate to optimize topdressing + ……….

How much sand to use for topdressing?

- Generic recommendation is 20-40 ft³ per 1000 sq. feet/yr (about 0.5 inch/M/yr)
  - ***UNL worked showed 20-24 ft³ for OM management***
- Varies by amount of:
  - Traffic
  - Grass species or cultivar
  - Nitrogen Applied
  - Water Applied
  - Microclimate/Location

130

#clipvol *"One bucket at a time"*

- Micah Woods, Asian Turfgrass Center
  - Asianturfgrass.com

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"Growth Potential"

- Pace Turf
  - https://www.paceturf.org/public/sand-and-growth-potential

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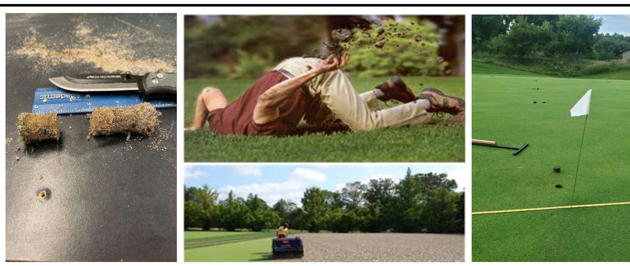

Dos and Don'ts of Organic Matter Sampling

133

Developing a Standard for Measuring Organic Matter in Putting Green Soils

- Collaborators:
  - Roch Gaussoin / Professor / Agronomy & Horticulture/University of Nebraska-Lincoln
  - Doug Linde / Professor / Plant Science / Delaware Valley University
  - James Murphy / Professor / Plant Biology / Rutgers University
  - Doug Soldat / Professor / Soil Science / University of Wisconsin-Madison
  - *Travis J. Miller* / Graduate Student / University of Wisconsin-Madison

Funded by

USGA **Mike Davis Program for Advancing Golf Course Management**

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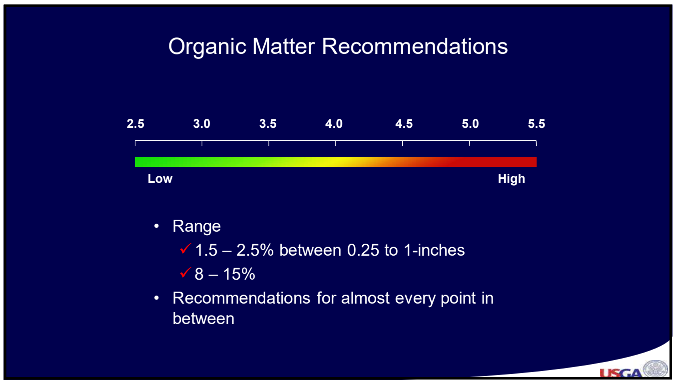

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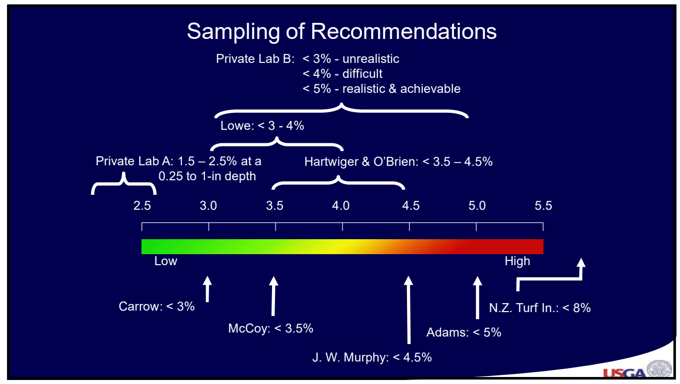

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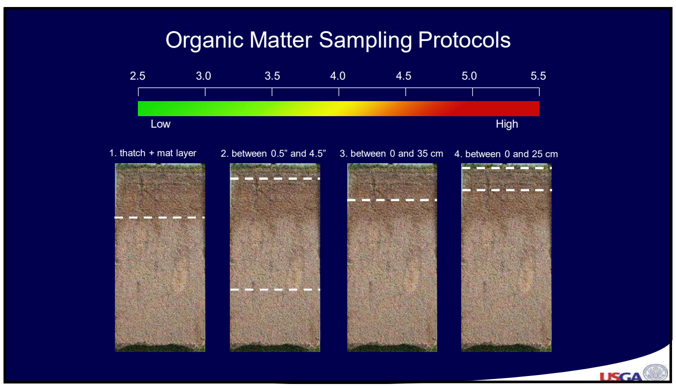

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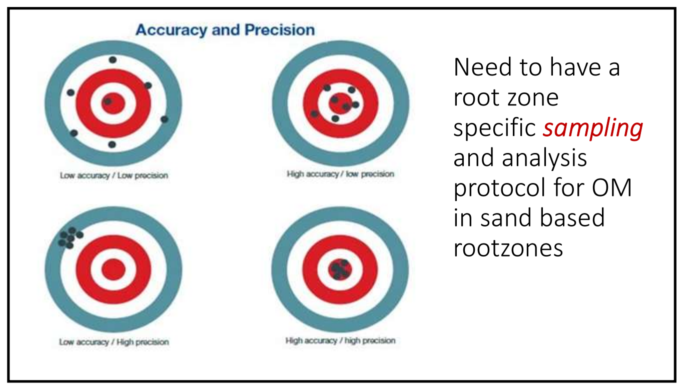

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How and when to take samples

- Choose 5-10 random locations 25 -30 ft apart
- Use 0.75-inch diameter probe to a depth of 1 inch (larger cores acceptable but not necessary)
- Leave verdure on without grinding and sieving
- samples should be taken at approximately the same time each year, with attention paid to topdressing and cultivation timings.

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Considerations:

1. As of this writing, most soil testing labs grind and sieve samples and use 360̊C for measuring organic matter. Ensure the lab you choose measures organic matter of the entire intact sample using 440̊C without subsampling and without grinding or sieving.
2. There are two conventions for sampling depth 0-1, 1-2, and 2-3 inches vs. 0-2, 2-4, and 4-6 cm. The committee did not address the differences between these two conventions, and both are likely appropriate for measuring and managing surface organic matter. Consistency will be most important as the conventions are technically the same.
3. Most of these recommendations were developed from samples from cool-season putting greens. Additional research on warm-season turfgrass surface organic matter is needed.
4. The next step for this committee is to create an ASTM (American Society of Testing Materials) standard by which all labs will utilize the same procedure for surface organic matter determination.

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A Standard Method for Measuring Putting Green Surface Organic Matter

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Layering

- Water retention is non-uniform
- Thatch/mat layers can store twice as much water than the root zone

NOT a function of drainage

Rather it is the difference in pore size distribution among layers

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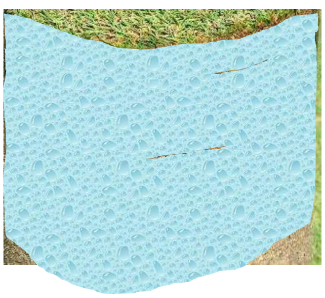

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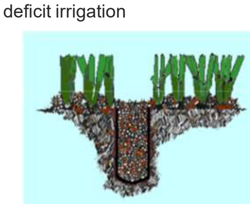
Layering

- Aeration alone not that effective
- Must topdress to dilute OM (change its pore size distribution) and use deficit irrigation



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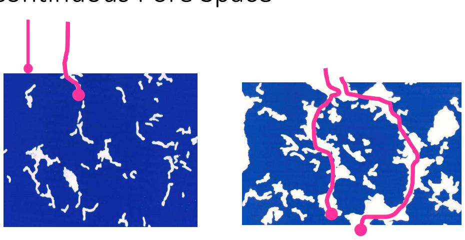
Discontinuous Pore Space



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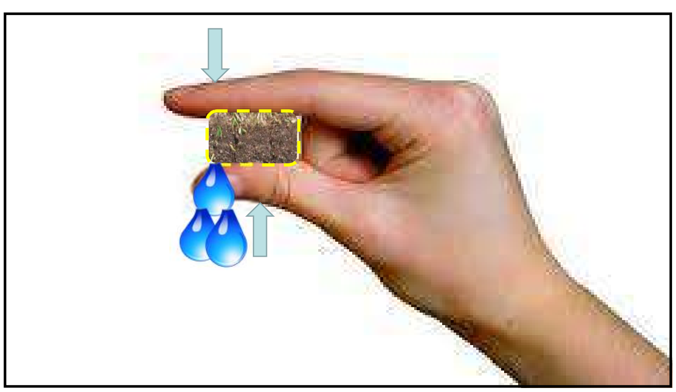

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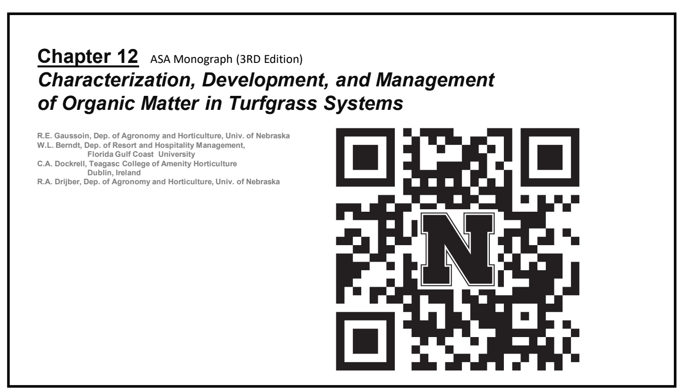

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